Natural Resources and the Environment 2000. Norway

Statistisk sentralbyrå • Statistics Norway
Oslo–Kongsvinger

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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 2000 contains updated resource accounts for energy and the latest figures for emissions to air. It also includes 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 2000 edition includes articles on various aspects of the Kyoto Protocol and the energy market. Finally, the appendix provides more detailed statistics in the form of tables.

Statistics Norway would like to thank the people and institutions who have supplied data for *Natural Resources and the Environment 2000*.

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 Knut Einar Rosendahl and Øystein Døhl. Alison Coulthard, Veronica Harrington Hansen and Elizabeth Sætre have translated the Norwegian version into English.

Statistics Norway
Oslo/Kongsvinger 15 August 2000

Svein Longva

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1. Introduction and summary

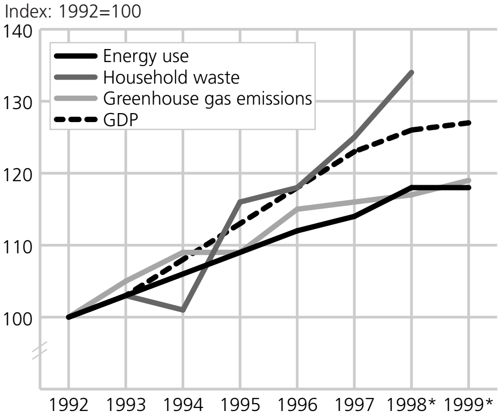
1.1. What environmental trends were apparent at the end of the 1990s?

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 still rising sharply, and markedly more rapidly than GDP (gross domestic product) (figure 1.1) and consumption in private households (figure 8.14). Energy use, some of which has negative environmental consequences, has risen in recent years, but somewhat more slowly than GDP. Energy use hardly rose at all in 1999. There are also positive signs: treatment of waste water is gradually improving, a larger proportion of household waste is being recycled, and emissions of lead to air have been practically eliminated (figure 1.2).

1.2. Summary and pressure indicators for priority areas of environmental policy

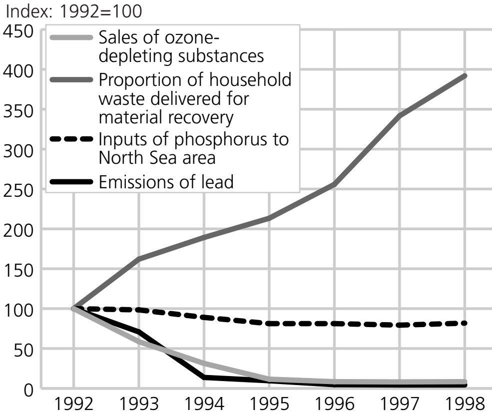
Here, we present a summary of each chapter of *Natural Resources and the Environment 2000*. Chapters 2 to 6 describe Norway's natural resources and resource-based industries and other activities that create environmental pressures. Chapters 7 to 11 focus more on actual environmental problems.

Figure 1.1. **Relative changes in GDP and important environmental indicators that are showing negative trends**



Sources: Statistics Norway and Norwegian Pollution Control Authority.

Figure 1.2. **Relative changes in important environmental indicators that are showing positive trends**



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

Box 1.1. Priority areas of Norwegian environmental policy

When trying to present an overall picture of environmental problems, it can be practical to classify them according to specific criteria. These may for example be based on the type of environmental impact they cause, the media (soil, air, water) they affect, who generates the problems or who is responsible for dealing with them. It is not an easy matter to devise a classification based on clear criteria, and at the same time include all the important environmental problems. International organizations such as the EU, the OECD and the UN have all drawn up suggestions with relatively similar starting points. Nevertheless, there are some differences in the classifications they use (see e.g. Eurostat 1999, OECD 1994 and 1998, EEA 1997, Nordic Council of Ministers 1997, UN 1996, Alfsen et al. 1992).

In Report No. 58 (1996-97) to the Storting on an environmental policy for sustainable development, eight priority areas of environmental policy were established. These are:

1. Conservation and sustainable use of biological diversity
2. Outdoor recreation
3. The cultural heritage
4. Eutrophication and oil pollution
5. Hazardous substances
6. Waste and recycling
7. Climate change, air pollution and noise
8. International cooperation on environmental issues and environmental protection in the polar areas.

These priority areas also provide the basic structure for the result monitoring system used by the environmental authorities, and therefore determine to some extent the types of environmental data that are given priority as part of the tasks of various government agencies. Report No. 8 (1999-2000) to the Storting on the Government's environmental policy and the state of the environment in Norway, which was submitted in autumn 1999, followed this up by setting targets for what is to be achieved in each of the priority areas.

An important way of documenting the state of the environment in various connections is to use indicators or key figures (see box 1.2 for an explanation of what is meant by an environmental indicator).

Natural Resources and the Environment 2000 describes environmental pressures in several of the priority areas of environmental policy and gives a basis for selecting relevant pressure indicators within these areas.

The summaries of some chapters also include a discussion of relevant environmental pressure indicators for each of the priority areas described in Report No. 8 (1999-2000) to the Storting (see boxes 1.1 and 1.2).

Chapter 2. Energy

This chapter provides updated statistics on resources and the production and use of crude oil, natural gas and hydropower. In 1999, the two most important trends in the energy sector were (1) strong growth in *production* of natural gas and electricity compared with the year before, and (2) stabilization of domestic *energy use* after relatively strong growth in recent years. The rise in production of natural gas continued the trend in previous years as more and more fields were brought on

Box 1.2. Environmental indicators

Indicators, or key figures, are selected data or constructed indices that are used to illustrate often complex phenomena or problems. As the name suggests, an indicator indicates something about the phenomenon. This may mean that it illustrates some aspects of a phenomenon clearly, whereas others are not well described. Often, several indicators are therefore used to describe a phenomenon. The number depends both on how many useful and illustrative indicators can be found and on their purpose and the user groups they are intended for.

The choice of indicators is largely based on expert judgement. A *good* indicator has as many as possible of the following characteristics:

- it is representative, i.e. important characteristics of the phenomenon are illustrated
- it is easy for users to interpret
- it shows trends over time
- it makes it possible to compare different countries or different regions
- there is a limit or reference value against which it can be compared
- the methods used are recognized and well-documented
- it is based on international standards
- the quality of the data is high
- the data are reasonably easily accessible and are updated at regular intervals.

It is important that environmental indicators can be used as tools to describe environmental problems and thus provide a basis for evaluating measures to deal with them. Environmental problems are caused by the effects of our activities on the environment. Our activities in turn are governed by economic, social and political factors and the relationships between them. For environmental indicators to be adequate and function as effective tools, they must also be linked to such socio-economic factors. One way of structuring environmental indicators that has become generally recognized is the PSR model (Pressure-State-Response), which was developed by the OECD (see e.g. OECD 1994 and 1998). This has been further developed as the DPSIR framework, which includes the driving forces behind environmental pressures and the impacts of environmental change. This is used for example by the European Environment Agency (EEA). Environmental problems are analysed by looking at:

- *driving forces*. These include population growth, economic activity, etc., which lead to
- *environmental pressures* such as emissions to air and water and extraction of natural resources. These in turn result in changes in
- *the state of the environment*, for example changes in water quality or air quality, which cause
- *environmental impacts* such as fish mortality, reduction in crop yields or species extinction. At some point, society will react, i.e. there will be a
- *response* to environmental problems, e.g. 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.

The work of Statistics Norway mainly provides a basis for indicators related to *driving forces* and *environmental pressures*. Important features of such indicators are whether it is possible to split data by sectors and whether they can be linked to economic models and projections.

line. As a result of a sharp rise in the price of crude oil in 1999, total revenues from the petroleum sector rose markedly compared with 1998. Electricity production rose as a result of high precipitation.

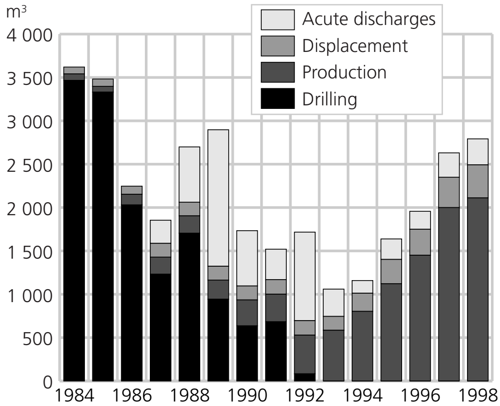
The stabilization of overall energy use from 1998 to 1999 is probably related to milder weather and the modest growth of the mainland economy. Despite the fact that electricity prices were somewhat lower, electricity consumption was unchanged from 1998. The rise in production and stabilization of consumption meant that Norway was a net exporter of electricity (measured in kWh) for the first time since 1995. An analysis indicates that a more efficient power market in which prices are the same for all users would have substantial economic and environmental benefits. The use of transport oils rose at the same rate as previously, while oil consumption for other purposes dropped somewhat. Another analysis shows that one important cause of the growth in electricity consumption since the mid-1970s is the increase in the number of households in Norway.

Production and consumption of energy are among the most important causes of environmental pressures, especially in connection with emissions to air. The oil and energy sector alone accounted for about 30 per cent of CO_2 emissions in Norway in 1999. Combustion of the extracted gas and oil generates CO_2 emissions that are an estimated 60 times higher than the emissions generated by the extraction process itself (see Chapter 7).

Indicators for oil pollution (priority area 4)

The petroleum sector is also an important source of marine oil pollution. Oil pollution is defined as part of priority area 4 in Report No. 8 (1999-2000) to the Storting. Oil spills have both short- and long-term impacts on marine life. Oil pollution is divided into two types, *operational discharges* and *acute discharges*. Operational discharges are legal, licensed discharges

Figure 1.3. **Discharges of oil from petroleum activities (cf. priority area 4)**



Source: Norwegian Pollution Control Authority.

associated with petroleum activities, whereas acute discharges are not licensed and may also be associated with other activities. Trends in both types are a suitable pressure indicator for oil pollution (figure 1.3). Acute discharges outside the petroleum industry can occur anywhere in Norwegian waters. Petroleum activities are the largest source of acute discharges, and accounted for about 60 per cent of the quantity of oil in acute discharges in 1999. Most acute discharges are small.

The largest proportion of operational discharges is made up of discharges of oil-contaminated water (produced water) that is pumped out of the wells together with oil and gas. These have risen in the last few years and caused a rise in overall discharges. The trend is expected to continue in the years ahead as more oil and gas is removed from the reservoirs and the water content rises.

Chapter 3. Agriculture

The most important environmental pressures resulting from agriculture are related to landscape change and discharges of nutrients. Statistics Norway's agricultural statistics show that in recent years, there have been no significant changes in farming practices (fertilization, livestock density, soil management) that would indicate a reduction in runoff of nutrients. Inputs of phosphorus and nitrogen from agriculture have been reduced by 26 and 19 per cent respectively between 1985 and 1998, but there have only been small changes in recent years. Major structural changes are taking place in the agricultural sector. From 1989 to 1999, the number of holdings was reduced from 99 000 to 72 000, while the total area of agricultural land rose slightly (see also the indicator for cultural landscapes in the summary of Chapter 10 below). There has also been constant pressure to convert land that is suitable for agriculture for other purposes (about 10 km^2 per year has been lost). Nevertheless, there has been a small rise in the agricultural area in use, which is explained by cultivation of new areas and the registration of marginal areas that were previously of little economic importance as agricultural areas in use (this is a result of reorganization of the grants system).

Chapter 4. Forest

The roundwood cut in Norway dropped from 1997 to 1998. The harvest still corresponds to less than half the annual increment, and the volume of the growing stock is rising by about 1.8 per cent per year. The annual increment corresponds to a net uptake of CO_2 that is equivalent to more than 40 per cent of Norway's total anthropogenic emissions. The sequestration of carbon in forests is not considered to be a way of meeting Norway's commitment under the Kyoto Protocol. The volume of the growing stock of forest in Norway has more than doubled since 1925, when the National Forest Inventory was started. The results of the Norwegian monitoring programme for forest damage show that the state of health of our forests, measured as mean crown density, has improved for the second year running.

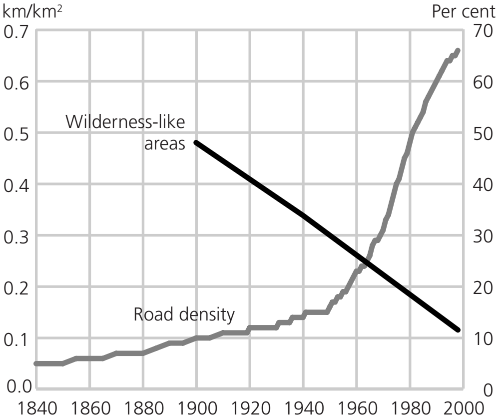
Forest ecosystems account for a substantial proportion of Norway's biological diversity. The conservation and sustainable use of biological diversity is one of the priority areas of Norwegian environmental policy. Biological diversity means the variety of life at all levels, i.e. species of plants, animals and microorganisms, their genetic material and the communities they form in interaction with each other and the abiotic environment (water, air, soil and rock).

Indicators for biological diversity (priority area 1)

The main causes of the loss of biological diversity are related to land use (alteration of the physical environment and land-use changes), pollution, the introduction of alien species (including gene technology) and over-exploitation (Report No. 8 (1999-2000) to the Storting). Forestry operations put pressure on biological diversity, and the extent to which forest ecosystems are disturbed is strongly dependent on the extent of the forest road network. The Directorate for Nature Management estimates that 900 of the 22 000 species associated with forests in Norway are rare or endangered.

Road-building is an important cause of fragmentation of biotopes and the natural environment. In addition, roads make new areas more accessible, opening the way for activities that may impoverish biological diversity, such as forestry. *Road density* is therefore an indicator of pressure on biological diversity. This is a

Figure 1.4. **Road density (including forest roads) and wilderness-like areas in Norway. km road per km² land area and percentage of Norway's total area (cf. priority area 1)**



Sources: Statistics Norway and Directorate for Nature Management.

general indicator, and the direct impact on biological diversity will depend on where roads are built and how much new activity results. It should therefore be supplemented by indicators of specific changes in habitats or studies of biological diversity (state indicators).

Road density in Norway rose steadily but not dramatically until 1950. After this, it has risen much more strongly, largely due to the construction of forest roads. Roads have also acted as more effective barriers than figure 1.4 suggests, since a number of existing roads have been widened and traffic density has risen. *The proportion of wilderness-like areas* (defined as areas more than 5 km from major infrastructure development) is another useful pressure indicator for biological diversity. In Norway, this proportion has dropped to about 12 per cent from more than 50 per cent in 1900. Socio-economic developments are thus exerting great pressure on biological diversity in Norway.

Chapter 5. Fisheries, sealing, whaling and fish farming

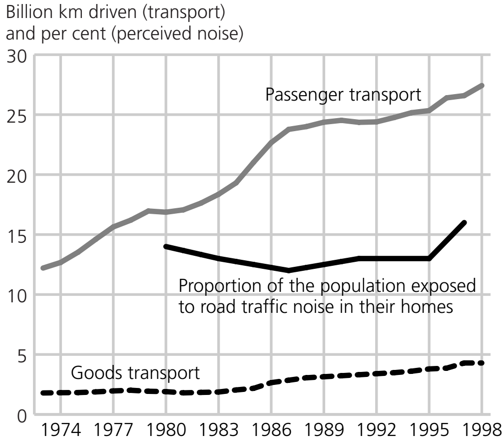
In 1997, Norway's fisheries ranked as number 10 in the world in terms of catch quantities, and the country was the world's largest fish exporter in terms of value. In 1999, the value of Norwegian fish catches dropped by about NOK 500 million to NOK 9.9 billion, and the total catch quantity dropped by more than 200 000 tonnes to 2.55 million tonnes. 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. Cod quotas have therefore been substantially reduced again from 1999 to 2000. 1999 was another record year for the fish farming industry; salmon production reached 410 000 tonnes and salmon exports were worth almost NOK 11 billion. The value of the production of farmed fish surpassed that of the traditional fisheries in both 1998 and 1999.

Chapter 6. Transport

Various forms of transport are a common cause of exposure to noise and pollution (Statistics Norway 1998). The volume of both road and air traffic is growing rapidly. For example, in 1998 each Norwegian travelled an average of almost 37 km every day, as compared with 18 km in 1970. Goods transport has also grown rapidly, and has risen by almost 50 per cent since 1980. This chapter quantifies the actual growth in passenger and goods transport in Norway during the past 50 years, and discusses the underlying causes of this growth and its environmental impact. The growth in transport is also considered in relation to current environmental policy targets.

Indicators for noise (priority area 7)
According to the surveys of living conditions, people consider noise from road traffic to be the most important cause of noise inside their homes. Other important sources of noise are aircraft and trains. It is estimated that just over 200 000 people have sleep problems caused by noise (Statistics Norway 1998). Noise is thus one of the environmental problems that affects the largest number of people in Norway. Noise is a significant problem in Norway, even if we compare ourselves with more densely-populated countries. This is mainly because a large proportion of the population lives near roads or railways (Report No. 8 (1999-2000) to the Storting). *The proportion of the population exposed to noise from road traffic* is thus a suitable indicator for noise.

Figure 1.5. **Growth in road transport work in Norway and the proportion of the population exposed to noise (cf. priority area 7)**



Sources: Surveys of living conditions, Statistics Norway and Institute of Transport Economics.

Since road traffic is the dominant source of perceived noise, *road transport work measured in kilometres driven* (vehicle kilometres) is also a pressure indicator for noise. Goods and passenger transport can be separated, because the noise generated per km driven is higher for goods transport (Kolbenstvedt et al. 1996). We have not distinguished between different vehicle types. In the surveys of living conditions carried out by Statistics Norway, people are asked whether they are exposed to noise, for example from road traffic, inside their homes.

Figure 1.5 shows that transport work has grown considerably in the last thirty years. The indicator tells us something about how much noise is generated in total, but not necessarily how much people are exposed to. Noise from road traffic can be reduced in various ways, for example by using quieter engines and tyres, by increasing the distance between the source of noise and housing, and by direct noise screening. The amount of noise per unit of transport work has been reduced over the years by the use of quieter engines in aircraft, trains and road vehicles. The figure shows that the level of perceived noise inside people's homes has not risen significantly between 1980 and 1997 despite the large increase in traffic work during the period. This may be a result of quieter means of transport and direct noise screening. However, if the growth in transport work continues it may be difficult to achieve the target of a 25 per cent reduction in noise annoyance by 2010 (Report No. 8 (1999-2000) to the Storting).

Chapter 7. Emissions to air

The extraction and use of fossil energy commodities is the most important cause of air pollution in the world. Such pollution may have adverse effects at local, regional and global level. Chapter 7 on emissions to air deals with these issues, and is largely concerned with priority area 7 – climate change, air pollution and noise.

The *global* problems related to emissions to air are climate change and depletion of the ozone layer.

Climate change (priority area 7)
With the rise in atmospheric concentrations of greenhouse gases, primarily carbon dioxide, methane and nitrous oxide, less radiation escapes from the earth's surface. This can result in a warmer climate, changes in precipitation patterns, wind systems and ocean currents, displacement of climate zones and a rise in sea level. There is great uncertainty associated with the effects of rising temperatures, but there may be serious consequences for world agricultural production, ecosystems and for low-lying areas that will be flooded by a rise in sea level.

Before the industrial revolution, the atmospheric concentration of carbon dioxide was approximately 280 ppm[1]. In recent years, this level has risen to about 370 ppm (University of California 2000). One indication that climate change is in fact occurring is the fact that the global mean temperature has been considerably higher in recent years than the average since 1856, when measurements started. An analysis made by Statistics Norway shows that the cost of reducing CO_2 emissions depend just as much on the development of clean energy sources in the future as on the target concentration of CO_2.

Through the Kyoto Protocol, the nations of the world have tried to coordinate their efforts to reduce greenhouse gas emissions. However, the extent to which countries will be permitted to pay for emission reductions in other countries instead of reducing their own emissions (emissions trading) has not yet been determined. In December 1999, a committee appointed by the government recommended that Norway's commitments should be fulfilled by means of a domestic quota-based emissions trading system for greenhouse gases, linked to an international system if one exists (NOU 2000:1). A majority of the committee recommends that all concerned should pay the full market price, whereas a minority considers that the process industry should be allocated quotas free of charge (grandfathered quotas).

An analysis by Statistics Norway indicates that grandfathered emission permits result in lower welfare than the current system of differentiated CO_2 taxes, whereas changing to a uniform CO_2 tax would result in higher welfare, but the differences are very small. Another analysis shows that in the long term, the ferro-alloy industry will be seriously affected by the introduction of tradable emission permits unless it is allocated grandfathered permits. For other energy-intensive industries, the effects would be small and would therefore not have much effect on employment in these industries.

Preliminary calculations show that Norwegian emissions of the greenhouse gas carbon dioxide (CO_2) rose from 41.7 million tonnes in 1998 to 42.3 million tonnes in 1999. This growth is mainly explained by a rise in emissions from mobile combustion. Total emissions from diesel vehicles and national sea and air traffic rose by almost 0.7 million tonnes. There was a drop in energy use in oil and

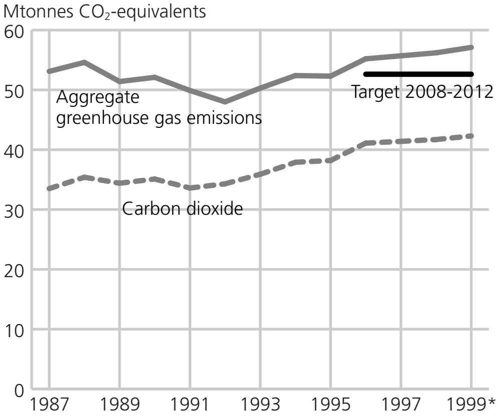
[1] ppm = parts per million, or 1/10 000 per cent.

gas production, but more gas was flared, so that emissions did not decrease correspondingly. Methane emissions were almost unchanged from the year before, whereas N_2O emissions rose by 5 per cent. In the period 1990-1999, total greenhouse gas emissions rose by more than 9 per cent, and emissions in 1999 were more than 8 per cent above the maximum level Norway must achieve by the period 2008-2012 under the Kyoto Protocol.

Climate change is a subdivision of priority area 7 (Report No. 8 (1999-2000) to the Storting). The national target is the same as Norway's commitment under the Kyoto Protocol: in the period 2008-2012, greenhouse gas emissions shall not be more than 1 per cent higher than in 1990. *Aggregate greenhouse gas emissions* are thus a pressure indicator for this priority area.

Norway's aggregate greenhouse gas emissions have risen in recent years, and are well above the Kyoto target at present (figure 1.6). Methane emissions have been stable since 1995, and emissions of fluoridized gases have dropped. However, the rise in CO_2 emissions has outweighed this and resulted in an overall rise in emissions.

Figure 1.6. **Greenhouse gas emissions in Norway (cf. priority area 7)**



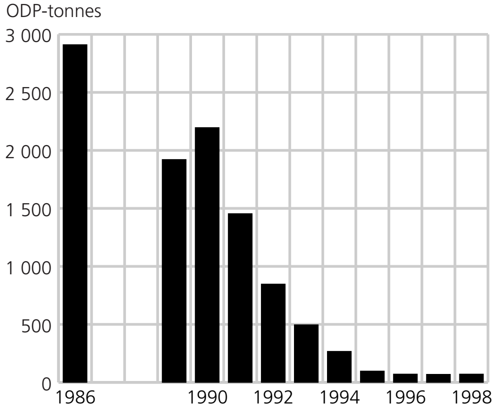
Source: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

Depletion of the ozone layer (priority area 7)

Depletion of the ozone layer is another global problem caused by air pollution. The ozone layer is the name for a layer of the atmosphere 10-40 km above ground level where there is an elevated concentration of ozone (O_3). This reduces the amount of ultra-violet (UV) radiation reaching the surface of the earth. Intense UV radiation can reduce the growth of land plants and algae and increase the risk of cancer in humans.

In recent decades, the ozone layer has been depleted by emissions of gases containing chlorine, particularly CFCs (chlorofluorocarbons). These are used mainly for cooling purposes, as propellants in aerosols and in furniture production. Natural emissions, mainly from volcanic eruptions, can also deplete the ozone layer. Extensive international cooperation has been organized to reduce emissions that deplete the ozone layer (the Montreal Protocol). Norway's national targets, as formulated in Report No. 8 (1999-2000) to the Storting, are linked to the Montreal Protocol and entail efforts to phase out ozone-depleting substances by specific dates, the latest being 2015. *The total input of ozone-depleting substances* is therefore an indicator of emissions of such substances. Since Norway does not produce any ozone-depleting substances, the total input is the same as the quantity imported.

Figure 1.7. **Imports of ozone-depleting substances to Norway**



Source: Norwegian Pollution Control Authority.

The consumption of ozone-depleting substances has dropped steeply since the mid-1980s (by about 98 per cent from 1986 to 1998, see figure 1.7). HCFCs now account for about 90 per cent of all consumption of these substances. Norway has met its commitments under the Montreal Protocol. The national targets set out in Report No. 8 (1999-2000) to the Storting have either been achieved, or there are good prospects of achieving them. Most of the other countries that contribute to the problem have also achieved or are well on the way to achieving their targets. The problem of depletion of the ozone layer has not been solved, but measurements, for example of the concentration of CFCs in the atmosphere, seem to indicate that the measures implemented are having an effect.

Long-range air pollution (priority area 7)
Long-range air pollution means pollution that is transported so far from its source that it leads to environmental problems in other countries. *Acidification* is one of the most important of these. Emissions of sulphur dioxide and nitrogenous gases result in the deposition of acidifying compounds. The gases are transported in the atmosphere and are deposited by two processes, wet and dry deposition. Oxidized nitrogen is deposited slowly and may therefore be transported a very long way from the source of the emissions. Deposition of oxidized sulphur, and especially of reduced nitrogen, is more closely related to the emission sources, because these compounds are deposited more quickly. However, the largest proportion of deposition of both sulphur and nitrogen in Norway is a result of long-range inputs from other countries.

Soil and water are affected by the deposition of acidic air pollution. Until now, acidification has mainly been caused by SO_2. The deposition of acidic nitrogen compounds has so far only had a moderate effect, but their relative contribution is rising. It has proved much more difficult to reduce emissions of nitrogenous gases than those of sulphur dioxide.

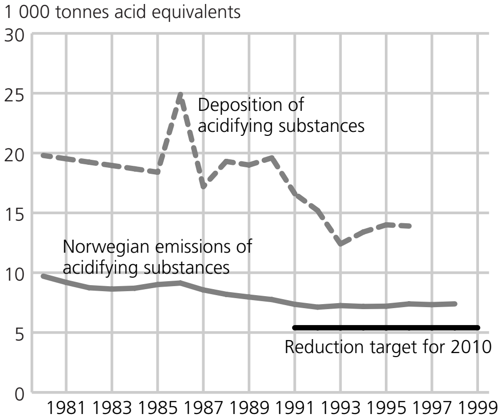
Acidification of lakes and rivers has major impacts on the flora and fauna in Norway, for example fish mortality. Acidifying air pollution can also cause forest damage in the form of foliage loss and discoloration. Leaching of nutrients from the soil caused by acidification is considered to be an important factor in long-term forest damage. Other effects of acidification include corrosion damage to buildings and other materials. Norway's national targets are linked to its commitments under the Convention on Long-range Transboundary Air Pollution (LRTAP). The total environmental pressure depends on the amount of these pollutants deposited, while Norway's contribution to this depends on its emissions. Since national emissions are the factor the Norwegian authorities have control over, Norwegian *emissions of acidifying substances* have been chosen as an important pressure indicator. However, *deposition of acidifying substances* is also included as an indicator, since this is more closely related to the actual environmental pressure (figure 1.8).

Total deposition of acidifying compounds of sulphur and nitrogen has been reduced by about 30 per cent since 1980. The areas of Norway where critical loads for acidification are exceeded have been reduced by more than 30 per cent since 1985, and the degree to which critical loads are exceeded has also been reduced (Report No. 8 (1999-2000) to the Storting). In 1997, Norway's own contribution to the deposition of acidifying substances made up 16 per cent of the total. Emissions in Russia, the UK and Germany caused 45 per cent of deposition in Norway.

Norwegian emissions of SO_2, NO_x and NH_3 converted to acid equivalents have been reduced by about 25 per cent. Sulphur emissions in Norway have been reduced by about 80 per cent since 1980, but must be reduced by a further 26 per cent by 2010 to meet the targets of the LRTAP Convention. Emissions of NO_x have risen by just over 20 per cent from 1980-1999, but must be reduced by more than 30 per cent by 2010 according to the LRTAP Convention. Nitrogen compounds also contribute to other problems such as the formation of ground-level ozone and eutrophication.

Thus, substantial reductions have been made in SO_2 emissions both in Norway and internationally, and this has resulted in marked reductions in the deposition of sulphur compounds. Emissions of NO_x

Figure 1.8. **Emissions and deposition of acidifying substances (NO_x, SO_2 and NH_3) in Norway (cf. priority area 7)**



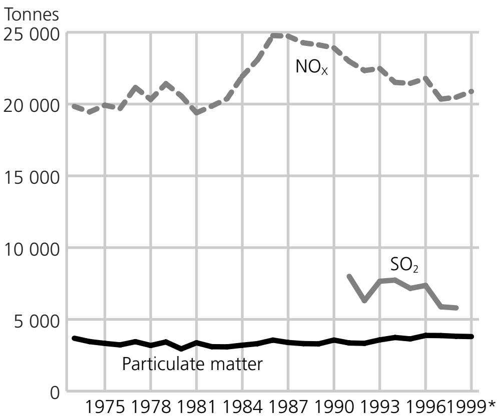
Sources: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority, Norwegian Meteorological Institute.

and NH_3 have not shown a corresponding decrease. There have been improvements, but acidification is still a significant environmental problem in Norway, and Norway must make substantial reductions in its own emissions to achieve the targets of the LRTAP Convention.

Local air quality (priority area 7)

Local effects of emissions to air are seen in limited areas such as towns and built-up areas, and the impact of emissions on human health is of particular importance here. Problems are mainly connected with components such as nitrogen oxides (NO_x), particulate matter and certain volatile organic compounds. Their specific effects vary, see box 7.1. Norway has set national targets to reduce the concentrations of each type of pollutant by specific amounts and by specific dates (see Report No. 8 (1999-2000) to the Storting). The problems associated with local air quality depend on factors such as the quantities released, where emissions take place in

Figure 1.9. **Emissions of particulate matter, SO_2 and NO_x in the 10 largest towns in Norway (cf. priority area 7)**



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

relation to where people are most likely to be exposed to them, and meteorological and topographical conditions. *Emissions of particulate matter, SO_2 and NO_x in Norway's 10 largest towns* are therefore more relevant indicators than Norway's total emissions (figure 1.9).

Emissions of NO_x and SO_2 have dropped in the 1990s as a result of a reduction in the sulphur content of fuels and the introduction of catalytic converters in cars. A sharp reduction in NO_x emissions from road traffic might have been expected with the increase in the proportion of the stock of cars fitted with catalytic converters, but the effect of this is to some extent counteracted by the growth in traffic and the growing use of diesel vehicles, which have high NO_x emissions. NO_x emissions from road traffic decreased by 4 per cent from 1998 to 1999. Emissions of particulate matter rose up to 1996, but have remained stable since then. Thus, the various components of local air pollution are showing different trends. Emission levels and concentrations of these pollutants are still so high that they represent a health hazard to some sections of the population at certain times.

Chapter 8. Waste

One of the most important environmental problems associated with waste is emissions of the greenhouse gas methane. These account for about 7 per cent of all Norwegian greenhouse gas emissions. The quantity of household waste generated is continuing to rise sharply. According to Statistics Norway's waste accounts for paper, metal, glass, plastic and wet organic waste, all these fractions have shown a tendency to rise in recent years, whereas the quantity of wood waste has decreased somewhat. Analyses show that there is a close relationship between the quantity of waste paper and the general level of consumer expenditure.

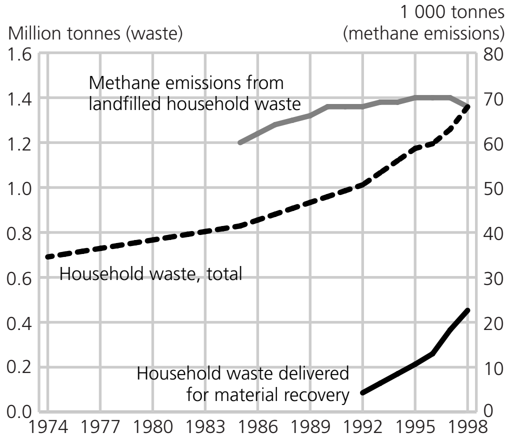
Despite the apparently broad agreement that the most important means of minimizing waste problems is to *prevent waste from being generated*, most of the measures actually implemented are still designed to promote more *environmentally-friendly waste treatment*. One of the national targets set out in Report No. 8 (1999-2000) to the Storting is that the growth in the quantity of waste generated shall be considerably lower than the rate of economic growth. Projections by Statistics Norway suggest that waste generation will in fact grow more slowly than GDP.

Some of the most important ways of improving waste management are sorting of household waste at source, collection schemes based on agreements with industry and return schemes for specific products. During recent years, there has been a marked rise in the number of municipalities that have schemes for sorting waste at source and in the number of fractions that are separated. For example, the amount of household waste used for material recovery rose from 60 kg per capita in 1996 to 102 kg in 1998. 1997 was the first year when more paper was used for material recovery than was landfilled. The authorities now have agreements with a number of branches of industry on return schemes for discarded products. These ensure that waste is managed in a more environmentally-friendly way, but do little to prevent waste generation.

The environmental problems associated with waste depend on the quantities and types of waste generated, and on how the waste is treated. Norway's targets therefore address both these factors. Two of them state that the growth in the quantity of waste generated shall be considerably lower than the rate of economic growth, and that the quantity of waste delivered for final treatment (i.e. landfill or incineration without energy recovery) is to be reduced to about 25 per cent of the total quantity of waste generated by 2010.

Indicators for waste (priority area 6)
Waste and recycling is a separate priority area of Norway's environmental policy, and we have chosen to focus on household waste. This accounts for a relatively large proportion of the total quantities of waste, and the figures are more reliable than those for other waste fractions. Waste quantities are believed to be related to the level of consumption. Material recovery probably gives an environmental benefit, since waste is used as a more environmentally-friendly factor input in production and less waste is landfilled or incinerated. This reduces emissions from

Figure 1.10. **Pressure indicators related to the generation of household waste (cf. priority area 6)**



Sources: Waste statistics from Statistics Norway, Norwegian Pollution Control Authority (1999) and Ligård (1982).

landfills and incineration plants. However, there has been little analysis of the overall benefits of recycling schemes, and these are considered to be uncertain (Bruvoll 1998). For example, certain recycling schemes require more transport than landfilling or incineration.

The *quantity of household waste generated* has grown fast during the 1990s, and more rapidly than household consumption. In recent years, the *proportion recycled* has risen, so that the quantity landfilled or incinerated has dropped slightly since 1997. The reduction in landfilling of waste combined with a rise in the amount of methane extracted from landfills has resulted in a slight decrease in *methane emissions* after 1996. Stricter standards for emissions from incineration plants have been introduced in recent years, which has resulted in a reduction in emissions of harmful gases. Although waste quantities have risen, there is reason to believe that increased recycling and a reduction in emissions from incineration and landfilling have prevented a corresponding increase in environmental pressure.

The indicators selected for waste (figure 1.10) are the quantity of household waste collected, quantity used for material recovery, and methane emissions from landfilled household waste.

Chapter 9. Water supplies and waste water

Norway has plentiful water supplies compared with most other European countries. Chapter 9 on water supplies and waste water describes water use, water treatment and problems associated with waste water. It is estimated that consumption of water in Norway corresponds to less than 1 per cent of total resources. Nevertheless, 700 water works (39 per cent of the total) still do not supply water of satisfactory quality according to the criteria set out for water intake, hygiene, water treatment and water quality.

Waste water is an important source of discharges of plant nutrients such as nitrogen and phosphorus. This can result in *eutrophication*, i.e. abnormally high anthropogenic inputs of nutrients to water recipients. The eutrophication process leads to a reduction in water quality in fresh water and marine areas. Water quality is of great importance both for biological production and biological diversity and for benefits people can obtain from using water in various ways.

The most important sources of pollution that lead to eutrophication are:

- Agriculture
- Municipal waste water
- Industry
- Fish farms (from Rogaland county and northwards)
- Long-range pollution (nitrogen compounds).

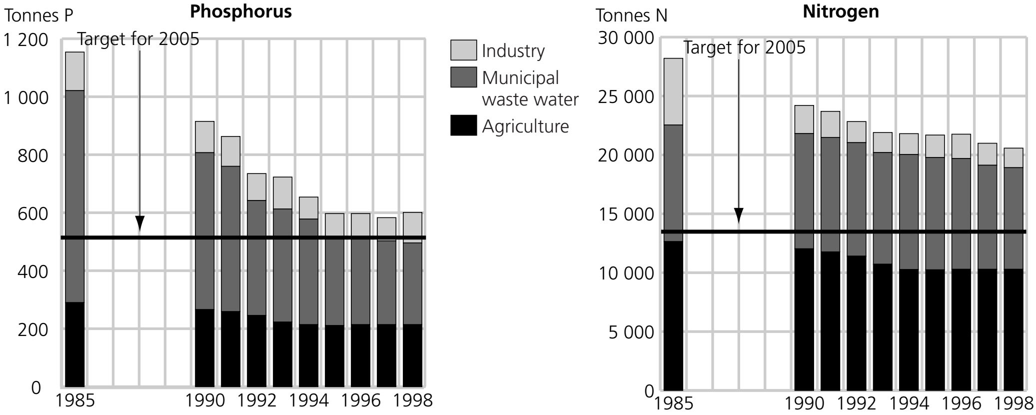
Indicator for eutrophication (priority area 4)

Norway's national target is that inputs of the nutrients phosphorus and nitrogen to parts of the North Sea that are adversely affected by eutrophication shall be reduced by about 50 per cent by 2005 using 1985 as the base year. An indicator for this is *calculated inputs of phosphorus and nitrogen to sensitive coastal areas of Norway*.

Anthropogenic inputs of phosphorus have been almost halved compared with the 1985 level, and the reduction target has been more or less achieved. It has proved to be more difficult and very costly to reduce nitrogen inputs to the same extent, and in 1997 inputs had been reduced by 26 per cent compared with the 1985 level (figure 1.11). Industry accounts for most of the reduction here, while the waste water sector and agriculture have contributed relatively little. The reduction target for nitrogen inputs is now being re-evaluated by the environmental authorities.

The municipal waste water sector has succeeded in reducing inputs of phosphorus to the North Sea by more than 60 per cent from 1985 to 1998. This is because measures to reduce discharges by the sector have been focused on phosphorus, and because the municipalities, which are responsible for waste water treatment, have been able to cover their costs by means of fees. In 1998, fees covered 95 per cent of the municipalities' costs, as compared with 102 per cent in 1997.

Figure 1.11. **Norwegian anthropogenic inputs of phosphorus and nitrogen to parts of the North Sea that are affected by eutrophication (cf. priority area 4)**



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

Despite the fact that the system of state grants has been discontinued, investments rose by about 30 per cent from 1997 to 1998. A substantial proportion of this was major investments to improve facilities for the removal of nitrogen in Oslo. Investments have generally been much higher in the North Sea counties than in the rest of the country, which has resulted in higher fees, but also a much greater reduction in discharges of phosphorus. For the Norwegian coast as a whole, aquaculture accounts for 66 per cent of total discharges of phosphorus. Most of this is discharged from Rogaland and northwards, outside the North Sea area.

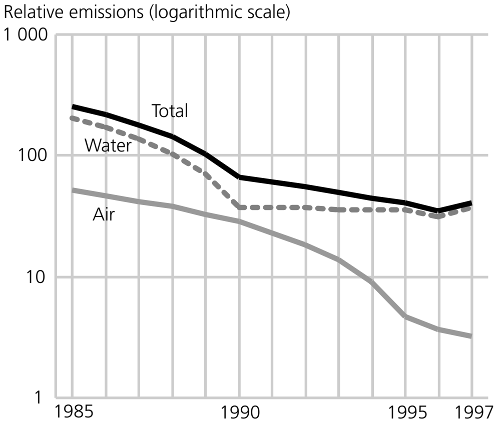
Indicator for hazardous chemicals (priority area 5)

Environmentally hazardous substances include heavy metals such as lead, mercury and cadmium, and organic compounds such as dioxins and PCBs (known as persistent organic pollutants, or POPs). These can have adverse effects on the environment or health even in low concentrations or in small quantities. Their properties include low biodegradability and a high bioaccumulation potential (they become more concentrated as they are transferred through food chains). Some of their most serious effects are disturbance of reproductive processes and fetal damage. These chemicals may also damage the immune system, the nervous system and muscle function in humans and animals. Some are carcinogenic.

Heavy metals and POPs may be released to air, soil or water, and there are many sources of pollution, including industrial emissions and runoff from mines, transport, the use of products, waste incineration, municipal waste water, runoff from agricultural areas and polluted sites, and polluted sediments. Long-range transport with winds and ocean currents is another route by which they enter the Norwegian environment.

Report No. 8 (1999-2000) to the Storting sets out specific time limits for the elimination or reduction of emissions of

Figure 1.12. **Total emissions of chemicals on the priority list weighted by how dangerous they are (cf. priority area 5)**



Source: Norwegian Pollution Control Authority.

substances that are considered to represent particularly serious health or environmental problems in Norway. There are more than twenty of these (substances and groups of substances), and they make up the Norwegian authorities' priority list of environmentally hazardous substances.

The white paper presents a *total index for emissions of all chemicals on the priority list, weighted according to how dangerous they are*, as a pressure indicator for hazardous chemicals. This is reproduced here as figure 1.12.

Total emissions of the chemicals on the priority list have been substantially reduced in the last 10-15 years. Industrial emissions used to be the most important source of pollution, but have generally been greatly reduced. However, emissions of chemicals from certain industrial sources, such as the offshore petroleum industry, have risen. More diffuse emissions, long-range transport of pollution and exposure during the use of products are significant problems. Inherited problems such as hazardous substances from earlier industrial activities in sediments in fjords, still have a major impact. In a number of fjords, the authorities have recommended restrictions on the consumption of fish and shellfish or prohibited their sale. The total index for the last part of the period shown is dominated by discharges to water. It should be noted that there are uncertainties associated with the factors that have been used to weight the contributions of the various chemicals.

Even though substantial reductions in emissions have been achieved in recent years, environmentally hazardous chemicals are still a serious problem. Figure 1.12 shows that there were considerable reductions in the first part of the period shown, but that discharges to water have changed very little in the last few years. A good deal still needs to be done before the target for this priority area has been achieved. In addition, new types of chemicals and products are constantly being brought on to the market, and we do not know what their impact will be.

Chapter 10. Land use and population in and near urban settlements

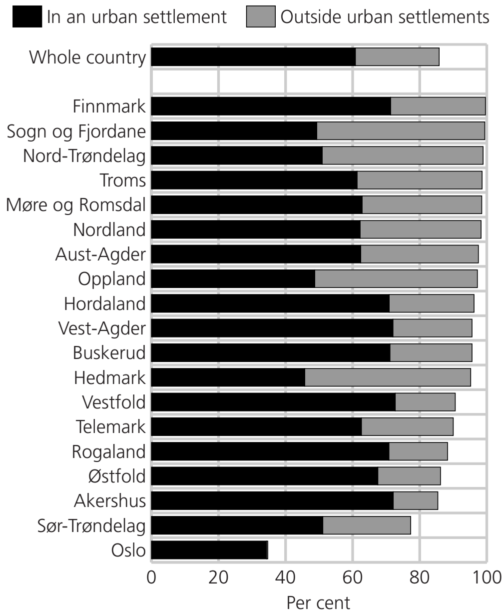
About 75 per cent of Norway's population now lives in towns and urban settlements, as compared with 35 per cent a hundred years ago. These urban settlements only take up 0.7 per cent of Norway's total land area. Roads occupy 15 per cent of the area in urban settlements, and buildings about 9 per cent. Dwellings account for less than half of this. However, there are large differences between settlements. Land use within urban settlements is important for the local environment and the quality of people's lives, and for environmental qualities such as pollution levels (related to transport) and biological diversity (related to green spaces). Sound land use is therefore important, and this chapter presents a number of analyses that can be useful tools for improving land use.

Indicator for outdoor recreation (priority area 2)

A pressure indicator for outdoor recreation tells us something about people's opportunities to take part in outdoor activities. Many factors play a role here, one of which is access to suitable areas. This depends partly on the distance between people's homes and outdoor recreation areas. One of the analyses in Chapter 11 describes the results of the 1997 Survey of Living Conditions. This showed that the dominant outdoor recreation activities for adult Norwegians were country walks and strolls[2,3]. This suggests that the distance between people's homes and suitable outdoor recreation areas is in fact important in determining how much opportunity they have to take part in such activities. Thus, *the number of people living less than 500 m from an outdoor recreation area* is a possible indicator of their opportunities to take part in outdoor recreation activities.

Digital mapping of areas that can be unambiguously defined as outdoor recreation areas has not yet been completed for all municipalities. This means that the distance from people's homes to such areas cannot be calculated. However, we do know where the boundaries of urban settlements run, and it is reasonable to suppose that it is easier to find outdoor recreation areas outside settlements. We

Figure 1.13. **Proportion of the population who live outside urban settlements or in an urban settlement less than 500 m from its boundary (cf. priority area 2)**



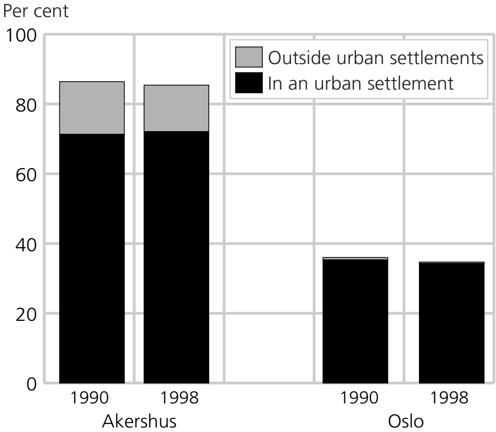
Source: Land use statistics from Statistics Norway.

have therefore chosen to assume that urban settlement boundaries are synonymous with the boundaries of outdoor recreation areas. However, it may be some distance to year-round recreation areas even outside settlements, and the indicator does not take into account the fact that there are also opportunities for outdoor recreation within settlements, e.g. in parks.

Figure 1.13 shows that there are large variations between counties, but that a relatively large proportion of the population lives close to outdoor recreation areas. In counties that have large urban settlements, a substantial proportion of the

2 A stroll is defined as a short walk close to the home, while longer walks are in the country or the mountains.
3 Shopping trips and walking to and from work are not included in the definition of a stroll.

Figure 1.14. **Proportion of the population who lives outside urban settlements or in an urban settlement less than 500 m from its boundary. Oslo and Akershus, 1990 and 1998 (cf. priority area 2)**



Source: Land use statistics from Statistics Norway.

population lives more than 500 m away from outdoor recreation areas (as we have defined them here). At present, data that permit an evaluation of trends over time are only available for Oslo and Akershus. Here, there has been a slight drop in the proportion of the population who live less than 500 m from an outdoor recreation area (figure 1.14). In Akershus, this is because there has been a substantial rise in the proportion of the population living in urban settlements. Oslo and Akershus differ from the rest of the country in that a much higher proportion of the population lives in urban settlements and population growth has been much higher in the 1990s. It is therefore uncertain how far these results can be extrapolated to the rest of the country, but our figures show that growth of the largest urban settlements appears to have reduced access to outdoor recreation areas.

The importance of the distance to outdoor recreation areas varies from one activity to another. For example, it is almost certainly more important for an activity such as “short walks” than for “long skiing trips in the mountains”. The indicator is therefore primarily useful as a measure of the accessibility of outdoor recreation areas within walking distance of the home.

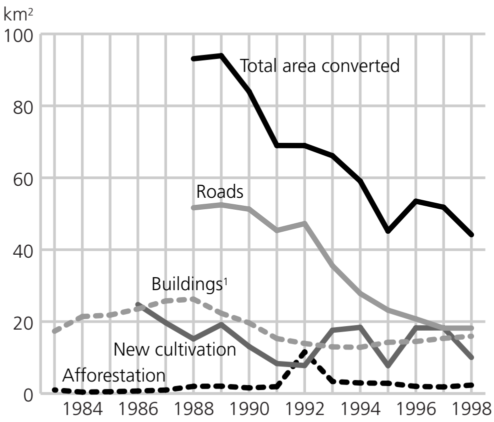
There is a clear need to develop more indicators, since the definition of outdoor recreation areas needs to be improved, time series are not available for the whole country, and other factors than accessibility also influence participation in outdoor recreation.

Indicator for cultural monuments and sites (priority area 3)

Changes in land use have a significant impact on the conservation of our cultural heritage. Archaeological and architectural monuments and sites, as well as cultural environments, are important elements in natural resource and environmental management. They are of historical value, provide a source of emotional and aesthetic experience, and are a unique repository of knowledge about our history. The cultural heritage also helps to give us a sense of identity and historical continuity. Monuments and sites may be lost through demolition, damage or decay. Changes in land use can also reduce the value of cultural monuments without actually destroying them, if the surroundings are changed in such a way that the historical context is lost. Active maintenance and controlled use of both the monuments and sites themselves and their surrounding environment is therefore necessary.

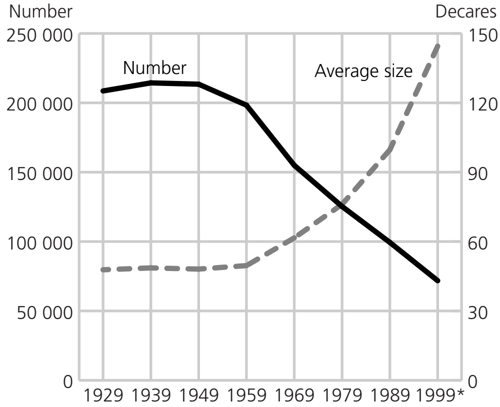
Since monuments and sites and cultural environments are often damaged by changes in land use, an appropriate pressure indicator is therefore the *area of land*

Figure 1.15. **Annual conversion of land for roads, new buildings[1] and new cultivation (cf. priority area 3)**



[1] The area of the buildings is multiplied by 5 to take into account the fact that areas immediately around the buildings are also changed significantly.
Sources: Statistics Norway, Norwegian Agricultural Economics Research Institute and Directorate of Public Roads.

Figure 1.16. **Number of holdings and average size in decares (cf. priority area 3)**



Source: Agricultural statistics from Statistics Norway.

converted for other purposes by new cultivation, road construction and building. This is not an exact measure of the pressure on monuments and sites and cultural environments or the rate at which they are being destroyed, but it can be useful in giving a general picture of developments. Many cultural monuments are in densely-populated areas where the greatest changes in land use are taking place.

During the 1990s, the area per year converted for other purposes has been reduced (figure 1.15). This is mainly because less land has been used for new roads. The reduction has been particularly marked for new forest roads, which are built in uninhabited areas. The area cultivated for the first time has varied a good deal from year to year, while areas built on for the first time have risen since the early 1990s. It should be noted that there is some uncertainty in the underlying data for all three categories of land-use change.

Indicator for the cultural landscape (priority area 3)

Open cultural landscapes are to a large extent associated with agriculture. The type and scale of farming are important for the character of the landscape, and the *average size of holdings* can therefore serve as an indicator of changes in the cultural landscape.

The average size of Norwegian holdings has risen since 1960, and this trend has become stronger in the 1990s (figure 1.16). Most of the land belonging to abandoned holdings has been taken over by those that are still in use, and the trend towards fewer larger holdings makes it easier to increase field size. This has an impact on biological diversity in the agricultural landscape. As the number of holdings decreases, it may also be more difficult to preserve farm buildings that are no longer in use.

Figure 1.15 indicates that the overall pressure on land as a result of conversion to other purposes has been reduced during the 1990s, but this does not apply to the same extent to all types of conversion. However, it has not been clearly demonstrated how close a connection there is between changes in land use and pressures on monuments and sites and cultural environments. Agricultural landscapes have probably become more open where the soil is cultivated, since the average size of holdings has risen substantially in the 1990s.

Chapter 11. Other analyses and research projects

Several analyses are presented in Chapter 11. An economic analysis of the *value of Norway's natural resources* shows that these make up only a small part of the country's total wealth. The resource rent, i.e. the economic return on resources in excess of the normal rate of return, has at times been negative, partly because some primary industries have been subsidized.

Statistics on *environmental costs in manufacturing industries* can be important in giving a picture of the efforts this sector is making to improve environmental conditions or reduce pressure on the environment. A study has shown that the metal manufacturing industry has invested heavily in reducing emissions to air, whereas the pulp and paper industry is concentrating on reducing discharges to water. The chemical industry has invested rather more in reducing discharges to water than emissions to air.

An analysis of *green taxes* shows that private households pay just over half the total levied. This influences demand for the taxed products, so that the real distribution of the green tax burdens between households and business and industry may be different.

A comparison of *environmental trends* and trends in *people's concern about the environment* shows some conflicting patterns. However, people's concern and attitudes to environmental problems do appear to be statistically related to their behaviour.

Chapter 11 also presents a study of *outdoor recreation* activities. In Norway, there is a close link between outdoor activities and the natural environment, and outdoor recreation is defined as a separate priority area in Report No. 8 (1999-2000) to the Storting. Many of the most popular outdoor activities take place in the countryside. In addition, the quality of outdoor recreation is very dependent on the quality of the environment, and in some cases on its being more or less undisturbed. The 1997 Survey of Living Conditions shows that for adult Norwegians, the dominant outdoor recreation activities are country walks and strolls near home (see also the indicator for outdoor recreation in the summary of Chapter 10).

Summary of possible indicators of environmental pressure for the priority areas of environmental policy set out in Report No. 8 (1999-2000) to the Storting. Preliminary list

Table 1.1. **Priority areas of environmental policy, important indicators of environmental pressure and description and evaluation of trends**

Priority area	Pressure indicator	Trends
1. Conservation and sustainable use of biological diversity	Road density. Areas without infrastructure development.	Road length is still increasing and "untouched" or wilderness-like areas have been drastically reduced in the past 100 years. This puts severe pressure on biological diversity in Norway.
2. Outdoor recreation	Proportion of the population living less than 500 m from the edge of an urban settlement.	Relatively large proportion of the population lives near outdoor recreation areas. Figures for Oslo and Akershus suggest that the proportion of the population who live > 500 m from from an outdoor recreation area has been rising during the 1990s.
3. The cultural heritage		
Cultural monuments and sites	Changes in land use.	Indicator suggests that overall pressure on land has decreased during the 1990s, but this is not equally true of all forms of land use. However, it has not been clearly demonstrated how close a connection there is between changes in land use and pressures on cultural monuments and environments.
Cultural landscapes	Average size of holdings.	The average size of Norwegian holdings has risen sharply since 1960, and this trend has become stronger in the 1990s. Most of the land belonging to the abandoned farms has been taken over by the remaining holdings, and there is reason to believe that field size has increased.
4. Eutrophication and oil pollution		
Eutrophication	Inputs of phosphorus and nitrogen to sensitive coastal areas.	The target for reduction of phosphorus inputs has been more or less achieved, but there is some way to go before the nitrogen target is reached.
Oil pollution	Operational and acute discharges of oil to the sea from petroleum activities.	Discharges are showing a rising trend and are expected to increase in the years ahead as the reservoirs are emptied.
5. Hazardous chemicals	Overall emissions of chemicals on the priority list, weighted by how dangerous they are.	Substantial reductions in emissions achieved in recent years, but environmentally hazardous substances are a major problem. A good deal remains to be done before the targets are reached. New types of chemicals and products are constantly being brought on to the market, and we do not know what their impact will be.
6. Waste and recycling	Quantity of household waste collected and quantity used for material recovery. Methane emissions from landfilled household waste.	Waste quantities have risen, but environmental measures and more recycling have somewhat reduced the environmental pressure from incineration and landfills.
7. Climate change, air pollution and noise		
Climate change	Total greenhouse gas emissions.	Total greenhouse gas emissions have risen in recent years. CO_2 content of the atmosphere is rising.
Depletion of the ozone layer	Total inputs of ozone-depleting substances.	Norway, and most other countries that have contributed to the problem, have met their commitments under the Montreal Protocol. The problem of depletion of the ozone layer has not been solved, but measurements, for example of the concentration of CFCs in the atmosphere, seem to indicate that the measures implemented are having an effect.
Long-range air pollution	Emissions (and deposition) of acidifying substances.	Substantial reduction achieved in SO_2 emissions in Norway and abroad, and thus a marked reduction in deposition of sulphur compounds. Corresponding reductions in NO_x and NH_3 emissions have not been achieved. Norway must make further reductions in emissions to achieve the targets of the LRTAP Convention. There have been improvements, but acidification is still a significant environmental problem in Norway.
Local air pollution	Emissions of particulate matter SO_2 and NO_X in Norway's 10 largest towns.	Different trends for the various pollutants. Emission levels and concentrations of these pollutants are still so high that they represent a health hazard to some sections of the population at certain times.
Noise	Growth in transport work. Proportion of the population exposed to noise.	Growth in transport work increases exposure to noise, but other factors help to moderate this. Noise is a significant problem, and continued growth in transport work may make it difficult to achieve the target of a 25 per cent reduction in noise annoyance.

2. Energy

Norway has large energy reserves, and extracts far larger quantities of energy commodities than are needed for domestic use. In 1999, extraction of energy commodities was more than eight times consumption. This is mainly accounted for by oil and gas extraction. Given the current rate of extraction, the calculated petroleum resources on the Norwegian continental shelf will be exhausted in 25 years and the gas resources in 120 years. Petroleum extraction accounted for about 14 per cent of Norway's GDP and 35 per cent of export income in 1999, which was a marked increase from the year before. This is mainly explained by a rise in prices.

Electricity production totalled 122.4 TWh in 1999, which is a rise of 5 per cent from the year before. This is 7.9 per cent higher than the expected level of production in a year when precipitation is normal, and the highest level since 1995. The total surplus for export was 1.8 TWh. This was the first time since 1995 that Norway was a net exporter of electricity.

The production, transmission and use of energy cause various pressures on the environment. A large proportion of global air pollution is generated by combustion of coal, oil and gas. The extraction and conversion of fossil energy sources also result in substantial emissions to air. Hydropower developments can have a significant impact on biological diversity, the cultural landscape and opportunities for outdoor recreation. About 60 per cent of Norway's total hydropower potential has been developed.

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 and reserves. Resources include all more or less definitely proven deposits. Reserves are recoverable resources in fields that are already developed or where development has been approved. At the end of 1999, the remaining Norwegian reserves of crude oil totalled 1.69 billion standard cubic metres oil equivalents (Sm^3 o.e.), which corresponds to 1.0 per cent of the world's crude oil reserves (table 2.1). Reserves of natural gas totalled 1.25 billion Sm^3 o.e., or 0.9 per cent of total world reserves. Trends in the estimates of Norwegian reserves are shown in tables A1 and A2 in the Appendix.

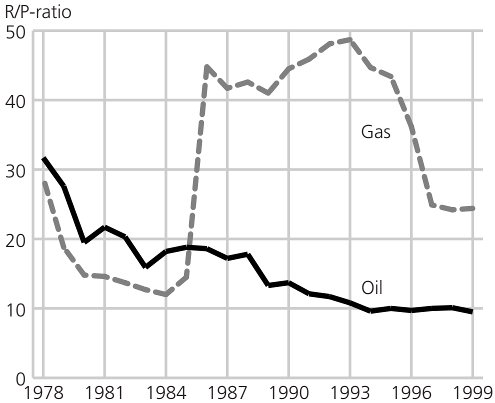
The Norwegian Petroleum Directorate has calculated that the remaining Norwegian

Table 2.1. **World reserves[1] of oil and gas as of 1 January 2000**

	Oil		Gas	
	Billion Sm^3 o.e.	Per cent	Billion Sm^3 o.e.	Per cent
World	161.5	100.0	145.8	100.0
North America	4.1	2.6	6.5	4.4
Latin America	18.8	11.6	7.2	4.9
Western Europe (incl. Norway)	2.9	1.8	4.5	3.1
Eastern Europe	9.4	5.8	56.7	38.9
Middle East	107.4	66.5	49.5	34.0
Africa	11.9	7.4	11.2	7.7
Asia and Oceania	7.0	4.3	10.3	7.1
OPEC	127.6	79.0	63.3	43.4
Norway	1.7	1.0	1.2	0.9

[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 (1999) 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**

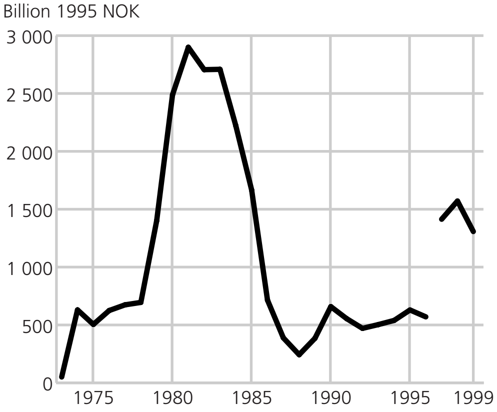


Sources: Energy statistics, Statistics Norway and Norwegian Petroleum Directorate.

petroleum resources total 4.4 billion Sm^3 o.e. crude oil (including wet gas) and 6.1 billion Sm^3 o.e. natural gas. Of this, 38 and 20 per cent respectively are defined as reserves (see above), and 20 and 34 per cent respectively are resources for which development has not been approved. The remainder, i.e. 42 and 46 per cent respectively, consists of uncertain estimates based partly on more efficient use of proven finds in the future and partly on 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 25 years, and the natural gas resources after 120 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 9 years for oil and 24 years for gas. The ratio between reserves and annual production (the R/P ratio) will change with time, depending on the rate of extraction, new extraction technology and decisions to develop new fields. Such decisions in their turn depend on the technology available, prices and the discovery of new fields. Historical trends in the R/P ratio are shown in figure 2.1. Both because the large gas field Troll East went on stream in 1996 and because the estimates of reserves were reduced, 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. Russia also has the world's largest gas reserves, a third of the total, and the Netherlands and Norway have the largest 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 &

Figure 2.2. **Estimates[1] of Norway's petroleum wealth. 1973-1999**



[1] The estimates are made at the beginning of each year. For the years 1997-1999, the discount rate used for writing down future revenues and costs was 4 per cent, instead of the 7 per cent used for earlier years.
Sources: Aslaksen et al. (1990) and various long-term programmes and national budgets, Ministry of Finance.

Box 2.1. Petroleum wealth

In practice, Norway's petroleum wealth is generally defined as the current value of future revenues from the sale of petroleum, minus the current value of future operating costs, including a normal rate of return on real capital in the sector. This corresponds to the current value of the future resource rent for petroleum, i.e. the amount by which the rate of return on petroleum extraction exceeds that on other forms of economic activity.

Gas Journal. For the world as a whole, 79 per cent of the oil reserves and 43 per cent of the gas reserves are in OPEC countries. The Middle East accounts for 66 per cent of the world's oil reserves and 34 per cent of its gas reserves. At the end of 1999, the R/P ratio indicated that the world's petroleum reserves will be exhausted after 43 years and its natural gas reserves after 63 years.

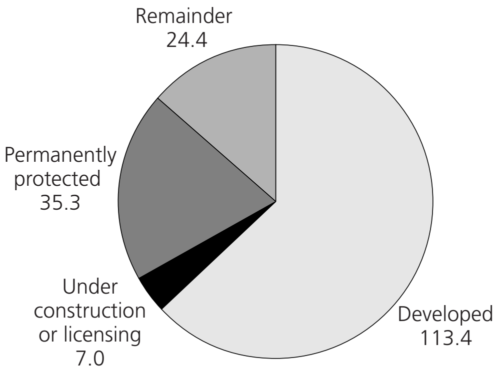
Figure 2.2 shows estimates of Norway's petroleum wealth for the years 1973-1999. A definition of petroleum wealth is given in box 2.1, and section 11.1 explains how it is calculated. The estimated value of Norway's petroleum wealth has changed a great deal in this period because of changes in expected future prices, costs and the resource base. Changes in expected prices have clearly been most important, but upwards revision of the estimated resource base has also had an effect. The petroleum wealth is reduced by extraction, but rises from year to year as future cash flows come closer in time.

The price rises in 1973-1974 and 1979-1980 resulted in expectations that oil prices would remain high in the future, while finds of new fields continued. This resulted in a sharp rise in the estimate of Norway's petroleum wealth. From 1981 to 1988, a steady reduction in expected prices resulted in a reduction of the estimated petroleum wealth from NOK 2 900 billion to NOK 243 billion. The reduction was four times larger than Norway's annual GDP at the time. It is interesting to note that as early as the beginning of 1984, two years before oil prices collapsed, Norway's petroleum wealth was reduced in response to a less optimistic view of future oil price trends. There was another smaller drop in price expectations in 1990. In 1992 and 1993, the figures for the resource base were revised upwards. In the mid-1990s, Norway's expected petroleum wealth had reached the same level as before the sharp rise in oil prices in 1979-1980.

Hydropower

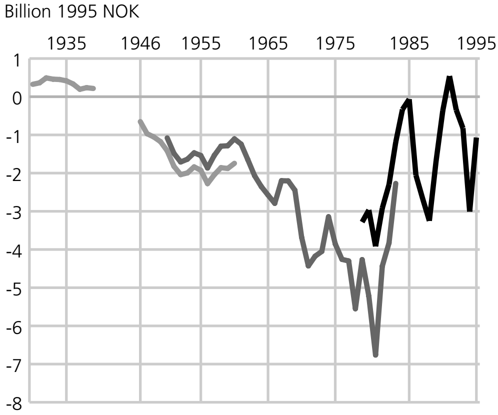
As of 1 January 2000, Norway's economically exploitable hydropower resources

Figure 2.3. **Hydropower resources as of 1 January 2000. TWh per year**



Source: Norwegian Water Resources and Energy Directorate.

Figure 2.4. **Resource rent[1] in the electricity supply sector using a required rate of return of 7 per cent. 1930-1939 and 1946-1995**



[1] Figures for 1930-1960 based on the old standard for the national accounts, 1961-1977 on the UN (1968) method, and 1978-1995 on the EC Commission et al. (1993).
Source: Lindholt (2000a).

totalled 180.2 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 2000, 113.4 TWh was developed and 35.3 TWh permanently protected (figure 2.3). Hydropower production capacity rose by 0.3 TWh from 1998 to 1999, and by a total of 3.5 TWh from 1990 to 1999. The rise is explained by new developments and upgrading and expansion of existing power plants. By way of comparison, electricity consumption rose by 12.8 TWh from 1990 to 1999. The power balance has thus become tighter since deregulation in 1991, when competition between electricity producers was introduced. Because producers now compete, they cannot pass the costs of expensive development projects on to consumers, and it has therefore not been profitable for them to make major investments. One of the main objectives of the 1991 Energy Act was to prevent investments that were not cost-effective. This seems largely to have been successful. In the longer term, better correspondence is expected between the willingness of the market to pay for the development of new power and the development costs. Even though there is now a better balance between supply and demand, electricity prices are still low, and there will be few new hydropower projects in the near future. The relationship between consumption and production is further described in section 2.3 under the heading Electricity.

The resource rent in the electricity supply sector for the periods 1930-1939 and 1946-1995 is shown in figure 2.4. The resource rent is defined as the economic return in excess of the normal rate of return in the sector. Section 11.1 explains this definition and the method of calculating the resource rent, and gives figures

Box 2.2. 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 consumption
Coal	28.1 GJ/tonne	..	0.80	0.10	0.60
Coal coke	28.5 GJ/tonne	..	0.80	-	0.60
Petrol coke	35.0 GJ/tonne	..	0.80	-	-
Crude oil	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 (1999)[2]	40.3 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 tonne/solid m^3	0.65	-	0.65
Wood waste (dry wt)	16.8 GJ/tonne	..	..	..	..
Black liquor (dry wt.)	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 (at 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	1.042	0.040
1 Mbarrels	5.65	1.57	0.13	1	0.16	0.139	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	25.94	1

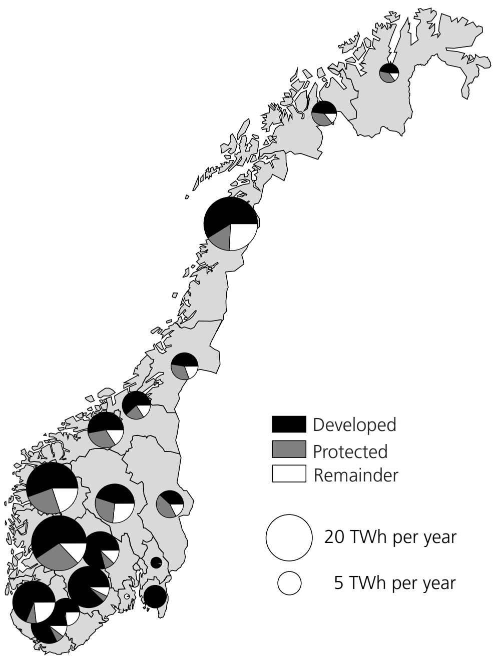
1 Mtoe = 1 mill. tonne (crude) oil equivalents
1 Mbarrel = 1 mill. barrels crude oil (1 barrel = 0.159 m^3)
1 MSm^3 o.e. oil = 1 mill. Sm^3 oil
1 MSm^3 o.e. gas = 1 billion Sm^3 natural gas
1 quad = 10^{15} Btu (British thermal units)

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 2.5. **Norway's hydropower resources as of 1 January 2000 by county. TWh per year**



Source: Norwegian Water Resources and Energy Directorate.

for the resource rent in other sectors that are based on the use of natural resources.

Between 1930 and 1995, the resource rent was generally negative. The hydropower sector is capital-intensive, and the high level of development activity determined by the public authorities and a low average willingness to pay were the causes of the negative resource rent. Between 1930 and 1995, capital costs rose somewhat more per year than net revenues in the sector. This was because the rate of investment was high, but electricity prices and revenues in the sector did not rise correspondingly.

The resource rent dropped from about NOK +0.5 billion in the 1930s to a minimum of about NOK –7 billion towards the end of the 1970s. It then showed an upward trend during the 1980s and 1990s. Electricity prices are still low in 2000, and it will probably be some years before the resource rent in the hydropower sector reaches a satisfactory level.

The counties Hordaland and Nordland have the largest developed resources, 13 and 12 per cent respectively of the total. Next follow Telemark, Sogn og Fjordane and Rogaland. These five counties account for 55 per cent of all Norway's developed resources. Nordland has 18 per cent of the country's remaining production capacity that is neither developed nor protected, Sogn og Fjordane has 13 per cent, and Oppland and Hordaland 11 per cent each. In counties such as Østfold, Akershus and Oslo, the entire hydropower potential is either developed or protected (figure 2.5).

Hydropower developments can have a significant impact on biological diversity, the cultural landscape and opportunities for outdoor recreation. The only large river in Norway that is untouched by hydropower developments is the Tana (Finnmark). Table A3 in the Appendix shows potential, developed and undeveloped hydropower in Norway. Any future hydropower developments will be based on the Master Plan for Water Resources and the Protection Plans for Water Resources. To protect river ecosystems, the scope of some projects may be limited or they may not be licensed (Ministry of Petroleum and Energy 1999). As a general rule, no new power plants may be constructed in protected watercourses, but projects that do not require licences may be carried out and existing power plants may be upgraded to a certain extent (Norwegian Water Resources and

Energy Directorate 1999). Environmental restrictions and the need to consider cost-effectiveness make it very uncertain how much of the remaining hydropower potential (see figure 2.3) is likely to be developed in the future. Apart from actual hydropower developments, other activities in and around watercourses may also have an impact on biological diversity. These include canalization, lowering water levels, land reclamation, extraction of deposits, removal of water, removal of waterside vegetation, cultivation, construction of roads and housing near rivers, measures to prevent erosion and the construction of flood protection works.

Coal

At the end of 1999, Norway's coal resources on Svalbard were about 64 million tonnes, defined partly as certain and partly as probable deposits. At the end of 1999, 35 per cent of the resources were classified as certain. 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 21.5 million tonnes at the end of 1999, in other words only one third of the coal resources. At the 1999 rate of extraction, the estimated quantity of coal for sale will last for 53 years. At the end of 1998, the world's exploitable coal resources were 984 billion tonnes (BP Amoco 1999). At the current rate of extraction, they will last for 218 years. The largest resources are found in the USA, Russia and China, which account for 25, 16 and 12 per cent respectively of the total.

Box 2.3. Environmental pressures caused by the extraction and use of energy

Emissions to air occur during the extraction, transport and use of oil and gas products, and use of wood as fuel in households. These can result in climate change, acidification, the formation of ground-level ozone and local air pollution (see Chapter 7).

Discharges of oil and chemicals to the sea occur during the extraction and transport of oil and gas products. They may injure fish, marine mammals and birds and reduce the yield from fisheries etc.

Infrastructure development takes place during the development of new capacity for energy generation, and includes the construction of dams, roads, onshore installations and transmission lines. These can have an impact on biological diversity and the value of cultural monuments, the cultural landscape and recreational areas. Hydropower production results in variable water levels in reservoirs and changes in discharge volumes in rivers.

Source: Ministry of Petroleum and Energy (1999).

2.2. Environmental problems associated with energy extraction and use

The production, transmission and use of energy cause various types of environmental pressures. The most important of these are emissions to air and water and infrastructure development (see box 2.3). The use of fossil fuels accounts for a large proportion of emissions to air. The energy sectors[1], primarily oil and gas extraction, account for a substantial proportion of Norwegian emissions, see table 2.2. These sectors generate almost 30 per cent of total Norwegian CO_2 emissions, and oil and gas extraction is the most important

[1] The energy sectors include oil and gas extraction, gas terminals, oil refineries, coal extraction and the production of electricity and district heating.

Table 2.2. **Emissions to air from the energy sectors. 1998***

	Emissions from the energy sectors	Share of total emissions in Norway
Pollutant	Tonnes	Per cent
Carbon dioxide (CO_2)	12 455 701	29.9
Methane (CH_4)	33 015	9.5
Sulphur dioxide (SO_2)	3 329	11.2
Nitrogen oxides (NO_X)	50 168	22.4
Non-methane volatile organic compounds (NMVOC)	209 628	60.8
Carbon monoxide (CO)	8 077	1.3
Particulate matter	564	2.3
Lead (Pb)	1.3	20.8
Cadmium (Cd)	0.05	8.0

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

source of NMVOC emissions in Norway (see also Chapter 7 on emissions to air). However, total emissions generated by the use of oil and gas produced in Norway throughout the world are far larger (e.g. about 60 times more CO_2). The extraction of coal on Svalbard accounted for over 1.5 per cent of total emissions of CH_4 in Norway in 1999.

The petroleum industry is also responsible for discharges of oil and various types of chemicals to the sea (see box 2.3). Total discharges of oil from Norwegian petroleum activities correspond to 2 per cent of overall inputs to the North Sea. Most of the oil is discharged during normal operations, but acute pollution incidents (spills) also occur. However, the main source of inputs of oil to the North Sea is discharges from land via rivers (Ministry of Petroleum and Energy 1999) (see also Chapter 1 under the heading indicator for oil pollution). Hazardous waste from oil drilling makes up a substantial proportion of all hazardous waste in Norway (see Chapter 8 on waste and figure 8.10).

Decommissioned drilling platforms may cause greater environmental problems in the future. Options for dealing with them include other use in the oil and gas industry, other forms of re-use, recycling, disposing of them on land or leaving part or all of platforms in the sea. Environmental protection measures in the petroleum sector in Norway are governed by legislation including the Act relating to Petroleum Activities and the Pollution Control Act. The Pollution Control Act can be used to regulate all releases of harmful substances from petroleum activities, but is currently used mainly to regulate discharges to the sea. The Act relating to Petroleum Activities includes provisions on the decommissioning of offshore installations.

The Government wishes to limit the extent to which the energy sectors contribute to the environmental problems mentioned in box 2.3, and various policy instruments are being used to achieve this. The main elements of these are listed below:

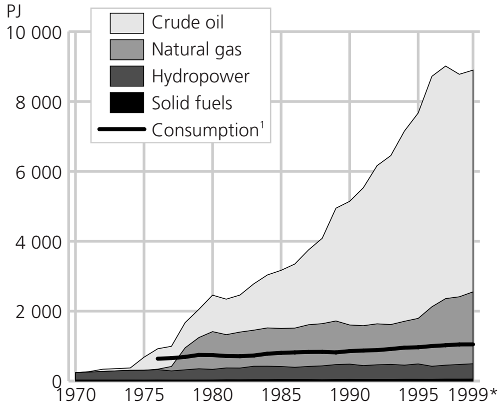
- Taxes are used for the purpose of limiting environmental pressures (e.g. the CO_2 tax).
- Decisions on which areas may be used for energy production are under state control (e.g. pursuant to the Act relating to Petroleum Activities, the Energy Act and the Watercourses Act).
- Applications for licences for specific development projects are dealt with by several directorates and ministries. All parties affected have an opportunity to make their opinions known during this process.
- Financial support is available for example for the development of new renewable energy sources (e.g. wind power).

- Research and development is being carried out on the environmental problems associated with the sector.

Norway's energy policy includes a development programme to encourage the development of renewable energy sources. The objectives are to construct wind power plants with a production capacity of 3 TWh/year, and to increase annual use of central heating systems based on new renewable energy sources, heat pumps and waste heat by 4 TWh/year, both by the year 2010 (Ministry of Petroleum and Energy 1999). In 1999, total production of wind power was about 13 GWh. In the same year, the Norwegian Water Resources and Energy Directorate granted a licence for the construction of a wind farm at Måsøy in Finnmark with 26 wind turbines. This will be Norway's largest wind farm, with an annual production of 150 GWh. The Norwegian Water Resources and Energy Directorate has also licensed the construction of a wind farm at Vågsøy in Sogn og Fjordane. Like hydropower developments, wind power developments can result in environmental problems. Wind farms disturb habitats for plants and animals, there is a danger that birds may collide with the installations, and biotopes may be built over or impoverished. Wind farms may also give rise to land-use conflicts and reduce the aesthetic value of the countryside. Further studies of their environmental impact are being carried out.

Measures that are primarily designed to reduce emissions to air are discussed in Chapter 7 Emissions to air, and those intended mainly to reduce emissions from transport are discussed in Chapter 6 Transport.

Figure 2.6. **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 Directorate.

2.3. Extraction and production

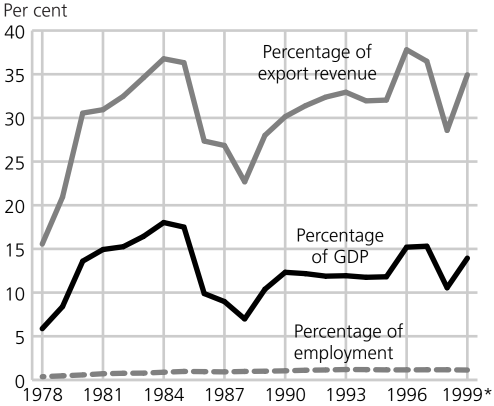
Total extraction of energy commodities in Norway rose by 1.4 per cent from 1998 to 1999, and extraction of natural gas rose particularly sharply. Since 1976, energy extraction has risen by an average of 10.3 per cent per year as a result of the growth in oil and gas extraction in the North Sea (figure 2.6). Total consumption of energy commodities in Norway has only risen by 2.2 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) has risen dramatically since 1976. In 1999, extraction of primary energy commodities was 8.5 times higher than consumption, so that almost 90 per cent of all energy extracted was exported. Appendix table A11 shows Norway's net exports of energy commodities to other countries in 1998.

Crude oil and natural gas

Extraction of oil and gas is Norway's most important industry measured in terms of export revenue and value added (proportion of GDP). In 1999, exports of crude oil and natural gas rose by NOK 43 billion from the year before, and totalled NOK 160 billion, or 35 per cent of the country's total exports (figure 2.7). The large variations in export revenue in recent years are explained by the very low crude oil prices in 1998 and very high prices towards the end of 1999. The industry accounted for 13.9 per cent of GDP, but only about 1 per cent of total labour input was directly related to oil and gas extraction.

In 1999, production of petroleum on the Norwegian continental shelf totalled 225.9 million Sm^3 o.e. This was a rise of 1.5 per cent from 1998. Oil production (excluding NGL[2] and condensate) was 168.6 million Sm^3 o.e. in 1999, 0.2 per cent lower than the year before. In the national budget for 2000, it was assumed that oil production would rise by 2.7 per cent from 1998 to 1999, but Norway undertook to reduce production by 100 000 barrels a day from 1 April 1999, which corresponds to about 3 per cent of expected production. As a result of technical problems and delays, production from Norwegian parts of the continental shelf has in fact been more than 200 000 barrels per day lower than expected. The required cuts in production have therefore had little impact on companies operating on the Norwegian shelf. Norway's crude oil production corresponded to 4.6 per cent of world production in 1999 (see table 2.3).

Figure 2.7. **Oil and gas extraction. Percentage of exports, gross domestic product (GDP) and employment**



Source: National accounts, Statistics Norway.

Production on most fields was lower in 1999 than in 1998. In 1998, the four largest fields were Oseberg, Gullfaks, Ekofisk and Statfjord, and production from these accounted for 45.4 per cent of total oil production on the Norwegian continental shelf. In 1999, this proportion dropped to 38.5 per cent. The largest reduction was on Statfjord, where production was 24.6 per cent lower than in 1998. This was partly a result of technical problems and partly because Statfjord and the other three fields are "old" and production was therefore expected to drop.

Net production of natural gas totalled 47.4 million Sm^3 o.e. in 1999, which is 8.7 per cent higher than in 1998. This corresponded to 2 per cent of total world production of gas in 1999 (see table 2.3). Norway has undertaken to deliver more than 70 million Sm^3 o.e. natural gas in

2 Wet gas or NGL (natural gas liquids) is often split into the following fractions: ethane, propane, butane and condensates. Butane and propane are known as LPG (liquefied petroleum gas).

Table 2.3. **World production of crude oil and natural gas in 1999***

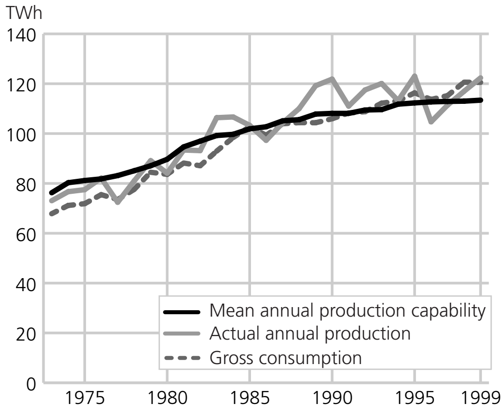
	Oil		Gas	
	Million Sm^3 o.e.	Per cent	Million Sm^3 o.e.	Per cent
World	3 747.0	100.0	2 349.8	100.0
OPEC	1 535.8	41.0	279.2	11.9
North America	454.2	12.1	748.0	31.8
Latin America	530.0	14.1	133.6	5.7
Western Europe	370.2	9.9	289.2	12.3
Eastern Europe	429.3	11.5	720.8	30.7
Middle East	1 176.6	31.4	131.6	5.6
Africa	381.2	10.2	86.1	3.7
Asia and Oceania	405.4	10.8	240.5	10.2
Saudi Arabia	449.1	12.0	31.7	1.3
Former Soviet Union	417.5	11.1	689.6	29.3
USA	344.6	9.2	557.0	23.7
Iran	203.8	5.4	31.2	1.3
China	185.4	4.9	24.4	1.0
Norway[1]	175.1	4.7	47.4	2.0
Mexico	170.6	4.6	49.6	2.1
Venezuela	161.6	4.3	25.8	1.1
UK	158.1	4.2	104.8	4.5
Canada	109.6	2.9	191.0	8.1
Indonesia	74.1	2.0	70.6	3.0
Algeria	43.9	1.2	60.2	2.6
Netherlands	3.3	0.1	83.4	3.5

[1] Figures for Norway differ from newer figures from the Norwegian Petroleum Directorate that are used elsewhere in this chapter.
Source: Oil & Gas Journal (2000).

2005. Gas production is therefore expected to rise in the next few years, as it did from 1998 to 1999. Production of NGL and condensate was about 0.1 million Sm^3 lower in 1999 than in 1998.

Troll East and Sleipner East are the two most important fields for natural gas production. Troll East alone accounted for more than 50 per cent of total natural gas production on the Norwegian shelf in 1999, and Sleipner East for 25 per cent of the total.

Figure 2.8. **Mean annual production capability, actual hydropower production and gross consumption of electricity in Norway**

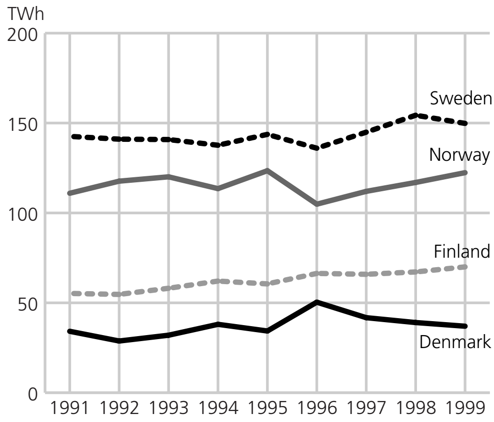


Sources: Norwegian Water Resources and Energy Directorate and Energy statistics, Statistics Norway.

Electricity

Electricity production in Norway in 1999 totalled 122.4 TWh, which was 5 per cent higher than the year before and the highest level since 1995 (see figure 2.8 and Appendix, table A8). Given the production capacity available at the end of 1999, production in a year with normal precipitation is calculated to be 114 TWh (including 0.7 TWh thermal power). The high level of production in 1999 was a result of ample rainfall and high inflow to the reservoirs. The degree of filling of the reservoirs was higher than normal from March onwards, and considerably higher than normal in the period May-August. To avoid full reservoirs and a risk of flooding in October, when high rainfall is expected, more electricity than normal was produced during these months. This resulted in a surplus of electricity for export in June-September. The surplus was particularly high in July and August, and was 1.7 TWh in each of these months. The net surplus for export for the whole of 1999 was 1.8 TWh. This was the

Figure 2.9. **Electricity generation in the Nordic countries**



Source: Nordel's secretariat (various years).

first time since 1995 that Norway was a net exporter of electricity. Gross consumption of electricity is also shown in figure 2.8. See section 2.4 for further information on consumption.

Figure 2.9 shows that electricity production in the Nordic countries varies considerably from year to year. These variations are caused mainly by fluctuations in precipitation and temperature. In 1996, below-normal levels of precipitation resulted in low hydropower production in Norway, Sweden and Finland. This was largely compensated for by an increase in thermal power production in Denmark, Finland and Sweden. In Denmark, production rose by almost 50 per cent from 1995 to 1996. In 1997, precipitation was close to normal, but 1998 and 1999 have been wetter than normal, and Norway's hydropower production has risen. The availability of more hydropower in Norway and Sweden in 1997 and 1998 seems to have resulted in a drop in production in Denmark. The rise in electricity consumption in the Nordic countries and variations in trade with countries outside the Nordic region mean that there is no simple one-to-one relationship between production in the various Nordic countries. Nevertheless, the figure shows clearly that their levels of electricity production in different years are related. Nordic thermal power production is largely based on fossil fuels that generate CO_2 emissions. In recent years, the power balance in Norway has therefore had an impact on CO_2 emissions in other Nordic countries.

If Norway improves its power balance by building gas-fired power plants, Norwegian CO_2 emissions will rise, but reduced imports of electricity may result in lower emissions elsewhere in the Nordic region or in other neighbouring countries. The overall impact on total emissions in the Nordic region will depend on a number of factors. Prices, and the changes in demand that can result from price changes, utilization of waste heat and the mix of power production from various sources abroad will all influence total CO_2 emissions.

Coal

Coal production on Svalbard in 1999 totalled 404 000 tonnes, which corresponds to just under 11.4 PJ. This is 23 per cent higher than in 1998, when operations were interrupted a number of times, for example by rockfalls. With the re-opening of the Svea mine in 1997 and production from the new field Sentralfeltet, coal production is expected to rise in the next few years. Norwegian coal production from 1916, when Store Norske Spitsbergen Kulkompani was established, up to 1999 has reached 24.2 million tonnes. Of total sales in 1998, rather more than half was used for energy purposes in Finland, Germany and on Svalbard, and a small amount for residential heating in Norway. The remainder was used for industrial purposes (particularly cement manufacturing) in Norway, the UK and Germany. World coal production in 1998 was just under 4.6 billion tonnes (OECD/IEA 1999c), which is equivalent to about 2 231 million toe or, in energy units, 94 EJ (BP Amoco 1999). Total production consisted of 80 per cent hard coal and 20 per cent brown coal. The largest producers are China and the USA, which in 1998 accounted for 28 and 26 per cent of the total respectively, converted to energy units. Europe excluding the former Soviet Union accounted for 12 per cent of the total, and more than half of this was produced in Germany and Poland. Brown coal accounted for almost 80 per cent of production in Germany, which is the world's largest brown coal producer.

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 rising and was about 46 PJ per year at the end of the 1990s. This is equivalent to about 10 per cent of energy production from hydropower. The figure is uncertain because the data are incomplete. In 1998, energy equivalent to about 4.8 PJ was generated for district heating by waste incineration, and about 90 per cent of this may be classified as bioenergy. In 1999, 211 000 tonnes of methane was generated in Norwegian landfills (preliminary figures), and this corresponds to an energy content of about 10.6 PJ. In recent years, more and more of this gas has been used for energy purposes or flared. In 1999, 21 500 tonnes (1.1 PJ) was extracted for these purposes, and an estimated 18 per cent was used for energy purposes.

The use of fuelwood contributes substantially to local air pollution, especially to emissions of particulate matter (see Chapter 7, Emissions to air). Bioenergy installations have been exempted from investment tax to promote the use of renewable energy sources. In 1998, 35 bioenergy projects received grants from the Norwegian Water Resources and Energy Directorate. These have the potential to result in energy production totalling 174 GWh/year in the form of processed biofuel (pellets and briquettes) and 157 GWh/year as bioenergy used directly for heating purposes (Norsk Bioenergiforening 2000).

2.4. Energy use

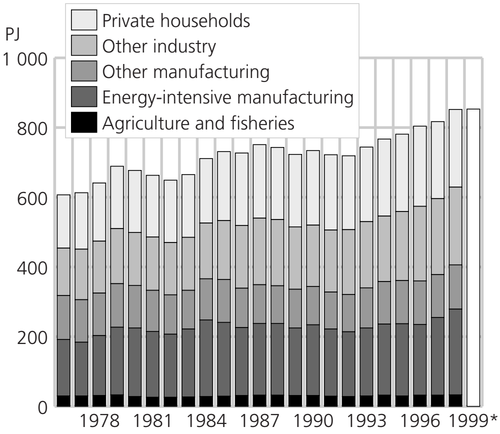
In 1999, Norway's total energy use (excluding international maritime transport), was 1 049 PJ. Energy use in the energy sectors accounted for 19 per cent of this.

Consumption of energy commodities, excluding the energy sectors and international maritime transport, totalled 851 PJ in 1998 and 853 PJ in 1999 (figure 2.10 and Appendix, table A5). Energy use rose by an average of 1.4 per cent per year from 1978 to 1998. 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

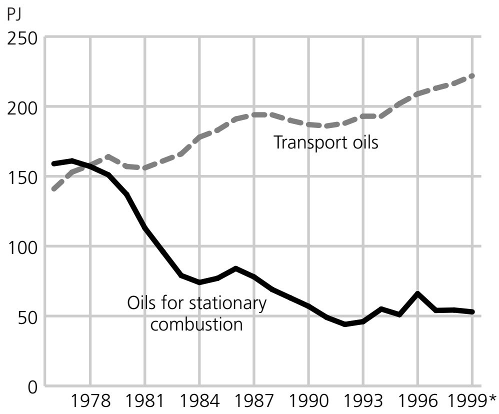
Net energy use in the energy sectors was 197 PJ in both 1998 and 1999 (preliminary figures). Electricity generation from natural gas in connection with oil and gas extraction, which accounts for most of this, decreased from 147 PJ in 1998 to 146 PJ in 1999 (see Appendix, table A6). In the period 1976-1997, energy use for this purpose rose by an average of 9 per

Figure 2.10. **Domestic energy use by consumer group**



Source: Energy statistics, Statistics Norway.

Figure 2.11. **Consumption of oil products**



Source: Energy statistics, Statistics Norway.

cent per year, but has dropped somewhat since then. Most of the natural gas is used for combustion for energy purposes, but in 1999, 19 per cent was flared, i.e. burnt without the energy being utilized. Electricity generation on oil platforms requires large amounts of energy, because the efficiency of this process is very low. The drop in energy use in the last few years 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.

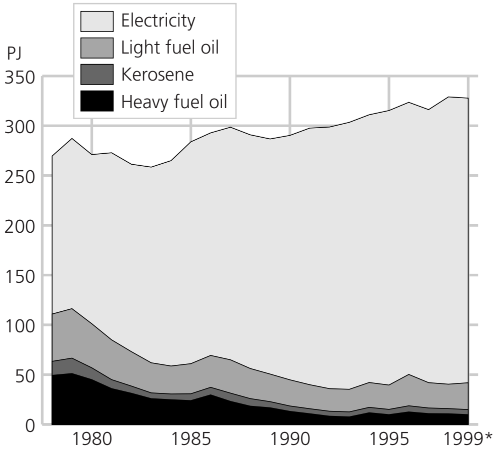
Energy use in the energy sectors results in large emissions to air. These are discussed in more detail in Chapter 7. See also Appendix, tables F3-F6.

Oil consumption

Total oil consumption, excluding the energy sectors and international maritime transport, dropped by about 8 per cent from 1976 to 1999, despite the fact that oil consumption for transport rose by 57 per cent, or 2.0 per cent per year, in the same period (figure 2.11 and Appendix, table A5). Transport now accounts for 81 per cent of total oil consumption, as compared with 47 per cent in 1976. Auto diesel and marine gas oil are the types of transport oils whose consumption has risen most. Rising air traffic both within Norway and to other countries in recent years has resulted in growing consumption of aviation fuel. There was a slight drop in sales of petrol from 1998 to 1999. Consumption of heavy fuel oil excluding international maritime traffic has dropped since the mid-1980s.

Consumption of oil for stationary purposes had dropped to less than one third of the 1976 level by 1992. Since then, the figures have fluctuated, but there has been a downward trend in the 1990s. From 1998 to 1999, there was a drop of 2.4 per cent (preliminary figures). Sales of heating kerosene and heavy fuel oil

Figure 2.12. **Electricity consumption (excluding energy-intensive manufacturing) and sales of fuel oils and kerosene as utilized energy**



Sources: Energy statistics, Statistics Norway and Norwegian Petroleum Institute.

also fell by 2 and 8 per cent respectively from 1998 to 1999, whereas sales of light fuel oil rose by almost 10 per cent (figure 2.12). General economic trends, temperatures and the relationship between oil and electricity prices influence trends in oil and kerosene consumption. Electricity prices to end-users are fluctuating more and more in step with the price of electricity on the power exchange. This means that there may be considerable variations in prices within as well as between years. The prices of oil products also vary through the year depending on trends in oil prices and stocks of oil products. Heavy fuel oil is widely used for industrial purposes (wood processing), while light fuel oils are used more in services and private households. Differences in trends for these products may therefore be explained by differences in consumption trends in the various consumer groups and in their opportunities to switch between different energy carriers at different times of year. Trends in energy prices are described in section 2.4.

Emissions to air associated with oil consumption are discussed in Chapter 7.

Electricity consumption

Net domestic consumption of electricity was 110.5 TWh in 1999, 0.1 per cent lower than the year before. However, consumption in 1998 reached the highest level ever recorded and was more than 6 TWh higher than the year before. In the period 1990-1997, consumption rose by an average of about 1 TWh per year. Electricity prices have been considerably lower in 1998 and 1999 than in 1997, when the degree of filling of the reservoirs was low. The drop in prices appears to have stimulated demand. In addition, increasing activity in service sectors and more use of electrical equipment has contributed to the rise in consumption. In the last few years, there has also been a rise in consumption by energy-intensive manufacturing. Consumption in this sector totalled 31.1 TWh in 1999, an increase of 0.7 TWh from the year before and about 2.8 TWh more than the average for 1990-1997. The increase is related to rising production in the metal manufacturing industry.

General consumption, i.e. net domestic electricity consumption minus consumption by energy-intensive manufacturing and spot power (non-contractual electricity supplied for electric boilers) totalled 75.1 TWh in 1999, see table A8 in the Appendix. This is a slight decrease from 1998, partly because the weather was milder in 1999 than in 1998. When the weather is milder than normal, the demand for electricity for heating purposes drops. If consumption is corrected for normal temperature conditions, which are taken to be the average for the period 1961-1990, the figure obtained is 77.4 TWh. This corresponds to a rise of about 2 per cent from 1998. An analysis of the growth in household electricity consumption is presented in section 2.6, and an analysis of the importance of temperature for energy consumption in section 2.7.

World energy use

In 1997, Norway, which has about 0.07 per cent of the world's population, accounted for 0.25 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 A10). Per capita energy use in Norway was 19 per cent higher than the average for the OECD countries and more than three times the world average. This is explained by factors such as a high income level, a large energy-intensive manufacturing sector, the cold climate which means that a great deal of energy is needed for heating, and a high volume of transport as a result of the scattered pattern of settlement. However, Denmark is the only Nordic country where per capita energy use is lower than in 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 64 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 89 per cent of the OECD average.

The energy mix varies between continents. Oil, coal and natural gas are important energy commodities in all continents, whereas nuclear power is used particularly in some industrial countries (BP Amoco 1999). The proportion of energy use based on nuclear power is higher in France than in any other country. In Norway, hydropower accounts for the highest proportion of energy use.

2.5. Energy prices

Electricity

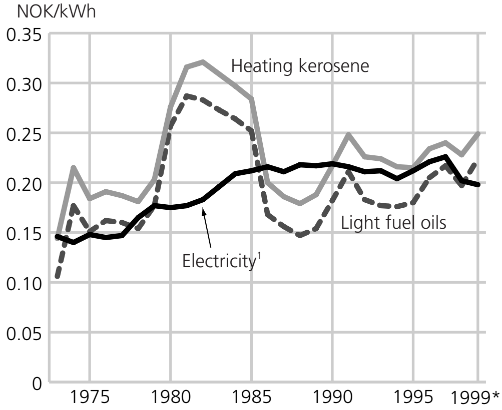
Electricity prices for most consumer groups were reduced from 1998 to 1999. The average electricity price for households, excluding taxes and transmission charges, was NOK 0.152 per kWh, about NOK 0.01 per kWh less than the year before. However, transmission charges rose by about NOK 0.008 per kWh from 1998 to 1999, and the electricity tax was raised by NOK 0.002 per kWh, so that the total price remained unchanged. For service sectors, the electricity price, excluding taxes and transmission tariffs, was reduced by NOK 0.017 per kWh or 10 per cent. Electricity charges for the manufacturing industries were also reduced by just over NOK 0.01 per kWh. Electricity prices for households and service sectors were 28 and 26 per cent respectively lower in 1999 than in 1997. High precipitation resulted in lower spot prices, which in turn gave lower prices for end users. Another reason for the drop in prices may be that there is no longer a charge for changing supplier. Because energy utilities are now competing for household customers, they are increasingly adjusting their prices to variations in the spot price. Utilities that do not adjust their prices will lose customers when the spot prices falls. In periods when the spot price is rising, utilities that do not adjust their prices will experience a large influx of customers. In 1999, electricity prices for households varied considerably through the year. About 90 per cent of all households buy electricity at variable prices. Electricity prices for manufacturing industries and services were more stable because fixed-price contracts are more widely used in these market segments.

Business and industry can to some extent switch between oil and spot-price electricity, and normally choose the cheaper alternative. In 1999, the price of spot power dropped by NOK 0.005 per kWh compared with the 1998 level, and was on average NOK 0.116 per kWh. Nevertheless, consumption of spot power dropped by 13 per cent, and totalled 4.3 TWh. Thus, there does not appear to have been general changeover from oil to spot power, even though this would have been predicted on the basis of price trends, see the section on fuel oils. This may be because the exemption from the electricity tax on spot power for users with reserve heating installations was abolished in 1999. In 1999, the electricity tax was NOK 0.0594 per kWh, but it was raised to NOK 0.0856 per kWh from 1 January 2000.

Fuel oils

In 1999, the prices of most petroleum products rose as a result of higher oil prices and increases in taxes. For example, the listed prices (excluding discounts) of light fuel oil and heating kerosene rose by 16 and 12 per cent respectively to NOK 0.40 and 0.48 per kWh, see table A9 in the Appendix. Despite the higher prices for oil products, sales of light fuel oil and heavy distillates rose by 6 and 28 per cent respectively from 1998 to 1999. Sales of heating kerosene and

Figure 2.13. **Prices of fuel oils and electricity[1] for heating (as utilized energy), in fixed 1980 prices including all taxes and tariffs**



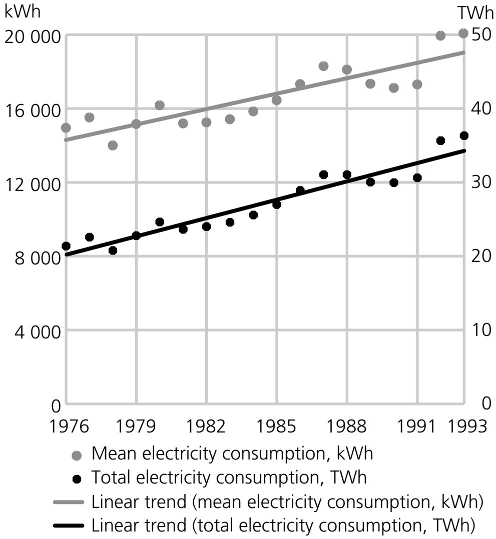
[1] Average price for the whole year.
Sources: Energy statistics, Statistics Norway, Norwegian Water Resources and Energy Administration and Norwegian Petroleum Institute.

heavy fuel oil dropped by 2 and 8 per cent respectively. Figure 2.13 shows trends in the price of utilized energy (i.e. corrected for efficiency) in fixed 1980 prices from 1973 to 1999. Table A9 in the Appendix shows the prices of heating products measured as energy supplied. Consumption of heavy fuel oil is very low (see Appendix, table A5) despite low prices. This is because permits and technical considerations greatly restrict their use. Heavy fuel oils are used mainly in manufacturing.

2.6. What causes the growth in household electricity consumption?

Electricity is used to run various types of technical equipment and provide services such as heating, lighting and hot water. In order to explain the rise in electricity consumption over time, it is useful to know how much electricity is used for different purposes. Detailed measure-

Figure 2.14. **Calculated mean electricity consumption per household (kWh) and total household electricity consumption (TWh), 1976-1993**



Source: Halvorsen and Larsen (1999b).

ments in all households are expensive and difficult to carry out in practice. An alternative method is to estimate electricity use for different purposes using an econometric model based on data for a sample of households.

To obtain information about the composition of household demand for electricity, we have used data from Statistics Norway's annual surveys of consumer expenditure for the period 1976-1993. We started by making an empirical analysis of the elasticity of household electricity demand, i.e. the extent to which electricity consumption can be adjusted in response to changes in prices, income or other factors of importance for energy demand (Halvorsen and Larsen, 1999a). On the basis of this, we have looked more closely at which factors contribute to the growth in household electricity consumption (Halvorsen and Larsen 1999b).

The results show that the calculated increase in mean electricity consumption per household is 1.7 per cent per year for the period 1976-1993 (see figure 2.14). Total electricity consumption is calculated by multiplying mean consumption per household in the sample by the number of households in Norway. The calculated total electricity consumption for all Norwegian households rose by an average of 3.1 per cent per year in the same period, measured along the trend line. The reason why total electricity consumption rose by more than mean consumption per household was that number of households in Norway increased by an average of 1.4 per cent per year during this period, as a result of population growth and a drop in the number of persons per household. This means that about 45 per cent of the growth in total household electricity consumption is a result of a rise in the number of households, and the remainder is a result of changes in factors that influence adjustments of electricity consumption in individual households. Several factors have tended to cause a rise in mean electricity consumption during the period studied. For example, more and more households have started to use electrical appliances such as tumble driers and dishwashers, and both household income measured in fixed NOK and the living space per household have risen.

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

Project documentation: Halvorsen and Larsen (1999a) and (1999b).

2.7. The importance of temperature for levels of energy use

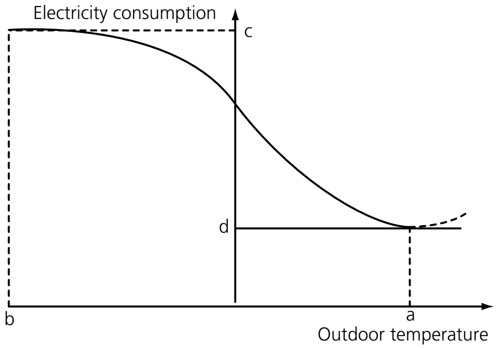
Trends in energy use are dependent on a number of factors. In the short term (months), temperature fluctuations are the most important factor for trends in energy use. In the longer term (years), economic conditions such as the price of energy carriers, economic growth and the way growth is split by sector are most important.

Our aim was to find out how much energy use in Norway changes when the temperature deviates from normal. The results show that if the temperature is on average one degree Centigrade colder than normal for one month, electricity consumption rises by almost 200 GWh and fuel oil consumption by almost 3 million litres per month.

The purpose of this study was to investigate the effect of temperature on energy use, and to discuss various methods that can be used for temperature correction. We assume that in practice, only energy use for heating purposes is directly influenced by the temperature. Most energy for heating is provided by electricity and fuel oils, and the data available only permitted us to study these two energy carriers. However, given certain assumptions, the results can also be used for other energy carriers that are used for heating purposes.

Figure 2.15 is a sketch of the relationship between the outdoor temperature and electricity consumption. Consumption is higher at low temperatures than at high temperatures. However, at very low temperatures, electricity consumption levels off because the capacity of either the heating system or the transmission system reaches its limits. Point c in the figure can therefore be interpreted as representing the maximum capacity of the system. As the temperature moves towards point a, the need for electricity for heating purposes will gradually disappear, although consumption may rise again if electricity

Figure 2.15. **Sketch of the relationship between the outdoor temperature and electricity consumption**



is used for cooling. Electricity consumption at point d may therefore be interpreted as temperature-independent consumption. The gradient along the curve is an expression of the sensitivity of electricity consumption to temperature, and this is used in temperature correction. When the gradient is steep, electricity consumption reacts sharply to temperature changes, and a relatively small deviation from the normal temperature will require a relatively large correction of electricity consumption.

In this study, we investigated the monthly temperature sensitivity for electricity and fuel oils in the period 1975-1996. The most important result is that temperature sensitivity for both electricity and fuel oil has changed during the period studied. This is mainly because there has been a shift in energy use away from the use of oil and towards the use of electricity as a result of the rises in oil prices in the 1970s. Together with better insulation and greater use of electrical equipment that produces heat as a side-effect, this has resulted in an increase in the temperature sensitivity of electricity in spring and autumn, a slight increase in winter, and a decrease in summer. Oil consumption has become generally less temperature-sensitive, because oil consumption for heating purposes has dropped sharply in the period studied. We also found that electricity and oil prices were very important for the choice of energy form, but less important for total energy use.

Project financed by: Statistics Norway.

Project documentation: Døhl (1999).

2.8. An efficient power market – consequences for energy-intensive manufacturing industries

An important principle in current economic theory is that unless there are special reasons for a different system, all users of an economic good should pay the same price for it. If this principle is not followed, the limited resources available are not used as effectively as possible. The principle applies to all goods, whether they are purely consumer goods (e.g. clothes and food), factor inputs (e.g. raw materials of all types) or goods that are used partly as consumer goods and partly as factor inputs in production processes. Electricity is an example of the latter type.

In Norway, energy-intensive manufacturing industries and the pulp and paper industry pay less for electricity than other sectors. This situation has arisen because in the past, these industries entered into power contracts in which the prices were determined by political processes. In theory, this type of pricing does not result in effective use of electricity. The aim of this project was to examine the consequences of altering the system so that all users pay the same price for electricity.

We have carried out calculations that illustrate what may be the consequences for energy-intensive manufacturing industries and the pulp and paper industry in Norway if they have to pay market prices for electricity. Furthermore, we have calculated changes in welfare through changes in the overall producers' surplus and consumers' surplus as a result of a changeover to market pricing of electricity for these branches. We have also calculated changes in pollution levels as a result of this changeover. Finally, we studied the ability of the municipalities where energy-intensive enterprises are located to adapt to the new situation, using a set of indicators.

The main conclusion is that society will gain in both economic and environmental terms if price policy towards energy-intensive industries is altered. The economic gains are of the order of NOK 500-1500 million per year, depending on the international regulatory framework that is developed for emissions of greenhouse gases. Market pricing of the electricity that energy-intensive industries now purchase relatively cheaply will result in downsizing of these industries. Some of the power thus made available can be exported – and thus replace thermal power production in other countries – and some can be used to delay new investments in electricity generation in Norway (including gas-fired power plants). Studies of the ability of municipalities to adapt to the new situation suggest that even though they would incur costs in the process, there is reason to believe that the transitional problems would be less dramatic than many people claim.

Project financed by: Ministry of the Environment.

Project documentation: Bye, Hoel and Strøm (1999).

2.9. Transmission constraints and market power in the Norwegian power market

Norway was one of the first countries to deregulate its power market, and the liberalization is generally considered to have been successful. However, there are few analyses of market power in the Norwegian power market. Market power means that one or more producers are able to influence the market price and thus increase their income.

In a hydropower system like that in Norway, it is difficult to quantify production costs. This also means that it is difficult to use traditional methods to reveal market power by comparing marginal production costs and market prices. There are many electricity generators in the Norwegian market, and traditional measures of market power suggest that opportunities for using market power are limited. However, in periods when there are constraints on transmission capacity between different areas, small local price areas can be created which are shielded from competition from surrounding areas by the transmission constraints. In these local areas, the number of producers may be considerably lower than if the Norwegian market is considered as a whole.

We made an empirical study of Nord Pool's (the Nordic power exchange) spot prices for the years 1993-1998. We tried to identify the degree to which the prices of electricity on the power exchange rise in areas that are shielded from the rest of the market as a result of transmission constraints. Since we cannot identify marginal production costs, we compared the short-term price trend in the local area with the price trend in areas with several producers. We assume that there is most opportunity to influence the price on the power exchange in a local area when demand elasticity is low, i.e. at night and at weekends.

We found that electricity prices are generally 10-15 per cent higher when transmission constraints arise than otherwise. However, we cannot exclude the possibility that this is because there are differences in marginal costs between regions. For the price area Kristiansand in southern Norway, we found that in 1998, prices rose by 15 per cent more at night than during the day when the area was separated from the rest of the country by transmission constraints. This result is robust when tested against a number of alternative model specifications, and we take this as evidence of market power. For other areas, we found no clear signs of this type of market power. Overall, our analysis thus shows that market power is a minor problem in the Norwegian power market. The socio-economic costs associated with the market power we did find are small compared with the investment costs that would be needed to provide more transmission capacity to the Kristiansand area. However, it should be stressed that our analysis cannot reveal all use of market power. For example, if regional production and consumption data were available, it would be possible to make more structural analyses of how the market functions when there are transmission constraints.

Project financed by: Research Council of Norway.

Project documentation: Johnsen, Verma and Wolfram (1999).

Documentation, energy in general: Statistics Norway (2000a).

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

3. Agriculture

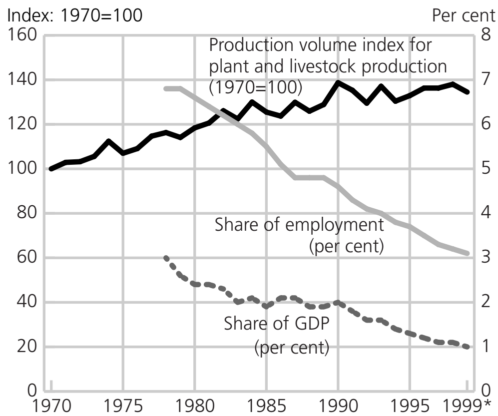
The agricultural sector has significant environmental impacts, both positive and negative. The open cultural landscape has largely been created by farming. But agricultural activities also contribute to pollution, and eutrophication of water bodies has been the focus of much attention. The environmentally 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.

3.1. Principal economic figures for agriculture

Employment, gross domestic product and production

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 3.1 per cent (figure 3.1). 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 1.0 per cent in the same period. Agricultural production measured according to the production volume index used by the Budget Committee for Agriculture rose by 38 per cent from 1978 to 1990 (Budget Committee for Agriculture 1999), but has shown no increase since 1990.

Figure 3.1. **Changes in the share of employment and GDP in the agricultural sector, and changes in agricultural production (index)**



Sources: Budget Committee for Agriculture (1999) and the National Accounts from Statistics Norway.

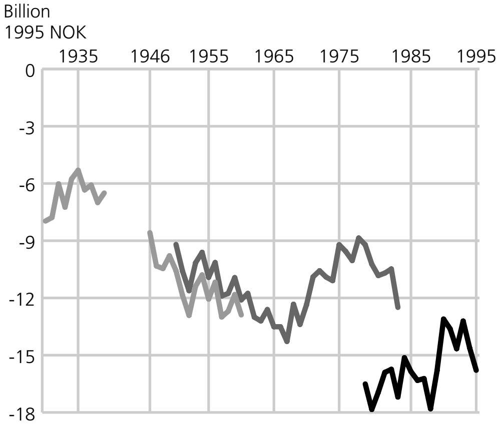
The economic return in agriculture expressed as the resource rent

The return on capital in agriculture in excess of the normal rate of return can be expressed as the resource rent or the proportion of the income from agriculture (including hunting and wildlife conservation) that is not used to cover current costs of inputs, work and capital. Corrections are made for agricultural subsidies because these are public expenses that will not be incurred if the resources are employed in an alternative way. The resource rent for agriculture is linked with agricultural land including uncultivated areas, and can be seen as an additional income over and above what will normally be earned in ordinary operations exposed to competition. The calculation of the estimated resource rent is based on a 7 per cent return on invested capital. A more detailed description of the resource rent for agriculture and other natural resource-based industries is given in section 11.1.

From 1930 to 1995 the resource rent for agriculture was negative (see figure 3.2). This reflects the fact that income was far from sufficient to cover operating expenses, labour expenses and a normal yield on invested capital. Although income from agriculture increased from 1930 to 1995, income corrected for subsidies and special taxes did not show the same upward trend, because there was a substantial increase in agricultural subsidies from 3 per cent of net product in 1930 to 123 per cent in 1995.

The costs of real capital increased by 168 per cent from 1930 to 1995. In 1995, there was about fourteen times as much capital behind each full-time equivalent person as there was in 1930. Moreover, labour costs were higher in the 1990s than in the 1930s, in spite of the fact that employment in agriculture fell by 80 per cent from 337 000 full-time equivalent persons in 1930 to 66 700 in 1995. This fall was due to the steep rise in real wages per full-time equivalent person. The main factors contributing to the negative resource rent were the high labour costs combined with the weak income trend. While the resource rent varied between NOK -5 billion and -8 billion in the 1930s, it sank to between NOK -13 and -18 billion in the 1990s.

Figure 3.2. **Resource rent for agriculture**

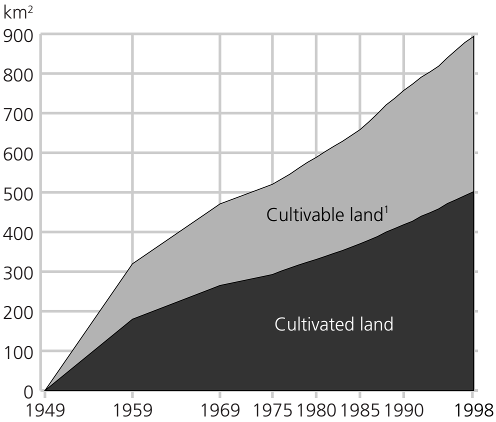


[1]1930-1960 figures are based on the National Accounts' old national standard, 1961-1977 are based on UN (1968), and 1978-1995 are based on European Commission et al. (1993).
Source: Lindholt (2000a).

3.2. Land suitable for agriculture

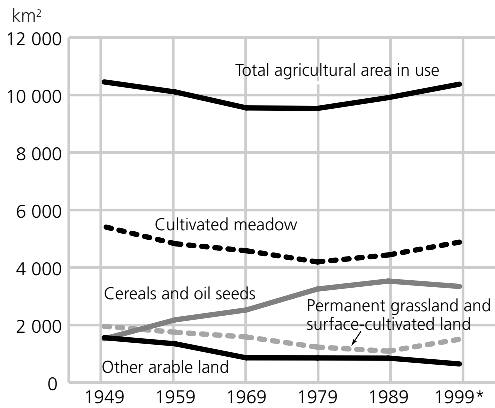
The total area of land potentially suitable for agriculture in Norway has been calculated to be about 19 000 km² (Grønlund 1997), of which about 10 000 km² is in use. In general, the best soils are cultivated, so that other cultivable land is normally of poorer quality.

Figure 3.3. **Accumulated conversion of cultivated and cultivable[1] land since 1949**



[1] For 1949-1976, only data for conversion of 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 statistics from Statistics Norway and Ministry of Agriculture.

Figure 3.4. **Agricultural areas in use**



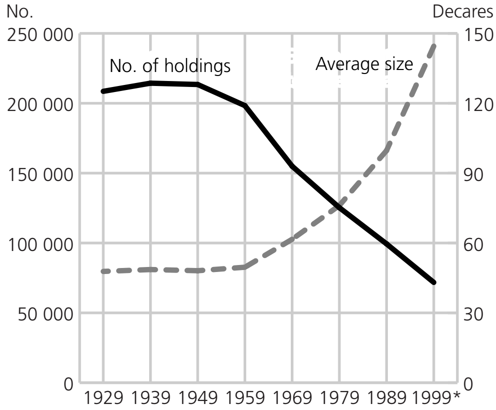
Source: Agricultural statistics from Statistics Norway.

Since 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 (Report No. 19 (1999-2000) 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 895 km^2, or about 4.7 per cent of the total area suitable for agriculture, has been used for such purposes (figure 3.3). 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. However, the statistics on lost land are uncertain.

Agricultural land in use

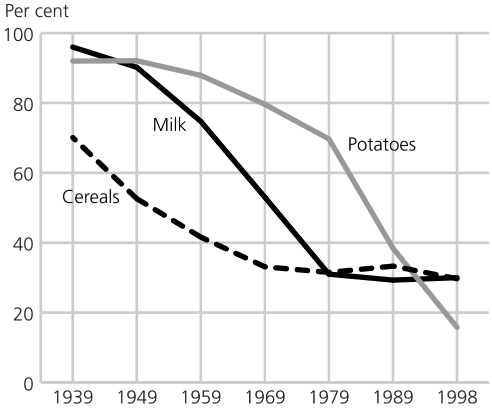
Since 1949, the area of agricultural land in use has varied between 9 500 and 10 500 km^2 (figure 3.4). Since the late 1980s, the area has gradually increased, and was 10 400 km^2 in 1999 (see Appendix, table B1). With a conversion of cultivated land in the range of 500 km^2, this should mean that an area of cultivable land of at least the same size has been cultivated. Some of the increase recorded in recent years is also due to the fact that marginal areas which were previously of little economic importance have been registered as land in use. This 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

Figure 3.5. **Number of holdings and average size in decares**



Source: Agricultural statistics from Statistics Norway.

Figure 3.6. **Production of cereals, potatoes and milk. Percentage of all farms with these types of production**



Source: Agricultural statistics from Statistics Norway.

use marginal areas (Budget Committee for Agriculture 1997). One of the reasons for reorganizing the grants system in this way 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 1999, cereal and oil-seed acreage made up 32 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 18 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 as much as 38 per cent since 1989. This is probably related to the introduction of acreage and cultural landscape support.

3.3. Production structure

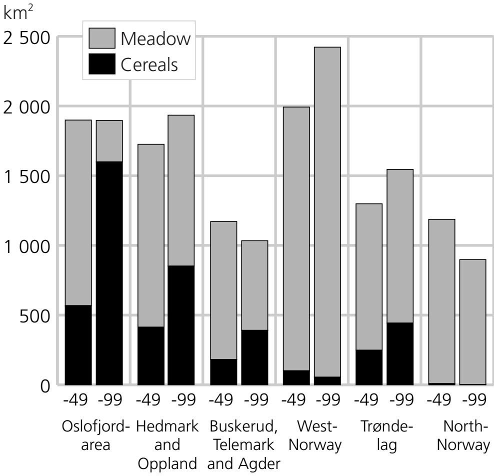
Major structural changes have taken place in agriculture in post-war years. There are three distinct trends in these structural changes:

- the area of agricultural land is distributed among fewer and larger farms
- each farm produces fewer products (specialization at farm level)
- production of important products is concentrated to a greater extent in certain regions (specialization at regional level)

Number of farms

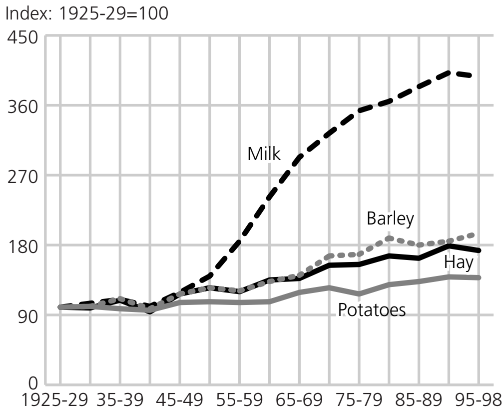
The structural changes gained speed after 1960. Since then the number of holdings has been reduced to about a third, while the average size of a holding has almost trebled (figure 3.5). The production structure has not yet stabilized. Much of the land on the discontinued farms has been taken over as additional land by the remaining farms.

Figure 3.7. **Area under cereals and meadow by region. 1949 and 1999***



Source: Agricultural statistics from Statistics Norway.

Figure 3.8. **Average crop per decare of barley, potatoes and hay and average milk production per cow. Relative changes**



Sources: Agricultural statistics from Statistics Norway and TINE Norske Meierier BA.

Specialization at farm level

There is also a trend towards greater concentration on fewer products on the individual farms. There has been a gradual transition from subsistence farming to industrial production and from many-sided to one-sided production. Predominant types of production such as cereals and milk have stabilized at about 30 per cent, while smaller types of production, such as potatoes, continue to be concentrated in fewer and fewer farms (figure 3.6).

Specialization at regional level

The third trend is seen in the tendency for some important types of production to become concentrated in particular regions. The most noticeable change is the decline in the area of meadow and the increase in the area under cereal cultivation in south-east Norway. In the counties of Østfold, Vestfold and Akershus (the Oslofjord area), the percentage of cereal has increased from 26 per cent of agricultural land in 1949 to about 79 per cent in 1999 (figure 3.7).

The climatic conditions in east Norway are suitable for the production of cereals and the countryside and ownership structure have made mechanization possible. A considerable proportion of livestock production (milk, beef, sheep, goats) is linked with the meadow areas. The production of milk is now concentrated in west Norway and in the mountain districts. Regional specialization can partly be explained by the way in which agricultural subsidies have been channelled.

3.4. Area and livestock productivity

Agricultural production has increased considerably despite the fact that the area of agricultural land has changed very little in size. This is due to the increase in inputs such as fertilizers, pesticides and machinery, and also to technological progress and developments in animal husbandry (figure 3.8). The increase in milk production per cow has been particularly high. Breeding and increased feeding have played an important part in this. Growth has now levelled off.

3.5. Environmental impacts

The negative environmental impacts of agriculture are pollution, alterations in biotopes and landscapes, and uses which conflict with other environmental interests. Priority has been given to the pollution problem, for instance in the North Sea Agreements (see box 9.1), and systematic, relevant statistics on pollution are available.

The most serious type of pollution from agriculture is considered to be runoff of nutrients (nitrogen and phosphorus). Agriculture accounts for about 10 and 35 per cent respectively of anthropogenic phosphorus and nitrogen inputs to the coast (Norwegian Institute for Water Research). These inputs are described in more detail in section 9.3. 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
- technical facilities.

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 7, and Appendix, tables F3-F5).

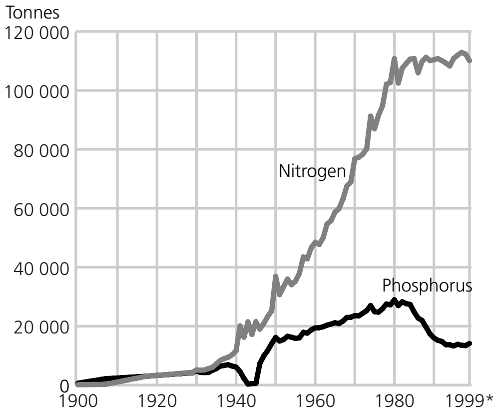
Application of commercial fertilizer

Commercial fertilizers are used to add plant nutrients to the soil. However, heavy application of fertilizer can increase pollution in lakes and rivers. Sales of commercial fertilizer increased rapidly in the second half of the twentieth century (figure 3.9). The phosphorus content in commercial fertilizer reached a peak at the beginning of the 1980s. Since then it has been more than halved and has totalled about 13-14 000 tonnes per year in recent years (see Appendix, table B2). The reduction in the use of phosphorus fertilizers has given a better adjustment to the needs of the plants; it has saved the agricultural sector a great deal of expense, and it has reduced the impact on the environment. Sales of nitrogen peaked around 1980 and have remained stable since then at about 110 000 tonnes. The level of fertilization is determined to an increasing extent by the use of fertilization plans, which means that the amount of fertilizer applied is determined on the basis of soil samples and recommended standards.

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.

Figure 3.9. **Sales of nitrogen and phosphorus in commercial fertilizers**



Sources: Statistics Norway and Norwegian Agricultural Inspection Service.

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.

To reduce soil erosion, the authorities provide grants for areas that are vulnerable to erosion on condition that the farmers leave them under stubble during the winter, i.e. do not till such areas in autumn. Support is provided 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 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. 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.

Table 3.1. **Emissions to air from agriculture (showing pollutants for which the sector is an important source). Tonnes and percentage of total emissions in Norway. 1998***

Pollutant	Tonnes	Percentage of total emissions in Norway
All greenhouse gases		
(in CO_2 equivalents)	5 601 400	10
- CO_2	638 762	1.5
- nitrous oxide (N_2O)	8 580	52
- methane (CH_4)	109 660	32
Acidifying compounds	1 620[1]	22
- ammonia (NH_3)	25 400	94

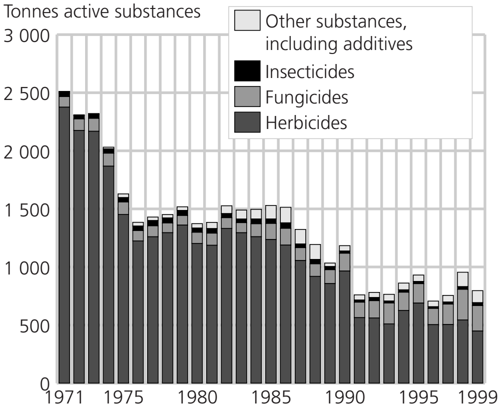
[1] Acid equivalents.
Source: Emissions inventory from Statistics Norway and Norwegian Pollution Control Authority.

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 3.1). 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.

Figure 3.10. **Sales of pesticides expressed as tonnes active substances**



Source: Norwegian Agricultural Inspection Service.

Table 3.2. **Percentages of the area of some crops treated with chemical pesticides. 1996**

Type of crop	Herbi-cides	Fungi-cides	Insecti-cides
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.

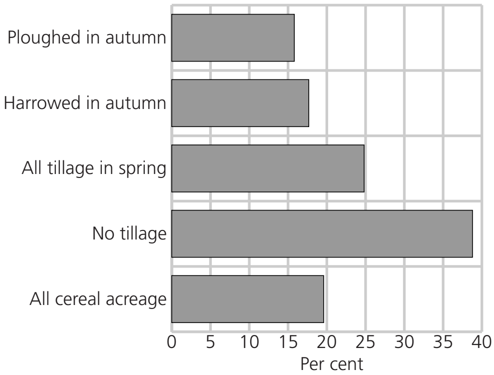
Sources of emissions of *nitrous oxide* (N_2O) from agriculture are the use of commercial fertilizer and manure, livestock, biological nitrogen fixation, decomposition of plant material, cultivation of mires, deposition of ammonia and runoff. Agriculture accounts for 50 per cent of total nitrous oxide emissions in Norway, and about half of this is emissions from runoff and the use of commercial fertilizer. All in all this means that 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 7 and Appendix, tables F3-F5).

Use of pesticides

Residues of pesticides in soils, water and food products can cause injury to human health and environmental damage. Thus, there is always a certain risk associated with the use of these substances. Total sales of pesticides, expressed as kilograms of the active substances, were greatly reduced in the first half of the 1970s, then increased somewhat and were almost halved from 1985 to1991. Since then consumption has risen again slightly (figure 3.10 and Appendix, table B3). The rise in 1998 may have had some connection with the anticipated rise in government charges in 1999, so that the increase in consumption led mainly to an increase in stocks. The quantity used and the effect on plants and the surrounding environment do not correspond completely. The degradation rates of different pesticides vary widely, as do their selectivity, mobility and toxicity. 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 agricultural land treated with chemical pesticides in 1996 (table 3.2). Measured in terms of the area treated, herbicides are the most widely-used pesticides. Herbicides are used against both annual and perennial weeds (couch-grass, etc.).

Figure 3.11. **Percentage 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 (2000).

The proportion of area sprayed varies somewhat from one type of cereal to another. A larger proportion of wheat than barley is sprayed, and even less of the area under oats is sprayed. Financially, the cereal farmer has most to gain by spraying areas where potential yield is high, where the price is good and where yields may be substantially reduced if pesticides are not used.

Where potato acreage is sprayed with fungicide, this is mainly 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 3.11). Thus, when tillage is reduced, erosion and pollution by nutrients is reduced, but larger amounts of pesticides are used. This means that given current agricultural practice, the environmental cost of reducing erosion by limiting tillage is greater use of pesticides.

Co-financed by: Ministry of Agriculture.

Further information available from: Henning Høie and Kjetil Mork.

Box 3.1. Ecological farming

Ecological agriculture is a collective term for various farming systems based on some common principles:
- no use of commercial fertilizer or chemical/synthetic pesticides
- cultivation of a variety of crops and diversified crop rotation
- cultivation systems should have a preventive effect on disease and pests
- organic material recycled as far as possible
- balance between livestock numbers and areas of farmland with respect to fodder production and use of manure.

Ecological agriculture has certain environmental advantages over conventional farming systems:
- often higher product quality
- less loss of nutrients and thus less pollution
- more varied agricultural landscape and therefore greater species diversity in and around agricultural areas
- no pesticide residues in soils or products.

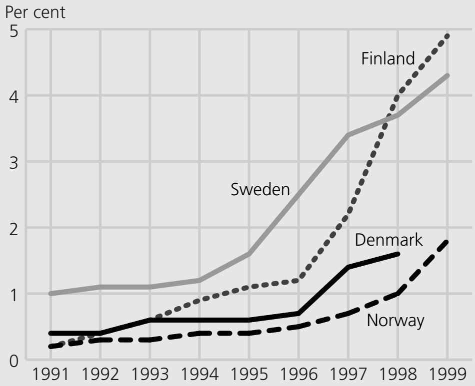
Ecological agriculture is considerably more labour-intensive than conventional agriculture, and yields are generally lower. This makes it more difficult to obtain earnings that are as high as those from ordinary agriculture, despite higher product prices.

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

Ecological agriculture expanded in Norway in the 1990s, as it did throughout the Nordic countries (figure 3.12). Areas approved for ecological agriculture have been registered since 1991, and the total area rose from 18 km^2 in 1991 to 149 km^2 in 1999 (see Appendix, table B4). Including the area in the process of conversion, about 1.8 per cent of the total agricultural area is farmed ecologically. Table 3.3 shows ecological farming by county in 1999.

Ecological agriculture is based on coarse fodder production to a larger extent than conventional agriculture. About 80 per cent of areas that are ecologically farmed are meadows, as against about 60 per cent in traditional farming.

Figure 3.12. **Areas farmed ecologically and in the process of conversion in the Nordic countries[1]. Percentage of total agricultural area**



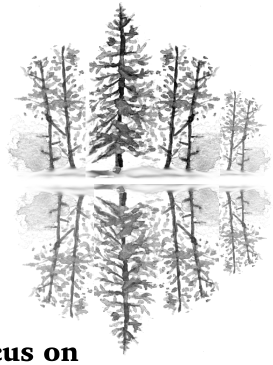
[1] In the case of Sweden, permanent grazing is not included. In Sweden, 9 per cent of arable land receives EU grants for ecological production, while only 4.3 per cent (1999) has been approved by KRAV.
Sources: Norway: Debio 1999, Denmark: Miljø- og energikontoret, Statistics Denmark, Sweden: KRAV Ekonomisk Förening, Finland: Agricultural Economics Research Institute.

Table 3.3. **Holdings and areas farmed ecologically and in the process of conversion. By county. 1999**

County	No. of holdings	Ecologically farmed area Decares	Area in the process of conversion Decares	Percentage of total agricultural area
Whole country	1 707	149 510	37 988	1.83
Østfold	54	4 783	1 492	0.82
Akershus and Oslo	110	13 056	2 523	1.95
Hedmark	162	18 280	3 351	2.03
Oppland	186	15 722	5 056	2.04
Buskerud	133	9 636	2 729	2.41
Vestfold	72	7 373	1 634	2.10
Telemark	69	5 722	2 194	3.12
Aust-Agder	39	2 439	468	2.46
Vest-Agder	41	4 645	494	2.60
Rogaland	44	5 036	566	0.58
Hordaland	100	6 156	1 411	1.65
Sogn og Fjordane	172	11 967	5 101	3.62
Møre og Romsdal	83	6 314	1 778	1.32
Sør-Trøndelag	128	14 174	2 714	2.23
Nord-Trøndelag	99	9 941	1 875	1.34
Nordland	99	8 830	3 244	2.10
Troms	43	4 957	1 359	2.34
Finnmark	6	479	239	0.69

Source: Debio (1999).

4. Forest



Most people in Norway associate forest with a diversity of resources. The direct benefits to people derive mainly from the forest as a source of timber and as an area for outdoor recreation. In this chapter we will focus on timber resources and activities connected with primary production.

The growing stock in Norway has increased considerably over a period of many years because the quantity of roundwood cut has been lower than the natural increment. One of the results of this accumulation of forest capital has been the uptake of large quantities of the greenhouse gas CO_2.

In the past two years, a slight improvement has been registered in the vitality of Norwegian forests expressed as the percentage of abnormally low crown density (leaf or needle mass). Other countries in the south and east of Europe are still registering a noticeable decline in the state of health of their forests.

4.1. The economic importance and development of forestry

Internationally

Forestry in Norway competes directly on the world market and is thus affected by international trade cycles. The demand for forest products increased throughout 1999 in Europe and North America (UN/ ECE 1999a). The level of building activity in North America is still high and there is a similar trend in Europe. This has led to an increase in the consumption of sawn timber and boards. It is anticipated that the moderate growth in the consumption of forest products will continue in 2000.

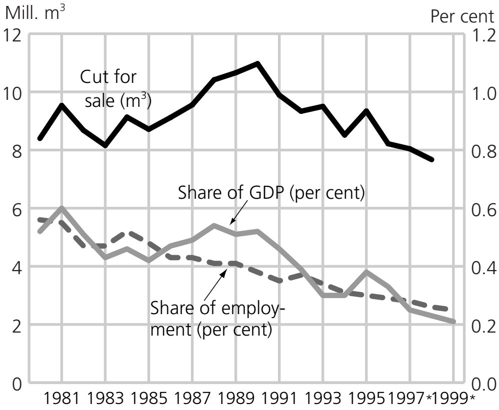
The internationalization of trade in timber, pulp and paper leads in time to larger and more multinational forestry groups. This means, among other things, an increase in long-distance transport of raw materials and products, and pressure on local prices and sales of timber.

The supply of timber in the EU is expected to increase in the wake of the forest clearance after the storm damage in, for example France and Germany, at the beginning of the year. It is not yet clear how much this will affect Norwegian forestry in 2000.

Nationally

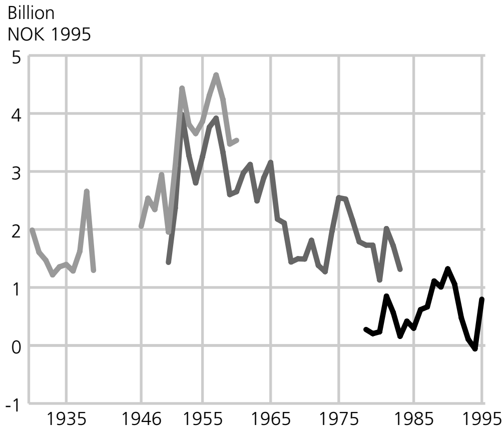
In 1999, labour input in forestry was 4 800 full-time equivalent persons, or 0.25 per cent of total employment (figure 4.1). According to the national accounts, forestry's share of total employment was more than halved from 1980 to 1999.

Figure 4.1. **Forestry: share of employment and GDP. Annual roundwood cut**



Source: National Accounts and Forestry statistics from Statistics Norway.

Figure 4.2. **Resource rent for forestry[1]**



[1] 1930-1960 figures are from the National Accounts' old national standard, 1961-1977 are based on UN (1968) and 1978-1995 are based on European Commission et al. (1993). Source: Lindholt (2000a).

The gross value of the roundwood cut for sale and industrial production in 1998 was NOK 2.6 billion. Forestry's share of Norway's GDP dropped from 0.57 per cent in 1980 to 0.21 per cent in 1999.

The resource rent is a measure of the value added by resource utilization after compensation for input factors goods, work and capital. New estimates show that the resource rent for primary forestry started to rise in the early 1930s and peaked at about NOK 4.5 billion in the 1950s (Lindholt 2000a). From 1960 until 1995 there was a clear trend towards a falling resource rent in primary forestry. Between 1980 and 1995, the resource rent for primary forestry varied between NOK 0 and 1.3 billion (figure 4.2). See also section 11.1.

The increase in the price of timber just after World War II and the subsequent Korean War, combined with reasonably priced input factors, was an important reason for the relatively high resource rent in the 1950s. The fall in the resource rent after 1960 can be explained by the fact that mechanization of forestry and the consequent marked reduction in the number of employees in the industry did not fully compensate for the increase in the costs of the input factors. Timber prices have also shown a weak trend as a result of changes in market conditions for sawn timber and for the pulp and paper industries.

4.2. Resources and harvesting

The main economic importance of forest lies in the raw materials it supplies for the sawmilling and pulp and paper industries. The forest and its biological diversity also have considerable intrinsic value as ecological resources and as a recreation area for a population that is becoming increasingly urbanized. More and more importance is now being given to multi-use considerations in forest industry.

Forest areas and biological diversity

Norway's varied climate, quaternary geology and topography make for a wide range of vegetation and conditions of growth for forest. According to the National Forest Inventory, productive forest, excluding forest in the county of Finnmark, covers 23 per cent of the mainland. Forest occurs in all Norwegian counties and this gives a variety of vegetation ranging from temperate deciduous in the south, similar to the vegetation in Central Europe, to high arctic in the far north and in the mountain areas.

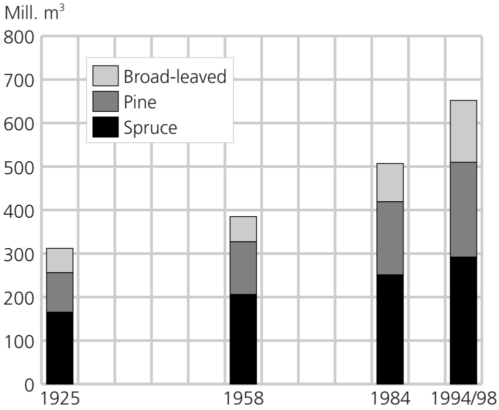
It has been estimated that 22 000 plant and animal species are associated with forest in Norway, and that about 900 of these are rare or endangered (Directorate for Nature Management 1997). Norway has ratified the Convention on Biological Diversity, which was adopted by the UN Conference on Environment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

At the end of 1997 a total of 1 995 km² of forest was protected. Included in this figure is 449 km² of productive coniferous forest or about 0.84 per cent of the total productive coniferous area. According to current plans for the protection of coniferous forest, a total of 1.06 per cent is to be protected. This does not include forest areas which, for rounding off reasons, have been included in new national parks (Report No. 17 (1998-99) to the Storting).

Areas and ownership structure

There is about 75 000 km² of productive forested area in Norway (excepting Finnmark) (Norwegian Institute For Land Inventory 1999). According to the Agricultural Census for 1989, there were a total of 125 000 forest properties. Individuals own 79 per cent of the forested area, and more than half of the forest properties, which represented 49.3 per cent of productive forest area in 1989, are managed in combination with agricultural operations.

Figure 4.3. **Volume of the growing stock without bark**



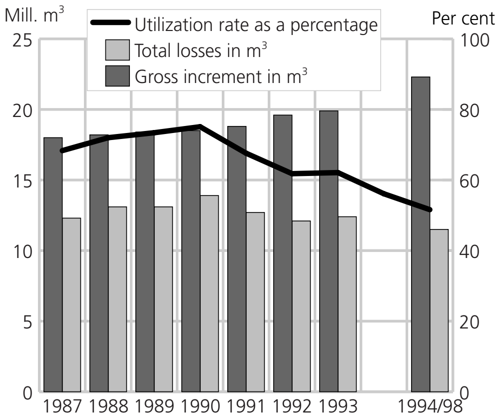
Sources: Material from Statistics Norway and National Forest Inventory.

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 4.3).

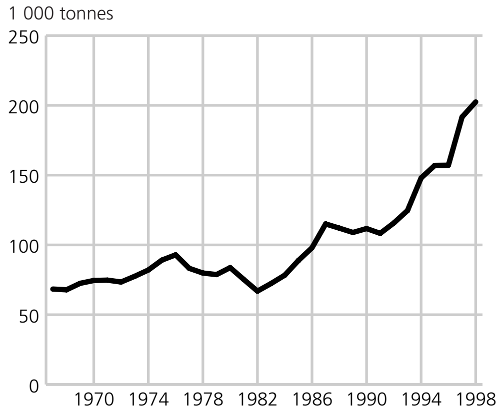
Annual figures for the volume of the growing stock, the forest balance, show the calculated figures for the growing stock at the beginning and end of the year. Data from inventories carried out by the Norwegian Institute for Land Inventory show that the total volume of the growing stock, without bark, below the coniferous forest line averaged 649 mil-

Figure 4.4. **Gross increment, total losses and utilization rate of the growing stock**



Source: Forestry statistics from Statistics Norway.

Figure 4.5. **The pulp and paper industry's purchases of Norwegian waste paper and cardboard**



Source: Federation of Norwegian Process Industries (2000).

lion m³ in the period 1994-1998. In addition to this, Finnmark is estimated to have about 3 million m³ of forest.

In 1997, the net increment (annual increment minus roundwood cut and calculated natural losses) in the growing stock was 10.8 million m³, or 1.6 per cent of the total volume (Appendix, tables C1 and C2). The estimated net increment was somewhat lower for deciduous trees than for spruce and pine.

A positive net increment means that the biomass of forests is increasing. The increase in the net biomass of forests including roots, bark etc. has given an uptake of CO_2 corresponding in recent years to about 40 per cent of Norway's anthropogenic CO_2 emissions.

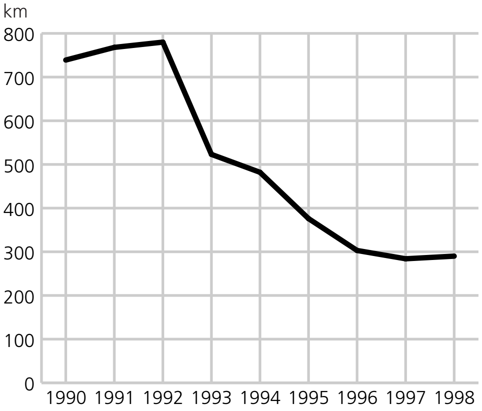
Roundwood cut

Preliminary figures for 1998 show that the total volume of the roundwood cut for sale and industrial production, excluding fuelwood for sale and industrial production, was 7.67 million m³ (Statistics Norway 2000a). This was made up of 4.1 million m³ special timber and sawlogs and 3.6 million m³ mixed sawlog/pulp and pulpwood. 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 averaged 51.6 per cent for the period 1994-1998 (figure 4.4).

Material recovery of wood fibre from paper and cardboard

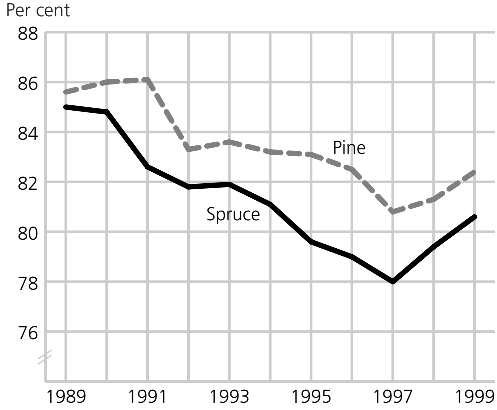
Annual purchases of Norwegian waste paper and cardboard by the pulp and paper industry have risen steadily from 68 400 tonnes in 1967 to 202 429 tonnes in 1998 (Federation of Norwegian Process Industries 2000), see figure 4.5. If the weight of waste paper and cardboard in tonnes is converted to cubic metres of timber, the quantity of waste paper and cardboard purchased in 1998 is found to correspond to about 738 000 m³ timber, or 9.6 per cent of the roundwood cut for sales and production in the same year.

Figure 4.6. **Annual construction of new forest roads**[1]



[1] Whole-year roads for lorries.
Source: Forestry statistics from Statistics Norway.

Figure 4.7. **Mean crown density of spruce and pine**



Source: Norwegian Institute for Land Inventory.

Silviculture

In 1997, total expenditure on planting, afforestation, weed clearance, juvenile spacing and drainage was NOK 249.9 million, thus continuing the trend of low investments in silvicultural measures, as this has been registered for a number of years (Statistics Norway 2000b).

Forest roads

For many years, the construction of forest roads has been an important contributory 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.) The rate of construction of forest roads per year has been more than halved from 1990 to 1998 (figure 4.6). In 1998, investments in forest roads totalled NOK 178 million (Statistics Norway 1999j). See also chapter 1 on indicators for biological diversity.

4.3. Forest damage

The causes of forest damage are many and often complex. Unfavourable climate and weather conditions, insect and fungal attacks, forest fires and air pollution are important factors for the health of forests.

Forest damage in Norway

Results from the Norwegian monitoring programme for forest damage (Norwegian Institute for Land Inventory 2000) 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 has since risen by 2.6 percentage points to 80.6 per cent in 1999 (figure 4.7). The measurements also show that the mean crown density for pine, which was 82.4 per cent in 1999, has shown a positive trend in recent years, with a rise of 1.6 percentage points since 1997. There are regional differences in the state of health of the forest.

Forest damage in Europe

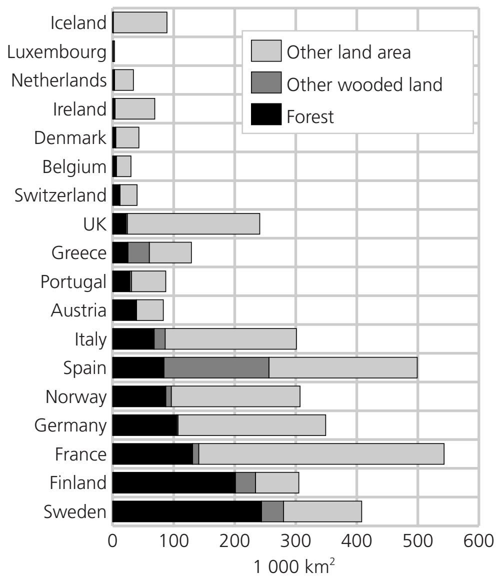
About 1.3 million km² or 36 per cent of the total area of the EU countries is forested. Sweden and Finland have most forest (see figure 4.8). Forestry and forest industries employ 2.2 million persons in this area.

All of the EU countries, Norway and the rest of Europe have been registering forest damage for some decades. European countries have been working together since 1985 to monitor the effects of air pollution on forests. In 1998, 31 countries took part in the programme. A total of 5 700 test areas in a systematic network measuring 16 x 16 km were surveyed (UN/ECE-EC 1999b). The main conclusions from these surveys for 1998 were as follows:

- The most common species of trees in Europe showed a general deterioration of crown density. With a few exceptions, this trend is most obvious in deciduous species such as beech, species of oak and maritime pine.
- Widespread soil acidification has been registered in the forests.
- Serious acidification of the soil was found, with few exceptions, in Czechia, Slovakia, south Poland and Belaruss. This region shows both the greatest air pollution and the greatest damage to trees expressed in reduced crown density.

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

Figure 4.8. **Forest area and total land area in EU and EFTA countries. 1990**



Source: UN-ECE/FAO (1995).

5. 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. In 1999, they accounted for about 16 per cent of exports of traditional goods from Norway. In 1997, Norway was the largest exporter of fish in the world. 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 in recent years. The spawning stock of Norwegian spring-spawning herring has now reached the same high level as in the 1950s, and the catches of herring in recent years have therefore been large. There has been a decline in the North-East Arctic cod stock in recent years, and the spawning stock has now reached the lowest level since 1989.

5.1. Principal economic figures for the fisheries

GDP and employment

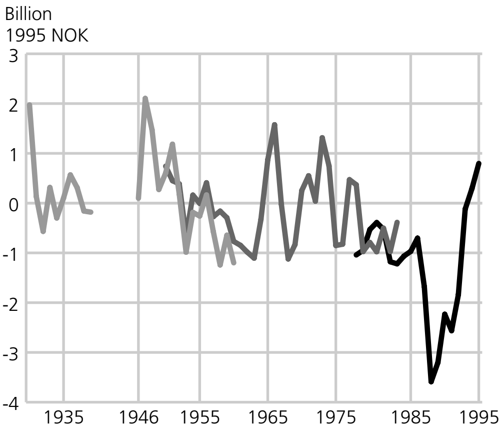
According to the national accounts, fishing, sealing, whaling and fish farming contributed NOK 9.0 billion to Norway's gross domestic product (GDP) in 1999. This is 0.8 per cent of GDP. The share of total employment was 0.9 per cent. At the end of 1999, 21 300 fishermen were registered in Norway, and fishing was the main occupation of 72 per cent of these.

The resource rent of fisheries, sealing, whaling and fish farming

The resource rent is the part of income from fisheries (including sealing, whaling and fish farming) that is not used to cover current costs of the input of work and capital. When subsidies are deducted from income, the resulting figure is what is earned by labour and capital in the industry. The resource rent can be regarded as an extra income over and above what would normally be earned by an ordinary enterprise exposed to competition. The calculation of the estimated resource rent was based on 7 per cent return on invested capital. A more detailed description of the resource rent of fisheries and other industries based on natural resources can be found in section 11.1.

Between 1930 and 1995, the resource rent fluctuated between positive and negative figures ranging from +NOK 2 to -NOK 3.5 billion (figure 5.1), thus illus-

Figure 5.1. **Resource rent[1] for fisheries**



[1] 1930-1960 figures are based on the National Accounts' old national standard, 1961-1977 are based on UN (1968), and 1978-1995 are based on European Commission et al. (1993).
Source: Lindholt (2000a).

trating the fact that income was only high enough in certain periods to cover operating expenses and wages and give a normal return on the invested capital.

Employment fell by 75 per cent during this period, from 66 000 full-time equivalent persons in 1930 to 17 300 in 1995, but has remained relatively stable for the past twenty years. Since real wages rose during the period, the total cost of labour as an input factor still rose from about NOK 2 billion in the 1930s to about NOK 4 billion in the 1990s. Payment for real capital as an input factor also rose during the same period because the volume of capital rose. The increase has been most noticeable during the past 10-20 years. Subsidies rose from under 10 per cent of net product before 1970 to between 15 and 55 per cent in the 1980s, but were substantially reduced in the 1990s.

The income from fisheries is determined by quantity and price and the variations in these factors account for the relatively large annual fluctuations in the resource rent. Bigger catches, a fast-growing fish farming industry and a larger volume of exports were responsible for the steep increase in the resource rent in the 1990s, in addition to the decrease in subsidies.

5.2. Trends in stocks

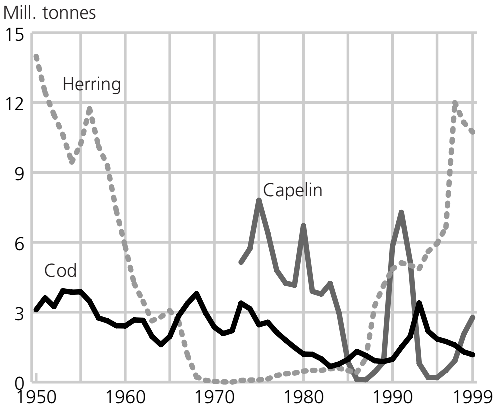
Barents Sea and Norwegian Sea

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 5.2).

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 D1). The spawning stock of Norwegian spring-spawning herring was calculated to be more than 12 million tonnes in 1997. 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. There have been several weak year-classes since 1992 and the anticipated reduction of the spawning stock has now been observed. In 1999 the spawning stock was estimated at just under 11 million tonnes.

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

Figure 5.2. **Trends for stocks of North-East Arctic cod[1], Norwegian spring-spawning herring[2] and Barents Sea capelin[3]**



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

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. This was reduced to 0.6 million tonnes in 1996 as a result of the decrease in the capelin stock, but had risen to 1.1 million tonnes in 1997, which corresponded with the new growth in the capelin stock (Toresen et al. 1998 and 1999). Better recruitment to the capelin stock has resulted in substantial growth from 1997 to 1998 and in 1999, for the first time since winter 1993, a modest experimental catch of capelin (80 000 tonnes) was permitted in the Barents Sea. The stock continues to grow and the total stock was estimated to be 2.8 million tonnes in 1999.

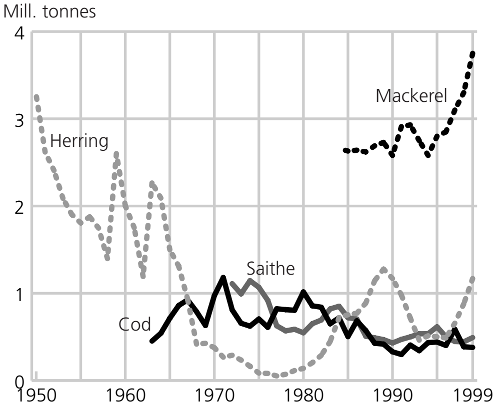
The cod stock was low throughout the 1980s, but rose again in the early 1990s. Since 1993, there has been a steady decrease to the current level of about 1.2 million tonnes. This is a result of a large harvest, in addition to an increase in cannibalism and a reduction in individual growth (Toresen et al. 1998 and 1999). The spawning stock of cod was calculated to be 300 000 tonnes in 1999. Experience has shown that the lowest level of spawning stock to give good recruitment[1] is 500 000 tonnes. To bring the stock up again quickly to this level, the ICES recommended that the total catch in 2000 should in principle not exceed 110 000 tonnes. This would mean drastic cuts in quotas. The recommendation from the Institute of Marine Research, which would result in a somewhat slower build-up of the spawning stock, was 260 000 tonnes. The quota set by the Norwegian-Russian Fisheries Commission was considerably higher than the recommended quota: 390 000 tonnes. There is considerable uncertainty about the future trend in the cod stock. This will depend not only on catches in the fisheries, but also on the interaction between the key species, herring, capelin and cod in the ecosystem in the Barents Sea and abiotic conditions such as the degree of inflow of warmer water from the Atlantic Ocean.

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 5.3 and Appendix, table D1). One reason for this is that recruitment to the

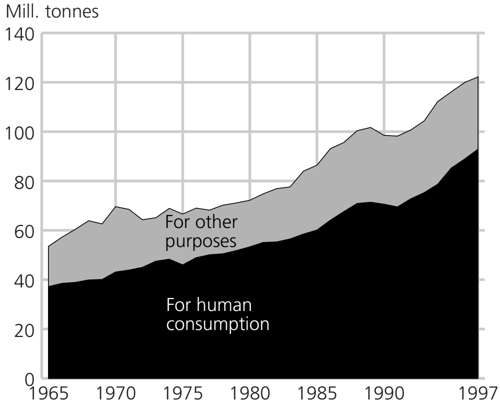
[1] The minimum biologically acceptable level (MBAL) is the minimum size of the spawning stock which has proved to result in satisfactory recruitment.

Figure 5.3. **Trends for stocks of cod[1] and saithe[1,2] in the North Sea, North Sea herring[3] and mackerel[3,4]**



[1] Fish aged one year and over. [2] Includes saithe west of Scotland. [3] Spawning stock. [4] Southern, western and North Sea mackerel.
Sources: International Council for the Exploration of the Sea (ICES) and Institute of Marine Research.

Figure 5.4. **World fish production[1] by main uses**



[1] The production data do not include marine mammals (seals, whales, etc.) or plants. Fish farming is included.
Source: FAO.

stock was generally poor, partly because of the large annual harvest of juvenile herring. The fishing pressure on adult herring was also high. 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 and the spawning stock in 1999 is calculated to be more than 1 million tonnes (figure 5.3). Stocks of demersal fish in the North Sea (cod and saithe are shown in figure 5.3) remained low throughout the 1990s.

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 strict regulation of the fisheries that was introduced in 1996 and 1997 appears to have had an effect, and resulted in a rise in the spawning stock (Toresen et al. 1999). The total spawning stock is now estimated to be well over 3.0 million tonnes. The largest component of the stock is found off Ireland. The North Sea component is about 3 per cent and the component that spawns in southern waters is between 15 and 20 per cent.

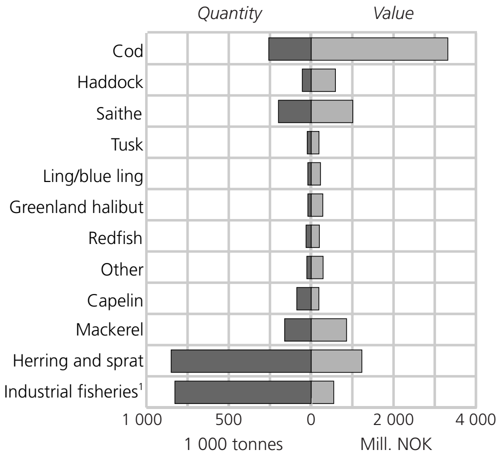
Mackerel can make lengthy migrations in a short space of time. There is therefore some exchange of individuals between all three components of the stock, and catches of all three are taken on Norwegian fishing grounds.

5.3. Fisheries

World catches

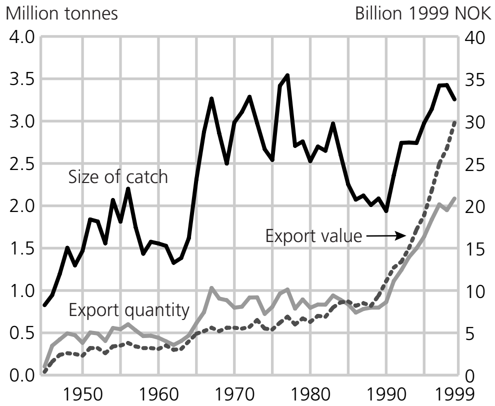
Production in the world's fisheries, including both fresh-water and marine catches and production in the fish farming industry, has increased substantially from slightly more than 50 million tonnes in 1965 to about 122 million tonnes in 1997 (figure 5.4). More than 70 per cent

Figure 5.5. **Norwegian catches by groups of fish species. 1999**



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

Figure 5.6. **Catches, weight of products exported and export value[1,2]**



[1] Fish farming included. [2] Deflated by the price index for foreign trade (1999=100).
Sources: Statistics Norway and Directorate of Fisheries.

of total production is from marine areas. World aquaculture production rose by about 8 per cent from 1996 to 1997, while the rise for fresh-water fisheries was 3-4 per cent. Marine fisheries showed a slight decline. However, catches have been higher in several areas, such as the north-western Pacific, where almost 30 per cent of all marine catches are taken, and in the north-eastern Atlantic. In the Mediterranean and Black Seas, catches dropped by about 5 per cent and in the south-eastern Pacific by about 15 per cent (FAO 1999a and b).

Norway's fisheries rank as number 10 in the world (excluding farmed production), with a total catch of 2.9 million tonnes in 1997. The countries at the head of the list are China (15.7 million tonnes), Peru (7.9 million tonnes), Japan (5.9 million tonnes), Chile (5.8 million tonnes), and the USA (5.0 million tonnes) (see Appendix, tables D7 and D8).

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 1997, the proportion was 76 per cent for the world as a whole and 66 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 1999 was 2.8 million tonnes, and the value of the catch was nearly NOK 10 billion. The total catch was about 200 000 tonnes less than in 1998 and the value about NOK 500 million lower. The catch of herring fell only slightly in 1999 compared with the previous year, but its value fell by about NOK 260 million to NOK 1.2 billion. The catch of cod was about 65 000 tonnes lower than in 1998, and its value also showed a slight decline to NOK 3.32 billion. After cod and herring, saithe has the greatest catch value. This was just over NOK 1 billion in 1999. First-hand values and catches in 1999 are shown in figure 5.5 (see also Appendix, table D2). Figure 5.6 shows trends in catches in Norwegian fisheries, weight of products exported and the export value of fish and fish products.

5.4. Fish farming

Production of farmed fish

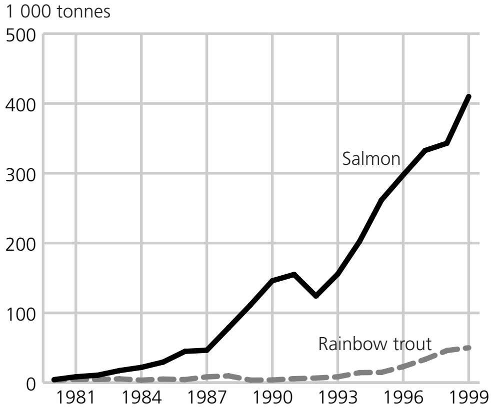
The production of farmed fish has risen steeply since the industry was established at the beginning of the 1970s. The slaughtered quantity of farmed salmon rose from 343 000 tonnes in 1998 to as much as 410 000 tonnes in 1999 (figure 5.7). More than 80 per cent of the farmed salmon is exported. The production of rainbow trout has also risen slightly and was about 50 000 tonnes in 1999. The value of the fish farming industry surpassed the value of traditional fisheries in 1998 and in 1999 stood at NOK 11 billion compared with NOK 10 billion for traditional fisheries (Statistics Norway 2000). However, the quantity of salmon and trout produced in 1999 only corresponded to 16 per cent of total catches.

The health of farmed salmon

Serious diseases affecting farmed salmon are:

- Furunculosis, caused by the bacterium *Aeromonas salmonicida* (diagnosed at three fish farms in 1999);
- Bacterial kidney disease (BKD), caused by the bacterium *Renibacterium salmoninarum* (diagnosed at five fish farms in 1999);
- Vibriosis and cold-water vibriosis, caused by the bacteria *Vibrio anguillarum* and *Vibrio salmonicida* (diagnosed at four and two fish farms respectively in 1999);
- Infectious salmon anaemia (ISA), a virus disease (diagnosed at eight fish farms in 1999);
- Infectious pancreatic necrosis (IPN), a virus disease (diagnosed at 138 fish farms in 1999).

Figure 5.7. **Fish farming. Slaughtered quantities of salmon and rainbow trout**

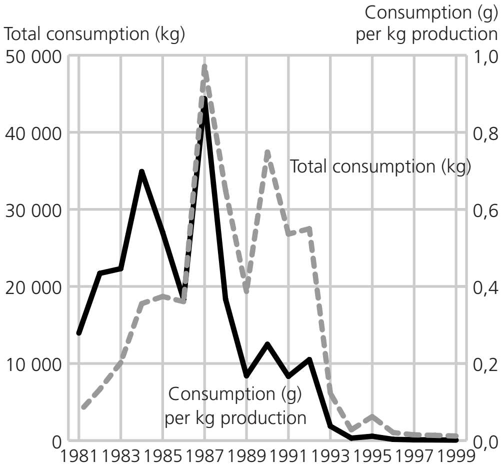


Sources: Statistics Norway, Directorate of Fisheries and Kontali AS.

The figures for the incidence of these diseases in 1999 are preliminary figures from the National Veterinary Institute and the Norwegian Animal Health Authority.

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 opera-

Figur 5.8. **Use of medicines (antibacterial agents) in fish farming**



Sources: Norwegian Medicinal Depot and Statistics Norway.

tion of fish farms are probably the main reasons for this. The consumption of antibacterial agents was highest in 1987, when it reached 49 tonnes (see figure 5.8 and Appendix, table D3). 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 1999, consumption fell to 591 kg, corresponding to 0.001 g per kg fish produced (figure 5.8). 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 which lives in salt water and falls off the salmon after a short period in fresh water) is still the most important cause of losses in the salmon farming industry. Annual losses can be as high as NOK 500 million (Kristiansen et al. 1999). The parasite is controlled by chemical means using delousing preparations (e.g. hydrogen peroxide) or biologically, using wrasses (goldsinny, corkwing, 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.

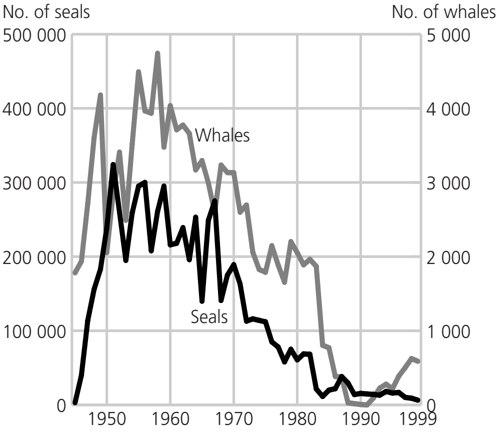
According to fisheries statistics (Statistics Norway 1999), the food fish processing plants suffered a shortfall in 1997 due to disease affecting 4.5 million fish (salmon). The total shortfall was 17.5 million fish and the other loss factors were escapees (0.5 million) and other reasons (12.5 million).

5.5. Sealing and whaling

Norwegian sealing has essentially been based on two species, harp seals and hooded seals, and has taken place in the Newfoundland area (until 1983), the West Ice (off Jan Mayen) and the East Ice (drift ice areas at the entrance to the White Sea). The most recent estimates for stocks of harp seals are 380 000 year-old and older animals in the West Ice and just over 1.9 million in the East Ice. The stock of hooded seals in the West Ice is about 110 000 (year-old and older) (Toresen et al. 1999).

Since the early 1980s, catches of seals have been small, varying between 10 000 and 40 000 animals per season (figure 5.9). According to preliminary figures for 1999, the total catch was 6 399 animals (mostly hooded seals). Since 1983, Norwegian sealing has taken place only in the West Ice and the East Ice. The catch in the West Ice includes both hooded seals (4 446) and harp seals (803), whereas in the East Ice it consists entirely of harp seals (1 150).

Figure 5.9. **Norwegian catches of seals and small whales**[1]



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

Until the early 1980s, the annual value of the seal catch was between NOK 10 and 40 million (current prices). In 1999, the value was about NOK 1.6 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 1999 season, only two trips were made to the sealing grounds in the West Ice and one to the East Ice.

Norwegian catches of small whales have consisted mainly of minke whales. The traditional commercial hunt was discontinued after the 1987 season, but was resumed in 1993, when 226 whales were taken. In 1999, 589 minke whales of a total quota of 753 animals were caught. The quota for 2000 is 655 animals. 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*.

The value of the small whale catch in 1999 was about NOK 24 million.

After the sighting survey carried out by the Institute of Marine Research in 1995, the *North East Atlantic* minke whale stock (which includes animals on the whaling grounds in the North Sea, along the Norwegian coast, in the Barents Sea and off Svalbard) was calculated to be 112 000 animals (Toresen et al. 1999).

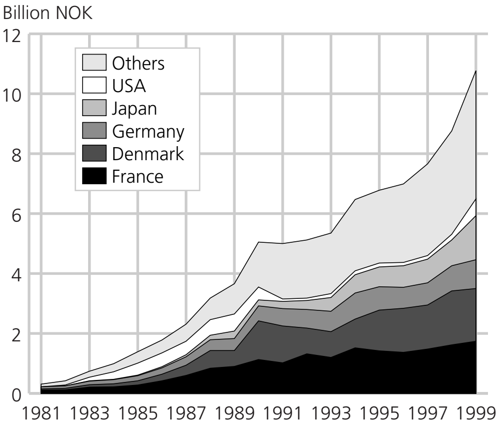
The present size of the *Central Atlantic* minke whale stock (Central Atlantic, Iceland, Jan Mayen) is estimated to be 72 130 whales (Toresen et al. 1999). This component has previously been estimated at 28 000 whales.

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 3.4 million tonnes, 2.1 million tonnes of which consists of fish (Toresen et al. 1999).

5.6. Exports

Preliminary figures show that in 1999 exports of fish and fish products were about 2.1 million tonnes, with a value of NOK 29.8 billion (figure 5.6 and Appendix, tables D4 and D5). Exports to EU countries accounted for 61 per cent of the total. Salmon exports totalled NOK 10.8

Figure 5.10. **Export value of salmon[1] by main purchasing countries**



[1] Mainly farmed salmon, but other salmon is also included.
Source: External Trade statistics from Statistics Norway.

billion in 1999 (figure 5.10 and Appendix, table D6). This corresponds to 36 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 dropped sharply after 1990, partly because of the high import duty imposed on whole fresh salmon, but rose again sharply from 1998 to 1999, particularly exports of filleted salmon. This was partly due to the failure of the supply from Chile to the American market. Exports to Japan continue to grow steeply, bringing Japan almost up to the level of Denmark and France as a purchasing country.

In all, the export value of fish and fish products accounted for 16.4 per cent of exports of traditional goods from Norway in 1999 (i.e. exports excluding crude oil, natural gas, ships and oil platforms) and 8.5 per cent of total exports of goods.

According to the FAO, Norway topped the list in 1997 of the world's largest fish exporters, ahead of China, the USA, Denmark and Thailand. The value of Norway's fish exports corresponded to about 7 per cent of the value of total world fish exports (Appendix, table D7).

5.7. Fisheries management

Regulation of fisheries

According to the FAO, 44 per cent of the marine stocks, for which stock information is available, are fully exploited and catches of these stocks are already so large that there is little room for increase. About 16 per cent of stocks are overfished and catches are in imminent danger of reduction due the decline in the stocks. Furthermore, it is estimated that 6 per cent of the fish stocks are exhausted, giving absolutely no yield, and that 3 per cent show a slight improvement (FAO 1999c). It is therefore of the utmost importance that catches are regulated in the best possible way.

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), 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 5.11 shows quotas and catches of North-East Arctic cod from 1978 onwards. Norwegian catches were substantially higher than the quotas for

Table 5.1. **Quotas of some important fish stocks in 1999 and 2000. 1 000 tonnes**

Stocks	1999 TAC	1999 Norwegian quota	2000 TAC	2000 Norwegian quota
North-East Arctic cod[1]	480	196.5	390	153.4
North-East Arctic haddock[2]	78	41	62	33.4
Norwegian spring-spawning herring	1300	741	1250	712.5
Barents Sea capelin[3]	80	48	435	261
Saithe north of 62° N	145	137.5	125	118.5
Saithe south of 62° N	110	52.2	85	40
Mackerel	484.615	151.75	560	169.95
North Sea herring[4]	265	76.85	265	76.85
North Sea cod[5]	132.4	12.51	81	13.77
North Sea haddock[5]	88.55	14.87	73	16.79

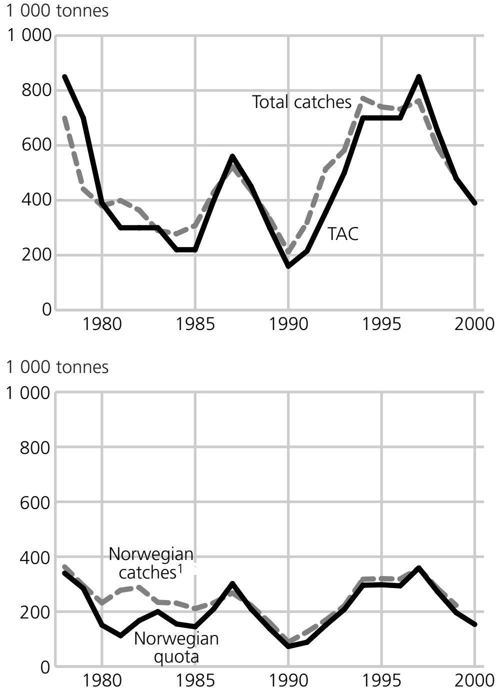
[1] Not including coastal cod. [2]Not including coastal haddock.
[3] Winter fishery. [4] Caught for human consumption in the North Sea. [5] Norway's quota in the agreement with the EU: quotas may subsequently be exchanged with other countries.
Source: Ministry of Fisheries.

much of the 1980s. Since then, the differences have been smaller. Table 5.1 shows quotas for some important fish stocks in 1999 and 2000.

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 reports *Havets ressurser 1998* and *1999* (Toresen et al. 1998 and 1999).

Further information may be obtained from: Frode Brunvoll.

Figure 5.11. **Quotas and catches of North-East Arctic cod**



[1] Including part of Russian quota caught by Norwegian vessels.
Sources: Ministry of Fisheries and Institute of Marine Research.

6. Transport

Transport has a major impact on the environment. A substantial proportion of air pollution is generated by combustion emissions from various modes of transport, and the Surveys of Living Conditions show that road traffic is the most common 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. Developing the transport sector can mean disturbing the natural landscape to such an extent that developments cover an entire area of land. Acute discharges of environmentally hazardous chemicals also occur in the transport sector. The volume of transport continues to rise. Since 1946, passenger transport in Norway has risen between twelve- and thirteen-fold and goods transport six-fold. In 1998, Norwegians travelled an average distance of nearly 38 km a day each.

6.1. Introduction

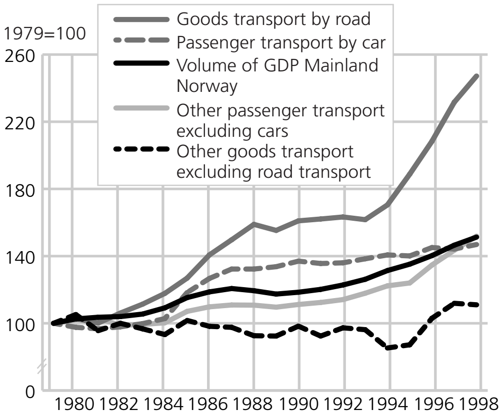
Road traffic is the most common cause of perceived exposure to pollution and noise (Statistics Norway 1998). Many towns and urban settlements were built without any thought for the noise problems that might arise. Aircraft, railways and ports also produce noise that can affect people's health and quality of life, but to a lesser extent than road traffic. The transport sector is also an important source of air pollution in that the combustion of fuel produces harmful emissions. Car tyres pollute by releasing plasticizing oils and by churning up harmful particulate matter from the road surface (especially studded tyres) (Norwegian National Rail Administration et al. 1999). In 1998 emissions to air from mobile sources accounted for 37.5 per cent of the total CO_2 emissions and 74.7 per cent of the total NO_x emissions.

Today's transport supply and demand is a result of a number of changes in the economy, in the labour market, in demographic factors, settlement, technology and infrastructure. To what extent it is possible to influence the volume of transport and the distribution between the various modes of transport must therefore be seen in the light of all these factors. Achieving results requires a holistic approach to the formulation of environmental policy. There are for example many different types of environmental problems facing the transport sector and this sector is only one of several that contribute to the increase in pollution (Ministry of Transport and Communications 1998).

Domestic transport work[1] continues to increase as it has done for the last few decades. From 1980 up to the end of 1998, passenger transport in passenger-

[1] Does not include transport to and from other countries.

Figure 6.1. **Growth in GDP for mainland Norway and volume of domestic goods and passenger transport**



Sources: National accounts and Transport and communication statistics from Statistics Norway.

kilometres has increased by 50 per cent. Goods transport in tonne-kilometres has increased by 48 per cent in volume, and if oil and gas transport from the North Sea is included, by no less than 180 per cent. Passenger transport by passenger car, goods transport by road and transport from the North Sea to the Norwegian mainland have contributed most to this development.

Among the transport industries[2], 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 4.4 per cent of GDP in mainland Norway in 1999 (preliminary figures). Figure 6.1 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 total number of passenger kilometres has increased by 8.8 per cent from 1995 to 1998. Passenger cars, which account for around 75 per cent of the number of passenger-kilometres, only increased by a little more than 4 per cent. In the same period, total goods transport (in tonne-kilometres) increased by 29 per cent, and of this total goods transport by road increased by 31 per cent. GDP for mainland Norway increased by 11.9 per cent in this period. GDP has therefore risen slightly more than passenger transport, but considerably less than goods transport by road. The Ministry of Transport and Communications expects slower growth in passenger transport than in GDP on mainland Norway in the period 1995-2010. The growth in goods transport by road, on the other hand, is expected to be roughly equal to the growth in GDP in the same period[3] (Report No. 36 (1996-97) to the Storting).

6.2. The environmental perspective in the transport sector

Land use, transport systems and the volume of transport are closely related. These factors influence each other and have a strong impact on a number of environmental factors. Transport activities can result in disturbances in the natural landscape when areas are built on and surrounding recreational areas and areas of natural habitat are affected. More roads may lead to increased traffic and new activities in previously undisturbed areas of natural habitat. This increase in traffic may damage the natural environment (Report No. 37 (1996-1997) to the Storting). According to the environmental programme of action for the transport

[2] Excluding transport on own account, which accounts for a significant proportion of the total transport work.
[3] A new prognosis for domestic passenger and goods transport up to 2020 will be available in April 2000.

sector (Ministry of Transport and Communications 1998), roads and road traffic have the greatest impact on biological diversity. Even though much greater effort is now made to minimize damage to the environment than was the case a few years ago, there are still some road development projects in progress or in the planning stages that will disturb important natural habitats.

In addition to disturbing the natural environment, noise from vehicles is a major environmental problem affecting many people. Noise from road traffic can be perceived as disturbing in different ways. There may be a high overall level of noise, isolated peaks of noise or a marked difference between background and noise peaks. Noise from road traffic comes from various sources. Noise from the propulsion unit is generated by the engine, fan and gear-box. Additional noise is produced by the tyres, the road and the airflow. Heavy vehicles (lorries and buses) produce most noise. Kolbenstvedt et al. (1996) have calculated that heavy vehicles usually produce 5-10 dBA more noise than passenger cars. This means that even though heavy vehicles account for on average 10 per cent of road traffic, their contribution to the noise level is as great as that of passenger cars. According to the Ministry of Transport and Communications (1998), about 260 000 individuals are highly annoyed by road traffic noise in their residential environment. It is assumed that this figure has remained relatively constant for a long time, but that there has been some reduction recently as a result of noise screens and insulation of the outer walls of buildings along national roads.

Transport also generates air pollution and emissions to water and into the ground. CO_2 emissions from transport activities have risen over the last few years due to an increase in the volume of transport. However, the transport sector has nonetheless accounted for a smaller proportion of total CO_2 emissions over the last few years. In 1998 emissions from all mobile sources accounted for 37.5 per cent of the total emissions.

Emissions from road traffic also have a considerable impact on air quality in Norwegian towns. In addition to NO_x and particulate matter in exhaust emissions, a considerable amount of particulate matter from the road surface is swept up into the air by road traffic. A reduction in the use of studded tyres and a greater number of cars fitted with catalytic converters will help to reduce pollution in the future (for further detail see chapter 7, section 7.8).

An overview of fuel consumption and emissions to air from road traffic in the period 1973-1998 is given in Appendix, table E3. Appendix, table E4 presents specific fuel consumption figures and emission coefficients for different types of vehicles.

Various measures are being implemented to reduce environmental damage from transport. One of the aims of the Norwegian Public Roads Administration is to ensure that new projects will help to minimize negative environmental impact by adapting developments to the local environment and focusing on good design. This is particularly challenging in towns and urban settlements and in valuable and vulnerable landscapes outside built-up areas. Another aim is to implement noise reduction measures without diminishing the aesthetic and cultural assets of the local environment.

After negotiations with the EU, the European car industry has taken on a commitment to reduce CO_2 emissions from passenger cars, preferably by 2005, but no later than by 2010. The agreed reduction will give a petrol consumption of about 0.05 litres/kilometre. This measure will slow down the rise in CO_2 emissions from cars in this period, but will not stop it (Norwegian National Rail Administration et al. 1999).

In order to protect the health of the urban population and their environment, the Government has, in addition to the regulations pursuant to the Pollution Control Act, adopted national targets for air pollution concentrations. To achieve these targets, measures are being implemented to increase the number of cars with non-studded tyres and more environmentally sound modes of transport, and to reduce the volume of traffic. Additional measures such as reduced speeds and more road-sweeping will have a positive impact on air quality. Furthermore, the Government has proposed road pricing in the largest urban areas. To the extent this reduces traffic queues, it will also result in lower levels of air pollution.

These proposals are based on the assumption that 80 per cent of all tyres will be non-studded by 2002. According to Report No. 8 (1999-2000) to the Storting, calculations from the National Public Roads Administration show that in several of these urban areas the use of studded tyres will not have decreased to 20 per cent by 2002. There has nonetheless been a marked decrease in the percentage of passenger cars on the road with studded tyres over the last few years, and there has been a considerable reduction in emissions of particulate matter from road traffic as a result.

The environment is not only affected by road traffic. Of the total CO_2 emissions from mobile sources in 1998, road traffic accounted for 58 per cent, air traffic for 7.6 per cent, while the figure for ships and boats was 28 per cent. Air traffic also produces substantial emissions of other greenhouse gases. Technological advances have in most areas resulted in a considerable reduction in emissions per passenger-kilometre. However, technological improvements and a more efficient traffic regulation system would not be able to prevent emissions of greenhouse gases from increasing because the growth in air traffic would cancel out this effect (Norwegian National Rail Administration et al. 1999).

6.3. Transport networks and vehicles

By 31 December 1998, the total length of public roads in Norway was 90 741 km, or 280 metres of road per km^2 of land area in Norway (excluding Svalbard and Jan Mayen). There are substantial variations between counties; in Oslo, for example, total road length per km^2 is 2 833 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 taken up by roads in urban settlements in Norway was 308 km^2 in 1998, accounting for 15 per cent of the area of urban settlements (see also chapter 10). In addition to public roads, Norway has about 100 000 km of forest roads that can be used all year round, tractor tracks and roads for winter use only.

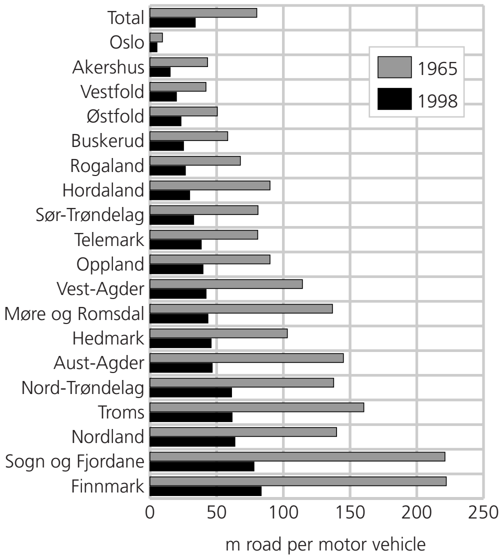
The number of metres of public road per vehicle dropped steeply from 1930 and up to the mid-1980s (table 6.1), so that car density today is far higher than it was

Table 6.1. **Length of public roads**

	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
1998	90 741	34	280

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

Figure 6.2. **Metres of road per motor vehicle by county**



Source: Directorate of Public Roads.

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. There has been little change in car density over the last ten years. By the end of 1998, there was an average of 34 metres of public road available per motor vehicle. Car density is highest in Oslo, where only 5.3 metres public road is available per car registered in Oslo, while in Finnmark the figure is over 83 metres (figure 6.2). As of 31 December 1999, there were a total of 2.72 million registered motor vehicles, of which 1.81 million were passenger cars, which is an increase of 2 and 1.5 per cent respectively on the previous year. In the course of 1999, close to 184 000[4] motor vehicles were registered for the first time, including 124 000 passenger cars. In the course of 1998 over 80 000[5] passenger and goods vehicles were scrapped under the refund payment scheme. At the end of 1998, the average age of the stock of Norwegian passenger cars was 9.9 years. The average age was lowest in Oslo, 8.3 years, and highest in the county of Oppland at 11.3 years. In 1970, the average age of the stock of passenger 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 1998, the total length of cycleways and footways along national roads was 2 800 km, an increase of about 1 000 km since 1990. Hordaland county built most foot-

[4] Both new and second-hand imported vehicles.
[5] Passenger cars (excluding ambulances) and goods vehicles with a total weight of less than 3.5 tonnes.

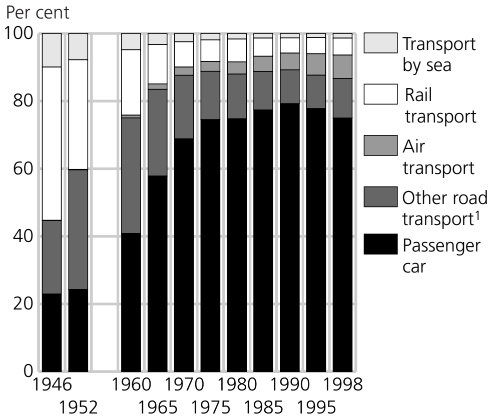
ways and cycleways along national roads in 1998, accounting for 11 km of the total increase of 64 km.

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.

6.4. 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 passenger cars were lifted in October 1960, and from 1960 to 1975 the proportion of total passenger transport work carried out by passenger cars rose from 40 to 75 per cent (figure 6.3 and Appendix, table E1). This proportion has changed very little since 1975. Passenger cars are the dominant mode of transport today, especially for short and medium-length journeys. The domestic transport work accounted for by passenger cars in 1998 was calculated at 46 billion passenger-kilometres, an increase of almost 1.9 per cent on the year before. Another important trend over the last few years is the considerable increase in air transport. While in 1970 air transport accounted for only a modest 2 per cent of domestic transport work measured in passenger-kilometres, this figure had risen to 6.9 per cent in 1998, almost equalling the percentage for transport by scheduled bus. The figure for rail transport was bypassed in 1988. Nonetheless, air transport only accounted for 9.3 per cent of the number of passenger-kilometres accounted for by cars. Since the average plane journey is a good 430 km, air transport work, measured by the number of passengers transported, is

Figure 6.3. **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.

moderate. In 1998 10 million passenger journeys were made by air, equivalent to 0.25 per cent of the total number of passengers on domestic journeys in 1998.

Railways, including suburban railways and urban tramways, accounted for over 3 billion passenger-kilometres in 1998, and, of this, 469 million passenger-kilometres were on suburban railways and urban tramways. The share of the total transport work carried out by railways was just over 5 per cent in 1998. Measured in passenger-kilometres, passenger transport by rail increased by as much as 14.3 per cent from 1995 to 1998. Due to a relatively steep increase in the total number of passenger-kilometres in the period 1995 to 1998 (8.8 per cent), the share of total transport work carried out by railways only increased by 0.2 percentage points to just over 5 per cent.

Table 6.2. **Number of passenger-km per inhabitant per day**

	Total	Passenger 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	34.80	27.58	3.49	1.72	1.57	0.45
1995	35.28	27.44	3.49	2.24	1.68	0.43
1996	36.75	28.27	3.81	2.46	1.74	0.46
1997	36.92	27.95	4.15	2.51	1.83	0.49
1998	37.75	28.30	4.42	2.62	1.89	0.51

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

Although passenger transport by sea may be common in some regions, the total volume is relatively limited. In 1998, 45 million passengers were carried on domestic routes, or 1.1 per cent of all transported passengers. Car ferry services accounted for 82 per cent of total number of passengers transported by sea.

The transport work of scheduled motor bus transport has remained almost unchanged since 1970, with just over 4.2 billion passenger-kilometres in 1998. The share of the total transport work declined from 14.4 to 7 per cent in the same period.

Norwegians travelled an average of 37.8 km per day each in 1998, more than a nine-fold rise since 1946 (table 6.2). The number of passenger kilometres travelled per capita per day by boat and train has varied during this period. We travelled by train almost as much in 1952 as we did in 1998. The other modes of transport have generally shown steady growth.

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 passenger cars. Families with children in particular give priority to car use. In 1997, 87 per cent of all married couples with children owned passenger cars, as compared with 78 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 passenger 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 1980-1995 (Monsrud 1999) 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 by passenger car. Statistics Norway's holiday survey (Statistics Norway 1999i) showed that cars were the most important mode of transport in half of all the holiday trips taken in 1998, while planes were used in 34 per cent. The remaining 16 per cent of the total number of holiday trips were divided fairly equally between rail, bus and boat/ferry. However, the percentage of holiday trips by car has declined in recent years, to 61 per cent in 1993. On the other hand, there was a sharp rise in the share of holiday trips by plane in the period 1993-1998, from 21 to 34 per cent of the total number of holiday trips. 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, passenger cars accounted for 70 per cent of holiday trips in 1998.

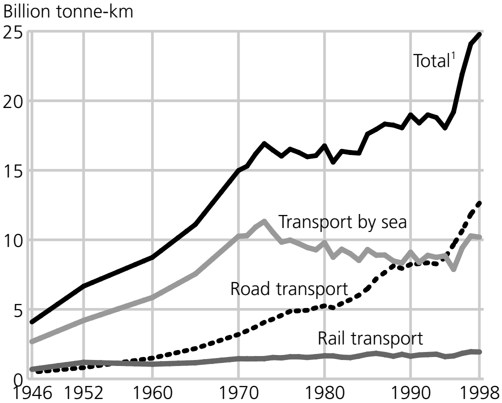
The Government's Long-term Programme for 1998-2001 (Report No. 4 (1996-97) to the Storting) presents projections of traffic trends up to 2010, drawn up by the Institute of Transport Economics. While the average rate of growth in transport work by passenger car and public transport in the period 1980-1995 was 2.2 and 1.3 per cent respectively, average annual growth is expected to drop to 1.3 for passenger 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 of slower growth in the number of people holding driving licences are based on a slower increase in the number of cars and slower growth of the labour force. The number of people holding driving licences increased by 1.2 per cent from 1995 to 1996, but dropped by 0.6 per cent from 1997 to 1998. The total stock of cars decreased by 0.6 per cent from 1995 to 1996, but rose by 7.8 per cent from 1996 to 1998.

6.5. Goods transport

In 1946, domestic goods transport work totalled 4.1 billion tonne-kilometres. By 1998, this figure had risen to 24.8 billion tonne-kilometres, excluding oil and gas transport from the North Sea (figure 6.4 and Appendix, table E2). Measured in absolute figures, the transport work accounted for by railways has remained relatively stable since 1946, while with the exception of the period 1988-1993, road transport work has risen steadily. In the last few years, transport from the North Sea to mainland Norway has shown a steep upward trend (cf. figure 6.5).

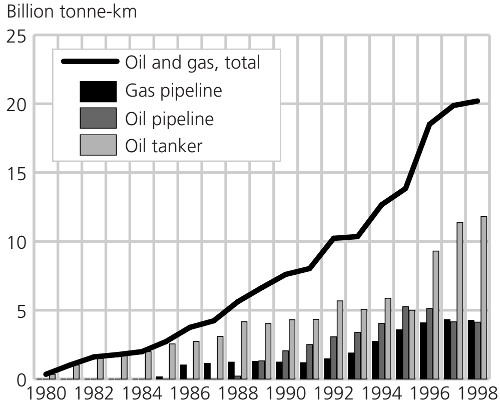
At the end of the 1950s, goods transport by rail and by road totalled about 1 billion tonne-kilometres each. In 1998,

Figure 6.4. **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 6.5. **Oil and gas transport from Norwegian continental shelf to mainland**



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

transport by rail had increased to 1.9 billion tonne-kilometres, while transport by lorries able to carry 1.0 tonne or more had increased to 12.6 billion tonne-kilometres.

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 1998, this figure had dropped to 41 per cent.

Goods transport by air is moderate and has not increased over the last few years. Total transport work was the same in 1998 as in 1985, 19 million tonne-kilometres.

Goods transport by road has shown steady growth since 1946. In 1994, road transport outstripped sea transport (excluding oil transport by ship from the North Sea) for the first time, and in 1998, goods transport by road accounted for over 51 per cent of total domestic transport work. In 1960, the corresponding figure was 17 per cent. In 1998, a total of 265 million tonnes of goods were transported by road. This was 80.5 per cent of total domestic tonnage transported in mainland Norway.

A society's transport service needs will change with economic growth and development. Studies carried out by Solheim (1997) show that the lorry is by far the dominant mode of transport even for distances of 30 to 150 kilometres, despite the fact that for half of these goods there were parallel rail or shipping routes. There is only any real competition in long-distance transport (over 400 km), but even here lorries have a more than 50 per cent share of the transport of general cargo. Transport by sea comes into its own in particular 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 goods transport by lorry is on the increase.

Even though the share of domestic transport by ship is on the decline, shipping is the dominant mode in international goods traffic. In 1998, 71.7 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, 177 million tonnes were transported, of which 85 million tonnes were carried by Norwegian ships. Goods imported and exported by lorry (Norwegian and foreign) accounted for 3.1 per cent, or 7.7 million tonnes.

In the Government's Long-term Programme for 1998-2001 (Report No. 4 (1996-1997) to the Storting), 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 of growth for sea/rail at 2.0 per cent. One of the reasons given to explain this is the introduction of a CO_2 tax in addition to existing taxes. Goods transport is expected to grow at a rate level with the growth in GDP. From 1995 to 1996, there was a 6.1 per cent growth in GDP, while domestic goods transport work increased by 9 per cent.

Oil transport from the North Sea to mainland Norway has grown dramatically, as shown in figure 6.5, and by 1998 it had almost equalled the transport work of all the other modes of transport together. In 1998, oil and gas transport totalled 20.2 billion tonne-kilometres and of this 11.8 billion was by ship, more than twice as much as in 1995. The remaining oil and gas transport is by pipeline, and goods transport of this kind has declined by 5 per cent in the same period.

Documentation, transport in general: Statistics Norway (1999h).

More information may be obtained from: Jan Monsrud and Ketil Flugsrud (emissions to air).

7. Emissions to air

Emissions of pollutants to air can cause a number of environmental problems, such as injury to health, climate change and depletion of the ozone layer. Rising concentrations of greenhouse gases disturb the energy balance of the earth, and may in the long term lead to major climate change. Carbon dioxide (CO_2) is the greenhouse gas with the greatest overall impact on the earth's energy balance. According to the Kyoto Protocol, Norway's greenhouse gas emissions may rise by no more than 1 per cent from 1990 to the period 2008-2012. However, Norway's emissions have risen by more than 9 per cent from 1990 to 1999, according to preliminary figures. This is mainly because of large increases in emissions of CO_2 and methane. From 1998 to 1999, emissions of CO_2 rose by 1.4 per cent, but there was little change in methane emissions.

In December 1999, a new international protocol on long-range transboundary air pollution in Europe was signed. It applies to emissions that cause acidification, eutrophication and the formation of ground-level ozone, i.e. sulphur dioxide (SO_2), nitrogen oxides (NO_x), ammonia (NH_3) and volatile organic compounds (NMVOCs). The greatest challenge Norway will face in meeting its commitments is to reduce emissions of NO_x and NMVOCs sufficiently. From 1990 to 1999, emissions of these gases rose by 4 and 14 per cent respectively.

7.1. Introduction

Emissions of pollutants to air may have local, regional or global effects. Local effects are seen in limited areas such as towns and urban settlements, 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 the enhanced greenhouse effect. 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 7.1 and 7.2 summarize the adverse effects of various air pollutants.

Sections 7.2 and 7.3 describe greenhouse gas emissions and analyses related to the Kyoto Protocol. Other environmental

Box 7.1. Harmful effects of air pollutants

Component	Important sources[1]	Effects
Ammonia (NH_3)	Agriculture	Contributes to acidification of water and soils.
Ground-level ozone (O_3)	Formed by oxidation of CH_4, CO_2, 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 µg/m^3 (8-hour mean).
Benzene (C_6H_6)	Combustion and evaporation of petrol and diesel, wood-firing	Carcinogenic, toxic effects on acute exposure to high concentrations.
Lead (Pb)	Road traffic, waste incineration, mineral production	Environmentally hazardous. No damage to health at concentrations currently found in air in Norway, but because lead accumulates in living organisms, formerly high emissions still constitute a health hazard.
Non-methane volatile organic compounds (NMVOCs)	Oil and gas activities, road traffic, solvents	May include carcinogenic substances. Contribute to formation of tropospheric ozone.
Hydrofluorocarbons (HFCs)	Cooling fluids	Enhance the greenhouse effect.
Hydrochlorofluorocarbons (HCFCs)	Cooling fluids	Deplete the ozone layer.
Carbon dioxide (CO_2)	Combustion of fossil fuels, changes in land use and deforestation	Enhances the greenhouse effect.
Carbon monoxide (CO)	Combustion (wood-firing, road traffic)	Increases risk of heart problems in people with cardiovascular 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 μg/m^3 (24 hour-mean) and 50 μg/m^3 (six-monthly mean). Contribute to acidification, corrosion and formation of tropospheric ozone.
Perfluorocarbons (PFC; 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 μg/m^3 (PM_{10}) and 20 μg/m^3 ($PM_{2.5}$). The latter is under revision.
Sulphur dioxide (SO_2)	Combustion, metal production	With other components, increases the risk of respiratory disease. Acidifies soil and water and causes corrosion Recommended air quality guidelines from Norwegian Pollution Control Authority: 90 μg/m^3 (24-hour mean) and 40 μg/m^3 (six-monthly mean).
Sulphur hexafluoride (SF_6)	Magnesium production	Enhances the greenhouse effect.

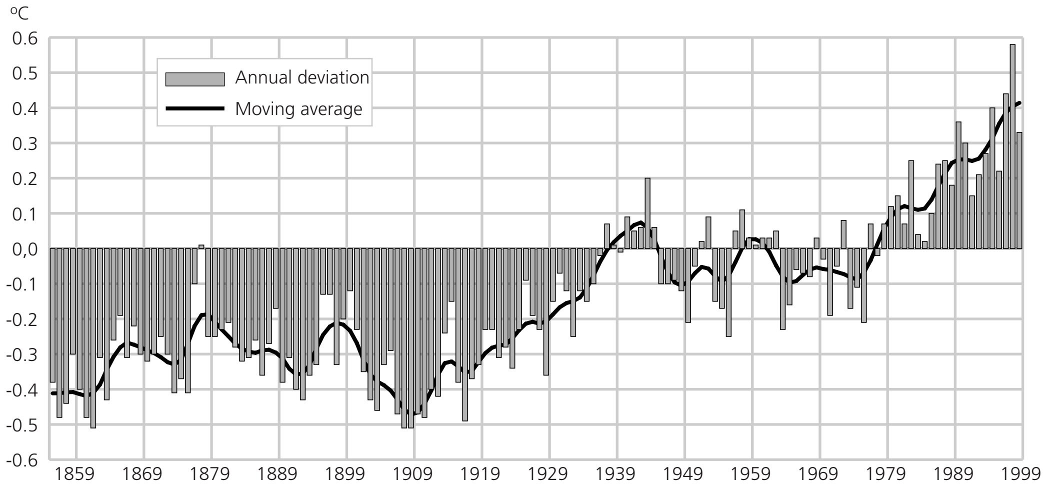
[1] The table indicates important anthropogenic sources. There are also major natural sources for several of these components.
Sources: Norwegian Institute for Air Research (1996b and 1996c), Norwegian Pollution Control Authority (1992 and 1993), IPCC (1996) and Norwegian Institute for Water Research/Norwegian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

Box 7.2. 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. forest, oceans, sediments) or anthropogenic (e.g. buildings, furniture, paper). In 1995, the natural sink in Norwegian forests was estimated to be 13.6 million tonnes CO_2 per year, which corresponds to about one third of total anthropogenic emissions in 1995 (Ministry of the Environment 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 7.1.
Depletion of the ozone layer	The atmospheric ozone layer is found in the stratosphere, 10-40 km above the earth, and prevents harmful ultra-violet (UV) radiation from the sun from reaching the surface of the earth. Episodes when the ozone content of the stratosphere is very low and the levels of UV radiation reaching the earth are high have been observed above Antarctica. Observations have also shown that the ozone content of the stratosphere above middle latitudes dropped by about 3 per cent in the 1980s (UNEP 1993). The causes of ozone depletion include anthropogenic emissions of CFCs, HCFCs, halons and other gases containing chlorine and bromine, all of which can break down ozone in the presence of sunlight. Depletion of the ozone layer increases the amount of UV radiation reaching the earth, and may result in a higher incidence of skin cancer, eye injury and damage to the immune system. In addition, plant growth both on land and in the sea (algae) may be reduced (SSB/SFT/DN 1994). (For imports of ozone-depleting substances to Norway, see figure 7.11.)
Formation of ground-level ozone	Ground-level 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 1998 there were considerably fewer pollution episodes[2] (10 days) than the average for the 10-year period 1988-1997 (21.5 days). The highest hourly mean concentration in 1998 was 140 $\mu g/m^3$ (Norwegian Pollution Control Authority 1999a). 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 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 section 7.4.).

[1] Health problems caused by air pollution are discussed in section 7.8.
[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 (1999a).

Figure 7.1. **Changes in global mean temperature compared with the normal value for 1961-199**



Sources: University of East Anglia and Norwegian Meteorological Institute.

problems caused by air pollution are discussed in sections 7.4-7.7, where the focus is on Norwegian emissions and trends in these emissions. Section 7.8 on local air quality also includes an analysis of the health effects and the costs associated with air pollution in Norway. Section 7.9 looks at how various driving forces and measures influence trends in emissions to air. Finally, 7.10 gives a brief overview of measures introduced by the authorities to reduce Norwegian emissions to air.

7.2. Climate change and greenhouse gas emissions

The chemical composition of the atmosphere determines how much radiation escapes from the earth through the atmosphere. Many of the gases found in the atmosphere absorb radiation, thus tending to raise the temperature at ground level. Without this greenhouse effect, the climate on earth would be much colder, and the global mean temperature would be about – 18 °C instead of + 15 °C, as it is today. Anthropogenic emissions of greenhouse gases have raised their concentrations in the atmosphere. The concentration of CO_2 in the atmosphere was about 280 ppm[1] before the industrial revolution, but has now risen to about 370 ppm (University of California 2000). This can disturb the energy balance and result in climate change on earth.

The three most important greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Emissions of CO_2 are mainly associated with the combustion of fossil fuels, but are also generated by various chemical processes in manufacturing industries. Methane is formed by decomposition of biological waste in landfills and by livestock (agriculture). Manure and the use and produc-

[1] ppm = parts per million, or 1/10 000 per cent.

tion of commercial fertilizers are the main sources of N_2O emissions in Norway.

The Kyoto Protocol sets out binding targets for greenhouse gas emissions from industrial countries. Overall, emissions from these countries are to be reduced by 5.2 per cent compared with the 1990 level by the period 2008-2112. However, Norway's emissions may rise by 1 per cent. In addition to CO_2, CH_4 and N_2O, the Kyoto Protocol applies to sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs). The Kyoto Protocol is discussed in more detail in section 7.3.

Global temperature change

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 7.1). 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 1999, the global mean temperature was 0.33 °C higher than the average for 1961-1990. 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 such a 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.

Box 7.3. 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).

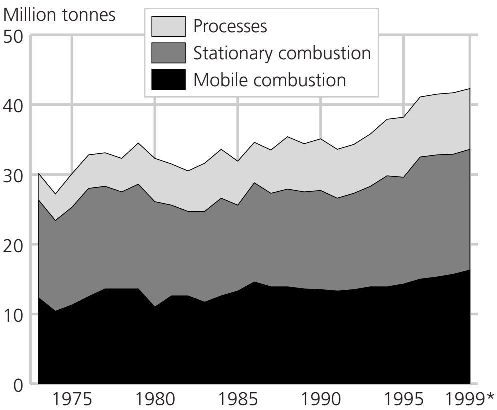
Mobile combustion includes emissions from all combustion of energy commodities in various modes of transport and mobile motorized equipment.

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.

Carbon dioxide (CO_2)

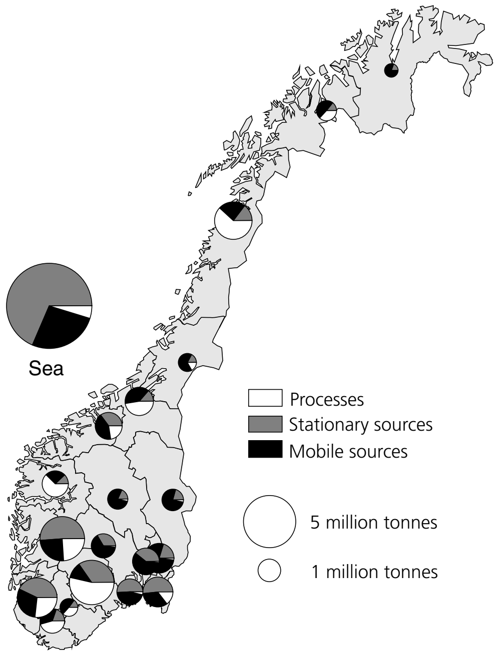
Norwegian emissions of carbon dioxide (CO_2) rose by 1.4 per cent from 1998 to 1999. Preliminary figures for 1999 show that emissions totalled 42.3 million tonnes, as compared with 41.7 million tonnes the year before. This is a rise of 20 per cent from the 1990 level (figure 7.2 and Appendix, table F1). The most important sources of CO_2 emissions in Norway are road traffic (22 per cent), combustion during oil and gas production (20 per cent) and in manufacturing industries (15 per cent), and processes during metal production (14 per cent).

Figure 7.2. **Emissions of CO_2 by source**



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

Figure 7.3. **CO_2 emissions in 1997 by source and county**



Map data: Norwegian Mapping Authority.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

The growth in CO_2 emissions from 1998 to 1999 is mainly explained by a rise of more than 4 per cent in emissions from mobile combustion. The rise is split more or less equally between road traffic, air traffic and shipping. For road traffic, the rise is mainly in emissions from diesel vehicles: emissions from petrol vehicles have dropped somewhat. Total process emissions decreased by 0.4 per cent in this period, mainly as a result of a drop in emissions from the production of chemicals. There was little change in overall combustion emissions from oil and gas extraction. Emissions from flaring rose by more than 10 per cent, but emissions from electricity generation on the continental shelf dropped correspondingly.

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 7.3 and Appendix, table F7). In 1997, Hordaland and Telemark were the counties with the highest CO_2 emissions. 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 production and the petrochemical industry are major sources in Telemark. Emissions from oil refineries are highest in Hordaland.

Projections suggest that Norwegian CO_2 emissions will rise by about 44 per cent from 1990 to 2010 (see NOU 2000:1) if the use of climate policy instruments continues unchanged and the gas-fired power plants at Kårstø and Kollsnes are constructed without facilities for CO_2 removal. If these power plants are not built, a 38 per cent rise in emissions is expected. The most important reason for this substantial rise is that the energy requirements of the petroleum sector and manufacturing are expected to rise steeply. Emissions from the transport sector and from the use of fuel oils are also expected to rise by more than the average for all sectors.

Methane (CH_4)

Methane emissions changed little from 1998 to 1999. Preliminary calculations for 1999 show that emissions totalled about 347 000 tonnes of CH_4, about the same as the year before. Methane emissions from landfills accounts for more than half of total methane emissions in Norway, and the agricultural sector (domestic animals and manure) for about one third.

However, in the period 1990 to 1999, methane emissions rose by about 10 per cent. Some of this is due to an increase in the amount of waste landfilled and a rise in agricultural emissions from growing numbers of livestock. Nevertheless, more than one third of the rise is related to the petroleum industry. Large amounts of methane evaporate when oil is loaded offshore.

Biological degradation of waste generates methane in landfills. Emissions are reduced by flaring and energy recovery of methane from landfills[2]. In 1998, 10 per cent of the methane generated was flared or used for energy recovery.

In 1997, Rogaland and Hordaland were the counties with the highest emissions of CH_4 (Appendix, table F7). This is explained by a combination of high emissions from livestock and from landfills.

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 5 per cent from 1998 to 1999 to a level of 17 000 tonnes. This was a result of higher emissions from the process industry, and also a rise in emissions from petrol vehicles because a higher proportion of the vehicles are now equipped with catalytic converters. When NO_x is converted to N_2, a small proportion of N_2O is also formed.

There is a large degree of uncertainty associated with the overall level of nitrous oxide emissions. This is partly because information on the sources is poor and partly because emissions can vary extremely widely. Emissions from the agricultural sector are largely related to the application of fertilizer and manure.

Emissions are highest in the counties where commercial fertilizer is manufactured (Appendix, table F7). Process emissions from the manufacture of fertilizer in Telemark and Nordland account for more than 30 per cent of the country's total emissions of N_2O.

Other greenhouse gases

Emissions of sulphur hexafluoride (SF_6) were reduced by 71 per cent from 1990 to 1998. Emissions of perfluorocarbons (CF_4 and C_2F_6) have also been substantially reduced in this period. These reductions are mainly a result of wide-ranging measures to reduce emissions from the process industry (magnesium and aluminium production).

[2] The GWP value (see box 7.4) of methane is 21 times higher than that of CO_2. Even though combustion of methane generates CO_2, it results in a net reduction in emissions expressed as CO_2 equivalents.

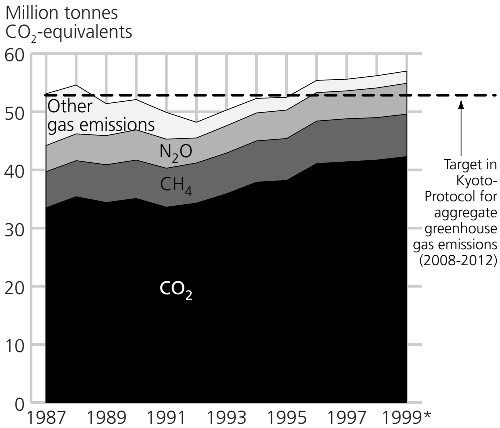
Emissions of hydrofluorocarbons (HFCs) rose from 0.1 to 69 tonnes from 1990 to 1998. These gases only constitute a very small proportion of total greenhouse gas emissions in Norway at present (0.2 per cent in 1998). However, HFC emissions are expected to rise in the next few years, mainly because they will replace chlorofluorocarbons (CFCs) and hydrofluorocarbons (HCFCs) in cooling equipment. Most HFC emissions are generated by leakages from products that are in use.

Aggregate emissions of greenhouse gases to which the Kyoto Protocol applies

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 7.4). In 1999, emissions of greenhouse gases in Norway totalled about 56 million tonnes CO_2 equivalents (see figure 7.4 and Appendix, tables F1 and F3). This corresponds to a rise of 9 per cent since 1990. Emissions rose by 2 per cent from 1998 to 1999.

According to the Kyoto Protocol, Norway's aggregate emissions of greenhouse gases in the period 2008-2012 may be up to 1 per cent higher than the 1990 level. Total emissions were about 8 per cent higher than this in 1998, and projections up to 2010 show that they will rise further (NOU 2000:1) if the use of climate policy instruments continues unchanged. Aggregate emissions of greenhouse gases are expected to be between 64.7 and 66.8 million tonnes in 2010, depending on whether or not the two planned gas-fired power plants are built, i.e. between 25 and 29 per cent higher than in 1990. Most of the rise is caused by higher CO_2

Figure 7.4. **Norwegian emissions of greenhouse gases**



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

emissions; overall emissions of other greenhouse gases are expected to decrease by about 4 per cent. The largest reduction is expected in emissions of PFCs and SF_6, while calculations show a slight rise in emissions of N_2O and CH_4.

Norway has introduced CO_2 taxes on the use of petrol, mineral oil, coal and coke and on emissions from oil and gas extraction on the continental shelf. However, a number of sectors, such as international maritime transport, coastal fisheries and international air transport, are exempt from this. Thus, only about 60 per cent of the total CO_2 emissions are subject to taxes. An alternative to taxing CO_2 emissions is to establish a domestic emissions trading system. The Government also has plans for Norway to make use of the Kyoto mechanisms, which include international emissions trading, in order to meet its emission targets. This is discussed further in section 7.3.

Box 7.4. GWP – Global Warming Potential

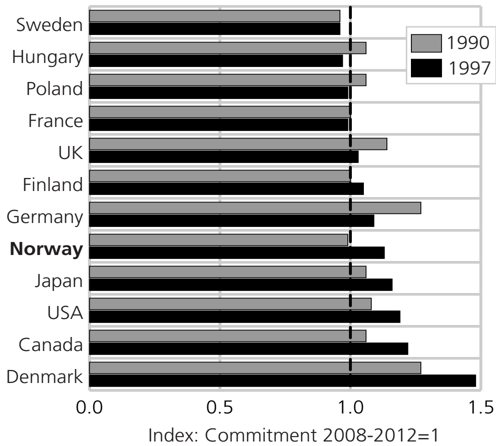
The GWP value of a gas is defined as the cumulative impact on the greenhouse effect of 1 tonne of the gas compared with that of 1 tonne of CO_2 over a specified period of time (usually 100 years). GWP values are used to convert emissions of greenhouse gases to CO_2 equivalents.

Greenhouse gas emissions in other countries

The national emissions inventories that have been reported to the IPCC show that CO_2 emissions in most industrial countries rose between 1990 and 1997. However, this does not apply to countries with transition economies (Russia and Eastern European countries), where there was a marked drop in emissions during the first half of the 1990s. Even though CO_2 emissions from these countries will probably rise again, they are expected to remain below the 1990 level.

Figure 7.5 shows reported emissions of the greenhouse gases CO_2, CH_4 and N_2O in 1990 and 1997 for some selected Annex I countries[3], and the countries' obligations under the Kyoto Protocol. The values in the figure are based on aggregate greenhouse gas emissions of the three gases in CO_2 equivalents converted to index values compared with 1990. In Norway, the USA, Denmark and Finland, there has been a substantial increase in aggregate emissions in the period 1990-1997. However, the USA and Norway were the only countries where there was also a rise in emissions from 1996 to 1997.

Figure 7.5. **Emissions in 1990 and 1997[1] and emission reduction commitments under the Kyoto Protocol[2] for the period 2008-2012**



[1]Hungary has not reported 1997 figures, so figures for 1996 are used here.
[2] Commitments under the Kyoto Protocol apply to 6 gases, but the changes shown here include only CO_2, CH_4 and N_2O.
Sources: UNFCCC (2000) and CICERO (Center for International Climate and Environmental Research).

According to the Kyoto Protocol, overall emissions from the EU states are to be reduced by 8 per cent. However, this overall commitment has been divided among the various countries. As a result, Luxembourg must reduce its emissions by 28 per cent, and Denmark and Germany by 21 per cent. In Sweden, on the other hand, emissions may rise by 4 per cent, and in Greece and Portugal by 25 and 27 per cent respectively. Projections show that overall emissions in the EU may in fact rise by 6 per cent from 1990 to 2010 (EEA 1999). The EU will therefore, like countries such as the USA and Norway, have to make use of the Kyoto mechanisms (see box 7.5), such as emissions trading, to meet its commitments.

[3] These correspond more or less to the member states of the OECD and countries with transition economies (Eastern Europe and Russia).

Box 7.5. 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.

Clean 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).

In the OECD countries, there has overall been a slight rise in CO_2 emissions from energy use in the period 1980-1997 (Appendix, table F9). Emissions of CO_2 per unit GDP and per capita are lower in Norway than the average for all the OECD countries. This is mainly because a large proportion of the energy used in Norway is provided by hydropower. However, average per capita CO_2 emissions for the world as a whole are only about half of the Norwegian level. Globally, electricity production makes the largest contribution to CO_2 emissions (OECD 1999).

7.3. Follow-up and consequences of the Kyoto Protocol

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 seen to be 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 (UN 1987).

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 third Conference of the Parties (COP3), held in Kyoto in Japan from 1 to 12 December 1997, resulted in the Kyoto Protocol.

In Kyoto, the Annex B countries[4] 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 an average of 5.2 per cent by the period 2008-2012. The quantitative commitments in the agreement are differentiated - some countries must reduce

[4] Annex B countries correspond more or less to Annex I countries under the Convention, which are the member states of the OECD and countries with transition economies (Eastern Europe and Russia).

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. Flexibility mechanisms (the Kyoto 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. 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. The Protocol has currently been ratified by 22 countries, but these are mainly small island states, and no countries that have undertaken commitments to reduce emissions have ratified the Protocol as yet.

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 most recent Conference of the Parties (COP5) was held in autumn 1999, and agreed on an intensified work programme for the year ahead. The aim is to adopt supplementary rules for the Kyoto Protocol at the Conference of the Parties in The Hague in November 2000 (COP6). Rules for the three Kyoto mechanisms – i.e. emissions trading, joint implementation and the clean development mechanism – are of central importance here (box 7.5).

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. In addition to measures to reduce domestic emissions (described in section 7.2), Norway is also dependent on being able to make use of the Kyoto mechanisms to fulfil its commitment.

In 1998, Norway appointed a committee to review a domestic quota-based emissions trading system for greenhouse gases, based on the Kyoto Protocol. In December 1999, the committee submitted its report (NOU 2000:1). The committee recommends the establishment of a system that is as broad-based as possible, so that it includes all gases and sources of emissions that are suitable for this type of regulation. Some emissions, such as N_2O and CH_4 from agriculture and combustion, are not considered to be suitable at present. If all sources the committee considers to be suitable are included, the system would apply to almost 90 per cent of Norway's emissions (if the various gases are emitted in the same proportions as in 1997). The committee recommends that the quotas should be allocated in the form of emission certificates that give the holder the right to emit a certain quantity of CO_2 equivalents. Regulation by quotas should in some cases be imposed at producer level, and in others on distributors or importers, or on end users. A majority of the committee recommends that all concerned should pay the full market price for emission quotas, in accordance with the polluter-pays principle. However, one minority recommends that some sectors of industry should be allocated quotas free of charge (grandfathering), whereas another minority considers this to be a political decision that is outside the mandate of the committee.

In addition to emissions trading, use of the clean development mechanism is one way of compensating for domestic emissions. 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.

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 (baseline projections) and on which countries are included in binding goals for emission reductions. The studies also show that the economic costs will be lower if a system of tradable permits is introduced than if each country is required 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 of emissions. Calculations of uncertainty and how uncertainty should be dealt with in the emission inventories are described in the first analysis below, while the second describes a method for verifying the Norwegian emission estimates. Next, four analyses of possible consequences of the Kyoto Protocol are presented. Two of these focus on Norway, and two on the international situation. The first describes possible effects of the introduction of greenhouse gas quotas on employment and CO_2 emissions in energy-intensive manufacturing. The second compares the effects of replacing today's differentiated CO_2 taxes with either a uniform tax or a quota system in which tradable quotas are allocated free of charge (grandfathering). The third analysis reviews the consequences for emissions and energy use of stabilizing the atmospheric concentration of CO_2. Finally, there is an analysis of the economic consequences for Western Europe of complying with the commitments set out in the Kyoto Protocol.

Uncertainties in the Norwegian greenhouse gas emission inventory and their management

The Norwegian emission inventory is based on a number of assumptions and uncertain data, and there are therefore uncertainties associated with the estimates. Accurate estimates of the level of uncertainty are important for users of the emission figures, both nationally and internationally. For example, they are needed when making decisions about which gases and emission sources to include in an emissions trading system, evaluating measures to reduce emissions or determining whether a country has met its agreed targets. Information on uncertainty levels can also be used in systematic efforts to improve the quality of the emission inventory. In this project, we have focused on greenhouse gas emissions that are regulated by the Kyoto Protocol.

The estimated uncertainty in the level of total anthropogenic greenhouse gas emissions in Norway[5] is ± 20 per cent (table 7.1). Emissions of CO_2 have been relatively accurately calculated (uncertainty less than ± 5 per cent), but the level of uncertainty is higher for the other greenhouse gases. It is particularly high for nitrous oxide, where even the order of magnitude

[5] Excluding forests as a sink.

Table 7.1. **Uncertainties in emission levels for each greenhouse gas separately and total GWP-weighted emissions**

	1990		
	Emissions (best estimate)[1]	Fraction of total green-house gas emissions	Uncertainty (per cent deviation from best estimate)
Total	52 mill. tonnes	1	21
CO_2	35 mill. tonnes	0.67	3
CH_4	300 ktonnes	0.12	22
N_2O	18 ktonnes	0.11	200
HFCs	0.13 tonnes	0.00	50
PFCs	390 tonnes	0.05	40
SF_6	95 tonnes	0.04	5
	2010		
	Emissions (best estimate)[2]	Fraction of total green-house gas emissions	Uncertainty (per cent deviation from best estimate)[3]
Total	63 mill. tonnes	1	17
CO_2	48 mill. tonnes	0.76	4
CH_4	286 ktonnes	0.10	20
N_2O	19 ktonnes	0.09	170
HFCs	580 tonnes	0.02	50
PFCs	185 tonnes	0.02	40
SF_6	21 tonnes	0.01	9

[1] The data may differ from emission data presented elsewhere in this report
[2] Projection based on Report No. 29 (1997-98) to the Storting on Norwegian implementation of the Kyoto Protocol. The figures have been modified to take into account later recalculation of the original estimates. The projections do not reflect Statistics Norway's opinion of future trends in emission levels or developments in emissions trading.
[3] The uncertainty in the level in 2010 is calculated as if these were historical data. The uncertainty associated with the projection itself is not taken into account.
Source: Rypdal and Zhang (2000).

of the emissions is often uncertain. Emissions of N_2O from agriculture contribute most to the overall uncertainty in the level of total greenhouse gas emissions, followed by emissions of methane from landfills and PFCs from aluminium production.

The uncertainties in projected emission trends are lower than the uncertainties in levels of emissions. The uncertainty in the

Table 7.2. **Uncertainties in emission trends 1990-2010[1] for each greenhouse gas separately and total GWP-weighted emissions**

	Change (per cent)	Uncertainty (percentage points deviation from change)
Total	21	4
CO_2	36	5
CH_4	-10	16
N_2O	10	13
HFCs	..	..
PFCs	-51	20
SF_6	-77	4

[1] Projection based on Report No. 29 (1997-98) to the Storting on Norwegian implementation of the Kyoto Protocol. The figures have been modified to take into account later recalculation of the original estimates. The projections do not reflect Statistics Norway's opinion of future trends in emission levels or developments in emissions trading.
Source: Rypdal and Zhang (2000).

projected trends from 1990 to 2010 is calculated to be ± 4 percentage points (table 7.2). Uncertainties in emissions of methane from landfills, nitrous oxide from vehicles, CO_2 from domestic shipping and HFCs from the use of products contribute most towards the uncertainty in trends. Emissions from all these sources are either rising or falling rapidly and are expected to do so up to the period 2008-2012.

The uncertainty in emissions trends is higher than the precision of the emission commitments undertaken by countries under the Kyoto Protocol. For example, the EU countries are to reduce their emissions by 8 per cent relative to 1990, and the USA by 7 per cent, while Norway's emissions may rise by up to 1 per cent. The high level of uncertainty also means that it is likely that emission estimates will have to be recalculated, i.e. that as new information becomes available, the estimates for whole time series (including the base year) will be altered. The pro-

Box 7.6. Method of calculating uncertainty in the greenhouse gas emission inventory

The greenhouse gas emission inventory is based on calculated emissions (often calculated using emission factors and activity data) and measurements of some types of emissions from large industrial plants. There are uncertainties associated with all the basic data, in some cases up to orders of magnitude. In order to calculate the total uncertainty, the following were estimated for all the basic data: uncertainty (expressed as two standard deviations), density (a probability distribution), and dependencies with other input parameters. The uncertainty in total emissions and trends was calculated by stochastic simulation. The contribution made by each source to the total uncertainty was calculated both by means of elasticities (derivation) and by simulation (correlation between total emissions and trends and the distribution of each input parameter).

posed rules require countries to recalculate their figures if new information becomes available or errors are revealed. A high level of uncertainty also means that there is a risk that some countries will adjust their estimates within the uncertainty range in order to keep emission trends as low as possible.

A high level of uncertainty in emission levels and trends for certain gases may restrict the ways in which emission estimates can be used. Cost-effective reduction of emissions is more difficult when there is a large degree of uncertainty in the absolute emission level for important sources. It is also difficult to include the most uncertain emission sources in a system of emissions trading. This is because there is a substantial risk that emission estimates will have to be recalculated (which then poses practical problems such as how to deal with the risk of losses on quotas that have already been traded) and also because countries taking part in the trading system may adjust their estimates within the uncertainty range.

The calculations of uncertainty levels apply to Norway. The level of uncertainty in other countries' greenhouse gas emission inventories will depend on which emission sources are dominant and the quality of the emission calculations. However, there is reason to believe that there is a relatively high level of uncertainty in most countries' inventories, and that it will remain high to the end of the period 2008-2012. Knowledge of which emission sources contribute most to uncertainties in emission levels and trends can be used in systematic efforts to reduce uncertainty levels. However, in the short term it will be difficult to reduce uncertainty significantly for some sources, because the processes that generate emissions are complex (e.g. nitrous oxide from agriculture and methane from landfills) and the information needed to improve the estimates is not available.

Because the uncertainty levels of the emission figures are so high, international systems are needed to manage uncertainty. These will also be needed when systems for national and international emissions trading are established. They must include systematic routines for quality control, detailed documentation, and national and international verification of reported data. In 1999, Statistics Norway prepared extensive documentation (Flugsrud et al. 2000) of Norwegian data and carried out verification of the data by comparing our emission figures with those reported by other countries (see next section).

Project financed by: Statistics Norway.

Project documentation: Rypdal and Zhang (2000).

Verification of the Norwegian emission inventory

Individual countries are required to report their greenhouse gas emissions from various sectors and sources in accordance with guidelines laid down by the IPCC. Successful functioning of the Kyoto Protocol and the Kyoto mechanisms is dependent on reliable emission inventories from each country. One method of verifying the data in inventories is to look at how large emissions from individual sources are in relation to selected indicators. In this connection, an indicator means a parameter that is linked to the emissions and therefore varies correspondingly. For example, energy use can be used as an indicator for carbon dioxide emissions. The emission intensity values for different countries, i.e. actual emissions divided by the relevant indicator, can then be compared and provide a way of verifying emission levels without examining detailed inventories.

We have tested this method on the Norwegian emission inventory by comparing Norwegian emissions with corresponding figures for Canada, Sweden and New Zealand. These countries were chosen because they have various features in common with Norway. They have cold winters, scattered patterns of population and there are similarities in industrial structure. We therefore expect the levels of their emissions in relation to selected indicators to be similar to those found in Norway.

We compared emission intensity values for Norway with those for other countries for two reasons. In addition to checking the reliability of the Norwegian data, we wished to find out which indicators are most suitable for use in verification. The indicators we used were activity data that are directly or indirectly related to emissions: for example energy use, population size and GDP. For an indicator to be suitable, the data must be available from a reliable source and they must be relevant, i.e. we must be able to assume that there is close correlation between activity data and emissions. We used data on emissions and the indicators selected for the years 1990 and 1996, so that we could also test how well the indicators explain emission trends.

Table 7.3. **The indicators considered to be most suitable for verification of emissions in each of the main sectors**

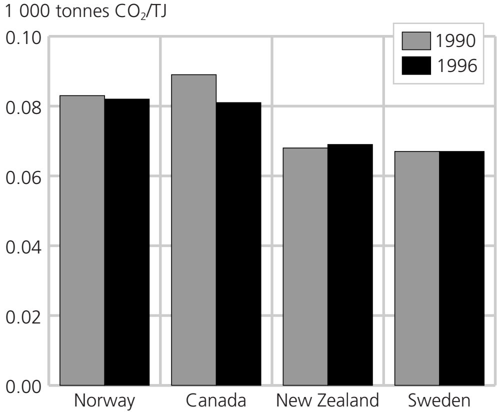
Main sector	Green-house gas	Indicator
Energy	CO_2	Energy use
Industrial processes	CO_2	Production
Agriculture	CH_4	Number of cattle
	N_2O	Agricultural output
Waste	CH_4	Quantity of waste landfilled

Source: Holtskog et al. (2000).

The main sectors used in reporting emissions to the IPCC are energy, industrial processes, solvent use, agriculture and waste. Table 7.3 lists the indicators we found to be most suitable for each of these. However, each sector consists of several sub-sectors, for which other indicators may be more suitable (see Holtskog et al. 2000).

When we used the best indicators for the various sub-sectors, Norway's emission intensity values were in most cases in the same range as the other countries'. In particular, the indicator energy use provides quite reliable verification of CO_2 emissions related to combustion processes (e.g. transport and energy production).

Figure 7.6. **Emissions of CO_2 in relation to energy use in the transport sector**



Source: Holtskog et al. (2000).

Figure 7.6 shows emissions of CO_2 per energy unit used in the transport sector as an example.

However, we had some problems in verifying Norwegian emission figures in the sectors industrial processes, waste and agriculture. For industrial processes, it was only possible to verify Norwegian CO_2 emissions from production of cement and aluminium. Some of the industrial emissions were not possible to verify because the other countries chosen had no corresponding manufacturing industry. In other cases, for example metal production, comparison was difficult because the sector was subdivided differently for the purpose of reporting the indicator (e.g. production figures) than for the purpose of reporting emissions.

The emission intensity values for methane from landfills were found to be higher in Norway than in the other countries. This may be either because Norwegian emissions are in fact higher, or because the emission factors used were too high. In the agricultural sector, the comparison was made using data that were so aggregated that it was difficult to find indicators that covered the various emission sources. There are two possible solutions to this: either to repeat the analysis at a more detailed level or to choose countries that are more like Norway with respect to the types of livestock, production, crop production, etc.

We consider this method to be suitable for evaluation of different countries' emission inventories by a neutral institution. However, differences in emission intensity values do not necessarily mean that there are errors in the calculations: they may also be the result of real differences in emissions or arise because the indicator does not describe the emissions precisely enough. In order to interpret the results, it is therefore necessary to have sufficient information on emission sources in each country. It can be difficult to find countries that are similar enough in all sectors, so that it would be an advantage to compare emission intensity values from more than four countries. Another alternative would be to use different groups of countries to compare different sectors.

No major errors in the Norwegian emission inventory were found during this study, but some minor errors were revealed. These were mainly emissions placed in other reporting categories than they should have been according to the IPCC guidelines. It should be noted that this verification method does not involve any evaluation of whether our emission figures are scientifically correct, i.e. whether they give a correct estimate of actual emissions. However, a comparison of emission intensity values does indicate that the estimation methods we use give reasonable results in relation to the methods used by the other countries.

Project financed by: Norwegian Pollution Control Authority.

Project documentation: Holtskog et al. (2000).

Greenhouse gas emission permits in energy-intensive manufacturing industries

According to the Kyoto Protocol, Norway's greenhouse gas emissions may rise by 1 per cent by the period 2008-2012 compared with the 1990 level. Alternatively, the flexibility mechanisms, i.e. direct or indirect trade in emission permits, may be used to reduce overall emissions internationally. Statistics Norway was asked by the committee appointed to review a domestic quota-based emissions trading system for greenhouse gases (for more information, see page 103) to analyse the consequences of introducing such a system, linked to an international market for emission permits, for emissions from energy-intensive manufacturing and employment in these industries.

Energy-intensive manufacturing includes the pulp and paper industry, metal manufacturing and the manufacture of basic chemicals, and in 1996 accounted for slightly more than 20 per cent of Norway's aggregate emissions of greenhouse gases. This corresponds to almost 12 million tonnes of CO_2 equivalents.

Although these industries generate substantial emissions, they only account for about 1.5 per cent of total employment in Norway. Nevertheless, in many cases an enterprise in one of these branches is a cornerstone of its local community. The closure of such enterprises would only have minor effects on employment for the country viewed as a whole, but the consequences would be dramatic for individual communities. To prevent this, there have been proposals to allocate permits to energy-intensive manufacturing enterprises free of charge (these are known as "grandfathered" permits).

At present, the taxation level for greenhouse gas emissions varies widely, from zero for process emissions to nearly NOK 400 per tonne CO_2 for petrol. According to economic theory, the optimal solution in socio-economic terms is to set equal prices per unit emission for all activities. This can be achieved by using a system of tradable permits or taxes.

In this study, we analysed how changes in the profitability of energy-intensive manufacturing caused by the introduction of emission permits for greenhouse gases would affect emissions and employment. We also analysed the effects of introducing more market-based prices for electricity for these industries. It is very uncertain what the price of greenhouse gas permits will be. In this analysis, we assumed that the international permit price will be NOK 125 per tonne CO_2 equivalent in 2010. This was also the price on which calculations were based in Report No. 29 (1997-98) to the Storting on Norwegian implementation of the Kyoto Protocol. We further assumed that the real price of permits will rise to NOK 200 in 2020 and that the market for permits will then be expanded to include non-Annex I parties. We used a market price of NOK 0.155 per kWh for electricity. We made short- and long-term analyses of four different scenarios:

1. A uniform permit price for CO_2 emissions from all activities.
2. As 1, but industrial enterprises are allocated grandfathered permits for an amount corresponding to 70 per cent

Table 7.4. **Percentage changes in emissions, employment and turnover when charges for greenhouse gas emission permits are introduced. Short-term effects**

Scenario		Sum energy-intensive manufacturing	Pulp and paper	Metal manufacturing	Aluminium	Ferro-alloys	Other metals
1: Permit price NOK 125,- per tonne CO_2	CO_2 emissions	-17	0	-17	0	-35	-22
	Employment	-8	-1	-17	0	-44	-4
	Turnover	-6	-1	-9	0	-39	-3
2: Permit price NOK 125,- per tonne CO_2 incl. grandfathered permits	CO_2 emissions	-2	0	0	0	-10	0
	Employment	-1	-1	0	0	-7	0
	Turnover	-1	-1	0	0	-10	0
3: Permit price NOK 125,- per tonne CO_2 incl. electricity price NOK 0.155 per kWh and switch of fuel in pulp and paper	CO_2 emissions	-19	-9	-19	-6	-35	-22
	Employment	-10	-1	-18	-8	-44	-4
	Turnover	-8	-1	-10	-6	-39	-3
4: Permit price NOK125,- per tonne CO_2 incl. grandfathered permits, electricity price NOK 0.155 per kWh and switch of fuel in pulp and paper	CO_2 emissions	-7	-9	-2	-6	-17	0
	Employment	-4	-1	-1	-8	-19	0
	Turnover	-4	-1	-2	-6	-22	0

Source: Bye et al. (1999b).

of their non-taxed greenhouse gas emissions in 1990.

3. A uniform permit price for CO_2 emissions from all activities and a market price for electricity corresponding to NOK 0.155 per kWh.

4. As 3, but industrial enterprises are allocated grandfathered permits for an amount corresponding to 70 per cent of their non-taxed greenhouse gas emissions in 1990.

Emissions from the pulp and paper industry are related to the use of fossil fuels to run boilers. All enterprises that use boilers can use more than one energy carrier. We therefore assumed that the pulp and paper industry can to some extent switch between fossil fuels and electricity. This type of flexibility is not possible for the process industries, since their emissions are largely related to the use of fossil fuels as direct factor inputs in production.

In the analysis, we assumed that an enterprise will close down if its short-term income does not cover its variable costs. In the long term, we assumed that it must also provide its owners with a reasonable rate of return. The required real rate of return was set at 7 per cent. We assumed that production levels would be unchanged in enterprises that survive, and that the same would apply to emission levels. However, the changeover to electricity would result in a certain decrease in emissions from the pulp and paper industry.

The analysis showed that in the short term, enterprises that generate in all 2 per cent of total emissions were not viable even without charges for emission permits. These enterprises account for 9 per cent of total employment in energy-intensive manufacturing. Excluding this category, table 7.4 shows that after the introduction of charging for emission permits, enterprises that generate 17 per

Table 7.5. **Percentage changes in emissions, employment and turnover when charges for greenhouse gas emission permits are introduced. Long-term effects**

Scenario		Sum energy-intensive manufacturing	Pulp and paper	Metal manufacturing	Aluminium	Ferro-alloys	Other metals
1: Permit price NOK 125,- per tonne CO_2	CO_2 emissions	-15	-18	-16	-6	-29	0
	Employment	-7	-3	-4	-8	-40	-4
	Turnover	-9	-4	-12	-6	-40	-1
2: Permit price NOK 125,- per tonne CO_2 incl. grandfathered permits	CO_2 emissions	-8	-18	-13	0	-13	0
	Employment	-2	-3	-2	0	-11	0
	Turnover	-5	-4	-11	0	-15	0
3: Permit price NOK 125,- per tonne CO_2 incl. electricity price NOK 0.155 per kWh and switch of fuel in pulp and paper	CO_2 emissions	-35	-24	-28	-46	-46	0
	Employment	-20	-3	-12	-51	-47	-4
	Turnover	-21	-4	-19	-40	-51	-1
4: Permit price NOK 125,- per tonne CO_2 incl. grandfathered permits, electricity price NOK 0.155 per kWh and switch of fuel in pulp and paper	CO_2 emissions	-21	-24	-16	-27	-29	0
	Employment	-12	-3	-4	-32	-40	0
	Turnover	-14	-4	-12	-24	-40	0

Source: Bye et al. (1999b).

cent of the remaining emissions would not survive. These enterprises provide 8 per cent of employment in energy-intensive manufacturing.

In the long term, the analysis showed that enterprises that generate in all 19 per cent of total emissions were not viable even without charges for emission permits. These enterprises account for 28 per cent of employment in energy-intensive manufacturing. Excluding this category, table 7.5 shows that after the introduction of charging for emission permits, enterprises that generate 15 per cent of the remaining emissions would not survive. These enterprises account for 7 per cent of employment in energy-intensive manufacturing. If market prices for electricity were introduced in combination with charging for emission permits, the analysis shows that enterprises that generate 34 per cent of total emissions would not survive. They also provide 20 per cent of employment in these industries. The introduction of grandfathered permits would reduce these losses to enterprises that generate 21 per cent of total emissions and provide 12 per cent of employment.

The ferro-alloy industry would be most seriously affected and the aluminium industry least affected by charges for emission permits. However, the long-term effects on the aluminium industry would be dramatically worsened if it had to pay the market price for electricity in addition to paying for emission permits. In this case, it would be as badly affected as the ferro-alloy industry. Without the introduction of charging for emission permits, the branch that would have the greatest problems appears to be the pulp and paper industry. Other metal manufacturing enterprises are expected to have fewest problems.

We also divided the country into six regions to identify the areas that were most seriously affected in these scenarios. The proportion of enterprises with major problems is highest in the Oslofjord region (the counties Akershus, Buskerud, Oslo, Vestfold and Østfold) even without the introduction of charging for permits. This reflects the fact that a large proportion of the pulp and paper industry is concentrated in the region. In the short term, Western Norway (Hordaland and Sogn og Fjordane) and North Norway (Nordland, Troms and Finnmark) would be most seriously affected by the introduction of charging for emission permit. In these regions, enterprises that provide between 20 and 30 per cent of employment in energy-intensive manufacturing are not viable in the sense that they cannot cover their variable costs.

In the long term, charging for emission permits would have the most serious consequences in Southern Norway (Rogaland, Vest-Agder, Aust-Agder and Telemark), closely followed by Western Norway. Many enterprises in Western Norway and North Norway that would suffer in the short term from the introduction of permit prices would find it difficult to remain profitable in the long term even if charging for emission permits was not introduced. In Southern and Western Norway, allocating grandfathered permits would have a significant effect in the long term, whereas only a small effect was found in other regions. Permit prices combined with market-based electricity prices would have a major impact on profitability in energy-intensive manufacturing. This is particularly true in Southern Norway, Central Norway (Møre og Romsdal, Sør-Trøndelag and Nord-Trøndelag) and Western Norway. Central Norway is the only region where the allocation of grandfathered permits would have a significant effect on employment.

If the goal is to keep jobs, the analysis shows that grandfathered permits may be an expensive solution. If total public-sector expenditure on grandfathered quotas is included, the cost per job saved varies from just over NOK 600 000 to NOK 1.2 million for the four scenarios.

Project financed by: Ministry of the Environment.

Project documentation: Bye, Døhl and Larsson (1999a) and (1999b).

CO_2 emissions: grandfathered emission permits or differentiated taxes?

CO_2 tax levels in Norway vary considerably between branches of industry and between energy carriers (see economic measures in section 7.10). In this project, we analysed the economic effects of replacing differentiated tax rates with a flat rate (uniform tax rate) or with grandfathered tradable CO_2 emission permits (i.e. allocating permits free of charge to already existing polluters). In our model, auctioned tradable emission permits give exactly the same consequences as a uniform tax.

The problem was analysed using a general equilibrium model for the Norwegian economy, MSG-6. We compared three different policy regimes.

The *differentiated tax scenario* (alternative 1) is a simulation of the Norwegian CO_2 tax system in 1999. In the *uniform tax scenario* (alternative 2), the CO_2 tax per tonne carbon is the same for all sectors and energy carriers. CO_2 emissions are the same as in alternative 1, and changes in government revenues from carbon taxes are counterbalanced by changes in employers' social security contributions. In the *emission permit scenario* (alternative 3), grandfathered emission permits are allocated to already existing polluters, defined on the basis of each sector's emissions in alternative 1. Total emissions are the same as in alternative 1 in this case as well, and the loss of revenue from CO_2 taxation is compensated for by raising employers' social security contributions.

In alternative 1, different polluters pay different prices for marginal increases in their emissions. This results in a distribution of emissions that is not in itself cost-effective. In a smoothly functioning permit market, all actors pay the same price for their emissions. This suggests that both grandfathered permits and a uniform tax rate will be more efficient than differentiated taxes.

However, interactions with the rest of the economy must also be taken into account. If price mechanisms are used to mitigate an environmental problem, other economic problems may inadvertently be aggravated (or in some cases reduced), and such effects can be difficult to predict in a complex economy. For example, the pre-existing labour taxes make it less attractive to work long hours, suggesting that the overall labour supply is lower than socially optimal at the outset. If consumer goods then become more expensive as a result of higher CO_2 taxation, this will make it even less attractive to work, since the income earned by one hour's work will now buy a smaller amount of consumer goods. This will reinforce the efficiency loss caused by the labour taxes. On the other hand, a rise in government revenue will make it possible

Table 7.6. **Long-term effects of a hypothetical changeover to a uniform CO_2 tax or grandfathered emission permits. Percentage deviation from alternative 1 (differentiated tax rates)**

	Uniform CO_2 tax (alternative 2)	Grandfathered emission permits (alternative 3)
Full consumption	0.03	-0.03
Material consumption	0.02	-0.11
Leisure	0.04	0.10
Employment	-0.05	-0.12
Real capital	-0.10	-0.16
Export surplus	-0.45	-0.38
Wage costs per hour	0.07	0.15
Implicit price of leisure	-0.46	-0.77
Price of material consumption	-0.43	-0.42
Employers' social security contributions	3.15	5.5
Uniform CO_2 tax/ permit price[1]	98.5	96.0

[1] Absolute levels in NOK.
Sources: Bye and Nyborg (1999) and (2000).

to reduce other, distortionary taxes. Grandfathered permits do not produce revenue, and thus give the weakest results as regards this last point.

The results are summarized in table 7.6, which shows percentage deviations from alternative 1 (differentiated tax scenario). The table shows the long-term results, i.e. the situation after the economy has stabilized. The variable "full consumption" is an aggregate of leisure and material consumption (goods and services), and can be interpreted as the model's indicator of utility. In the model, any conflicts of interest between social groups are ignored, so that the utility indicator may be said to express the average person's valuation of consumption and leisure.

A changeover from differentiated taxes to a uniform rate results in a calculated rise of 0.03 per cent in long-term full consumption per year. Instead of looking at the long-term results, we could have summarized utility over the whole time period by discounting. The discounted utility rises by 0.07 per cent. The difference is so small because the differentiated tax rates give higher revenues from the CO_2 tax, so that the employers' social security contributions can be lower. A changeover to grandfathered permits, on the other hand, results in a drop of 0.03 per cent in long-term full consumption per year, corresponding to a reduction in discounted utility of 0.04 per cent. The positive effect of equal marginal costs of emissions in the emission permit scenario is overshadowed by the negative effects of higher employers' social security contributions. Grandfathered CO_2 permits thus also result in lower welfare than a uniform CO_2 tax (which here corresponds to auctioned permits). However, the differences in the estimated welfare effects of the three scenarios are very small.

The results provide little evidence that the cost-effectiveness of the Norwegian CO_2 tax system in 1999 is particularly low. The system results in different marginal costs for emissions from different polluters, but is reasonably efficient as a means of collecting government revenues. There thus appears to be little to be gained by changing to a system where all sectors pay a uniform CO_2 tax. According to our calculations, the use of grandfathered permits would result in lower welfare than the current system, but once again the difference is very small.

Project financed by: Statistics Norway.

Project documentation: Bye and Nyborg (1999) and (2000).

Consequences for emissions and energy use of stabilizing the atmospheric CO_2 concentration

Stabilization of the CO_2 concentration in the atmosphere may be necessary to prevent undesirable climate change. The extent of the measures that must be implemented to stabilize the CO_2 concentration depends not only on the concentration target, but also on the assumptions made about future economic growth, energy demand and supply, etc. This study was based on two baseline scenarios representing different assumptions about the future, and looked at the CO_2 taxes that would be necessary to achieve different concentrations.

We used a long-term model (Petro) for the oil, gas and coal markets, and included various assumptions. For example, producers are assumed to adapt to the optimal extraction rate for the resources over time. On the demand side, we assume that there are opportunities for substitution between the various fossil fuels. Changes in one of the markets thus also have effects in the other markets. Further, we assume the existence of unlimited supplies of a single, carbon-free alternative energy source that serves as a perfect substitute for all fossil fuels. This energy source is assumed to be considerably more expensive than fossil fuels to start with, but its price falls with time as a result of technological development, with the result that extraction of fossil fuels becomes unprofitable in the long run. The results were considered in relation to two reference scenarios, A1 and A2.

- In A1, energy demand rises strongly in the next hundred years, while global CO_2 emissions only rise moderately as a result of relatively rapid technological development relating to the alternative carbon-free energy source.

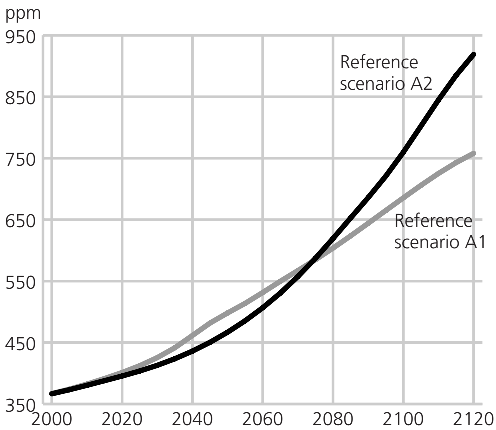
- In A2, energy demand rises moderately, but CO_2 emissions rise strongly in the long term because the alternative energy source remains expensive (slow technological development).

The results show that the most important factor in determining future emissions and thus the policy measures that will be required is the change in the cost of the alternative energy source. If the technology for the alternative energy source develops slowly, high carbon taxes (or other measures) are needed to stabilize the concentration at a particular level. On the other hand, rapid development of technology for the alternative energy source will mean that lower carbon taxes are sufficient to achieve the same concentration level.

For a given concentration target that is to be reached in 2150 by taxing CO_2 emissions, the two reference scenarios generate quite different emission and concentration profiles. If a cheap, carbon-free energy source is expected to be available from the middle of the century, global emissions can be higher to start with than if more pessimistic assumptions are made. The results show that the emission paths based on A1 are higher than the corresponding paths based on A2 until 2090. This is because if the emission path falls towards the end of the century (as in A1), higher emissions can be permitted at the beginning of the period than if the emission path continues to rise (as in A2). This means that the concentration level in 2100 is higher in the mitigation scenarios based on A1 than in those based on A2 if the same long-term concentration target is to be achieved in 2150.

One result common to all the mitigation scenarios is that emission reductions are almost entirely due to a reduction in the

Figure 7.7. **Trends in CO_2 concentration in reference scenarios A1 and A2**



Source: Kverndokk et al. (2000).

use of coal. There are various reasons for this. Firstly, coal has a higher carbon content than oil and gas, so that the price of coal rises more after the introduction of a carbon tax. In addition, the consumer price of coal is lower than that of gas, and the difference between coal and oil is even larger, so that the relative price rise is greater. A third factor is that conventional oil and gas resources are expected to be more or less exhausted during the next hundred years. Most of these resources can be profitably extracted even if the price drops somewhat. Provided that the carbon tax is not too high, there is only a modest reduction in total extraction of these resources in the next hundred years. This means that measures to reduce CO_2 emissions in the long term must include measures directed towards coal. Coal consumption must be reduced more in A2 to reach a given concentration because the alternative energy source is more expensive.

In the model, carbon taxes are first imposed in industrial countries (the Annex B area) for a period of around 30 years. If this results in an international drop in fossil fuel prices, it may increase demand in developing countries. This is particularly true for oil, since trade in gas and coal between the Annex B-area and other countries is limited. Nevertheless, the results show that the problem of carbon leakage to countries outside the Annex B area is limited or non-existent in this initial period. This is because OPEC reduces production when taxes are introduced, so that the price does not fall much. However, the model does not include carbon leakage that may occur if the production of energy-intensive goods becomes more competitive and therefore increases outside the Annex B area.

Another important result is that OPEC and other oil producers will only lose a relatively small proportion of their oil wealth as long as the CO_2 concentration target is not set too low. For producers outside OPEC in particular, oil wealth may in fact rise because oil consumption rises at the expense of coal after the introduction of taxes. We found that for oil producers, carbon taxes are preferable to increased competition from the carbon-free energy source as a means of stabilizing the CO_2 concentration. This is certainly true for the non-OPEC countries. Carbon taxes will reduce oil consumption less than gas and coal consumption, whereas the carbon-free energy source has a stronger effect on oil consumption.

Project financed by: Statistics Norway.

Project documentation: Kverndokk, Lindholt and Rosendahl (2000).

Economic effects in Western Europe of complying with the Kyoto Protocol

According to the Kyoto Protocol, the EU has undertaken to reduce its annual emissions of greenhouse gases in the period 2008-2012 by 8 per cent compared with the 1990 level. Switzerland must reach the same target, whereas Norway's emissions may rise by up to 1 per cent compared with the 1990 level. In a joint project involving several research institutions in Europe, we have studied the economic consequences if the EU states, Norway and Switzerland meet their overall commitments by means of a common market for emission permits in these countries. In a market of this kind, some countries can emit more greenhouse gases than agreed if they pay other countries to reduce their emissions. The extent to which this will be possible is not yet clear, so that the assumptions we have used here may not in fact form the basis for the economic consequences when the Kyoto Protocol is implemented.

The project developed a large-scale macroeconomic model (E3ME) for the EU states, Norway and Switzerland to study these and other issues. The model contains a detailed description of the industrial structure of each country, and focuses on describing energy demand and emissions to air satisfactorily. It describes emissions of 11 components, including the six greenhouse gases to which the Kyoto Protocol applies. In the reference scenario, up to 2015, it is assumed that emissions of all greenhouse gases except CO_2 follow the projections of the IPCC (UN Intergovernmental Panel on Climate Change). These projections are based on measures that individual countries expect to introduce to reduce emissions of these five greenhouse gases in response to the

Kyoto Protocol. The model can then be used to analyse what level of CO_2 tax or CO_2 permit price is necessary to achieve the goals of the Protocol.

In the reference scenario of the model, CO_2 emissions in Western Europe rise by 8.5 per cent from 1990 to the period 2008-2012. At the same time, emissions of the other greenhouse gases drop by 26 per cent, so that total greenhouse gas emissions rise by 1 per cent if no measures to reduce CO_2 emissions are introduced. We found that to reduce total greenhouse gas emissions by 8 per cent, as required by the Kyoto Protocol, CO_2 emissions must be reduced by 2-3 per cent. This means that the permit price necessary to meet the Kyoto Protocol target is much lower than it would be if the percentage reduction required applied to CO_2 only. The average permit price for the five-year period is around NOK 400 per tonne CO_2.

In the analyses, we assumed that revenues from the CO_2 tax or from sales of domestic emission permits will be used to reduce income tax. Introduction of a CO_2 tax to achieve the Kyoto target increases total GDP in Western Europe by 0.8 per cent. This is because a reduction of income tax leads to more use of labour, so that the level of activity rises. Employment rises by 1 per cent. Thus, according to the model, the introduction of CO_2 taxes pays double dividends. If countries instead allocate grandfathered permits to existing enterprises, GDP decreases by 0.3 per cent, and employment remains more or less unchanged.

When CO_2 emissions are reduced, emissions of other pollutants such as NO_x, SO_2 and particulates are automatically reduced as well. This reduces health damage and other adverse effects of air pollution. The E3ME model can be used to calculate emissions of these pollutants and the associated costs. It is therefore possible to calculate the ancillary benefits of using CO_2 taxes to achieve the targets of the Kyoto Protocol in the form of reduced air pollution in Western Europe. These benefits are valued at almost NOK 100 billion (1990 NOK), or 0.13 per cent of total GDP in Western Europe.

Co-financed by: EU.

Project documentation: Ellingsen, Rosendahl and Bruvoll (2000) and Rosendahl (2000a).

7.4. Acidification

Acid rain is caused mainly by emissions of sulphur dioxide (SO_2), nitrogen oxides (NO_x) and ammonia (NH_3). These substances can remain in the atmosphere for several days before being deposited as acid rain or as dry deposition. Nitrogen and sulphur compounds can be dispersed over long distances. Most of the acid rain Norway receives (about 85 per cent) originates from emissions in other countries.

Acid rain has a number of impacts. Acidification of soils results in leaching of nutrients and metals. Acid rain also damages trees directly, causing loss of foliage. In Norway, the most serious impact of acid rain is its effects on fresh-water organisms. Rivers and lakes in Southern Norway and the southern parts of Eastern and Western Norway are most severely affected. In addition to its impact on the flora and fauna, deposition of acidifying substances results in corrosion damage to buildings and cultural monuments.

Deposition of nitrogen compounds also adds nutrients to soils and water, and in excessive amounts this can lead to eutrophication of lakes and coastal waters and alter natural ecosystems. However, in Norway the acidification caused by airborne inputs of these substances is still considered to be more important.

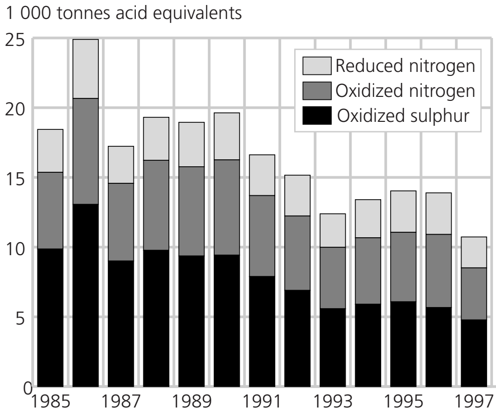
European emissions of SO_2 and NO_x mainly originate from combustion of fossil fuels, for example for industrial purposes, heating and electricity generation. Road transport, shipping and air traffic are also important sources of NO_x emissions. Emissions of ammonia are mainly related to the agricultural sector (livestock production and fertilization).

In 1979, the ECE[6] Convention on Long-range Transboundary Air Pollution (LRTAP) was adopted. The first two protocols under this convention dealt with reductions of sulphur dioxide and nitrogen oxide emissions. Later, protocols have also been developed for other long-range pollution such as volatile organic compounds, heavy metals and persistent organic pollutants (POPs). In December 1999, a new protocol was signed which covers various types of long-range transboundary air pollution. In addition to SO_2, NO_x and NH_3, it also applies to volatile organic compounds (VOCs, see section 7.6). Emission ceilings have been negotiated for individual countries, based on critical loads for acid rain and ground-level ozone.

Deposition of acidifying substances in Norway

Implementation of the LRTAP protocols for SO_2 and NO_x has reduced emissions of acidifying substances in Europe and thus the deposition of such substances in Norway (figure 7.8). Sulphur compounds still make up the largest proportion of deposition in Norway expressed in acid equivalents, but the importance of nitrogen oxides has been rising in recent years. Despite the reduction in total deposition of sulphur and nitrogen compounds, critical loads were still greatly exceeded in 1994 in large parts of the southern half of Norway and in smaller areas elsewhere, for example in eastern parts of Finnmark county (Norwegian Institute for Water Research 2000).

Figure 7.8. **Deposition of acidifying substances in Norway[1]**



[1] Calculations for 1997 were made using a different model and the figures are therefore not directly comparable with those for earlier years.
Source: Norwegian Meteorological Institute.

Sulphur compounds deposited in Norway originate mainly in Russia, the UK and Germany, but SO_2 emissions from international shipping are also an important source of sulphur deposition (table 7.7). The UK is also the source of a large proportion of the oxidized nitrogen that is deposited in Norway. As a result, the UK is the country outside Norway itself that makes the largest total contribution to acid rain here. Reduced nitrogen is not dispersed over such long distances as

[6] Economic Commission for Europe.

Table 7.7. **Contributions of different countries to deposition of acidifying substances in Norway. 1997**

	Total (1000 tonnes acid equivalents)	Oxidized sulphur (1000 tonnes S)	Oxidized nitrogen (1000 tonnes N)	Reduced nitrogen (1000 tonnes N)
Total	10.8	76.4	52.5	31.2
Norway	1.7	4.9	9.5	10.1
Other Nordic countries	1.0	3.7	6.0	5.2
UK	1.6	10.0	10.8	3.2
Germany	1.2	9.7	5.0	3.6
France	0.6	4.0	3.0	2.0
Russian Federation	1.1	15.1	1.0	0.5
Poland	0.5	4.7	1.3	1.3
Sea[1]	1.1	7.0	9.0	-
Other countries and sources	2.0	17.3	6.9	5.3

[1] Includes emissions from shipping and petroleum activities.
Source: Tarrason and Schaug (1999).

oxidized nitrogen and sulphur, and a larger proportion of the deposition therefore originates from a country's own emissions.

Most Norwegian emissions of SO_2, NO_x and NH_3 are deposited in Norway or over the sea (Tarrason and Schaug 1999), but about 10 per cent of each pollutant is deposited in Sweden.

Sulphur dioxide (SO_2)

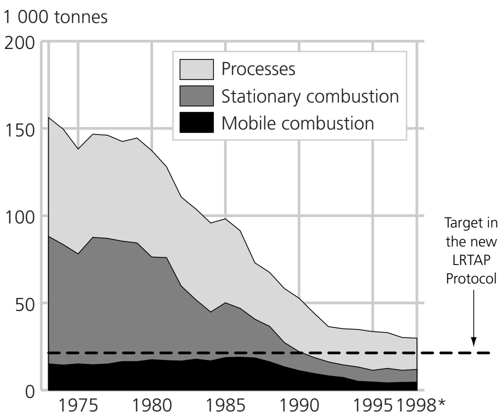
In 1998, Norwegian emissions of sulphur dioxide were just under 30 000 tonnes. This is a reduction of about 78 per cent compared with the 1980 level. Norwegian emissions are thus lower than the goal for the year 2000 set out in the Oslo Protocol. However, in the new LRTAP protocol, Norway has undertaken to ensure that emissions in 2010 do not exceed 22 000 tonnes, which is a reduction of more than 25 per cent from the 1998 level.

In the period from 1980 to 1992, there was a particularly marked reduction in SO_2 emissions from industrial processes and stationary combustion (figure 7.9). The drop in process emissions is 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. The reduction in SO_2 emissions from combustion can be explained by a changeover to the use of electricity, the use of lighter oil products, a reduction in the sulphur content of oil products, and the installation of more and better equipment to control emissions. Since 1987, emissions from mobile combustion have also dropped because the sulphur content of fuels has been reduced.

Industrial processes accounted for about 60 per cent of Norway's SO_2 emissions in 1998, and stationary and mobile combustion for 25 and 15 per cent respectively. Almost 40 per cent of the total in 1998 was generated by the manufacture of iron, steel and ferro-alloys (Appendix, table F6). Emissions from carbide production accounted for 9 per cent of the total, and domestic sea traffic for 10 per cent.

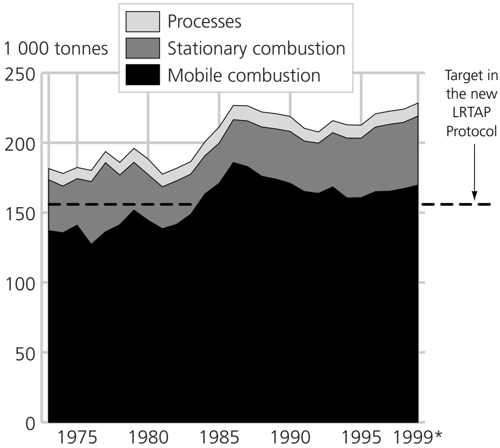
Foreign ships in Norwegian waters emit large amounts of SO_2 (Flugsrud and Haakonsen 1998). These emissions are not included in the emission inventory developed by Statistics Norway and the

Figure 7.9. **Emissions of SO_2 by source**



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

Figure 7.10. **Emissions of NO_x by source**



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

Norwegian Pollution Control Authority because the database used to calculate emission figures has no figures for years before 1996 and the sulphur content of the fuel is uncertain. Norway has used a number of different instruments to reduce its SO_2 emissions. The most important of these are taxes on industrial emissions, the use of discharge permits under the Pollution Control Act to regulate emissions, and restrictions on the permitted sulphur content of mineral oils (Report No. 8 (1999-2000) to the Storting). In addition, a grading system for taxation of shipping will be introduced, based partly on levels of SO_2 emissions.

Nitrogen oxides (NO_x)

Emissions of nitrogen oxides are generated mainly by shipping (ca. 40 per cent), road traffic (ca. 25 per cent) and oil and gas extraction (ca. 15 per cent). Preliminary figures for 1999 show that overall NO_x emissions have risen by 2 per cent from 1998. This is mainly a result of an increase in flaring during oil and gas production and a growth in shipping.

In the period 1980-1999, emissions of nitrogen oxides have risen by about 20 per cent (figure 7.10). The growth in the use of private cars resulted in a steep rise in NO_x emissions until 1987. Car traffic has continued to rise throughout the 1990s, but this has not resulted in a corresponding rise in NO_x emissions because a growing proportion of the vehicle stock is fitted with three-way catalytic converters, which reduce NO_x emissions. In 1990, only 7 per cent of private cars (petrol-driven) had catalytic converters, as compared with 54 per cent in 1999.

In all counties, NO_x emissions are dominated by mobile sources. This means that there are large emissions in densely-populated areas (Appendix, table F7). 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 industries. In the county with the next-highest NO_x emissions, Akershus, mobile sources account for 94 per cent of the total.

According to the earlier NO_x protocol, Norway has undertaken to stabilize its emissions below the 1987 level from 1994. This commitment was met until 1998, but the emission ceiling was exceeded by 2 000 tonnes in 1999. In the new LRTAP protocol, Norway has agreed to an emission ceiling of 156 ktonnes NO_x in 2010. This corresponds to a reduction of about 30 per cent from the 1999 level.

A number of measures will have to be implemented to meet these commitments. A grant scheme has been established to promote emission-reducing measures on coastal shipping, ferries and fishing vessels (Proposition No. 1 (1999-2000) to the Storting). The state budget also includes a grading system for tonnage dues, based on environmental declarations for ships. The regulations relating to motor vehicles include provisions on permitted emissions of nitrogen oxides. In addition, the road tax for heavy-duty vehicles will be differentiated according to their NO_x emissions from 1 July 2000. The tax rate will be determined on the basis of which of the emission standards set out in the relevant EU directive they satisfy (see also section 7.10).

Ammonia (NH_3)

Preliminary calculations for 1999 indicate that ammonia emissions totalled 27 000 tonnes, which is an increase of 16 per cent from 1990. Ammonia emissions are generated mainly by commercial fertilizer and manure and by treatment of straw with ammonia. A smaller proportion of the emissions are related to mobile combustion. The catalytic converters used in cars to reduce NO_x emissions convert most of these gases to N_2, but some NH_3 and N_2O is also formed. Ammonia emissions dropped by 2 per cent from 1998 to 1999 as a result of lower emissions from agriculture.

According to the new LRTAP protocol, Norway has undertaken to ensure that ammonia emissions are no higher in 2010 than in 1990. This means that they must be reduced by about 3 500 tonnes during the next 10 years. Report No. 8 (1999-2000) to the Storting does not specify what measures will be taken to achieve this. Emissions from mobile combustion will continue to rise as more cars are fitted with three-way catalytic converters. Unless car traffic is reduced, it is likely that agricultural emissions must be further reduced from their 1990 level to compensate for the rise in road traffic emissions.

Acidifying emissions in other countries

In the new LRTAP protocol, countries have set targets for further reductions of SO_2 and NO_x emissions by 2010. The UK, Germany and Russia are the countries outside Norway that make the largest contributions to total deposition of acidifying substances within the country. Table 7.8 shows trends in emission levels and the targets set for 2010 for these three countries and for Norway, Sweden and Denmark. The emission ceilings that have been set require Germany to reduce its SO_2 emissions by 90 per cent and NO_x emissions by 60 per cent compared with the 1990 levels, while the corresponding figures for the UK are 83 per cent for SO_2 and 56 per cent for NO_x.

Table 7.8. **Emissions and emission targets for SO_2 and NO_x. 1 000 tonnes**

	SO_2			NO_X		
	Emissions		Target	Emissions		Target
Country	1990	1997	2010	1990	1997	2010
UK	3 731	1 656	625	2 673	1 835	1 181
Germany	5 313	1 468	550	2 693	1 803	1 081
Russian Federation[1]	4 460	2 449	-	3 600	2 379	-
Sweden	119	69	67	338	280	148
Denmark	182	109	55	282	248	127
Norway	53	30	22	219	223	156

[1] The figures apply to the European part, within the EMEP area.
Sources: Norwegian Meteorological Institute (2000) and UN/ECE (1999).

7.5. Depletion of the ozone layer

The stratospheric ozone layer prevents ultra-violet (UV) radiation from the sun from reaching the surface of the earth. Depletion of the ozone layer can have a negative environmental impact. An increase in the amount of UV radiation reaching the earth may result in a higher incidence of skin cancer, eye injury and damage to the immune system. In addition, growth of plants and plankton may be reduced.

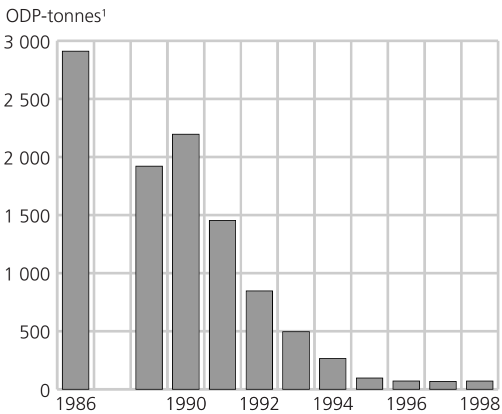
Substances that deplete the ozone layer include hydrochlorofluorocarbons (HCFCs), chlorofluorocarbons (CFCs) and other gases containing chlorine and bromine. Such gases have been used as cooling agents, propellants in aerosols and in the production of foam plastic. In new products, these gases are being replaced with hydrofluorocarbons (HFCs), which are greenhouse gases.
In accordance with the Montreal Protocol, the consumption of ozone-depleting substances in Norway has dropped steeply since the mid-1980s (figure 7.11). 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.

Measurements of the thickness of the ozone layer have been made in Norway since the mid-1930s. 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 above Norway (Braathen 1999 and Norwegian Institute for Air Research 1996a).

7.6. Formation of ground-level ozone

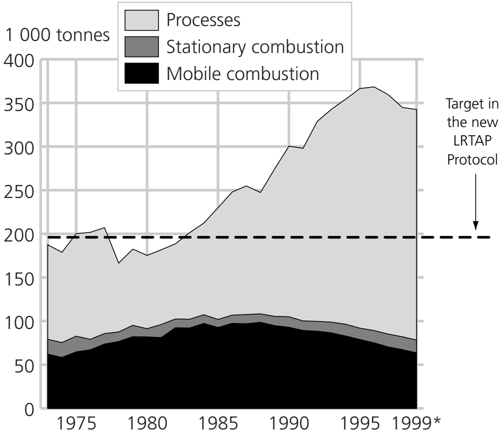
Ozone in the lower part of the atmosphere (the troposphere) is a pollutant. The gas is extremely reactive and has adverse effects on health, vegetation and materials. Ground-level ozone is formed by chemical reactions between oxygen, nitrogen oxides (NO_x) and volatile organic compounds (VOCs) in the presence of sunlight. High concentrations of ground-level ozone in Norway occur particularly when a high pressure ridge forms over Europe in summer. Under such conditions, polluted air is transported to south-

Figure 7.11. **Imports of ozone-depleting substances to Norway**



[1] The ozone-depleting potential (ODP) varies from one substance to another, and the figures are totals weighted according to the ODP of each substance (ODP factors).
Source: Norwegian Pollution Control Authority.

Figure 7.12. **Emissions of NMVOCs by source**



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

ern Norway at the same time as the pollutants are exposed to sunlight.

Volatile organic compounds are released during combustion and also during evaporation of fuels and solvents. The main sources of nitrogen oxides are mobile and stationary combustion.

The new protocol under the LRTAP convention (see section 7.4) applies to long-range air pollutants that are responsible for three different environmental problems – acidification, eutrophication and the formation of ground-level ozone. These include NO_x and NMVOCs[7] (non-methane volatile organic compounds). Nitrogen oxides also cause acidification and increase the risk of respiratory disease. National emissions of NO_x are therefore presented in section 7.4, and emissions at municipal level in section 7.8. In this section, we present more information on NMVOC emissions.

NMVOCs

Emissions of NMVOCs have risen steeply from the late 1970s to 1999 (figure 7.12). About half of Norway's NMVOC emissions are now generated by evaporation during loading of crude oil offshore. Emissions from solvents and petrol engines also account for a substantial proportion of the total. The rise in emissions during this period is mainly a result of the growth in the volume of crude oil transported and also, in the period 1973-1987, an increase in petrol consumption.

In the 1991 VOC protocol, Norway undertook to reduce these emissions by 30 per cent by 1999, using 1989 as the base year. Despite this, emissions have risen by almost 25 per cent in this period. Most of the rise is explained by an increase in the

[7] The protocol uses the term VOCs, but methane is not included. Methane is an important greenhouse gas, and is covered by the Kyoto Protocol.

volume of crude oil loaded on tankers at offshore installations and oil terminals. Emissions decreased by 1 per cent from 1998 to 1999. This is explained by the rising proportion of cars fitted with three-way catalytic convertors and the introduction of a recovery facility for oil vapour at one of the terminals. In the new LRTAP protocol, Norway has agreed to an emission ceiling of 195 ktonnes NMVOCs in 2010. This corresponds to a reduction of more than 43 per cent compared with 1999. To achieve this target, the government will focus particularly on measures to recover VOCs during loading and unloading of crude oil.

7.7. Heavy metals

Most cadmium compounds are carcinogenic. Cadmium bioaccumulates in fish and mammals and has a long biological half-life in mammals (Norwegian Pollution Control Authority 2000a). Lead is suspected to affect children's intellectual development (Norwegian Pollution Control Authority 2000b), and is also liable to bioaccumulate. The emission figures for both cadmium and lead are uncertain. There are no new figures for 1998 for industrial emissions, and the total figures have therefore not been updated. The Norwegian Pollution Control Authority has asked 33 industrial enterprises to report new emission figures in order to update the statistics (Norwegian Pollution Control Authority 1999b), and it is hoped that this will improve the quality of the data.

In 1998, emissions of lead totalled just above 6 tonnes, which is a reduction of 97 per cent compared with 1990. The steep reduction is explained by the fact that leaded petrol is no longer sold in Norway. Nevertheless, some lead is found naturally in petrol. Almost half of total lead emissions can be traced back to mobile combustion sources, and 29 per cent to stationary combustion sources. Process emissions from manufacturing account for 24 per cent of the total. Lead pollution in air is now well below the level believed to cause injury to human health.

Emissions of cadmium dropped by 47 per cent from 1991 to 1997. The most important sources of cadmium emissions are stationary combustion and industrial processes, and these account for about 95 per cent of the total. Emissions from housing are almost entirely generated by the use of fuelwood. In the Århus Protocol under the LRTAP Convention, Norway has undertaken to reduce lead and cadmium emissions from their 1990 levels. No quantitative targets were specified, but they will probably be negotiated at a later date.

7.8. Local air quality and emissions to air in towns and built-up areas

The most important pollutants in a description of air quality in towns and built-up areas are particulate matter, nitrogen oxides (NO_x) and sulphur dioxide (SO_2). In recent years, SO_2 emissions (see section 7.4) have been so greatly reduced that they no longer make a significant contribution to poorer air quality in Norwegian towns.

Road traffic and the use of fuelwood are the main sources of particulate matter. In Oslo, these sources accounted for 82 per cent of total emissions in 1997. Both particulate matter and NO_x increase the risk of respiratory diseases. Exposure to particulate matter increases the risk of coughs, bronchitis and sinusitis (Ministry of the Environment 1999a). Particulate matter can worsen the condition of people who suffer from chronic respiratory diseases. Particulates may also carry allergens and carcinogens. In the worst case, exposure to particulate matter can be a cause of death. Rosendahl (2000b) has calculated that in Oslo, 330 to 600 deaths a year are hastened by particulate matter, depending on the assumptions used. On average, each death represents a loss of residual lifetime of seven years. The Ministry of the Environment (1999a) estimates that particulate matter causes 1 200 cases of illness and more than 400 premature deaths a year in Oslo. In Norway as a whole, calculations show that there may be up to 2 200 premature deaths a year (Rosendahl 2000b).

The relationship between emissions to air and air quality is not always straightforward. One tonne of particulate matter emitted from chimneys as a result of wood-firing may not have the same effect on air quality where people are affected as one tonne of particulate matter emitted in car exhaust or from wear and tear of asphalt. Emissions from road traffic are released at a height where people are exposed directly, whereas emissions from chimneys take place 3 m or more above ground level. Such emissions are therefore dispersed in the air masses and are less concentrated when they reach ground level. Asphalt dust is worn off roads whenever studded tyres are in direct contact with the road surface. If the road surface is damp, the dust is not raised by traffic, but collects on the road. On days when the roads are dry, the dust that has collected is whirled up into the air. Weather conditions also influence air quality. 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.

The concentrations of benzene, carbon monoxide (CO) and ozone (O_3) are also important for air quality. Benzene is carcinogenic, and emissions originate from incomplete combustion of petrol, the use of fuelwood and other combustion. Measurements in Oslo and Drammen suggest that benzene levels are relatively high and in some cases higher than in other countries where similar measurements have been made (Report No. 8 (1999-2000) to the Storting). CO increases the risk of heart problems in people with cardiovascular diseases. Together with NMVOCs (non-methane volatile organic compounds), NO_x and methane, CO also contributes to the formation of ground-level ozone. Ozone increases the risk of respiratory diseases and damages vegetation.

The following section presents an analysis of the health effects and socio-economic costs of local air pollution in Norway. This is followed by further information on emissions of the pollutants that are most important for local air quality.

Health effects and social costs of air pollution in Norway

Air pollution in Norwegian towns is high at times, which increases the risk of health problems in the population. In a new study, we have attempted to estimate the total social costs related to such health effects in Norway. The analysis was based on data from the Norwegian Institute for Air Research (1996b), which has calculated annual pollution levels in Oslo, Bergen, Trondheim and Drammen. In addition, we used rough estimates of pollution levels in other towns and urban settlements and in less densely-populated areas. Health effects are primarily caused by concentrations of particulate matter (particles less than 10 μm in diameter).

It is difficult to calculate the extent of health damage caused by air pollution and the associated costs. A number of Norwegian and international studies have produced documentation of specific relationships between pollution levels and an elevated risk of disease and premature death (e.g. Hansen and Selte (1997) and a list in WHO (1997)). However, the extent to which these relationships also hold true at low concentrations is uncertain, i.e. we do not know whether there are threshold values for pollution. In this study, we therefore calculated health effects using three different threshold values, without trying to determine which assumption is most realistic.

In an analysis of the social costs of health effects, it is particularly important to consider how to set a value on premature death. Since air pollution mainly affects people who are nearing the end of their lives, the question is whether the same value should be used as for road accidents, for example, where a fixed value is used for a statistical life (NOU 1997:27). An alternative is to set a value on the loss of life-years rather than on a statistical life. These are ethical questions that are difficult to answer. In this study, we have therefore used both methods of valuation. Using the value of a statistical life gave social costs that were almost three times higher than using the value of the life-years lost.

The different assumptions about the level of the threshold value and the different valuation methods give a wide range of final results. The lowest estimate of the total social costs of health effects associated with air pollution in Norway was NOK 2.6 billion, whereas the highest estimate was NOK 28 billion. The costs are almost entirely associated with the effects of particulate matter. Epidemiological studies have found that other pollutants such as NO_2 do not lead to such serious health effects as particulate matter, and NO_2 therefore only makes a small contribution to the total costs. Premature mortality caused by chronic exposure to particulate matter is clearly the dominant health effect. The results suggest that there are several hundred premature deaths a year as a result of this, and that each person's life is shortened by about 7 years as a result. Most of the costs are directly related to a reduction in life quality as a result of higher morbidity and premature mortality. The market-based costs (including public-sector costs) make up less than five per cent of the total.

Oslo's share of the total costs as calculated in this study is between NOK 1.6 and 7.8 billion, or 60 and 27 per cent respectively of the lowest and highest estimates of the total costs in Norway (see table 7.9). Oslo accounts for such a large proportion of the total because there are high concentrations of particulates in the town and it has a high proportion of the total population. Bergen, Trondheim and Drammen together account for between 12 and 17 per cent of the total. The concentration of particulates in these towns is a little over half the level in Oslo. Assumptions about the threshold value have less effect on the results for the four towns than on the results for Norway as a whole, because these assumptions are of

Table 7.9. **Social costs of air pollution in Norway. Whole country and selected towns. Billion 1997 NOK**

Whole country	2.6-28.0
Oslo	1.6-7.8
Bergen	0.2-1.8
Trondheim	0.1-1.1
Drammen	0.1-0.5
Other urban settlements, >15 000 inhabitants	0.6-8.3
Rest of country	0-8.5

Source: Rosendahl (2000b).

much greater importance in areas with a scattered pattern of settlement.

The costs per kg particulate matter emitted in the four towns shown in table 7.9 lie between NOK 300 and 4 000. The costs are highest in Oslo and lowest in Drammen. This is explained by the fact that in a larger and more densely populated a town, more people are exposed to a given level of emissions. In smaller towns and urban settlements, the costs per kg are probably somewhat lower than for Drammen. The costs per kg particulate matter are also somewhat higher for exhaust emissions than for emissions from other sources. For an average diesel vehicle, the costs in the four towns correspond to between NOK 1 and 10 per litre, and for wood they are between NOK 3 and 35 per kg for fuelwood burnt in small stoves. Combustion of petrol and fuel oil contribute less to emissions of particulate matter, so that the costs are well below NOK 1 per litre petrol and less than NOK 0.50 per litre fuel oil. The benefit obtained if an average car uses non-studded instead of studded winter tyres is estimated to be several thousand NOK per winter.

Despite large uncertainties, we can conclude that the social costs of health effects related to air pollution in Norway are high, even though concentrations of pollutants are relatively low compared with those in many other countries. There is thus a substantial potential for social benefits if effective measures are introduced to cut emissions from road traffic and other sources in towns and larger urban settlements.

Project financed by: Norwegian Pollution Control Authority.

Project documentation: Rosendahl (2000b).

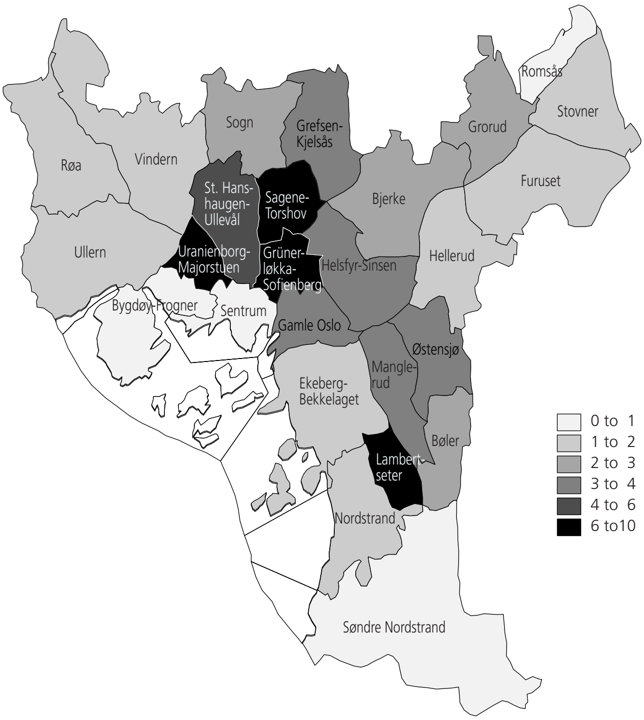
Particulate matter

Particulate matter is often defined as all particles of diameter less than 0.01 mm. Such particles are so small that if people breathe them in, they are drawn right down into the lungs. Although national emission figures can tell us something about pollution levels and trends, it is primarily local emissions that are important. The following section therefore starts with a brief discussion of trends in national emissions, and then focuses on emissions in certain selected urban areas. There is also a description of how emissions are distributed within the city of Oslo.

Emissions of particulate matter in Norway

Emissions of particulate matter totalled almost 25 000 tonnes in 1999. This is a rise of nearly 6 per cent since 1990. However, from 1998 to 1999, emissions dropped by 0.5 per cent. For Norway as a whole, heating in private households accounted for 61 per cent of emissions in 1998. Most of this was generated by fuelwood use. Emissions in exhaust from road traffic (mainly from diesel vehicles) accounted for 14 per cent and dust from wear and tear of asphalt for 7 per cent.

Figure 7.13. **Average emissions of particulate matter from fuelwood use in Oslo, by urban district. 1996. Tonnes/km²**



Source: Haakonsen (2000).

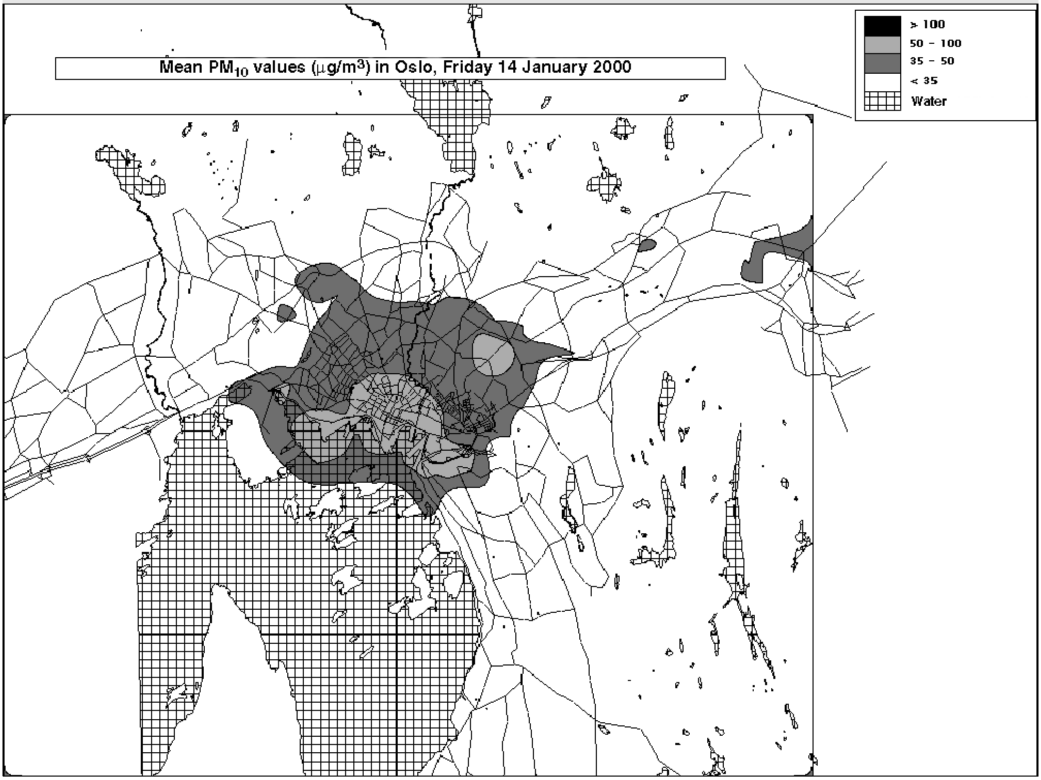
However, as described below, the picture is different if we look at individual towns and urban settlements.

Emissions of particulate matter in some towns

The emission figures for the towns Oslo, Bergen, Drammen and Lillehammer show that fuelwood use and road traffic are the most important sources of emissions of particulate matter. However, air quality also depends on other factors than the quantities emitted. Various dispersion effects influence the effect of emissions on air quality, and dust is only raised from roads on days when the road surface is dry. Furthermore, emissions in winter account for only about half of all exhaust emissions but all emissions related to the use of studded tyres and fuelwood.

Fuelwood use alone generated 43 per cent of particulate emissions in Oslo in 1997. These figures are uncertain, but it is clear that this is a significant source of particulate emissions in all four towns. In Lillehammer, 69 per cent of all particulate emissions originated from fuelwood. Total emissions from heating of private housing in the town accounted for 72 per cent of emissions of particulate matter. For the other towns, the corresponding figure was about 50 per cent. Road traffic (ex-haust and wear and tear of asphalt)

Figure 7.14. **Example of a pollution forecast for Oslo. Particulate matter (PM_{10}). µg/m³**



Sources: Norwegian Meteorological Institute and Norwegian Institute for Air Research.

accounted for between 30 and 47 per cent of emissions of particulate matter in the four towns. It is necessary to be cautious in drawing conclusions about trends in emissions and emission levels from fuelwood use. This is because the figures are very uncertain, particularly for the early 1990s. The figures for Oslo are assumed to be more reliable than those for the other towns.

Emissions in Oslo

For the four towns mentioned above, emissions in 1996 have been split between basic units and urban districts (see box 7.8). Figure 7.13 shows as an example how emissions of particulate matter from fuelwood use in 1996 were split between the various urban districts in Oslo. Emissions were highest in the areas within Oslo's inner ring road. Emissions may vary widely between basic units within the same urban district. In certain basic units, emissions are higher than 50 tonnes/km². The urban districts where emissions are highest are Uranienborg-Majorstua, Grünerløkka-Sofienberg and Sagene-Torshov. These are all districts where there is a large proportion of older town housing where wood can be used for heating, and are also the districts where population density is highest. In suburban areas where most housing is from after the Second World War, few

Box 7.7. Emissions to air by municipality

These figures include emissions to Norwegian territory from international maritime and air transport and domestic activities in Norway. The figures for national emissions, on the other hand, only include domestic activities in Norway. The methods used to calculate emissions to air are described in Flugsrud et al. (2000), Daasvatn et al. (1994) and Bang et al. (1999). Emission figures may be found on Statistics Norway's website (www.ssb.no).

buildings have chimneys, and average emissions are lower. Industry, waste incineration plants and heating plants contribute to higher emissions in certain basic units, in addition to fuelwood use.

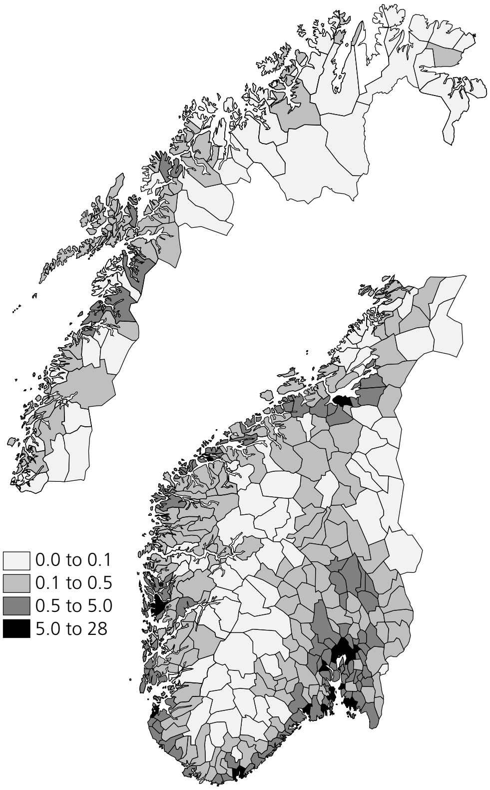
The Oslo Public Health Authority is now testing a model intended to provide detailed maps showing pollution forecasts for Oslo. Figure 7.14 shows a map for 14 January 2000. The maps forecast pollution on a specific day, not average pollution levels in Oslo through the winter. The areas where pollution was expected to be worst on 14 January are the light grey areas within the darker zone. According to plan, this forecasting system will be put into operation in winter 2000-2001.

NO_x

Section 7.4 describes trends in NO_x emissions in Norway and how they are split between sources. In the following, we look in more detail at emissions at municipal level.

In 1997, NO_x emissions were highest in the municipalities of Oslo, Porsgrunn and Bergen. Emissions totalled 6 400 tonnes in Oslo and 3 750 tonnes in Porsgrunn. In Oslo, road traffic accounted for 69 per cent of total emissions. Waste incineration

Figure 7.15. **NO_x-emissions by municipality in 1997. Tonnes per km²**



Map data: Norwegian Mapping Authority.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

and landfill gas accounted for 9 per cent, as did Norwegian ships (including both domestic and international sea traffic). In Porsgrunn, manufacturing accounted for 84 per cent of total emissions, and road traffic for 12 per cent. This does not indicate that people use cars less in Porsgrunn than in Oslo, but that industrial emissions are higher. In Bergen, manufacturing industries accounted for only 1 per cent of total emissions. Road traffic accounted for 77 per cent and Norwegian shipping for 10 per cent. Figure 7.15 shows emissions in tonnes per km² split

Box 7.8. Calculation of air pollution per basic unit

Statistics Norway has calculated emissions to air per basic unit in 12 Norwegian municipalities (Flugsrud et al. 1996, Haakonsen et al. 1998a and 1998b, and Haakonsen 2000) for the Norwegian Pollution Control Authority. Basic units are the smallest geographical unit Statistics Norway uses for statistical purposes, and an urban district consists of several basic units.

Emission 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 in co-operation with NORGIT. The Public Health Authority, Oslo uses AirQUIS for daily monitoring of air quality and in impact assessment to evaluate measures to combat pollution.

by municipality. The highest values are found in Stavanger, Porsgrunn, Moss and Tønsberg. As a general rule, emissions 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, Aure and Bremanger. These municipalities produce metals, cement, basic chemicals (methanol) and metals respectively. Per capita NO_x emissions are also high in certain municipalities with few inhabitants where there are national highways. Table F8 in the appendix shows emissions to air by municipality, and references for the calculation method are given in box 7.7.

CO

Carbon monoxide (CO) emissions rose from 1973 to the mid-1980s, but since then there has been a marked reduction. From 1990 to 1999, total emissions were reduced by 30 per cent, with a reduction of 6 per cent from 1998 to 1999 alone. 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 1998, road traffic accounted for 55 per cent of total CO emissions. Most of this was generated by petrol-driven engines. In 1998, a petrol-driven car emitted 19 times as much CO as a diesel one for each kg of fuel used. Heating of housing, particularly with fuelwood, accounted for 25 per cent of total emissions. Manufacturing accounted for 9 per cent, and the rest was generated by the use of motorized equipment, small boats and shipping.

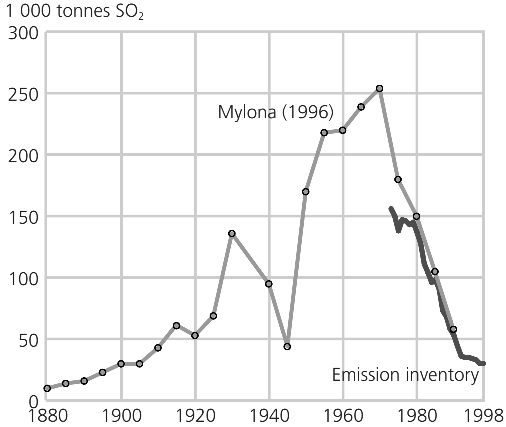
7.9. Factors that influence trends in emissions to air

Driving forces behind trends in emissions to air can be identified at several levels. Economic growth is an important driving force, since it creates a demand for growing quantities of fossil fuels in production, and at the same time provides greater prosperity and results in the use of more transport and energy for heating by private households. But economic growth can also act as a driving force for the development and introduction of technological innovations that can reduce emissions. Economic growth is generally accompanied by a rising level of education and a high level of general knowledge in the population. An understanding of about environmental problems and people's attitudes to them can act as driving forces that persuade the authorities to introduce measures to deal with the problems and encourage the adoption of international environmental agreements. Such agreements can in turn be regarded as driving forces that acting on national authorities, who then take steps to control environmental problems. These may include taxes on energy commodities, which can influence consumption and thus emission levels, or direct taxation of emissions, which makes it more advantageous to introduce technological solutions to reduce emissions. Efficiency measures and end-of-pipe measures to control emissions have direct and quantifiable effects on emissions. In the next section, we describe some factors that may have been of importance for trends in SO_2 and CO_2 emissions. After this, we present a quantitative analysis of the driving forces behind trends in Norwegian emissions to air, including other pollutants as well.

Trends in Norwegian emissions of SO_2 and CO_2

Figures 7.16 and 7.17 show Norwegian emissions of SO_2 in the period 1880-1998 and of CO_2 in the period 1930-1998. SO_2 is emitted during the combustion of fossil fuels and by industrial processes. Except for a drop in connection with the Second World War, emissions of SO_2 rose throughout the period 1880-1970. CO_2 emissions are mainly generated by combustion of fossil fuels and some industrial processes. Only combustion emissions are shown in figure 7.17. Like SO_2 emissions, CO_2 emissions have been rising after the Second World War. The growth in emissions can be related to economic growth and an associated rise in industrial activity and rising consumption of energy

Figure 7.16. **Emissions of SO_2 from Norway in the period 1880-1998**



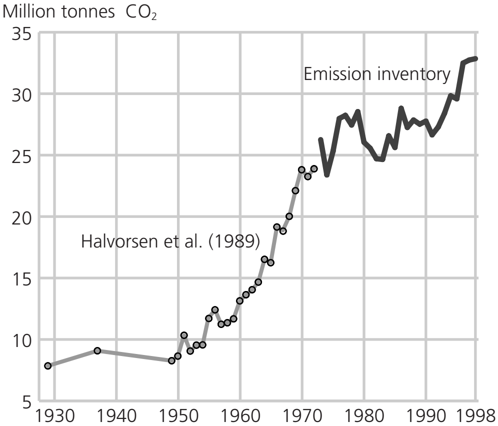
Sources: Mylona (1996) and Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

commodities. Since 1970, SO_2 emissions have dropped sharply, whereas CO_2 emissions have shown a marked rise. To understand this difference, we need to look more closely at historical developments in factors that affect these emissions. These includes research into the problems, environmental agreements, measures taken by the authorities and attitudes to environmental problems.

Scientific understanding of environmental problems

SO_2 that is released into the atmosphere is a cause of acid rain. This is now a familiar expression in Norway because of the damage acid rain has caused to forests and the acidification of rivers and lakes. The term acid rain is not new; it was first used by Angus Smith in 1872 (Seip 1995). However, the link between fish mortality and acid rain did not become clear until the 1950s and 1960s, and scientists did not fully accept the theory until the 1970s (Seip 1995).

Figure 7.17. **Emissions of CO_2 from combustion in Norway in the period 1929-1998**



Sources: Halvorsen et al. (1989) and Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

A rising concentration of CO_2 in the atmosphere enhances the greenhouse effect. The theory of the greenhouse effect was launched as early as 1827 (Alfsen et al. 2000), and calculations of the temperature rise to be expected if the CO_2 level doubled were published in 1896 (Fuglestvedt 1999). A numerical climate model that showed predicted climate trends into the 21st century was presented at a UN conference held in Stockholm in 1972 (Alfsen et al. 2000).

International environmental agreements
In 1983, the first sulphur protocol under the Convention on Long-range Transboundary Air Pollution (LRTAP) was signed in Helsinki. In this protocol, Norway undertook to reduce its SO_2 emissions by 30 per cent in the period 1980-1993. In 1994, another sulphur protocol, the Oslo Protocol, was signed, and Norway undertook to reduce its emissions by 76 per cent compared with the 1980 level. At the end of 1999, Norway signed the new Protocol to Abate Acidification, Eutrophication and Ground-level Ozone. According to this, Norway has undertaken to reduce its SO_2 emissions even further by 2010 (see section 7.4 and table 7.8).

It was not until 1997 that negotiations led to the Kyoto Protocol, in which industrial countries undertook to reduce their aggregate greenhouse gas emissions (see section 7.3). To date, only a few countries have ratified the protocol, and central provisions are still being negotiated. Thus, no international agreement is in effect for the reduction of CO_2 emissions, as there is for SO_2. Nevertheless, the protocol is already having an effect on policy development in many countries. For example, during the intense debate on the construction of gas-fired power plants in Norway in winter 1999-2000, both sides used the Kyoto Protocol in support of their arguments.

Measures to reduce emissions
Emissions of SO_2 have been reduced since 1970 as a result of several factors. Heavy fuel oil for heating has to some extent been replaced by lighter fuel oil, and the sulphur content of energy commodities has been reduced. These changes have taken place as a result of measures implemented by the authorities, such as taxes and regulations on the sulphur content of petroleum products (see section 7.10). Industrial emissions have also been greatly reduced as a result of requirements to install equipment to control emissions. The closure of some of the plants that generated most pollution has also reduced emissions.

An important difference between SO_2 and CO_2 is that it is possible to reduce SO_2 emissions to some extent using end-of-pipe solutions that remove sulphur. There is as yet no commercially available technique for removing CO_2. Research is in progress to find techniques that can reduce CO_2 emissions from gas-fired power plants by up to 90 per cent, but it will probably take several years before there are any practical results. The replacement of fossil fuels with bioenergy will reduce Norwegian CO_2 emissions, since bioenergy does not result in net CO_2 emissions[8]. However, an increase in the use of bioenergy may reduce air quality because emissions of particulate matter will rise. Supplies of bioenergy are not sufficient or cost-effective for all applications. Other carbon-free energy sources are not very competitive in today's energy market. This means that extensive measures will have to be implemented, including changes in production and consumption patterns, in order to reduce CO_2 emissions. It may well be more difficult to gain acceptance for such changes than has been the case for measures to reduce SO_2 emissions.

Attitudes to environmental problems
In general, first priority seems to be given to dealing with local and regional environmental problems such as SO_2 emissions. The costs of solving local problems are often low in relation to the benefits obtained. In the case of global environmental problems (e.g. CO_2 emissions) the benefits for individual people are small or negligible compared with the costs of reducing one's own emissions, but the overall benefits of avoiding climate change may be very large (Bruvoll et al. 1999).

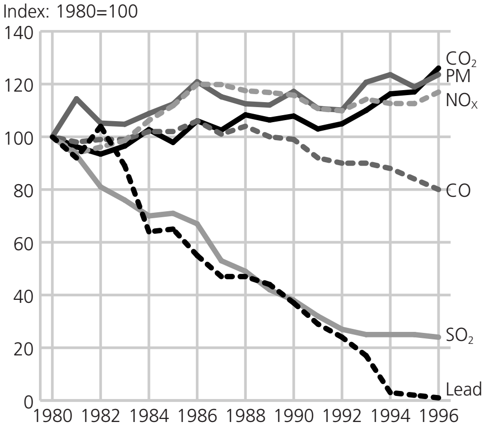
There has been considerable motivation for Norway to reduce SO_2 emissions because their adverse effects have been so clear. People could see for themselves that once well-stocked lakes had lost all their fish, and in the southernmost part of the country particularly, there was clear forest damage. The mechanisms linking CO_2 emissions and the greenhouse effect are more complex. The most serious results of the greenhouse effect probably lie in the future, and people are therefore less aware of them than they are of fish mortality and forest damage. However, many scientists believe that global warming is already occurring, with effects such as rising global mean temperature, milder winters in northern areas and a rising frequency of extreme weather conditions throughout the world.

Driving forces behind changes in emissions to air
Data for a number of countries show that once a certain income level is reached, economic growth appears to reduce some environmental problems. This is partly because a higher value is put on the environment as income increases, and at the same time the technological advances made possible by higher income levels slow down or reduce pollution. Other environmentally harmful emissions that are relatively costly to deal with, such as greenhouse gas emissions, continue to rise. However, they rise at a much lower rate than economic growth.

In this analysis, we looked at various driving forces behind trends in air pollution in Norway, including economic growth. There have been major changes in air pollution in Norway in the last twenty years, see figure 7.18. Emissions of sulphur, lead and other heavy metals have been considerably reduced. Emis-

[8] CO_2 emissions from bioenergy are not included in the inventory, since a tree fixes the same amount of carbon during growth as is released during combustion of the wood.

Figure 7.18. **Changes in emissions to air in Norway in the period 1980-1996**



Source: Bruvoll et al. (1999).

sions of greenhouse gases and NO_x have risen, and other emissions have remained relatively stable.

Changes in emissions in the period 1980-1996 were decomposed into seven different components, each of which has contributed to the changes. These components reflect the effects of population growth (the population component), the growth in per capita GDP (the scale component), changes in industrial structure (the composition component), more efficient use of energy (the energy intensity component), changes in the mix of energy commodities (the energy mix component), differences in emissions between stationary and mobile combustion (the combustion method component) and the effects of other technological changes and political measures (the other technique component).

The population grew by 7 per cent in the period studied, so the *population component* alone accounted for a rise of 7 per cent in all emissions, see table 7.10. The

Table 7.10. **Contribution of various components to changes in emissions in the period 1980-1996. Percentages**

Component	Lead	SO_2	NO_x	CO	Particulate matter	CO_2
Population	7	7	7	7	7	7
Scale	51	51	51	51	51	51
Composition	-12	-8	4	-11	-12	10
Energy intensity	-42	-22	-31	-42	-34	-33
Energy mix	19	-21	6	20	26	-6
Combustion method	0	0	3	0	1	0
Other technique, energy	-112	-31	-19	-42	-13	0
Other technique, process	-9	-52	-4	-3	-3	-2
Total change	-99	-76	17	-20	24	26

Source: Bruvoll and Medin (2000).

scale component is 52 per cent. These two components give a total rise in GDP of 59 per cent. This means that if the other components that influence the relationship between production and pollution were constant over the period studied, the growth in GDP would result in a 59 per cent rise in emissions. However, as a result of changes in the other components, the net rise in emissions was considerably lower than the overall growth in GDP.

Some polluting sectors have contracted during the period, thus tending to lower emissions. At the same time, other sectors such as the energy sector have shown strong growth, and as a result the overall effect of the *composition component* on changes in emissions was relatively small.

More efficient use of energy is one of the main reasons why the growth in emissions was lower than the growth in GDP.

The *energy intensity component* has contributed towards reductions in all emissions. Total energy use relative to total Norwegian production dropped by 18 per cent in the period, and the effect on emissions was in the range 13 to 22 per cent.

The *energy mix component* was less important than the energy intensity for all gases except SO_2. This component measures the effect of a change in the proportions of the various energy commodities used in each sector. The positive growth in the use of gas and the negative growth in the use of oil dominate this component. Due to the drop in the use of heavy fuel oils, the energy mix changes were particularly important for the reductions in SO_2 emissions. For CO_2, the reduction in the use of heavy oil and other oils dominated. For lead, less use of petrol in private services and other industries dominated this component, but a rise in petrol use in private households somewhat dampened the effect. The effect was positive for particulate matter, due to increased use of diesel and wood.

Combustion emissions from energy commodities are generally higher for mobile than for stationary combustion, and the proportion used for mobile consumption rose during the period of the study. The *combustion method component* therefore tended to result in a rise in emissions of NO_x and particulate matter.

The *other technique component* includes technological changes that are not covered by the other components. These are often a direct result of political measures to deal with emissions. These effects are dominant for lead, SO_2 and CO. They include the development of replacements for lead in petrol, a change over to oil with a lower sulphur content and the implementation of emission abatement technologies. Catalytic convertors in cars helped to reduce emissions of NO_x and CO_2, while a reduction in the use of studded tyres in winter was most important as regards particulate matter. For CO_2, the other technique component has no effect on emissions from combustion, since it is currently not possible to treat CO_2 emissions.

The de-linking of economic growth and emissions is mainly due to new technologies. Economic growth follows technological progress, which has improved the utilization of energy. In general, reduced energy intensity helps to lower emissions of all pollutants related to energy use. In addition, environmentally motivated political action, in combination with other technological changes, has been a decisive factor in cases where emissions have actually been reduced. Even though the Norwegian economy has experienced large structural changes and changes in the use of various types of energy, the effect of these changes has been relatively small compared to that of technological change.

Project financed by: Ministry of the Environment.

Project documentation: Bruvoll and Medin (2000).

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

Below, we describe measures that have been introduced primarily to reduce emissions to air and briefly mention some other measures. 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.

Legislation

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. Direct regulation is not an effective instrument for dealing with smaller emission sources, and these are generally governed by regulations and economic instruments.

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. Regulations pursuant to the Pollution Control Act relating to the sulphur content of fuel oil and the tax on products containing sulphur also influence local air pollution that is related to industrial activities and domestic heating.

The first restrictions on exhaust emissions from road vehicles were introduced in the 1970s. They have been altered several times since then and now apply to all types of vehicles. There are limit values for emissions of NO_x, CO, VOCs and particulate matter (Report No. 58 (1996-97) to the Storting). Since 1994, emissions from all petrol-driven cars have been controlled as part of the periodical EEA roadworthiness tests.

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

Voluntary agreements

The first agreement between the authorities and business and industry in Norway on quantified emission reductions was adopted in 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 introduced in 1991, and according to Report No. 29 (1997-98) to the Storting applies to about 60 per cent of all CO_2 emissions in Norway. 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 (see e.g. Bye et al. 1999a, table 4.1). 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.

One of the Government's targets is that 80 per cent of all cars in the four largest towns in Norway should be using non-studded tyres in winter by 2002. The Directorate of Public Roads has calculated that despite reductions in the use of studded tyres, this target will not be reached (Report No. 8 (1999-2000) to the Storting). From winter 1999-2000, the municipalities have therefore been given the authority to charge for the use of studded tyres. In Oslo, the annual charge for the use of studded tyres for a whole winter is NOK 1000. This has been combined with an offer to refund NOK 250 per studded tyre if they are replaced by new non-studded winter tyres. According to the Oslo Public Health Authority, raising the proportion of cars using non-studded tyres to 80 per cent will probably not be sufficient to satisfy the new EU directive on air quality (Oslo City 1999). It may therefore be necessary to take steps to increase the percentage using non-studded tyres even further.

In Proposition No. 1 (1999-2000) to the Storting from the Ministry of the Environment, the Government expressed its intention of using environmental taxes more widely. The objective is to encourage more environmentally-friendly behaviour without increasing overall taxation levels.

The sulphur tax applies to mineral oil, coal, coke and emissions from oil refineries (Proposition No. 1 (1999-2000) to the Storting, Ministry of Finance). In 1999, the tax rate for mineral oil was NOK 17 per kg SO_2 released. Mineral oil with a sulphur content of less than 0.05 per cent by weight is exempt from the tax. In practice, the sulphur content of all autodiesel is below this level, and the tax is not levied on autodiesel.

Autodiesel is taxed at a lower rate than petrol (Proposition No. 1 (1999-2000) to the Storting, Ministry of Finance). Differences in the environmental costs of their use provide little justification for this (Proposition No. 54 (1997-98) to the Storting, Ministry of Finance). The Government wishes to eliminate this difference, and the autodiesel tax was therefore raised by NOK 0.20 per litre from 1 January 2000. Furthermore, an additional tax of NOK 0.25 per litre was introduced for autodiesel containing more than 0.005 per cent sulphur. The main reason for the latter is that petroleum products with a low sulphur content result in smaller emissions of particulate matter than those with a high sulphur content. Reduction of the sulphur content of autodiesel is an important means of reducing emissions of particulate matter from diesel vehicles. If fuel with a lower sulphur content is used, it is possible to install equipment in heavy-duty vehicles that can reduce particulate emissions by up to 90 per cent (Proposition No. 1 (1999-2000) to the Storting, Ministry of Finance). A lower sulphur content will of course also result in lower SO_2 emissions. The oil companies have now started to supply autodiesel with a sulphur content of less than 0.005 per cent (Birkeland 2000). This is exempt from the extra tax of NOK 0.25 per litre, but is somewhat more expensive to produce.

Another measure related to road traffic, which was adopted in the state budget for 2000, is differentiation of the weight-based road tax for heavy-duty vehicles according to their environmental impact. This is an extra tax that applies to diesel vehicles weighing 12 tonnes or more. It is differentiated by weight and according to the emission standards that the vehicle satisfies. This ensures that the tax rate for vehicles with low emissions is lower than for those with higher emissions.

The Government will make arrangements to facilitate the use of road pricing schemes where the local authorities wish to introduce them. These schemes will be designed in such a way that drivers must pay for their adverse impact on others in the form of noise, emissions and delays

(Report No. 8 (1999-2000) to the Storting).

Other measures
The Norwegian Public Roads Administration has decided that the speed limit on the main roads in Oslo is to be reduced to 60 km/h on days when at least 20 000 people are expected to be exposed to a concentration of particulate matter exceeding 100 $\mu g/m^3$ for (Norwegian Public Roads Administration, undated). Notification of the reduction will be given the day before it is put into effect.

Domestic fuelwood use is an important source of emissions of particulate matter in many areas. Possible measures to reduce this include equipment to control emissions, speeding up the replacement of old stoves and information campaigns (Report No. 8 (1999-2000) to the Storting). Oslo has run a scheme involving partial refunds to encourage delivery of old, polluting wood-fired stoves in central parts of the town. The campaign ran during autumn of two consecutive years, and more than 800 old wood-burning stoves have been replaced with new, cleaner types (Kjønnerud 2000). Bergen has been running a similar scheme in winter 1999-2000, which has resulted in the replacement of 500 stoves (Grindheim 2000). A recent change in the legislation will have the opposite effect: the regulations relating to standards for buildings and products for buildings have been amended to permit closed wood-burning stoves to be moved and reinstalled even if they do not satisfy the requirements for new stoves (maximum level of emissions 10 g particulate matter per kg wood). This will delay the replacement of wood-burning stoves.

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.

Emission inventory co-financed by: Norwegian Pollution Control Authority.

Documentation, emission inventory: Flugsrud et al. (2000).

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

8. Waste

The most important environmental problems directly associated with waste include emissions of the greenhouse gas methane from landfills and emissions of various substances to air from incineration plants. Methane emissions have remained fairly stable in the last few years, while improved technology for emission control has reduced most environmentally harmful emissions from waste incineration.

The quantity of household waste has risen in recent years, and was equivalent to 308 kg per person in 1998. However, generation of waste by manufacturing industries has been somewhat reduced. Projections by Statistics Norway indicate that the total quantities of waste generated will continue to rise, but that there may be further reductions in environmentally hazardous emissions as a result of higher emission standards and the use of cleaner combustion technology. Increased material and energy recovery and flaring of methane are expected to keep methane emissions at about the current level during the next few years.

8.1. Introduction

Environmental problems associated with waste

Emissions of the greenhouse gas methane from rotting waste in landfills constitute one of the most serious problems associated with waste management. In 1998, methane emissions from landfills accounted for 7.1 per cent of Norway's total greenhouse gas emissions (table 8.1) (Statistics Norway 2000f). To limit these emissions, a growing proportion of the methane generated is extracted and flared or burnt for energy recovery. In 1995, 5 per cent of the municipal landfills extracted gas, and this had risen to 18 per cent in 1998. The landfills that extracted gas accounted for 51 per cent of all municipal waste that was landfilled. About 21 000 tonnes of methane was flared or used for energy recovery in 1998, as compared with 1 000 tonnes in 1990. Despite this, methane emissions from landfills rose from 182 000 tonnes in 1990 to 194 000 tonnes in 1996. However, since 1996 they have dropped by 2 per cent to 190 000 tonnes in 1998 (see also Chapter 7).

Incineration of waste results in emissions of harmful gases. However, these have been reduced in recent years by the introduction of stricter standards for emissions from incineration plants. With the exception of lead and cadmium, emissions from waste incineration account for only a very small proportion of Norway's emissions to air. In 1998, incineration of waste resulted in the emission of 1.3 tonnes of lead,

Table 8.1. **Emissions from waste treatment. Changes from 1987 and share of total emissions in Norway. 1998**

	Change from 1987 Per cent	Percentage of total Norwegian emissions
Incineration plants		
Nitrogen dioxide	-18.2	0.4
Carbon dioxide	40.6	0.3
Particulate matter	-50.4	0.1
Lead	-2.1	19.9
NMVOCs	37.5	0.1
Sulphur dioxide	-70.2	0.6
Cadmium[1]	-65.0	6.3
Quantity of waste incinerated	43.1	
Landfills		
Methane (greenhouse gas)	13.1	7.1[2]
Seepage: heavy metals		1
Seepage: nitrogen[3]		2
Seepage: phosphorus[3]		1

[1] Change from 1991.
[2] Calculated as the percentage of total greenhouse gas emissions.
[3] Figures for 1996.
Sources: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority (emissions to air) and Report No. 8 (1999-2000) to the Storting (seepage).

or 20 per cent of Norway's total emissions of lead. In addition, 6 per cent of all cadmium emissions in 1998 were generated by waste incineration. Locally, emissions of NO_x can also be significant. In Oslo, 9 per cent of NO_x emissions originated from waste incineration in 1997.

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 eutrophication. These problems are mainly associated with older landfills, since there are very strict requirements for newer sites to avoid such emissions. In 1995, seepage from 20 per cent of all municipal landfills was treated, and this had risen to 32 per cent in 1998. The landfills that treated seepage handled 56 per cent of all municipal waste that was landfilled in 1998. Waste management can also result in problems related to unpleasant smells, littering and vermin.

Box 8.1. National targets for waste and recycling

1. The growth in the quantity of waste generated shall be considerably lower than the rate of economic growth.
2. The quantity of waste delivered for final treatment is to be reduced to an appropriate level in economic and environmental terms. Using this as a basis, the target is for 25 per cent of the total quantity of waste generated to be delivered for final treatment in 2010.
3. Practically all hazardous waste is to be dealt with in an appropriate way, so that it is either recycled or sufficient treatment capacity is provided within Norway.

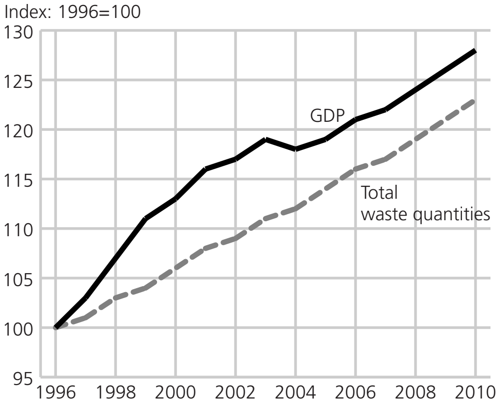
Source: Report No. 8 (1999-2000) to the Storting.

Waste contains materials and energy that can be recovered and used. Energy recovery from waste can replace the use of fossil fuels, and material recovery can replace production based on limited supplies of virgin raw materials.

Main objectives of waste policy

According to the environmental authorities, waste must be managed in such a way as to minimize injury and nuisance for people and the natural environment. At the same time, the resources required by waste and its management must be minimized. Three national targets for waste and recycling were published in a white paper last year (Report No. 8 (1999-2000) to the Storting). These are shown in box 8.1.

Figure 8.1. **Projections of GDP and total waste quantities for the period 1996-2010**



Source: Bruvoll and Ibenholt (1999).

The first of these targets means that in future, a given level of economic activity, measured as GDP, should result in substantially smaller quantities of waste. The white paper does not attempt to specify how great a difference there should be in the rates of growth, but it must be enough to provide a real benefit, and it must be sustained. According to projections by Statistics Norway, total waste generation in Norway is expected to rise by 10 percentage points less than GDP in the period 1996–2010 if waste policy remains unchanged (see figure 8.1). This is because the use of factor inputs in both production and consumption is expected to become more effective (Bruvoll and Ibenholt 1999) (see section 8.6). It therefore seems that this target will be achieved without further measures being implemented.

The second national target is the reduction of the quantity of waste delivered for final treatment (landfilling or incineration without energy recovery) to 25 per cent of the total quantity generated by 2010. This means that 75 per cent of all waste must be used for material recovery or energy recovery in ten years time. It is considered that this will reduce the quantity of waste delivered for final treatment to an appropriate level in economic and environmental terms. In 1996, the quantity of waste delivered for final treatment was calculated to be 43 per cent of the total quantity generated (Report No. 8 (1999-2000) to the Storting).

The third and final national target is related to waste containing hazardous chemicals, which can result in serious pollution or a risk of injury to people or environmental damage if it is not correctly treated. The white paper requires that practically all hazardous waste must be dealt with in an appropriate way and through the official channels. Transport of hazardous waste across national borders is to be minimized and must only be permitted if Norway does not have capacity to deal with the waste or if the recipient country needs the waste for its recycling industry.

Policy instruments for waste management

Various instruments are used to regulate waste management in practice. The central authorities have laid down the overall framework for municipalities and business and industry. New instruments that are introduced should as a general rule supplement those that already exist (Report No. 8 (1999-2000) to the Storting).

The 1981 Pollution Control Act and appurtenant regulations include a number of provisions relating to waste management. In addition, there are various regulations governing the management of different waste fractions. Management of hazardous waste is governed by separate regulations, which lay down that hazard-

Table 8.2. **Important waste policy instruments and measures**

Instrument/measure	How is it to be implemented?	Reasons
Municipalities to take on more responsibility and duties as regards overall waste management.	Preparation of waste plans and establishment of reception facilities for hazardous waste required. Municipalities urged to introduce sorting of waste at source.	Waste plans are a planning tool to improve waste management. Reception facilities for hazardous waste are to ensure treatment through official channels.
Prices of different types of waste management shall reflect their socio-economic costs.	Municipalities must cover their actual costs when setting municipal waste management fees. With the introduction of the fee for final waste treatment, some of the external environmental costs of waste management have also been priced and included.	Intended to reduce quantities of waste landfilled and increase re-use and material and energy recovery.
Grading of waste management fees.	Fees must be set in such a way that the price of waste collection services depends on the quantity and/or type of waste delivered.	To reduce waste quantities and encourage sorting of waste by individual subscribers. Complies with the polluter-pays principle.
Business and industry to take on more responsibility for waste from their own products.	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 batteries, car tyres, packaging, waste paper, and electrical and electronic products. There are also tax and return schemes for beverage cartons, waste oil and scrapped cars.	To make sure that business and industry are responsible for management and recycling of waste from their own products, and to promote the development of products that entail lower waste management costs.
Improving knowledge and understanding of waste and waste management.	Establishment of Norsas (Norwegian Resource Centre for Waste Management and Recycling), information campaigns. Development and improvement of waste statistics in Statistics Norway and other bodies.	To raise awareness of waste problems and encourage recycling: applies to industry, the public sector and the general public.
Restrictions on landfilling of wet organic waste.	As a general rule, landfilling of wet organic waste will not be permitted after 2000.	To reduce emissions of methane from landfills and make use of the resources in wet organic waste.
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 acid emissions, etc.	To avoid serious pollution of lakes and rivers and reduce emissions of the greenhouse gas methane and other harmful emissions to air.

Sources: Norwegian Pollution Control Authority and Report No. 8 (1999-2000) to the Storting.

Box 8.2. 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 generated by economic activities, both private and public. Includes both consumer waste and production waste. 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.

ous 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.

Table 8.2 lists some of the most important instruments and measures that have been implemented by the authorities.

8.2. Waste generation

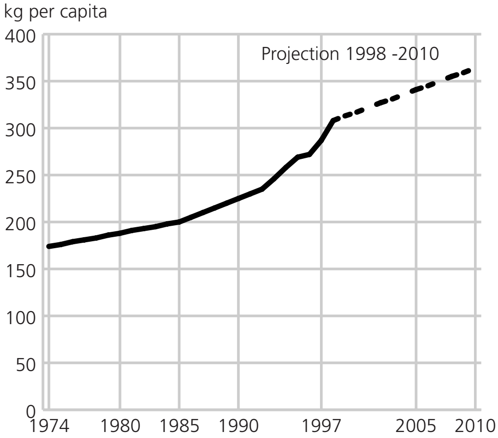
It is difficult to give exact figures for the total quantity of waste generated each year in Norway. This is partly because it can be difficult to define precisely which materials are to be considered as waste and partly because the quantities can be difficult to measure precisely. The main objective of the waste accounts is to provide a better overview of waste quantities and streams in Norway, for each

Table 8.3. **Quantities of waste generated in Norway, by material. 1996**

Material	1 000 tonnes	Source
Total	6 658	
Paper and cardboard	921	Statistics Norway (1999a)
Metal	717	Statistics Norway (1998d)
Glass	142	Statistics Norway (2000g)
Wet organic waste	1 556	Statistics Norway (1998e)
Plastic	364	Skullerud and Stave (2000)
Wood	1 144	Statistics Norway (2000e)
Textiles[1]	86	Rønningen (1999)
Other materials[1]	1 078	Rønningen (1999)
Hazardous waste	650	Norsas (1996)

[1] Preliminary calculations.

Figure 8.2. **Per capita generation of household waste and projections to 2010**



Sources: Waste statistics from Statistics Norway, Bruvoll and Ibenholt (1999) and Ligård (1982).

type of material. Waste accounts have so far been drawn up for paper and cardboard, metals, plastic, wood, glass and wet organic waste. Preliminary calculations have also been made for textiles, stone, gravel and soil, and "other materials".

Table 8.3 shows figures for waste generation in Norway in 1996 for those materials for which waste accounts and figures from other sources are available.

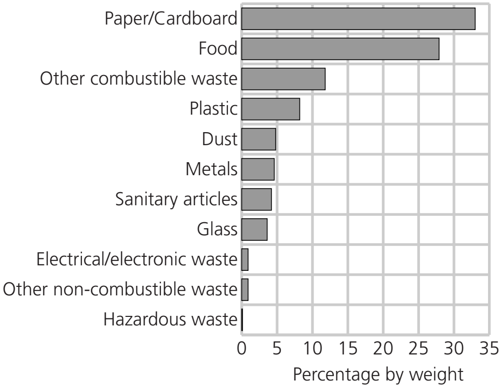
Calculations show that a total of more than 6.5 million tonnes of waste was generated in 1996. In addition, a large amount of waste consisting of stone, gravel and soil is generated every year. In 1996, this was calculated to total about 18 million tonnes (Rønningen 1999).

Household waste

Calculations show that each person in Norway generated an average of 308 kg household waste in 1998 (Statistics Norway 1999c). The total quantity of household waste was 1 358 000 tonnes in 1998. This is 100 000 tonnes more than in 1997, and the largest rise from one year to the next since Statistics Norway started to register waste statistics. The amount of household waste generated has been rising ever since the first survey was made in 1974, when each person generated an average of 174 kg household waste, see figure 8.2 and table G2 in the Appendix (Statistics Norway 1999c, Ligård 1982). Some of the rise may be explained by better registration methods and the fact that a larger proportion of waste is delivered to approved facilities. Nevertheless, it is clear that per capita generation of household waste is still rising. This may be partly explained by trends in standards of living and consumption patterns.

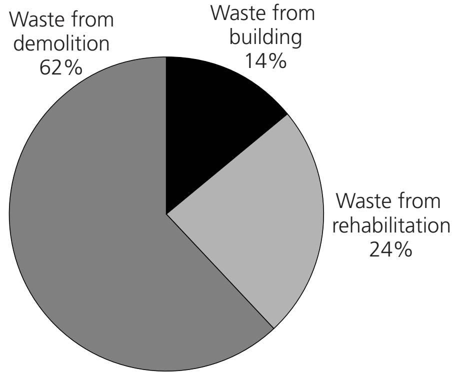
According to Statistics Norway's projections of waste quantities (Bruvoll and Ibenholt 1999), the quantities of household waste will continue to rise until 2010, but at a rather slower rate than economic growth. These projections are based on waste figures for 1995, and per capita generation of household waste is calculated to be 364 kg in 2010. This corresponds to a rise of 45 per cent in the

Figure 8.3. **Composition of household waste in 1997**



Source: Heie (1998).

Figure 8.4. **Distribution of construction waste by activity. 1998**



Source: Statistics Norway (1999e).

total quantity of household waste, while private consumption is expected to rise by just above 50 per cent.

Sorting surveys show that household waste in Norway contains about 33 per cent paper and cardboard, almost 28 per cent food waste and 8 per cent plastic (Heie 1998), see figure 8.3. 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.

Waste from building, demolition and rehabilitation

Construction waste accounts for a large proportion of total waste quantities in Norway. In recent years, the environmental impact of this type of waste has received more attention from the environmental authorities, environmental organizations and the construction industry itself. Much of this waste can be reused or recycled.

Statistics Norway has calculated the annual quantities of waste generated by building, demolition and rehabilitation. This has been done by finding factors for waste production per square metre for each activity, and then combining these with statistics on the areas built, demolished and rehabilitated. The results are uncertain, mainly because it is difficult to obtain reliable statistics on the areas rehabilitated and demolished each year. The factors for the quantities of waste generated per square metre are also somewhat uncertain, mainly because calculation of the factors was based on a limited number of projects.

The calculations showed that the total quantity of waste from building, rehabilitation and demolition in 1998 was 1.5 million tonnes. A great deal of this (1.1 million tonnes, or 68 per cent) consists of concrete and bricks, and three-quarters of this fraction is generated by demolition (table 8.4). Wood is the next largest fraction. In 1998, a total of 240 800 tonnes of wood waste was generated, and half of this was from rehabilitation of buildings. The calculations also show that more than 7 700 tonnes of hazardous

Table 8.4. **Waste generated by building, rehabilitation and demolition in 1998, by waste type. Tonnes**

	Total	Construction	Rehabilitation	Demolition
Total	1 542 800	209 500	372 200	961 100
Concrete and bricks	1 056 800	77 100	181 000	798 800
Wood	240 800	41 500	122 900	76 500
Metals	42 800	3 200	9 100	30 600
Plaster	37 100	14 100	21 000	2 200
Paper, board and plastic	16 800	8 000	2 400	6 500
Hazardous waste	7 700	200	2 900	4 700
Of this, asbestos	6 400	-	2 600	3 800
Mineral wool and EPS	6 400	3 500	1 900	1 000
Glass	4 700	1 100	2 100	1 700
Waste of unknown composition	130 200	61 300	29 300	39 600

Source: Statistics Norway (1999e).

waste was generated in 1998, and 6 400 tonnes of this was asbestos.

Statistics on the areas built, rehabilitated and demolished are taken from Statistics Norway's building statistics, the Norwegian Mapping Authority and the market research company Prognosesenteret AS. The greatest uncertainty is associated with the calculations of the area rehabilitated: for example, rehabilitation of buildings carried out by owners themselves is not included in the statistics.

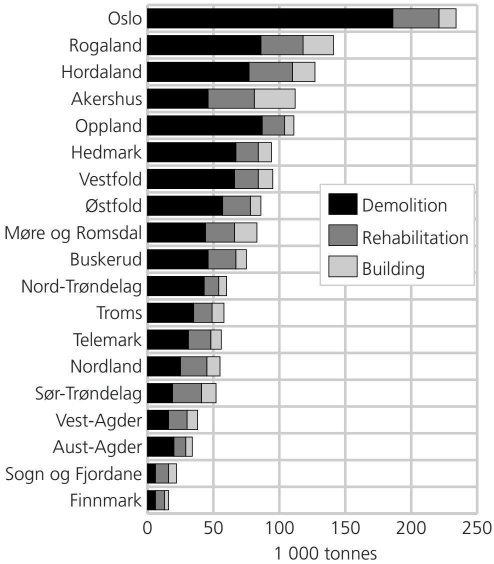
The calculations show that in 1998, the total area of buildings demolished was around 1.5 million m². The area built was 6.6 million m², and the area rehabilitated was calculated to be 5.1 million m². Nevertheless, demolition is the activity that generates most waste (figure 8.4). In 1998, 961 100 tonnes of waste was generated by the demolition of buildings. Building is the activity that generates least waste per square metre, and the calculations show that in 1998, a total of 209 500 tonnes of waste was generated. Rehabilitation of buildings generated 372 200 tonnes of waste.

In 1998, 15 per cent of all waste from building, demolition and rehabilitation of buildings was generated in Oslo. The proportion was highest for demolition, and 19 per cent of the total from this activity was generated in Oslo. The level of building activity was high in both Akershus and Rogaland, and these counties accounted for the largest proportions of waste from building (15 and 11 per cent respectively). Waste from rehabilitation of buildings was relatively evenly distributed among the counties. Most waste was generated by rehabilitation in Oslo, Akershus, Rogaland and Hordaland, and each of these counties accounted for 9 per cent of the total. See also figure 8.5 and tables G4 and G5 in the Appendix.

Production and consumer waste from manufacturing industries

In 1996, Norwegian manufacturing industries generated 2.5 million tonnes production and consumer waste (Statistics Norway 1997, 1998b). 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

Figure 8.5. **Construction waste by type of activity and county. 1998**



Source: Statistics Norway (1999e).

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.

A new survey of waste from manufacturing industries in 1999 is in progress, and the results will be published towards the end of 2000. See Natural Resources and the Environment 1998 (Statistics Norway 1998) for a more detailed discussion of waste from manufacturing industries.

Table 8.5. **Quantities of hazardous waste generated in Norway in 1997. Tonnes**

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

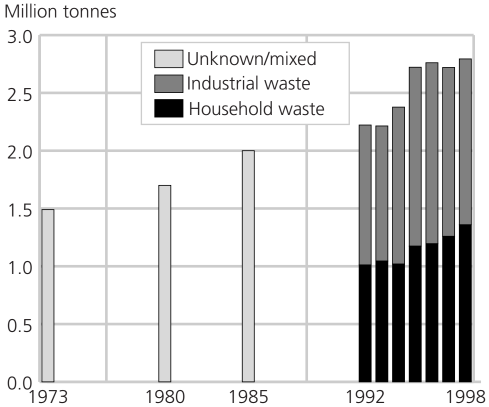
Source: Norsas (1999a).

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 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 (the Norwegian Resource Centre for Waste Management and Recycling). Norsas has calculated that in 1997, 655 900 tonnes of hazardous waste was generated in Norway, see table 8.5.

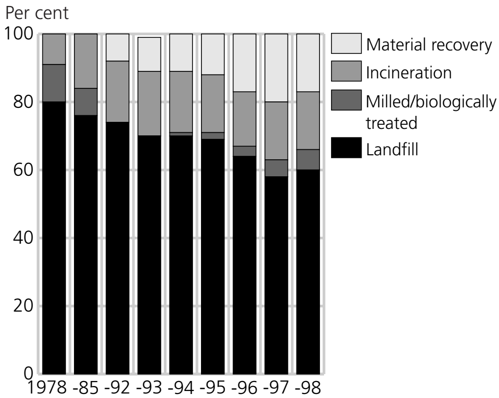
The quantities of hazardous waste generated by manufacturing industries rose from 320 000 tonnes in 1993 to 400 000 tonnes in 1996 (Statistics Norway 1997, 1998b). The rise from 1993 to 1996 can

Figure 8.6. **Total quantities of municipal waste**[1]



[1] Figures for 1993, 1994, 1996 and 1997 calculated on the basis of sample surveys. The figures are corrected for intermixture of industrial waste in household waste in the period 1992-1997.
Source: Waste statistics from Statistics Norway.

Figure 8.7. **Municipal waste according to method of treatment**



Source: Waste statistics from Statistics Norway.

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

8.3. Waste management

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. Some forms of treatment, such as material recovery and incineration combined with energy use, utilize the resources in the waste.

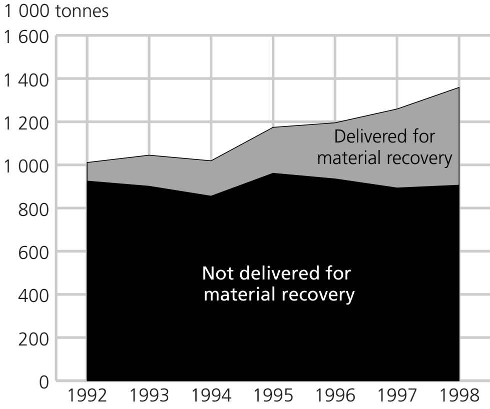
Municipal waste management

Statistics Norway's figures for municipal waste management include almost all household waste and a proportion of industrial waste. Industrial waste is only included in these statistics if the municipalities administer the collection scheme. In 1992, 1995 and 1998, 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 1998, municipal waste collection systems dealt with 2.79 million tonnes of waste (figure 8.6). This is a rise of more than 73 000 tonnes from 1997, and over 571 000 tonnes since 1992.

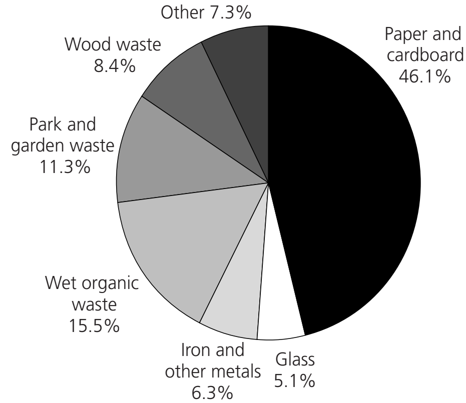
Most municipal waste is still disposed of in landfills. The quantity landfilled decreased until 1997, but rose by about 95 000 tonnes from 1997 to 1998 (figure

Figure 8.8. **Household waste, total and quantities delivered for material recovery**



Source: Waste statistics from Statistics Norway.

Figure 8.9. **Household waste delivered for material recovery[1], by material. 1998**



[1] Park and garden waste is composted: this is not strictly speaking material recovery, but is classified as biological treatment. See also figure 8.7.
Source: Waste statistics from Statistics Norway.

8.7). This was because the quantity of industrial waste dealt with in municipal collection schemes and used for material recovery dropped from more than 300 000 tonnes in 1997 to just under 190 000 tonnes in 1998. In 1998, the proportion delivered for material recovery was 17.3 per cent, or just over 480 000 tonnes (figure 8.7). The proportion of municipal waste incinerated has remained more or less the same from 1992 to 1998 (16-18 per cent), but the quantities disposed of in this way have risen because of the rise in overall waste generation. The proportion treated biologically has risen from under 0.5 per cent to about 6 per cent in the same period.

The proportion of household waste delivered for material recovery has risen from 9 per cent in 1992 to 33 per cent in 1998. The total quantity delivered for material recovery in 1998 was 452 000 tonnes, or 102 kg per capita. From 1997 to 1998, per capita material recovery rose by 19 kg, while the total quantity of waste generated rose by 21 kg per capita (Statistics Norway 1999c).

Paper, cardboard and beverage cartons made up by far the largest fraction of waste delivered for material recovery (46.1 per cent of the total). Figure 8.9 shows the various materials as proportions of the total recycled in 1998. See also table G3 in the Appendix.

A proportion of industrial waste is also processed through municipal waste collection schemes. In 1998, this totalled 1.44 million tonnes, a drop of more than 130 000 tonnes from 1996. Thirteen per cent of the industrial waste dealt with in municipal schemes was used for material recovery in 1998. This is a drop of almost 8 percentage points from 1997, and this is partly explained by the fact that a larger proportion of industrial waste is being delivered to private recycling companies.

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. The overall rise in material and energy recovery during the three-year period was relatively modest, from 57 to 63 per cent.

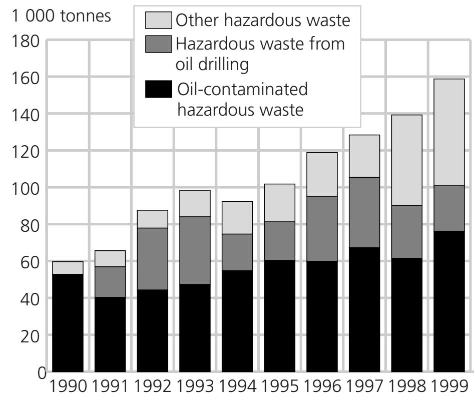
See *Natural Resources and the Environment 1998* (Statistics Norway 1998) for a more detailed discussion of the management of waste from manufacturing industries.

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 8.10 and tables G6 and G7 in the Appendix. In 1998, various categories of oily waste made up 44 per cent of the total and waste from oil drilling 28 per cent. The

Figure 8.10. **Quantities of hazardous waste delivered to the hazardous waste management system, main fractions**



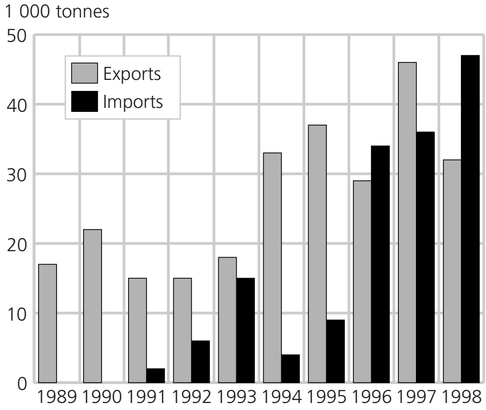
Source: Norsas (1999b).

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 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 (Norwegian Resource Centre for Waste Management and Recycling) and those from Statistics Norway on hazardous waste generated by Norwegian industry.

See *Natural Resources and the Environment 1998* (Statistics Norway 1998) for a

Figure 8.11. **Exports and imports of hazardous waste**



Source: Norsas.

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 1999, just over 275 000 tonnes of waste paper was exported. This is 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 33 000 tonnes of waste paper was imported (PIL 2000).

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 (figure 8.11). 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[1] from waste incineration in Denmark. This is delivered 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).

Other 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. There are now a number of companies involved in various recycling and collection schemes. See for instance *Natural Resources and the Environment 1998*, table 5.6.

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

Table 8.6. **Quantities of waste generated and proportion delivered for material recovery, by material**

	Paper and cardboard waste		Wood waste		Wet organic waste[1]		Plastic waste		Glass waste		Metal waste[1]	
	Quantity generated 1 000 tonnes	Recycling Percentage	Quantity generated 1 000 tonnes	Recycling Percentage	Quantity generated 1 000 tonnes	Recycling Percentage	Quantity generated 1 000 tonnes	Recycling Percentage	Quantity generated 1 000 tonnes	Recycling Percentage	Quantity generated 1 000 tonnes	Recycling Percentage
1985	829	16	..	..	..	..	..	..	..	..	..	..
1986	875	16	..	..	..	..	245	..	..	..	..	..
1987	873	18	..	..	..	..	258	..	..	..	..	..
1988	906	17	..	..	..	..	253	..	..	..	..	..
1989	860	19	..	..	..	..	267	..	..	..	..	..
1990	907	20	1 266	..	1 097	..	280	..	..	..	..	..
1991	928	23	1 213	..	1 186	..	294	..	..	..	..	..
1992	941	26	1 178	..	1 312	..	307	..	..	..	542	76
1993	931	29	1 185	..	1 413	29	324	..	117	27	459	84
1994	929	34	1 172	..	1 487	31	337	..	123	31	658	61
1995	926	37	1 158	..	1 572	35	353	0	136	23	507	102
1996	921	40	1 144	29	1 556	36	364	2	142	24	717	78
1997	990	44	1 153	..	..	..	368	2	134	25	..	..

[1] The figures for metal waste and wet organic waste are uncertain.
Sources: Waste statistics from Statistics Norway, Treforedlingsindustriens bransjeforening, Norsas and Directorate of Customs and Excise.

8.4. Waste accounts

Introduction

The objective of the waste accounts is to provide a better overview of waste quantities and streams in Norway. They are intended as a practical tool, for example in following trends in the quantities of important waste fractions and in verifying whether political goals are achieved. Accounts are drawn up for each material type (glass, metal, paper, etc.), and calculations are made of the quantity of each type generated annually, who generates the waste, which product types it consists of and how it is dealt with.

Table 8.6 shows the main results for some of the materials for which waste accounts have been prepared so far.

Paper and cardboard

Calculations using the supply of goods method show that the total quantities of waste paper rose from 1983 to 1988. During the first half of the 1990s, the quantities remained relatively 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, or 45 per cent (figure 8.12).

There have been changes in the treatment and disposal of waste paper during this period. Calculations show that in 1988, 67 per cent was landfilled and 17 per cent was used for material recovery. In 1997, 41 per cent of the waste paper was landfilled and 44 per cent used for material recovery. 1997 was the first year when more paper was used for material recovery than was landfilled. In the same year, 11 per cent of the waste paper was incin-

Box 8.3. Methods used in the waste accounts

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 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 January 2000, accounts had been developed and published for *paper and cardboard, glass, wet organic waste, metals, plastic and wood*.

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

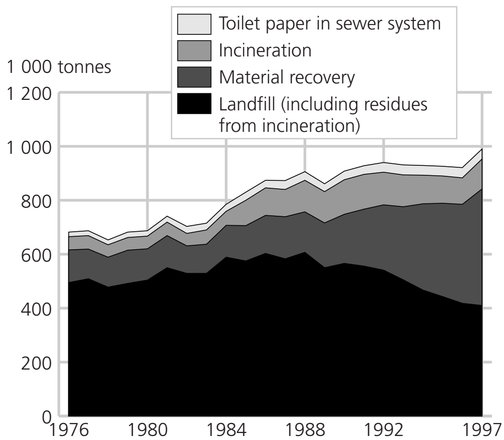
Two different methods have been used to estimate waste quantities. One might be called the "*supply of goods method*", and is a theoretical method of calculating waste quantities. It assumes that waste quantities are equal to the supply of goods after correction for the lifetime of the products. The supply of goods 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.

erated. See also tables G8–G10 in the Appendix.

The transition from typewriters to word processors and then computers does not appear to have resulted in a drop in paper consumption. For example, the annual quantity of waste generated from printed matter has risen by more than 100 000 tonnes from 1990 to 1997. Projections of waste quantities indicate that the quantity of waste paper will rise by almost 30 per cent between now and 2010 (Bruvoll and Ibenholt 1999) (see section 8.6).

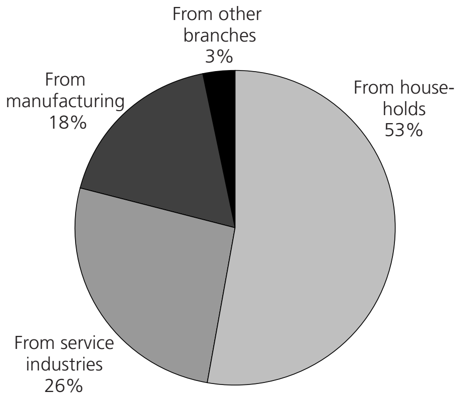
Private households generate the largest proportion of waste paper in Norway. In 1997, 53 per cent of all waste paper was generated by households, while service industries accounted for 26 per cent

Figure 8.12. **Waste paper by method of treatment/disposal**



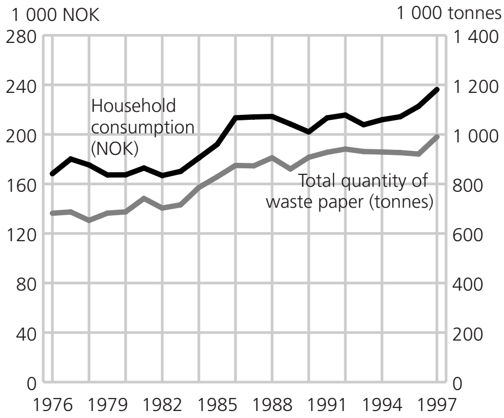
Source: Statistics Norway (1999a).

Figure 8.13. **Waste paper by origin. 1997**



Source: Statistics Norway (1999a).

Figure 8.14. **Relationship between household consumption[1] and quantities of waste paper and cardboard**



[1] Expenditure per household per year. Fixed 1997 prices.
Source: Statistics Norway (1998g and 1999a).

(figure 8.13). There have only been small changes in the proportions of waste paper generated by different sectors since 1985.

A preliminary analysis suggests that the quantities of paper and cardboard waste fluctuate with economic trends and private consumption. Even though the total quantity of waste paper and cardboard includes also industrial waste, the similarity with trends in private consumption is striking. Figure 8.14 compares total consumption expenses in an average household with the total quantity of waste paper and cardboard. This indicates that the quantity of waste paper rises when there is an economic upturn, and drops when there is a downturn.

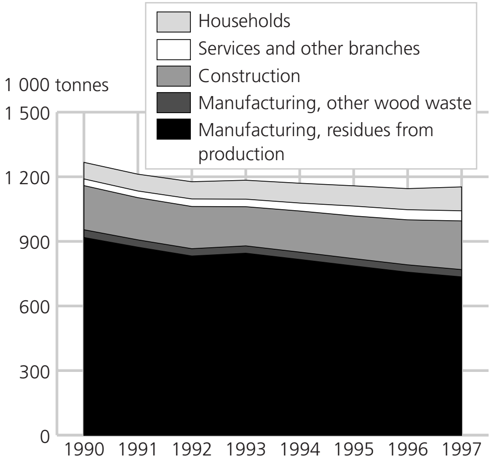
Wood

In 1997, slightly more than 1.15 million tonnes of wood waste was generated in Norway. Manufacturing industries are the most important source of this waste category. Wood waste from manufacturing accounted for 770 000 tonnes or 69 per cent of the total quantity in 1997 (see Appendix, table G13). An estimated 95 per cent of this is residues from production, i.e. plank ends, chippings, bark, pulp, etc. The construction industry accounted for 20 per cent of the total, and 10 per cent was generated by private households. A substantial proportion of wood waste from households is in the form of discarded furniture. The figures for private households are uncertain, particularly because there is insufficient information on furniture in household waste.

From 1990 to 1997, the quantity of wood waste in Norway decreased by 10 per cent, as a result of a drop in the quantity of waste generated by manufacturing industries. However, this trend is based on only two measurements, and is therefore somewhat uncertain.

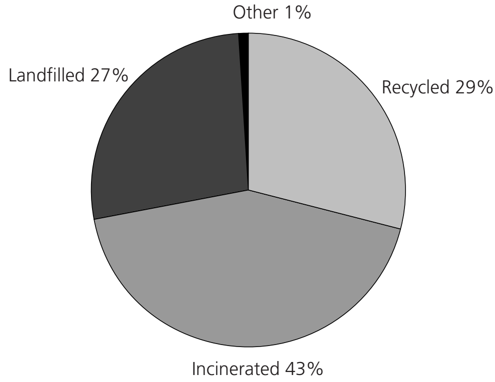
The amount of wood in consumer waste was 420 000 tonnes in 1997. The largest fraction of this was 225 000 tonnes from

Figure 8.15. **Wood waste by origin**



Source: Frøyen and Skullerud (2000).

Figure 8.16. **Wood waste by method of treatment/disposal. 1996**



Source: Frøyen and Skullerud (2000).

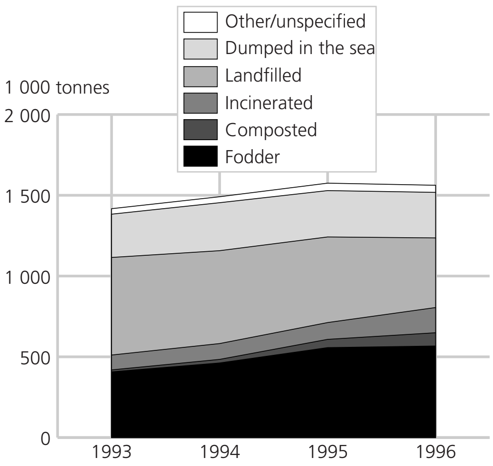
construction products. Construction waste also contains plank ends and other material that could be classified as scrap from production, but in the waste accounts we have chosen to consider all this as construction products. Much of the wood waste that is impregnated or surface-treated in some other way is generated as construction waste, but it is difficult to estimate how much from the currently available data. However, it is safe to assume that construction waste contains considerably more untreated than surface-treated wood waste.

The next largest group of products is furniture, which is also the group that has shown the largest rise during the period. The quantity discarded rose from 87 000 tonnes in 1990 to 128 000 tonnes in 1997, a rise of 47 per cent.

Packaging makes up a markedly smaller proportion of wood waste than of plastic and paper waste. However, the quantity of wood packaging rose by 26 per cent from 1990 to 1997, which is a much larger rise than for plastic and paper packaging (the quantity of plastic waste rose by 4 per cent and the quantity of paper waste decreased by 14 per cent during the same period). The most important types of wooden packaging are various types of boxes and pallets and cable drums.

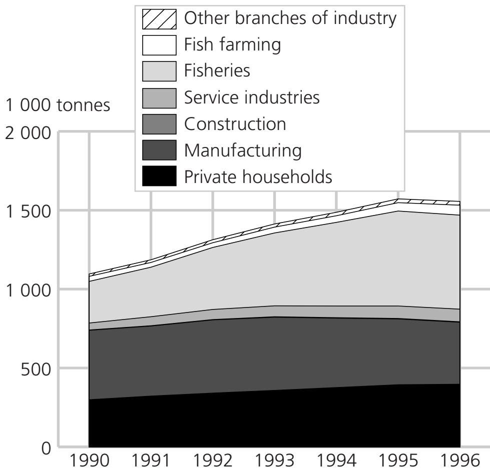
In 1996, 43 per cent of all wood waste was incinerated, most for energy recovery, and 29 per cent was used for material recovery. This includes the production of chipboard, the use of chippings as bedding for livestock and the use of bark in parks, etc. The production of wooden briquettes for fuel may in some cases have been classified as material recovery, even though this is in fact a form of energy recovery. Composting is classified as other treatment (Frøyen and Skullerud 2000).

Figure 8.17. **Wet organic waste by method of disposal**



Source: Statistics Norway (1998e).

Figure 8.18. **Wet organic waste by origin**



Source: Statistics Norway (1998e).

Wet organic waste

Wet organic waste is defined as readily degradable organic waste. This waste fraction generates the greenhouse gas methane if it is broken 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.

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. Calculations using the waste statistics method (see box 8.3) show that 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 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. This suggests that 1.5 million tonnes may be a minimum estimate and that the actual quantity is somewhat higher.

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 8.17). The quantity landfilled has dropped from about

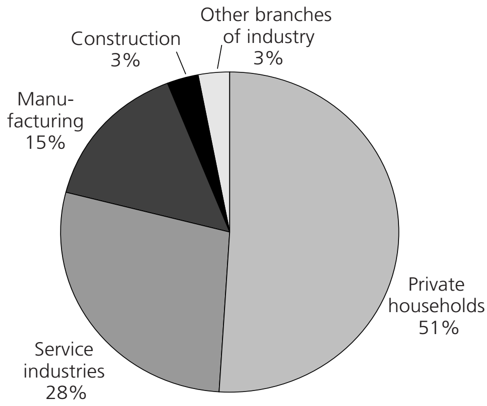
600 000 tonnes in 1993, while the quantity used for fodder production rose from 407 000 to 567 000 tonnes, and the quantity composted from 12 000 to 82 000 tonnes in the period 1993 to 1996.

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 8.18 and table G15 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 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 (Statistics Norway 1998e). It is expected that the quantity of wet organic waste landfilled will decrease steadily, as fewer licences will be granted for landfilling of this fraction in the future (Statistics Norway 1998e).

The quantity of wet organic waste is expected to rise by 31 per cent to about 2 million tonnes in 2010. This is a relatively high rate of growth, and is explained by the very strong growth of the fish farming industry and relatively strong growth of service industries that generate wet organic waste (Bruvoll and Ibenholt 1999).

Figure 8.19. **Plastic waste by origin. 1997**



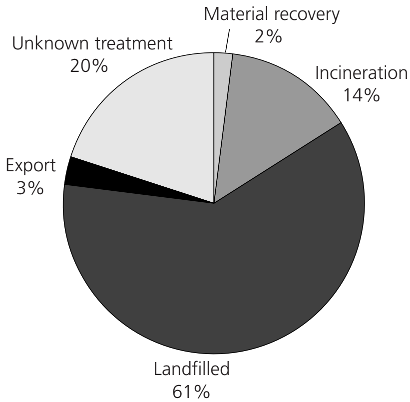
Source: Skullerud and Stave (2000).

Plastic

There has been steady growth in the quantities of plastic waste throughout the 1990s, and in 1997 more than 360 000 tonnes of plastic waste was generated in Norway. Between 1986 and 1997, the quantity of plastic waste generated in Norway rose by 50 per cent. The trend in recent years suggests that the growth in plastic waste is slowing.

Packaging makes up the largest fraction of plastic waste, and accounted for 23 per cent in 1997. This proportion has been almost unchanged since 1986. The only product category that has shown a relatively large rise during this period is sanitary and household products, which have risen by 350 per cent. The other product categories have followed the

Figure 8.20. **Plastic waste by method of treatment/disposal. 1997**



Source: Skullerud and Stave (2000).

general trend, with only a weak rise in quantities.

Plastic waste from households made up 51 per cent of the total quantity of plastic waste in 1997. Service industries accounted for 28 per cent, and manufacturing for 15 per cent of the total. The proportions contributed by the various sectors have not changed to any great extent during the 1990s. However, the figures for households and service industries show a drop from 1996 to 1997. The main reason for this was a large temporary increase in the refund payment for scrapped cars in 1996, which resulted in more than 200 000 vehicles being scrapped in 1996, as compared with 50 000–60 000 in a normal year. See table G17 in the Appendix.

Most of the plastic waste delivered is landfilled. The proportion used for material recovery is rising, and makes up 2 per cent of the total. The heat value of plastic is high, and a proportion of the 14 per cent incinerated is used for energy recovery. The figures for methods of treatment are relatively uncertain, and have so far only been calculated for the years 1995-1997. Since the time interval is so short and the figures are uncertain, it is difficult to draw any clear conclusions from the small changes the figures show between 1995 and 1997.

Glass

In 1998, 131 000 tonnes of glass waste was generated in Norway. According to the calculations, windows was the most important product group, and accounted for 37 per cent of the total. The other important product group is packaging, which made up 36 per cent of the total.

Households generate 42 and the construction industry generates 34 per cent of the total quantity of glass waste. Manufacturing industries generate 10 per cent. However, these figures are uncertain, since the figures from different sources do not agree. Service industries generate 12 per cent of the total.

Glass waste and its treatment only involve relatively minor environmental problems, since treatment generates hardly any emissions. In practice, there are only two ways of treating glass waste: material recovery or 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 26 per cent of the glass waste generated in Norway in 1998 was used for material recovery (see table G19 in the Appendix). This corresponds to almost 35 000 tonnes, and consists almost entirely of glass packaging. Only insignificant amounts of other product types are used for material recovery (Statistics Norway 2000g).

According to Statistics Norway's projections, the total quantity of glass waste will rise by just over 29 per cent between 1996 and 2010, and the projected quantity in 2010 is 157 000 tonnes (Bruvoll and Ibenholt 1999).

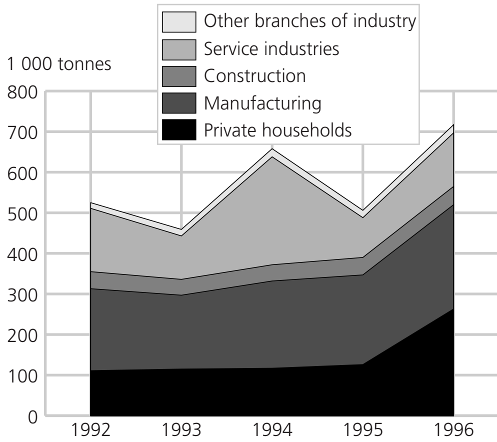
Metals

The metal accounts deal with all types of metal waste. Iron accounts for the largest quantities of metal waste. Calculations using the waste statistics method (see box 8.3) show that in 1996, slightly more than 700 000 tonnes of metal waste was registered in Norway. This is a rise of almost 200 000 tonnes from 1992.

The figures in the waste accounts for metals 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 (Statistics Norway 1998d).

Calculations using the supply of goods method (figures estimated from statistics on imports, exports and production of goods) suggest that the quantity of metal waste actually generated is three to four times higher than the reported figures (see Appendix, table G20). There may be several reasons for this. 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 calculations using the supply of goods method.

Figure 8.21. **Registered metal waste by origin**



Source: Statistics Norway (1998d).

Furthermore, some metal “disappears” through corrosion.
The most important sources of metal waste in Norway are manufacturing industries, private households and service industries (figure 8.21). 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. Calculations presented in Bruvoll and Ibenholt (1999) suggest that the total quantity of metal waste will rise by almost 20 per cent up to 2010.

About 70 per cent of the registered metal waste is delivered for material recovery.

Some of this (about 34 per cent) is exported before material recovery. Somewhat more than 20 per cent of the registered metal waste is landfilled, although this is sometimes done temporarily before material recovery. Manufacturing industries are the sector that uses the highest proportion of metal waste for material recovery (93 per cent in 1996).

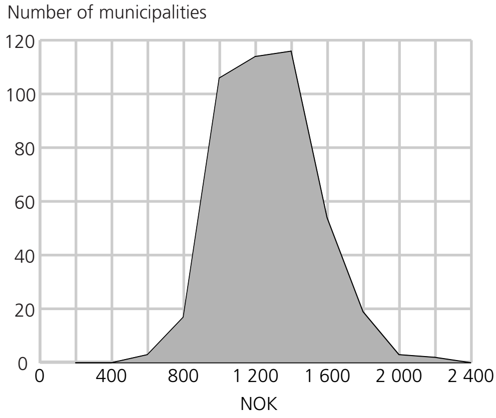
8.5. Municipal waste management fees

The fees charged by the municipalities for refuse collection and waste management vary widely. In 1998, the waste management fee ranged from about NOK 500 to over NOK 2 000 per household.

The average standard fee (the rate most commonly charged) has risen from NOK 981 in 1995 to NOK 1 182 in 1998 (the figures for 1995 have been corrected for the increase in prices, see Appendix, table G22). This corresponds to a rise of 20 per cent. The rise is related to the reorganization of municipal waste collection systems and a general increase in the collection and delivery systems offered.

In recent years, the environmental authorities have argued that waste collection fees should be graded, so that people who generate little waste or sort their waste pay a lower fee. This is in accordance with the polluter-pays-principle. Many municipalities have now introduced such systems. This means that households can pay lower waste management fees by reducing the amount of waste they generate or by sorting waste. Almost 50 per cent of all municipalities report that subscribers have the opportunity to choose between different services for which the fees vary. In many cases, subscribers who deliver little waste can choose cheaper systems. 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.

Figure 8.22. **Number of municipalities by the size of the standard waste management fee, 1998**



Source: Statistics Norway (1999f).

8.6. Projections of waste quantities and the environmental costs of waste management

Projections of waste quantities are used by municipalities, waste generators and the authorities in long-term planning of waste policy. We have projected the quantities of waste collected by the municipal waste management system, waste generated by manufacturing industries, and total generation of waste in Norway, all up to 2010.

The relationship between waste quantities and environmental damage is not linear. Technological advances and new treatment methods make it possible to remove more of the pollutants emitted by waste treatment. This means that other factors than waste quantities must also be taken into account in a consideration of future

Table 8.7. **Waste quantities in 1995 and projections of waste quantities up to 2010**

	Quantities (1 000 tonnes)		Growth (per cent)
	1995	2010	
Municipal waste, total	2 722	3 556	31
Industrial waste	1 460	1 725	18
Household waste	1 262	1 831	45
Total waste excluding stone, gravel and soil[1]	6 379[1,2]	7 819	23

[1] Figure for 1996.
[2] The total amount of waste presented in table 8.3 (6 658 000 tonnes) has been updated with the most recent figures in the waste accounts.
Source: Bruvoll and Ibenholt (1999).

environmental pressures related to waste. We have therefore also made estimates of the environmental pressures due to final waste treatment up to 2010.

The driving forces behind the rise in waste quantities are general economic growth and its distribution between sectors, and trends in private consumption. The projections of waste quantities are based on economic projections using about the same rate of growth as in the latest long-term programme. The most recent years for which data on the waste quantities generated are available are used as the base years. For municipal waste, the projections show that generation of household waste will grow at the same rate as consumption of goods, i.e. by 45 per cent in the period 1995–2010, see table 8.7. The annual rate of growth for Per capita generation of household waste is expected to rise more slowly than it has for the last thirty years. The total quantity of industrial waste is expected to rise by 18 per cent.

The projections also include an estimate of total waste generation in Norway. From1996 to 2010, total waste quantities are expected to rise by 23 per cent, excluding stone, gravel and soil, etc. If stone, gravel and soil, etc, are regarded as waste, the expected rise during the same period is 17 per cent. The total quantity of waste generated is expected to rise at a lower rate than general economic growth (34 per cent), since the rate of growth of factors related to waste generation (consumption, production and factor inputs) is expected to be lower than economic growth.

New projections have also been made for waste generation by manufacturing industries. Some of this waste will be delivered to municipal facilities, and will therefore also be included in the projections for municipal waste. Total quantities of production and consumption waste generated by manufacturing industries have been calculated for 1996–2010, and are expected to rise by 16 per cent during this period.

The environmental pressure exerted by waste incineration is expected to be reduced by almost 50 per cent from 1997 to 2010. This estimate is based on the assumption that the quantity of waste incinerated will rise at the same rate as the quantity of municipal waste, and that the best available technology for controlling emissions is used at all times. Emissions of heavy metals and other environmentally hazardous substances will decrease by more than the average figure, while emissions of NO_x and SO_2 will be halved. Emissions of CO_2 are expected to rise, since no technology for CO_2 removal is available as yet. Emissions of landfill gas are based on Norconsult (1999), and are estimated to remain more or less unchanged.

Project financed by: Ministry of the Environment.

Project documentation: Bruvoll, A. and K. Ibenholt (1999).

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

More information on waste statistics and waste analyses may be obtained from: Øystein Skullerud, Kristin Aasestad, Svein Erik Stave, Barbara Kupis Frøyen, Nina Arnesen, Annegrete Bruvoll and Olav Skogesal.

9. Water supplies and waste water treatment

Norway has plentiful supplies of water. Water supplies in Norway are characterized by widespread use of surface water. Thus, the increased pressure on water resources due to population growth, urbanization and industrialization often leads to microbiological pollution of drinking water sources. Owing to poor municipal economy, combined with low priority, many small water works do not have the required hygienic safety.

Discharges of waste water, which contains nutrients such as phosphorus and nitrogen, often result in 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. Between 1985 and 1998, the local authorities managed to reduce discharges of phosphorus and nitrogen to the North Sea by 61 and 13 per cent respectively. These reductions were achieved through the construction of sewer systems and advanced waste water treatment plants. The costs of collecting and treating waste water are covered largely through municipal fees. Sewage sludge is a resource for agriculture because it contains nutrients and organic material. In 1998, 68 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.

9.1. 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.

Drinking water is often described as our most important foodstuff and it is of vital importance to our health and life style and to the whole of modern society. Good water and sufficient water is therefore a primary objective of water supplies. The drinking water regulations (Ministry of Health and Social Affairs 1995) require all water works supplying more than 100 persons or 20 households or holiday homes or supplying water to food manufacturers, health institutions, etc. to be approved by the authorities. Present status shows that very many water works have still not been approved and many do not have the water disinfection facilities required by the regulations (Norwegian Food Control Authority 2000).

Discharges of phosphorus and nitrogen from the waste water treatment sector have been a matter of concern for many years, because these nutrients play an important role in eutrophication of rivers, lakes and coastal areas. Eutrophication leads among other things to excessive growth of algae and oxygen depletion. Sewerage systems 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 eutrophication and periodical algal blooms. In addition, Norway has signed the North Sea Agreements, 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 removed so successfully 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 two 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.

9.2. Water supplies and water consumption

The National Institute of Public Health collects data each year, on behalf of the central authorities, from water works which supply at least 100 permanent residents or 20 households or holiday homes. In 1994 and 1998 it also carried out an overall assessment of the quality of the water supplied. A satisfactory water supply is defined on the basis of assessments of the water works' infrastructure, of the pollution situation in the catchment areas of the water sources, and of whether the treatment plants can guarantee a good quality of water. The municipal food control authorities and health services supervise the water supply facilities and the water supplied by the water works, and are therefore also informed about the status of water supplies at the local level.

As of 31 December 1998, 1 800 water works were registered as supplying permanent residents. Another 43 water works were registered as only supplying water to holiday homes. Of the 1800 water works, 1075 were municipal, 16 were inter-municipal, 707 were privately owned and 2 were state-owned (table 9.1). These water works supplied about 3.95 million persons, or 89 per cent of the

Table 9.1. **Number of water works and number of persons connected to water works of different sizes, by type of ownership. Whole country. 1998**

Size of water works by no. of persons supplied	Total		Municipal water works		Inter-municipal water works		Private water works		State-owned water works	
	No. of water-works	No. of persons	No. of water-works	No. of persons	No. of water-works	No. of persons	No. of water-works	No. of persons	No. of water-works	No. of persons
Total	1 800	3 948 100	1 075	2 894 500	16	813 600	707	239 600	2	400
Percentage	100%	100%	60%	73%	1%	21%	39%	6%	0%	0%
0–99	323	19 900	127	8 000	-	-	195	11 800	1	100
100–999	1 042	338 000	585	213 200	-	-	455	124 500	1	300
1 000–19 999	387	1 313 100	329	1 178 500	7	31 300	51	103 300	-	-
20 000–	42	2 277 100	33	1 494 800	9	782 300	-	-	-	-
Unknown size	6	..	1	..	-	-	5	..	-	-

Source: National Institute of Public Health.

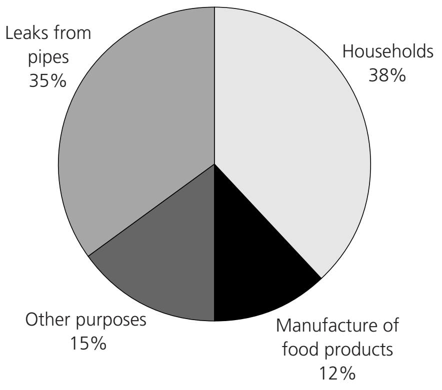
Norwegian population. In addition to these water works, there are a large number (4000-5000) of water supply systems which supply water to individual enterprises, such as abattoirs, hotels, camping sites, schools, etc., but there is little information available about them. It can be seen from the table that about 75 per cent of the water works supplied fewer than 1000 persons each. Forty-two water works supplied more than 20 000 persons and collectively they supplied water to more than half of the population. The remainder of the population are supplied by smaller water works, or take water from their own wells, rivers and lakes.

In 1996, the total water production at Norwegian water works was estimated to be around 860 million m^3. Norwegian water works mainly use surface water for water supplies. 67 per cent of the water works used surface water as the source of water in 1998, while 33 per cent used groundwater as their source of water (National Institute of Public Health 2000). Nevertheless ground water only constitutes 12-13 per cent of total water production (National Institute of Public Health 1998).

The drinking water regulations contain the stipulation that all water must be disinfected or treated to prevent infection. About 450 of the water works which are based on surface water still do not have the required disinfection facilities. Most of the water works without disinfection facilities are located in the counties of Hordaland, Møre og Romsdal, Sør-Trøndelag, Nordland and Troms. In some cases, the quality of the ground water is so good and so stable that exemptions are made from the requirement regarding disinfection. Most of the ground water works are relatively small in size and the number of persons supplied with ground water is thus proportionately smaller than those supplied with surface water. A large proportion of the water works in the counties of Hedmark, Oppland, Buskerud and Vestfold use ground water as a source of water.

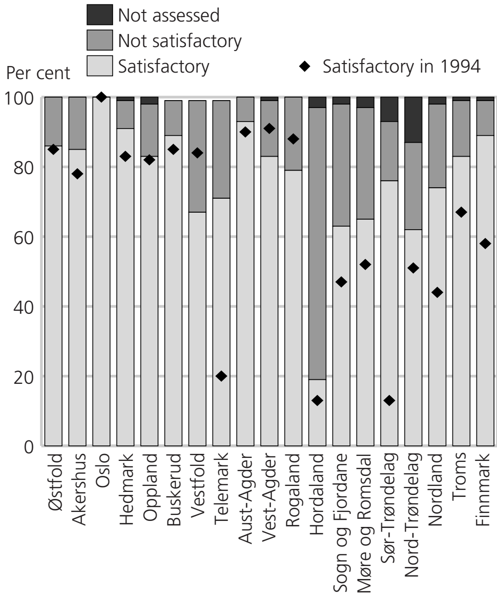
Although it only represents a small proportion of total consumption, ground water is often a better alternative than

Figure 9.1. **Distribution of water production from Norwegian public water works. 1996**



Source: National Institute of Public Health.

Figure 9.2. **Percentage of the population with a satisfactory or not satisfactory water supply. By county. 1998**



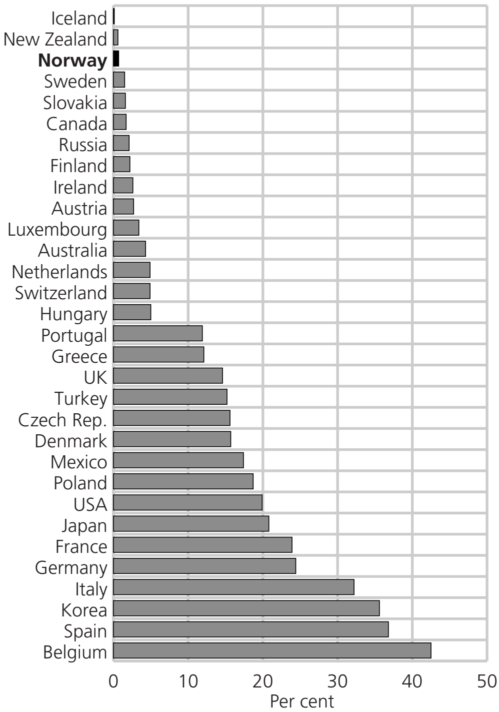
Source: National Institute of Public Health.

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, which is largely due to the lack of clean surface water.

Figure 9.1 shows how water production from public and private water works is utilized. It is important to note that many industrial enterprises have their own water supply. This means that the food manufacturing industries, where many enterprises are supplied with water from their own facilities, use far more water than can be seen from the figure. Private households account for the largest proportion of consumption at 275 million m^3 (38 per cent) or about 230 litres per connected person per day. It should however be noted that more than one third of the water supplied by water works is lost by leaks from pipes and joints. There is some uncertainty associated with these figures, and in particular with the quantity of water lost through leaks, which may be somewhat higher than shown here.

An investigation of the quality of the water supplied by public and private water works (National Institute of Public Health 2000) showed that much remains to be done here. As of 31 December 1998, about 770 of the 1 800 water works (43 per cent) were still supplying water of unsatisfactory quality according to the criteria set out for water intake, hygiene, water treatment and water quality (figure 9.2). These water works supplied 22 per cent of the population connected to water works. A similar survey carried out in 1994 showed that water production at as many as 62 per cent of the water works was unsatisfactory. In 1994 these works

Figure 9.3. **Percentage of total water resources utilized by selected countries**



Source: OECD (1999).

supplied 34 per cent of the population connected to water works. In 1998, 76 per cent of the population were connected to water works with satisfactory water supplies, while the corresponding figure in 1994 was 66 per cent. In other words, there has been an improvement in the country as a whole.

The most important measures for improving the quality of water supplied by a water works are removal of humus and disinfection. It is generally the small water works that fare badly in surveys. It has long been the view that the quality of the water in Norway is entirely satisfactory and that it is therefore not necessary to invest in water treatment equipment to improve it. The small private water works have often given higher priority to keeping water charges low than to investing in adequate water treatment.

Industry and agriculture are also large consumers of fresh water, but are largely self-sufficient. Using factors deriving from investigations in Sweden as a basis, water consumption in Norwegian industry has been estimated at 1 280 million m^3. In the agricultural sector, most water is used for livestock and irrigation of crops. The climate means that the need for irrigation in Norway is low compared with some other European countries and preliminary figures issued by Statistics Norway indicate that total water consumption in agriculture is about 265 million m^3. There is a great deal of uncertainty associated with these figures.

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 Norway corresponds to well under 1 per cent of the water resources available (figure 9.3). However, there are major regional differences here. By way of comparison, it is worth mentioning that countries such as Belgium and Spain utilize 43 and 37 per cent respectively of total water resources (OECD 1999).

The consumption of water is assumed to be closely connected with changes in the economy of the country. Industry flourishes in times of prosperity and, since industry is the largest consumer of water, consumption rises. It is not known which factors affect household consumption, but as more and more households start paying for water according to measured consumption, the price of water may

Table 9.2. **Inputs of phosphorus and nitrogen to Norwegian coastal waters from agriculture, industry and municipal waste water. 1998**

		Phosphorus		Nitrogen	
	Number of inhabitants	Total input tonnes	Per capita input, kg	Total input tonnes	Per capita input, kg
Whole country	4 420 000	6 431	1.45	62 918	14.23
- North Sea area[1]	2 250 000	610	0.27	20 625	9.17
- Area around the inner Oslofjord and catchment area of river Glomma[2]	1 450 000	302	0.21	11 673	8.05

[1] Sensitive area for phosphorus, see box 9.1.
[2] Sensitive area for nitrogen, see box 9.1.
Sources: Statistics Norway and Borgvang and Tjomsland (2000).

become one of the factors affecting consumption.

9.3. 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 (North Sea Agreements, see Box 9.1) are being achieved. These calculations use discharge figures for waste water, agriculture, aquaculture and industry, and take into account retention in fjords and river systems.

In 1998, total Norwegian anthropogenic inputs of nutrients to the Norwegian coast from agriculture, industry, aquaculture and waste water were calculated to be of the order of 6 430 tonnes of phosphorus and 63 000 tonnes of nitrogen (Borgvang and Tjomsland 2000), see Appendix, table H1. Discharges of waste water accounted for 20 and 29 per cent respectively of the total anthropogenic inputs of phosphorus and nitrogen in 1998. Table 9.2 shows discharges for the whole country and for the two regions to which international agreements on reductions apply.

The great variation in discharges of phosphorus per inhabitant between Eastern Norway and the rest of the country is due firstly to the fact that most of the fish farms in Norway are located on the coast from Rogaland northwards. Fish farms were responsible for 66 per cent of total discharges of phosphorus in 1998. Secondly, the pollution control authorities have set different standards for waste water treatment because conditions in recipients in these areas vary a great deal. This has resulted in the investment of substantial resources in the treatment of waste water and industrial discharges in areas draining to the North Sea and the Skagerrak and measures to reduce runoff from agriculture in the same area (see Chapter 3).

Figure 9.4 and Appendix, table H2 show how the different sectors contributed to inputs of phosphorus and nitrogen to the North Sea from 1985 to 1998. Since inputs from fish farms are marginal in the North Sea area, this sector has been excluded from the figure. Inputs of phosphorus and nitrogen from municipal waste water were reduced by 61 per cent and 13 per cent respectively from 1985 to 1998. The corresponding reductions in total discharges from all sectors (except

Box 9.1. Definitions. Treatment plants, etc.

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 population equivalents (P.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 P.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 private plants in areas with scattered settlements).

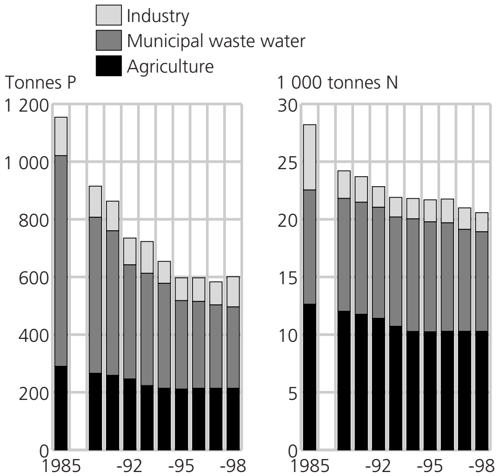
The North Sea counties (or region) are the counties from Østfold to Vest-Agder, which drain almost entirely into the Skagerrak or the North Sea.

The North Sea Agreements
The North Sea Agreements refer to the joint declarations made by the countries round the North Sea to reduce the pollution of the North Sea. One of the targets was to halve the total inputs of the nutrients nitrogen and phosphorus during the period 1985 to 1995. Since these targets were not achieved by the end of 1995, the time limit was extended to 2005. As of 1998, phosphorus inputs to the North Sea had been reduced by 48 per cent in relation to the 1985 level.

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 the border with Sweden 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, the eastern parts of Vest-Agder and the south-eastern parts of Sør-Trøndelag.

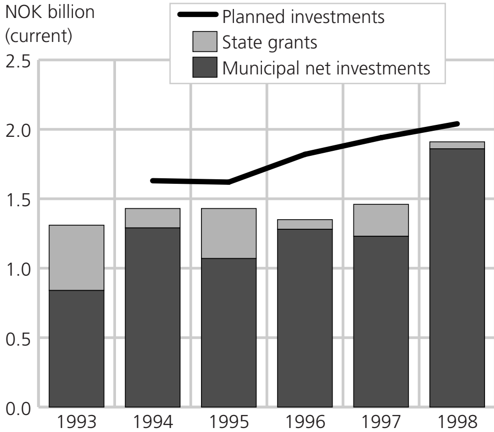
The sensitive area for nitrogen includes all land that drains to the inner Oslofjord and the coastline from the border with Sweden to Strømtangen lighthouse (the catchment area of the river Glomma). In this area, the authorities have given priority in recent years to the development of nitrogen removal processes at certain large waste water treatment plants.

Figure 9.4. **Norwegian anthropogenic inputs of phosphorus (P) and nitrogen (N) to the coastal zone from the border with Sweden to Lindesnes (the North Sea area)**



Source: Borgvang and Tjomsland (2000).

Figure 9.5. **Gross investments planned and carried out in 1993-1998. Municipal waste water treatment sector**



Source: Waste water treatment statistics from Statistics Norway.

fish farms) were 48 and 26 per cent respectively.

9.4. Economy of the waste water treatment sector

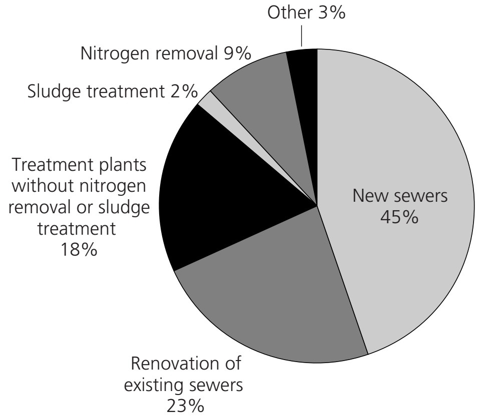
According to the North Sea Agreement, which is a significant driving force as regards the treatment of waste water, inputs of phosphorus and nitrogen are to be reduced by half between 1985 and 2005. As a result of major investments in chemical treatment plants, a far greater reduction has been achieved in the discharges of phosphorus than of nitrogen. In order to meet the target of a 50 per cent reduction in discharges of nitrogen, total investments in waste water treatment plants with nitrogen removal facilities were increased in 1998 to NOK 167 million for the country as a whole, compared with NOK 5 million in 1997. Total gross investments in the municipal waste water treatment sector amounted to NOK 1.91 billion in 1998. Total costs to the municipalities were NOK 3.62 billion, while about NOK 3.46 billion was collected in the form of waste water treatment fees.

Investments

Total gross investments, which include sewer systems and waste water treatment, increased by 31 per cent from NOK 1.46 billion in 1997 to NOK 1.91 billion in 1998 (current NOK). This is the highest figure since 1993 when the statistics were started (figure 9.5). The steep growth in investments is largely due to the recommencement after prolonged delays of the construction of nitrogen removal facilities in Oslo.

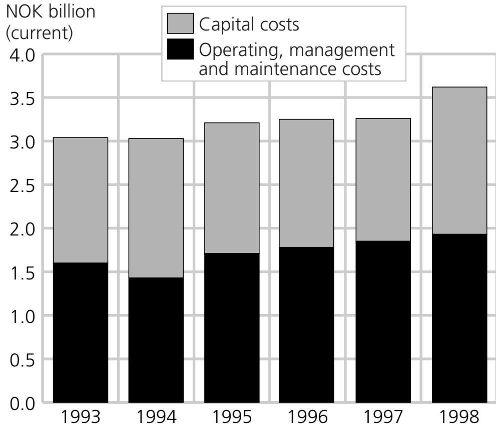
For the country as a whole, 93 per cent of planned investments were carried out in 1998 (Appendix, table H8). By way of comparison, between 71 and 88 per cent were carried out between 1994 and 1997. Most of the investments are still in sewer systems, i.e. new sewers and renovation

Figure 9.6. **Gross investments by category. Municipal waste water treatment sector. Whole country. 1998**



Source: Waste water treatment statistics from Statistics Norway.

Figure 9.7. **Total annual costs in the municipal waste water treatment sector, whole country**



Source: Waste water treatment statistics from Statistics Norway.

of existing sewers (figure 9.6). These amounted to 68 per cent of total investments in 1998. Measured as a percentage, this is a fall from the previous year because investments in nitrogen removal facilities increased so steeply. Investments in nitrogen removal processes in treatment plants accounted for 9 per cent in 1998, as against only 0.4 per cent in 1997. Investments in treatment plants without nitrogen removal processes accounted for 18 per cent and sludge treatment facilities for 2 per cent.

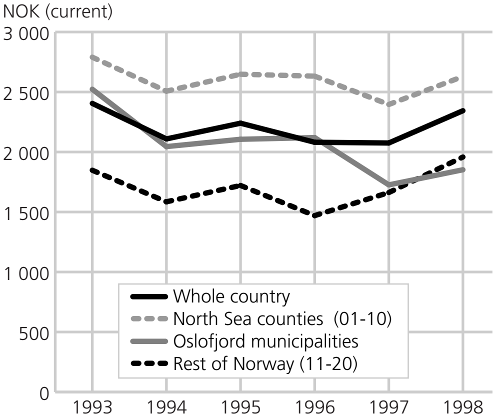
Finnmark was the county with the lowest total gross investments between 1995 and 1998. Investments were highest in Hordaland, which also had the highest gross investments per subscriber. In 1998 Hordaland had total investments of NOK 301 million, NOK 189 million of which was spent on new sewers. Oslo saw a large increase in investments in 1998 due to the nitrogen removal facilities mentioned above. As regards investments per subscriber, Oslo was lowest in 1995, 1996 and 1997, while Sør-Trøndelag was lowest in 1998. The North Sea counties showed the same trend as the national average as regards gross investments per subscriber. No state grants were allocated in 1998, but previously promised grants were disbursed.

Costs

The annual costs incurred by the municipalities consist of operating, management and maintenance costs plus capital costs (depreciation and interest on investments).

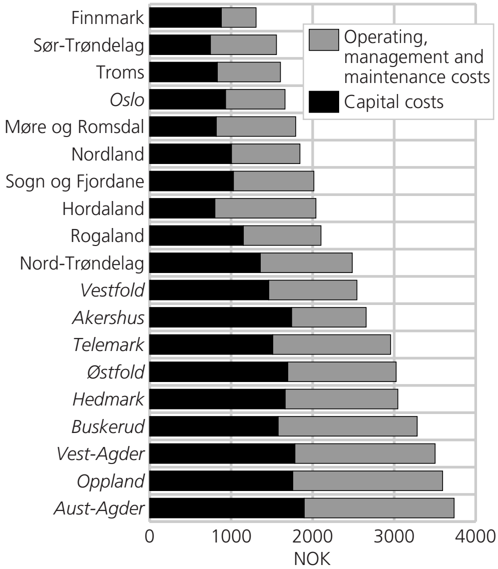
In 1998, the waste water treatment sector cost the municipalities a total of NOK 3.62 billion (figure 9.7). This is an increase of 11 per cent compared with the year before. Operating, management and maintenance costs have remained stable and amounted to NOK 1.93 billion, while capital costs increased by 20 per cent to NOK 1.69 billion. This increase can be

Figure 9.8. **Annual costs per subscriber in the municipal waste water treatment sector**



Source: Waste water treatment statistics from Statistics Norway.

Figure 9.9. **Annual costs per subscriber in the municipal waste water treatment sector. County. 1998. (North Sea counties in italics)**



Source: Waste water treatment statistics from Statistics Norway.

ascribed to heavier investments and higher interest rates.

Annual costs increased in all the counties from 1997 to 1998 (Appendix, table H9). Hordaland had the largest increase at 21 per cent. Total costs were however highest in Oslo and Akershus, which both had costs totalling about NOK 430 million. In the case of Oslo, this was due to investments in nitrogen removal facilities.

The costs per subscriber also rose in all the counties, with the exception of Troms (figure 9.8 and Appendix, table H10). However, 1997 was an “exception” with generally lower annual costs than the year before. The picture for the last six-year period is not clear. At county level, the average annual costs per subscriber varied from NOK 1 305 to 3 735 in 1998 (figure 9.9). On a municipal basis, annual costs per subscriber varied between NOK 95 and 15 027, but most of the municipalities had annual costs of less than NOK 4 000. The standard deviation is relatively large. This may be because some municipalities saw a steep increase in investments in 1998. This will have a substantial effect on annual costs per subscriber in these municipalities.

Fees

Connection fees (non-recurring fees) and annual fees are the municipalities’ income from the waste water treatment sector.

For the country as a whole, the average connection fee rose from NOK 8 836 in 1994 to NOK 12 267 in 1999 (Appendix, table H10). In the North Sea counties (from Østfold to Vest-Agder), this figure rose from NOK 10 000 in 1994 to NOK 15 717 in 1999, while for the remainder of the country, it rose from NOK 8 069 to NOK 9 936. However, there are marked differences between the municipalities as regards connection fees. The difference between municipalities in the same county can be as large as NOK 80 000.

The municipalities fix annual fees on the basis of the size of the subscriber's dwelling or measured water consumption. The average rate of the annual fee (by municipality) for the whole country for a dwelling of 140 m² was NOK 1 934 in 1999, as against NOK 1 770 in 1998. This is a growth in real terms of 7 per cent from 1998 to 1999. In 1994, the average annual fee was NOK 1 073. In the North Sea counties, the average annual fee rose from NOK 1 376 in 1994 to NOK 2 543 in 1999, while in the rest of the country the average rose from NOK 872 to NOK 1 536 in the same period.

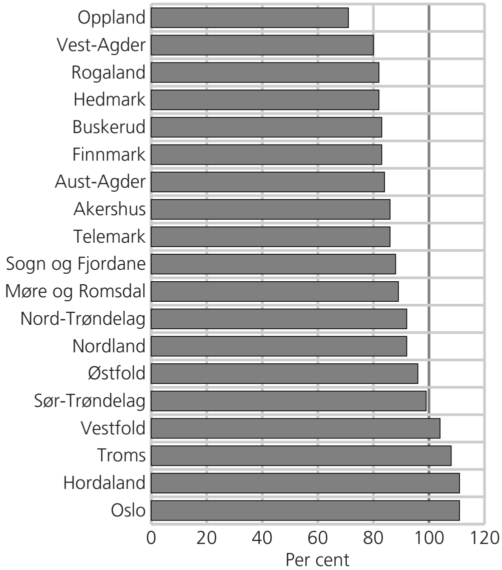
Income from fees

In 1998, the municipalities collected NOK 3.46 billion in total waste water treatment fees (Appendix, table H9). The municipalities' income from fees increased for the country as a whole and in 18 out of 19 counties. The growth in real terms for the country as a whole was 3 per cent compared with the year before. Income from connection fees amounted to NOK 255 million. This is just under 8 per cent of the municipalities' income from fees. The remainder consists of annual fees.

Income-to-cost ratio

The income-to-cost ratio shows how much of the annual costs are covered by the fees. The fees collected by a municipality are not supposed to exceed its annual costs over time. The municipalities are free to choose whether they will collect a lower fee. The income-to-cost ratio for the country as a whole was 95 per cent in 1998. The corresponding

Figure 9.10. **Ratio between income from fees and annual costs (income-to-cost ratio) in the counties. Municipal waste water treatment sector. Average for the period 1993-1998**



Source: Waste water treatment statistics from Statistics Norway.

figures for the years 1993 to 1997 were 77, 91, 92, 95 and 102 per cent. In 1998, 40 per cent of Norway's 435 municipalities covered more than 100 per cent of their waste water treatment costs from income from fees.

At county level, Oslo, Vestfold, Hordaland and Troms stand out, because they have repeatedly had a higher income-to-cost ratio than the other counties since 1993 (figure 9.10 and Appendix, table H9). In 1998, two of these counties, Vestfold and Hordaland, had acceptable cost-to-income ratios as stipulated by the regulations issued by the Ministry of Environment.

Twelve per cent of the municipalities had an income-to-cost ratio of 50 per cent or less, 38 per cent had a ratio of between 51 and 90 per cent, while 23 per cent had

Box 9.2. Definitions. Costs, fees, etc.

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

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

The **annual cost per subscriber** for the whole country or by county is calculated as total costs divided by the number of subscribers. This means that large municipalities weigh more than small municipalities.

The **rate of the average annual fee** (by municipality) is calculated as 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 every municipality weighs the same.

Costs of operation, management and maintenance. These include the municipality's share of the cost of managing inter-municipal plants.

Capital costs consist of depreciation and interest on investments. Investments are costs that are depreciated over a number of years. Capital costs are calculated as an annuity based on a depreciation period of 20 years for the investments and an interest rate 1 percentage point higher than the annual average interest on a loan from the Local Government Bank of Norway with a term of 20 years (annual average). The extra 1 per cent is added to take risk into account. For 1998 onwards the interest rate has been set at 5.11 per cent + 1 percentage point

an income-to-cost ratio of between 91 and 110 per cent. The remaining 27 per cent had an income-to-cost ratio of 111 per cent or more. We find 35 per cent of the population in municipalities with an income-to-cost ratio of more than 110 per cent.

9.5. Sewerage systems, discharges and waste water treatment

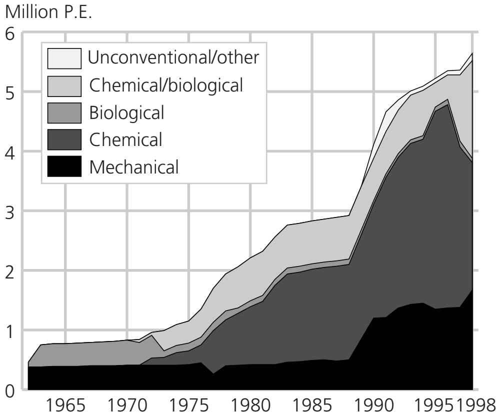
Waste water treatment plants and treatment capacity

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, at the beginning of the 1970s it became more common to build plants which also include a chemical purification process to remove phosphorus. In recent years, the emphasis has been on building separate nitrogen removal facilities at some of the larger plants in Eastern Norway. A further two plants with nitrogen removal facilities will be built in the next few years, and this will reduce the discharge of nitrogen to vulnerable coastal areas considerably.

Figure 9.11 shows a sharp increase in hydraulic capacity in 1988-1990, but only part of this is a real increase. Part of the reason for the apparently large increase in capacity is that during this period the authorities started to register plants with strainers and sludge separators as mechanical treatment plants.

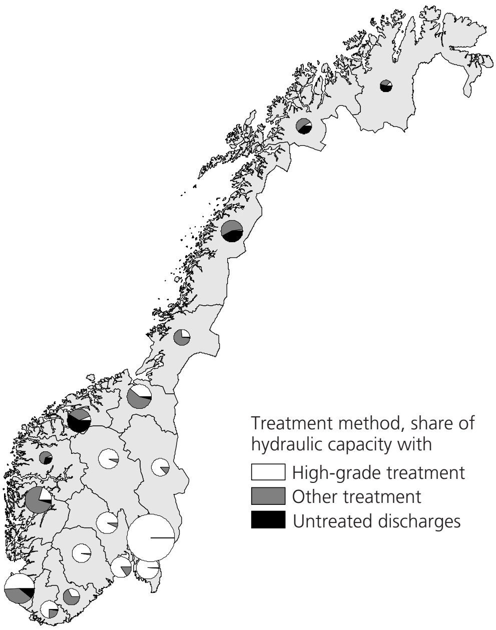
In Norway, the most important means of preventing excessive algal growth in fjords and river systems is the reduction of phosphorus inputs, and substantial resources have therefore been invested in chemical treatment of waste water, which is necessary to remove phosphorus. This resulted in a large increase in chemical and chemical/biological treatment capacity during the 1990s. Other European countries have considered the removal of organic matter to be more important and thus make more use of biological treatment.

Figure 9.11.**Hydraulic capacity by treatment method**



Source: Waste water treatment statistics from Statistics Norway.

Figure 9.12. **Hydraulic capacity at municipal sewerage systems, by treatment method[1]. 1998**



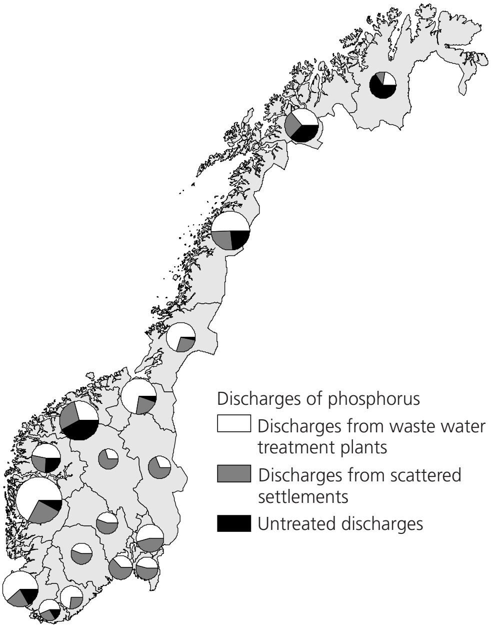
[1] High-grade plants are plants with chemical and/or biological treatment.
Source: Waste water treatment statistics from Statistics Norway.

In 1998, 2 738 municipal and private waste water treatment plants with a treatment capacity of at least 50 population equivalents (P.E.) were registered in Norway. Their total treatment capacity was just under 5.64 million P.E. In addition, just over 500 sewerage systems with direct discharges of untreated sewage were registered, and these had a total capacity of 0.63 million P.E. In Eastern and Southern Norway, a large proportion of municipal waste water is treated in high-grade (chemical and/or biological) treatment plants (figure 9.12). Such plants account for 91 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 H3 and H4.

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. The addition of estimated figures for the remaining municipalities brings the total length of sewers up to about 35 800 km (corresponding to 89 per cent of the earth's circumference at the equator). Waste water sewers account for 48 per cent of this, storm water sewers for 21 per cent and combined sewers for 31 per cent. As regards materials, 46 per cent of the sewers are made 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).

Figure 9.13. **Discharges of phosphorus from sewerage systems by county. 1998**



Source: Waste water treatment statistics from Statistics Norway.

No information on sewer systems has been collected since 1996 and, as some of the data reported in earlier years were incomplete, it is difficult to give quantitative information on the current situation and trends. However, almost 68 per cent of investments in 1998 were used on the sewer system (figure 9.6). There is reason to believe that individual municipalities have more information on their sewers (length, type and age) than Statistics Norway has received.

Discharges from municipal sewerage systems

Slightly less than 80 per cent of the population of Norway are connected to municipal waste water treatment plants or to municipal sewers that discharge untreated waste water. In 1998, total discharges of phosphorus from municipal sewerage systems were calculated to be about 816 tonnes, and the average treatment efficiency was 66 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 119 tonnes of phosphorus, or about 15 per cent of the country's total discharges from municipal sewerage systems.

As 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 700 tonnes of phosphorus was discharged from these plants in 1998. The average treatment efficiency in this area was calculated to be 29 per cent.

Many areas have sewerage systems that discharge untreated waste water. More than 500 of these sewerage systems were registered in 1998, mainly in the counties of Sogn og Fjordane, Møre og Romsdal, Nordland, Troms and Finnmark. It is calculated that these sewerage systems discharged about 208 tonnes of phosphorus in 1998, or as much as 25 per cent of the total discharges of phosphorus from municipal sewerage systems. Most of this phosphorus is discharged to marine recipients such as fjords and open coastal waters.

Of a total quantity of about 2 400 tonnes of phosphorus entering waste water treatment plants, about 1 580 tonnes was removed. This is retained as a component of sewage sludge, and is subsequently used in, for example, integrated plant nutrient management. Figure 9.15 summarizes material flows for phosphorus in waste water.

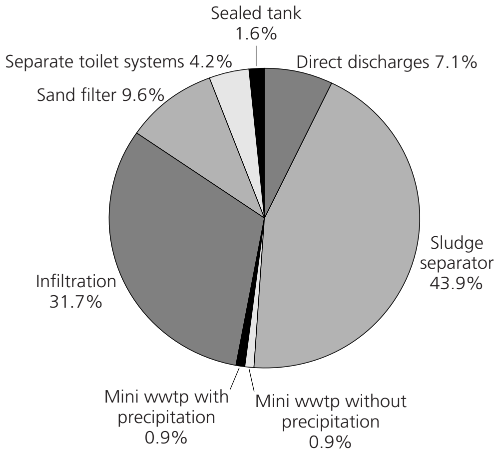
Discharges from separate waste water treatment plants (scattered settlements)

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 1998, total discharges from these were calculated to be 354 tonnes of phosphorus (figure 9.15). The average treatment efficiency was about 34 per cent, which means that about 180 tonnes of phosphorus was retained by these treatment plants. Sludge separators (43.9 per cent of all plants) and infiltration (31.7 per cent) are the most common treatment methods for waste water from scattered settlements (figure 9.14).

The statistics for scattered settlements only include permanent residents. They do not include discharges from holiday homes (cabins). Discharges from holiday homes vary considerably in quantity from one municipality to another, depending on the number of holiday homes and how much they are used in the course of a year. There is very little information available today about the extent of such discharges.

Figure 9.14. **Treatment methods for waste water from scattered settlements by type of treatment plant. 1998**



Source: Waste water treatment statistics from Statistics Norway.

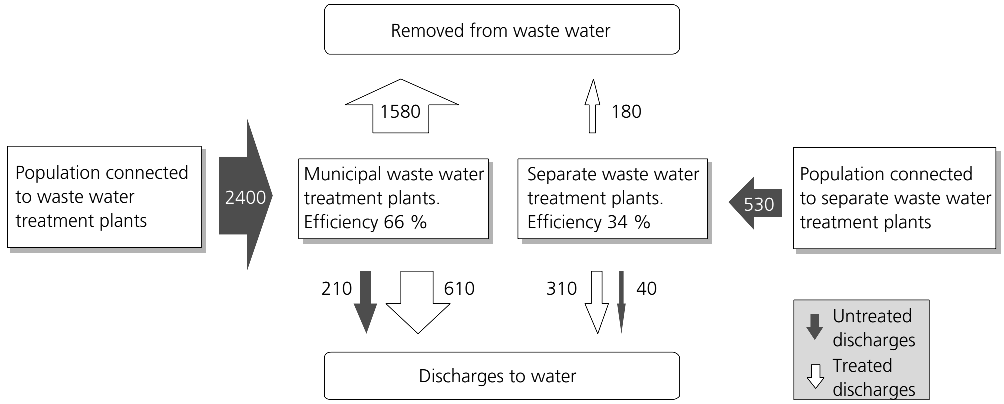
Other sources of discharges

Leaks from sewers and overflow in periods of heavy precipitation 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 in sludge

Sludge is a residual product of waste water treatment plants, and contains both organic matter and plant nutrients that can be used as fertilizer or in integrated

Figure 9.15. **Material flow diagram for phosphorus in waste water[1], tonnes. 1997**



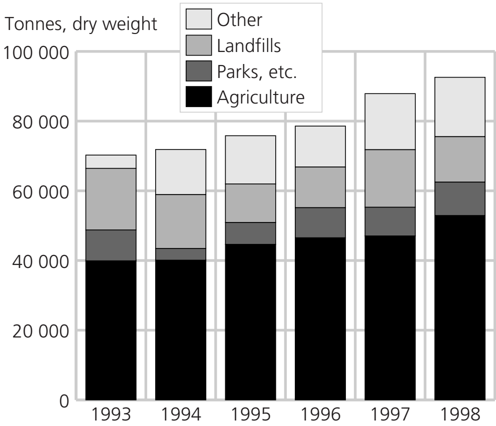
[1] Leaks from sewers not included.
Source: Waste water treatment statistics from Statistics Norway.

Table 9.3. **Content of heavy metals (1998) and nutrients (1996) in sewage sludge**

	Average for all plants	Highest registered value (mg per kg DW[1])	Limit value (mg per kg DW[1]) Agricultural areas	Limit value (mg per kg DW[1]) Parks and other green spaces	Total quantity in sewage sludge used
Heavy metals:					
Cadmium (Cd)	0.97 mg per kg DW	10	2	5	100 kg
Chromium (Cr)	28.51 mg per kg DW	644	100	150	2 850 kg
Copper (Cu)	287.07 mg per kg DW	3 490	650	1 000	24 260 kg
Mercury (Hg)	1.34 mg per kg DW	26,5	3	5	100 kg
Nickel (Ni)	15.40 mg per kg DW	263	50	80	1 530 kg
Lead (Pb)	21.70 mg per kg DW	266	80	200	2 700 kg
Zinc (Zn)	340.06 mg per kg DW	1 841	800	1 500	31 850 kg
Other substances:					
Organic matter	62.53 % of DW				57 720 tonnes
Kjeldahl-N	2.82 % of DW				2 600 tonnes
Ammonium-N	0.31 % of DW				290 tonnes
Total phosphorus (P)	1.62 % of DW				1 500 tonnes
Potassium (K)	0.17 % of DW				160 tonnes
Calcium (Ca)	3.30 % of DW				3 050 tonnes

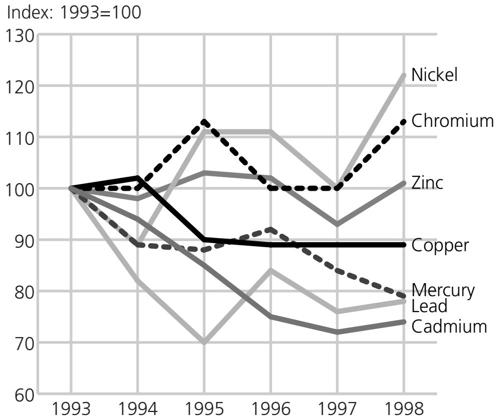
[1] Dry weight (DW) = dried sludge or what is left over when the water has been removed (mainly organic matter and nutrients).
Source: Waste water treatment statistics from Statistics Norway.

Figure 9.16. **Quantities of sewage sludge used for different purposes. Whole country**



Source: Waste water treatment statistics from Statistics Norway.

Figure 9.17. **Trend in content of heavy metals in sewage sludge, calculated on the basis of annual median values**



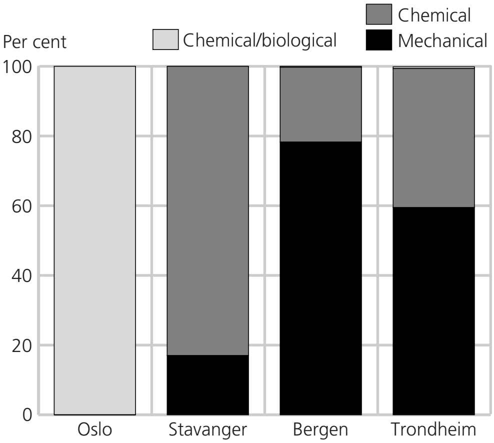
Source: Waste water treatment statistics from Statistics Norway.

plant nutrient management. In 1998, a total of 92 300 tonnes of sludge, expressed as dry weight, was used for various purposes (figure 9.16). Of this, 58 per cent was used in integrated plant nutrient management on agricultural areas and 10 per cent on parks and other green spaces. The remainder of the sludge was used in landscaping landfills (14 per cent) and for other purposes (18 per cent).

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. Waste water from some types of industry and storm water from urban centres where traffic is heavy can contribute to a high content of heavy metals in waste water. Using the average content of heavy metals and the total sludge used, we have calculated the total content of heavy metals in sewage sludge used. These calculations show that the sludge that was utilized in 1998 contained 100 kg each of cadmium and mercury (table 9.3), but there is a great deal of uncertainty attached to these calculations. Even though the average figures are fairly low in relation to the authorities' requirements regarding the use of sewage sludge on agricultural areas or parks and other green spaces, there will be times when the content of certain heavy metals exceeds the limit values at many plants. This sludge cannot be used on agricultural areas or parks and other green spaces.

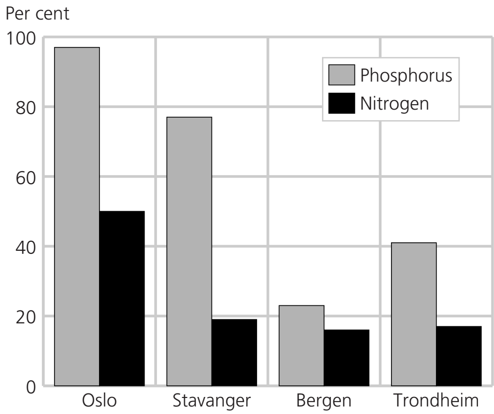
Figure 9.17 shows the trend in median values in relation to the 1993 level. It would appear that the content of cadmium, copper and mercury has been reduced, but the content of nickel has risen during this period.

Figure 9.18. **Treatment methods in the four largest cities expressed as a percentage of total hydraulic capacity. 1998**



Source: Waste water treatment statistics from Statistics Norway.

Figure 9.19. **Calculated treatment efficiency at waste water treatment plants in the four largest cities. 1998**



Source: Waste water treatment statistics from Statistics Norway.

9.6. The four largest cities in Norway – a comparison

A comparison of the key figures for the waste water treatment sectors in Oslo, Bergen, Trondheim and Stavanger reveals noticeable differences in the state and efficiency of waste water treatment plants and in investments, costs and income-to-cost ratios (Appendix, table H11). This is largely due to differences in pollution situations and thus different requirements regarding waste water treatment in the different cities.

Waste water treatment plants and connection to sewerage systems

In the four cities, between 93.7 per cent (Bergen) and 99.5 per cent (Oslo) of the population are connected to municipal sewer systems. Since Oslo is situated in the area covered by the North Sea Declarations, this city has been giving priority to the construction of plants with chemical/biological treatment processes for many years. Other cities have given preference to mechanical or chemical treatment processes (figure 9.18). The plants in Oslo have a total treatment efficiency for phosphorus of 97 per cent, while the corresponding figures for Stavanger, Bergen and Trondheim are 77, 23 and 41 per cent respectively (figure 9.19).

Investments

Oslo had the highest total investments in 1998 at approximately NOK 251 million, NOK 166 million of which derives from the construction of a new plant with nitrogen removal facilities. Oslo accounted for 13 per cent of total investments for the country as a whole. Investments per subscriber were NOK 967.

Bergen came a close second with total investments of NOK 236 million and had a very high figure for investments per subscriber (NOK 2 346). In Bergen, which has had the highest investments per subscriber for the past four years, investments have mainly been in new sewer systems and waste water treatment plants without nitrogen removal facilities or sewage sludge treatment. In Trondheim and Stavanger, investments per subscriber have shown a general decline in recent years. These two cities also have the lowest total investments.

Annual costs

Oslo far exceeded the other cities in 1998, with annual costs of about NOK 432 million. In Bergen, where investments were almost as high, costs only amounted to NOK 197 million. However, Oslo had lower annual costs per subscriber at NOK 1 661 than Bergen with NOK 1 959. One reason for this is that Oslo has a larger number of subscribers, but it may also be due to the fact that Oslo has lower capital costs due to low investments in earlier years.

It is interesting that Stavanger, despite very low investments totally and per subscriber in 1998, had total annual costs of NOK 125 million and by far the highest annual costs per subscriber at NOK 2 456. The figures provide no clear explanation of why Stavanger's annual costs were so high. The reason may be that Stavanger, along with Trondheim, had the highest investments per subscriber in 1993 and 1994, which affects today's capital costs. However, this is not reflected to the same extent in the annual costs for Trondheim. Bergen, which has had by far the highest total investments and investments per subscriber for the past four years, has also lower annual costs per subscriber.

Another explanation may be that Stavanger had very much higher treatment efficiency for phosphorus than Bergen and Trondheim. Phosphorus can only be removed chemically, and it is possible that chemical treatment plants entail higher costs than mechanical ones, which are the most common type of plant in Bergen and Trondheim.

Income-to-cost ratios

Stavanger was not able to cover its high costs by means of fees in 1998. The city collected a total of NOK 93 million in fees, which gave an income-to-cost ratio of 75 per cent. Oslo had the highest income-to-cost ratio in 1998 (125 per cent), while Bergen and Trondheim had 114 and 109 per cent respectively.

In 1999, the connection fee per subscriber ranged from NOK 3 906 in Bergen to NOK 32 893 in Oslo. This is a wider span than in 1998. In Oslo, the connection fee rose by more than 800 per cent from 1995 to 1999, while in Stavanger it has remained stable in recent years, at just under NOK 15 000. In 1999, the annual fee varied from NOK 1 456 in Stavanger to NOK 2 388 in Trondheim.

9.7. 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, 91 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. In the North Sea counties, as much as 91 per cent of the phosphorus is removed from waste water. 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.

It has not been possible so far to carry out reliable analyses at municipal level of the relationship between the input of resources in the waste water treatment sector and their environmental effect. This will be the focus of attention in the years to come. Only when such an analysis is available, will it be possible to judge the extent to which the municipalities, through measures in the waste water treatment sector, are helping to improve the aquatic environment in a cost-efficient way.

According to the current guidelines from the Ministry of the Environment, the municipalities may only cover their real costs through waste water treatment fees. Thus 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. In other words, high fees will contribute to a reduction of the pollution load in rivers, fjords and coastal areas.

Co-financed by: Norwegian Pollution Control Authority.

Documentation: Bersvendsen et al. (1999).

Further information may be obtained from: Kjetil Mork (physical data) and Julie Hass (economic data).

10. Land use and population in and near urban settlements

Today, 3/4 of Norway's population lives in towns and urban settlements and the number is still rising. Many user interests are represented in urban settlements and adjacent areas and many of these areas are under considerable development pressure. How the land is used is of great importance in terms of economics and the environment as well as for the local environment and quality of life. Sound land use planning and management requires knowledge of the facts and an appreciation of the overall picture. This chapter contains examples of new methods of generating land use statistics in order to establish these facts. For example, new methods have made it possible to calculate that roads occupy on average 15 per cent of all the area in urban settlements in Norway, while buildings only occupy under 9 per cent.

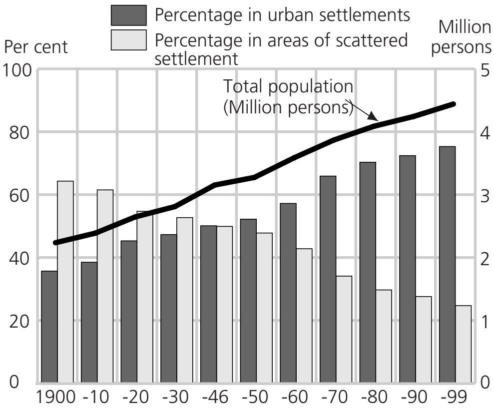
10.1. Introduction

An increasing percentage of the population lives in or near urban settlements. This has put the land in these areas under pressure and it has become even more important to control and monitor the development of land use. The increase in population density often results in environmental problems such as higher concentrations of pollution in the air, but can also result in environmental gains such as a reduction in the energy used for transport. The sustainable development of towns and urban settlements is one of the main topics in the Ministry of the Environment's report on regional planning and land use policy (Report No. 29 (1996-97) to the Storting). The planning of an environmentally friendly development pattern should focus on strengthening town centre activity and settlement, reducing the need for transport, making more efficient use of the land and ensuring that green areas are protected for recreational purposes and to preserve biological diversity.

A large proportion of Norway's population is concentrated on a relatively small proportion of its area, primarily along the coast and in agricultural areas. In these areas the growth of urban settlements is particularly problematic. Over the years a number of measures have been implemented to regulate the use of land resources that are vulnerable and in short supply. The Land Act, for example, strictly regulates the use of agricultural land.

There is a lack of national statistics that would enable us to gauge whether measures that have been implemented are having the desired effect and whether the environmental policy objectives mentioned above have been reached. A number of pilot projects have therefore

Figure 10.1. **Total population and percentage of population resident in urban settlements/ areas of scattered settlement**



Source: Population statistics, Statistics Norway.

been launched so as to generate new statistics that can throw light on the success of these objectives. Land use statistics will focus on the environmental impact of human activity and measure the effect of political instruments. In addition, the figures will provide a knowledge base for the formulation of future environmental policy strategies.

10.2. Land use and population in urban settlements at the beginning of the year 2000

To put it simply, an urban settlement is 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 geographical unit whose boundaries are constantly changing in pace with building developments and changes in the number of residents.

The main trends in the nationwide land use statistics are presented below. These trends give a picture of where we live, how densely populated Norway is and how densely developed Norway's urban settlements are.

Urban settlement trends from the past to the present

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 urban areas, to the current situation where about 75 per cent of the population live in towns and urban settlements (figure 10.1). Changes in methods of operation in the primary industries and the evolution of the industrial and service sectors have led to an increase in the number of people moving to urban settlements. General population growth has also contributed to this trend, and some areas of scattered settlement have developed into urban settlements. Other smaller settlements have grown and merged into bigger units. At the same time, in areas with a weak industry structure, a decline in population has meant that some urban settlements no longer belong to this category.

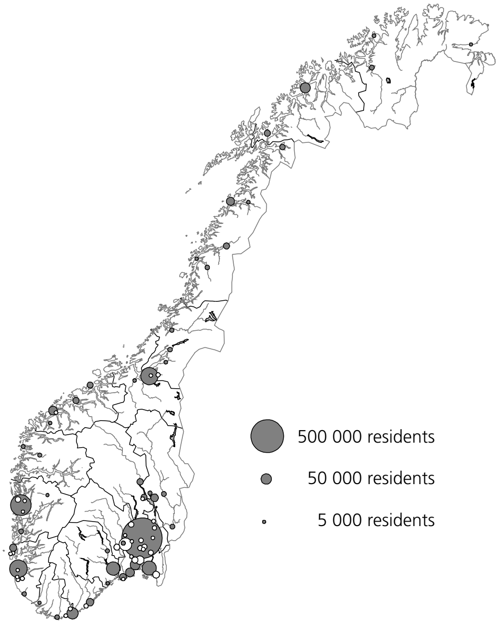
New tools (geographical information systems – GIS) and a recently developed method have made it possible to delimit urban settlements automatically from 1998 onwards. Preliminary figures for 1999 show that the percentage of the population living in urban settlements, the number of urban settlements and their area are all continuing to rise.

Preliminary figures show that as of 1 January 1999, there was a total of 970 urban settlements and 3 344 427 persons were resident in these urban settlements. The total area taken up by urban settlements was 2 120 km^2, or 0.7 per cent of the total land area. In other words, only a small percentage of the total land area in Norway is taken up by urban settlements.

The percentage of the population resident in urban settlements is greatest in the counties of Oslo and Akershus, where 99.6 and 87 per cent respectively of the total county population live. The lowest percentage of residents in urban settlements is found in the counties of Sogn og Fjordane, Oppland and Hedmark, where about half of the total population live in urban settlements (see Appendix, table I1).

Even though a large percentage of the population live in urban settlements, there are still only a few fairly large towns in Norway. Only 15 towns have a population of between 20 000 and 100 000, and only Greater Oslo, Bergen, Trondheim and Stavanger/Sandnes have more than 100 000 inhabitants. As of 1 January 1999, 28 per cent of Norway's total population lived in one of these major towns.

Figure 10.2. **Urban settlements with 5 000 residents or more. 1998***



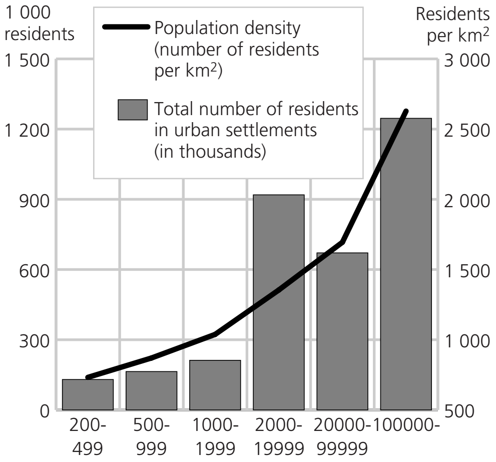
Map data: Norwegian Mapping Authority.
Source: Land use statistics, Statistics Norway.

Geographical distribution of urban settlement areas

In absolute figures, the counties with the largest totals of urban settlement areas are Akershus and Hordaland, while the smallest totals are found in the counties of Finnmark, Sogn og Fjordane and Nord-Trøndelag (see Appendix, table I1). 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 land area taken up by urban settlements, followed by the counties of Vestfold and Akershus, with urban settlement taking up 6 and 5 per cent respectively of their total areas. The smallest proportion of urban settlement area is to be found in Finnmark, where only 0.1 per cent of the total land area is taken up by urban settlement (Appendix, table I1). There is a marked distinction between Greater Oslo and other urban settlements in Norway, not only in terms of numbers of residents, but also in area and extent, stretching over eleven municipalities and three counties. If the whole of Greater Oslo were to be placed within the limits of the county of Oslo, as much as 55 per cent of the area of the county would be taken up by this urban settlement.

Figure 10.2 shows the geographical distribution of urban settlement areas.

Figure 10.3. **Population and population density in urban settlements, by number of residents in urban settlement**



Source: Land use statistics, Statistics Norway.

Table 10.1. **Average population density in the urban settlement area belonging to the Greater Oslo urban settlement, by municipality. 1999***

Municipality	Population in urban settlement. No. of persons	Area of urban settlement km²	Population density. Persons per km²
Greater Oslo urban settlement in total	761 259	266.4	2 858
Oslo	498 110	133.3	3 736
Bærum	97 298	47.3	2 058
Asker	43 136	30.4	1 421
Skedsmo	36 016	18.0	2 004
Lørenskog	28 765	12.2	2 364
Oppegård	22 287	9.4	2 366
Rælingen	12 300	4.6	2 661
Røyken	5 652	4.0	1 405
Ski	9 217	3.4	2 699
Nittedal	7 335	3.4	2 184
Sørum	1 143	0.5	2 514

Source: Land use statistics, Statistics Norway.

Population density

Population density within urban settlements, calculated as an average per county, is easily largest in Oslo, which has 3 738 residents per km², followed by Sør-Trøndelag and Akershus (see Appendix, table I1). Population density in urban settlements is on average lowest in Oppland, Hedmark, Sogn og Fjordane and Aust-Agder. However, there are substantial variations within the individual county in the population density of the urban settlements.

If we look at population density in relation to the size of an urban settlement, a clear pattern emerges (figure 10.3). Urban settlements with between 200 and 499 residents have the lowest average population density, and density increases with the size of the urban settlement. At the other end of the scale are the urban settlements with over 100 000 residents and an average population density of 2 628 residents per km².

If we look at population density within the Greater Oslo urban settlement, there are marked differences between the various municipalities (table 10.1). Population density is greatest in Oslo municipality, where there are about 3 700 residents per km². However, Oslo municipality occupies only half of the area of Greater Oslo. In the surrounding municipalities the population density for the Greater Oslo urban settlement varies from 2 700 residents in Ski municipality to 1 400 in Røyken municipality. The table illustrates how the development of the urban settlement area in Greater Oslo has been very different in the different municipalities, and that there is significant but also very different potential for further development. In the three municipalities with the greatest urban settlement area within Greater Oslo (except Oslo municipality) population density is lower than in the other municipalities.

Greater Oslo has an average population density of 2 858 residents per km^2. Corresponding figures for Trondheim, Stavanger/Sandnes and Bergen are 2 387, 2 230 and 2 187 respectively. However, in all the major urban settlements substantial areas are reserved for purposes other than residential use, for example green spaces and large areas for transport. The land use statistics have therefore been further developed to include population density measurements specifically for residential areas in urban settlements (see section 10.3 under Land use statistics for urban settlements).

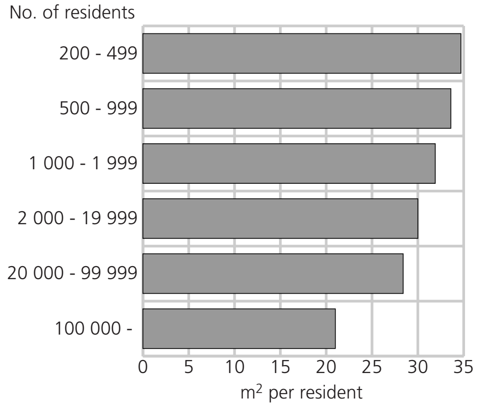
Buildings and roads in urban settlements

In land use planning, it is considered important to view land use and transport together (Ministry of the Environment 1993). Emphasis is given to increasing building density, preferably within existing built-up zones, so as to minimize pressure on areas adjacent to the urban settlement and reduce the need for transport. Land use for residential and transport purposes therefore provides important indicators of the state of the environment in urban settlements.

Calculations of built-up areas, based on the GAB register, the official Norwegian register for property, addresses and buildings, show that buildings occupy on average 9 per cent of the area in Norwegian urban settlements and that only 4 per cent of the urban settlement area is used for residential purposes (see Appendix, table I2). However, as data in the GAB is incomplete and of varying quality, calculations of this kind are not very accurate.

In Oslo county, 15 per cent of the urban settlement area is taken up by the base area of buildings. In Rogaland, the figure

Figure 10.4. **Building base area per resident, by number of residents in urban settlements. 1998***

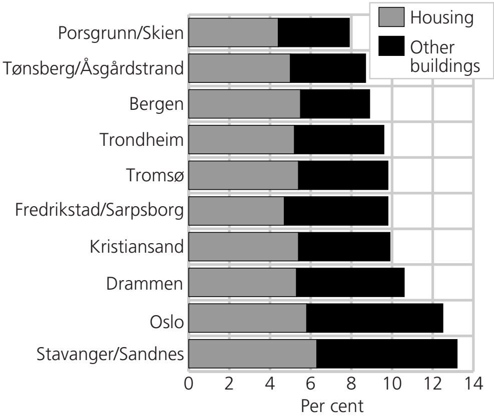


Source: Dysterud et al. (1999).

is 10 per cent, while the county of Aust-Agder has the lowest percentage of land use for buildings. With regard to land use for residential purposes, Oslo is again top of the list, followed by Rogaland, while Oppland has the lowest percentage. On a national scale, approximately the same area is taken up by dwellings as by all the other buildings put together. In Oslo, however, buildings take up 30 per cent more area than dwellings. At the other end of the scale is the county of Hordaland, where other buildings take up 19 per cent less area than dwellings.

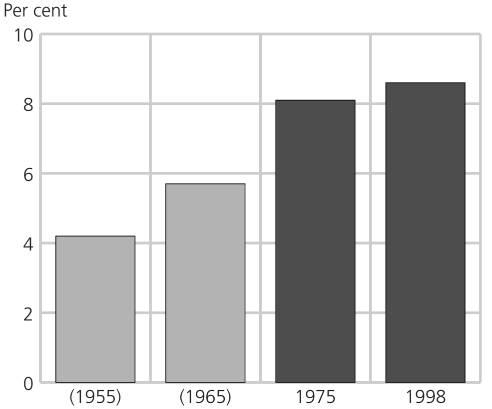
On average, however, the large urban settlements have as a rule both the highest building density and the highest population density. In urban settlements with 200-499 inhabitants, 6 per cent of the area is taken up by buildings, of which 3 per cent are dwellings, while in cities or major towns, 11 per cent of the area is taken up by buildings, of which 6 per cent are dwellings (see Appendix, table I3). In the smallest urban settlements, the inhabitants each have an average of 35 m^2 of

Figure 10.5. **Land used for buildings as percentage of urban settlement area. 10 largest urban settlements in Norway. 1998***



Source: Dysterud et al. (1999).

Figure 10.6. **Land used for buildings within urban settlements. 1955-98**



Source: Dysterud et al. (1999).

housing base area at their disposal, while in the major urban settlements, they each have 21 m^2 (figure 10.4).

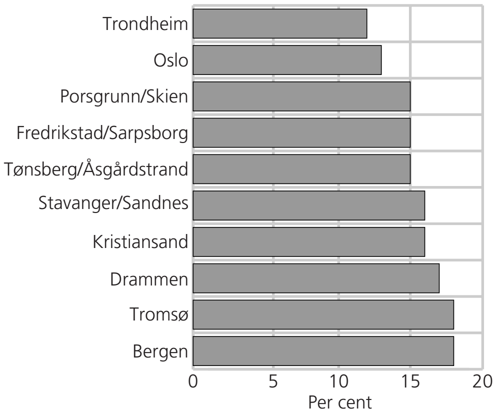
In the major urban settlements, the percentage of land area used for buildings is highest in Stavanger/Sandnes, closely followed by Greater Oslo (figure 10.5). Skien/Porsgrunn has the lowest percentage.

The last nationwide survey of the proportion of land used for buildings in urban settlements was carried out for the year 1975 (Statistics Norway 1982). The percentage of land area used for buildings was at that time calculated to 8.1 per cent (figure 10.6), and this would apparently indicate that the proportion of land used for buildings in urban settlements has increased over the last 25 years. However, any comparison between past and present land use should be undertaken with caution because of differences in method and in background data.

The proportion of land used for buildings in urban settlements has also been calculated for the years 1955 and 1965 to 4.2 and 5.7 per cent respectively of the total urban settlement area. As calculations were made on the basis of urban settlement boundaries as they were in 1975, areas have probably been overestimated for these two years. This means that the proportion of the area taken up by buildings seems exceptionally modest for 1955 and 1965 compared with 1975.

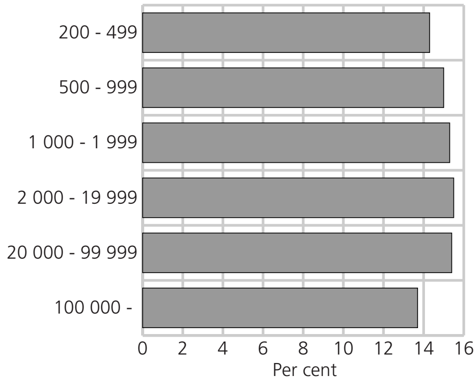
Roads occupy large areas within urban settlements. Calculations show that road area within urban settlements in Norway in 1998 totalled 308 square kilometres. A much greater proportion of the area within urban settlements is taken up by roads than by buildings. While buildings occupy on average 9 per cent of the urban settlement area, roads take up 15 per cent, or 1.7 times more. Roads are important for efficient transport, but are at the same time a major indirect cause of noise and pollution. In addition, roads occupy large areas of land and can act as barriers to other activities.

Figure 10.7. **Road area as percentage of urban settlement area. 10 largest urban settlements in Norway. 1998***



Source: Dysterud et al. (1999).

Figure 10.8. **Road area as percentage of urban settlement area, by number of residents. 1998***



Source: Dysterud et al. (1999).

Calculations of road area are based on roads registered in the Vbase road database. This register does not include some transport arteries and areas, such as forest roads, cycle paths, parking spaces and roads shorter than 50 metres. Road area is calculated by applying a standard width or road type to each road. This will result in a certain amount of error in the calculations, but the error will primarily affect local figures.

There are modest variations between counties in the area taken up by roads within urban settlements. The counties of Troms and Oppland have the greatest proportion of area occupied by roads, while Oslo, Trøndelag and Aust-Agder have the smallest (see Appendix, table I2).

If the ten largest urban settlements in Norway are compared, there is slightly more variation in the data (figure 10.7). Bergen and Tromsø have the largest percentage of road area, while at the other end of the scale are Trondheim and Greater Oslo.

If we look at the percentage of road area according to the size of urban settlement, the differences are even smaller. Figures compiled for urban settlements all over Norway show that the proportion of road area has no connection with the size of the urban settlement. The percentage of road area is lowest in urban settlements of at least 100 000 inhabitants, and greatest in urban settlements of between 2 000 and 19 999 inhabitants. However, there are some small variations. Figure 10.8 shows the percentage road area in urban settlements of varying size.

10.3. Further development of land use statistics

Land use statistics for urban settlements

At the beginning of this chapter, a number of political objectives were mentioned in connection with sustainable

Table 10.2. **Land use in Fredrikstad urban settlement . 1994* and 1998***

Land use	Area 1994 km²	Area 1998 km²	Change in area by land use category. 1994-98 Per cent	Percentage of the total urban settlement area by land use category. 1998
Total area	35.950	36.304	1.0	100.0
Residential area - single family houses	10.799	11.200	3.7	30.9
Residential area - blocks of flats	0.403	0.417	3.5	1.1
Manufacturing and storage	2.028	2.050	1.1	5.6
Commercial and administration	2.923	3.034	3.8	8.4
Mixed use - commercial and residential	0.238	0.260	9.2	0.7
Institutions	0.901	0.927	2.9	2.6
Sports facilities	0.476	0.476	0.0	1.3
Communications	5.068	5.089	0.4	14.0
Agricultural buildings	0.316	0.322	1.9	0.9
Other built-up areas	0.350	0.367	5.7	1.0
Water	2.346	2.346	4.9	6.5
Unclassified	10.102	9.816	-2.8	27.0

Source: Land use statistics, Statistics Norway.

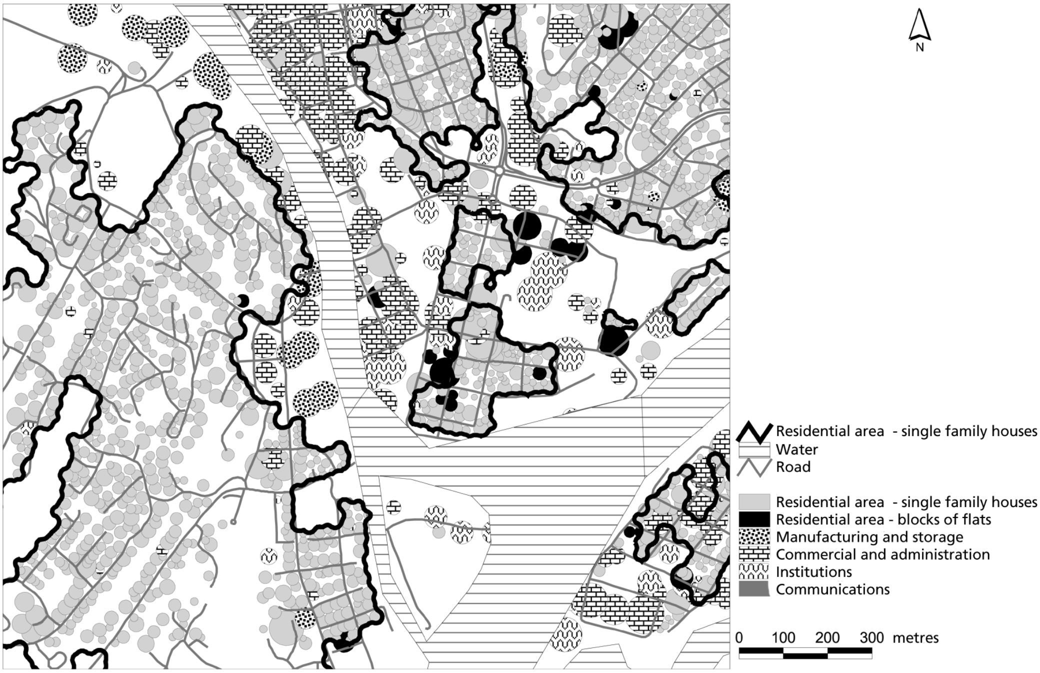
urban settlement trends, including the objective of making more efficient use of land in urban settlements. Today roads occupy large areas within urban settlements, and an increase in building density would have the potential to reduce transport needs and thereby the area used for transport purposes. Greater building density also minimizes the pressure on areas adjacent to the urban settlement. It is stressed that an increase in building density must be confined to already existing built-up zones in the urban settlement. In order to monitor developments in land use and measure how far these developments have been effected in accordance with overriding political objectives, it has been necessary to develop new methods for the production of land use statistics.

Using administrative registers, land use statistics for urban settlements can be established by utilizing the connection between type of building and the adjoining outdoor area. The base area of a building gives us information about the size of the area taken up by the building itself, and this is the basis for the calculation of the proportion of area used for buildings (see section 10.2 under Buildings and roads in urban settlements). Land use, on the other hand, refers to the area of the site in its entirety, i.e. the base area of the building and the adjoining outdoor area. Changes in land use within urban settlements are often made gradually, and by linking information about land area and buildings, very small changes can be observed.

In the course of developing this method (Engelien 2000), Fredrikstad urban settlement[1] was used as an example, with specific focus on changes from 1994 to 1998. Fredrikstad urban settlement had 53 424 inhabitants as of 1 January 1998, i.e. 80 per cent of the inhabitants of the

1 Fredrikstad urban settlement refers to that part of the Fredrikstad/Sarpsborg urban settlement that falls within Fredrikstad municipal boundary.

Figure 10.9. **Section of Fredrikstad urban settlement. Delimitation of residential area (single family houses). Relation between land use on sites and in area**



Source: Land use statistics, Statistics Norway.

municipality lived in this urban settlement. The area of the urban settlement in 1998 was 36 km².

Table 10.2 shows areas in the various land use categories in 1994 and 1998 and the changes in each category from 1994 to 1998. Calculation of land use was not made according to whether the change took place as a result of expansion or internal changes within the urban settlement boundaries since 1994. By far the largest proportion of the urban settlement area that has been categorized was taken up by residential areas (single family houses), followed by transport areas, which only took up half as much of the urban settlement area. Although the uncategorized area also accounts for a large percentage of the urban settlement area, this figure has dropped in the same period, indicating that building density has increased.

The relative growth of the various land use categories has varied over the period, but since many of the categories account for a very small part of the total area, this does not affect the overall picture to any great extent. Multi-purpose buildings (office and residential space) have increased most in relative terms, by over 9 per cent, but still only accounted for 0.7 per cent of the total area of the urban settlement in 1998.

The extension and the distribution of some land use categories are difficult to determine on the basis of existing data registers. One example is green spaces,

Table 10.3. **Residents and population density in Fredrikstad urban settlement. 1994 and 1998***

	1994	1998	Change in per cent
Population	51 951	53 424	2.8
Population in residential areas	45 217	47 279	4.6
Population per km² urban settlement area	1 445	1 472	1.9
Population per km² residential area	3 160	3 149	-0.3
Total area (km²) urban settlement	35.95	36.30	1.0
Total area (km²) residential areas	14.31	15.01	4.9
Percentage of population living in residential areas (per cent)	87.0	88.5	1.5

Source: Land use statistics, Statistics Norway.

which are very important for recreation and for maintaining biological diversity.

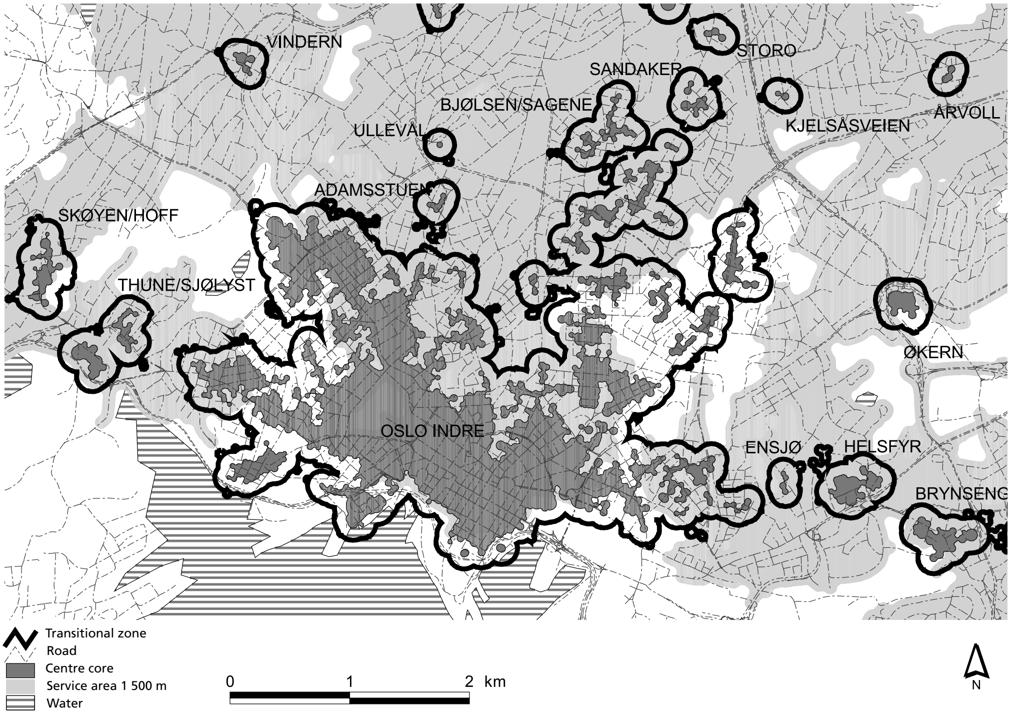
As well as measuring land use at site level, we can also define large areas according to their main use, e.g. residential areas, industrial areas or commercial and service areas. Dividing the area in this way gives an overall picture of the land use in the urban settlement. This can give an impression of how efficiently the areas are used and show where there is potential for further development. Figure 10.9 shows an example of the link between land use on sites and the predominant land use in large areas. Each building has an adjoining outside area, the use of which is defined by the building on it. The site itself is represented on the map by a circle. Large areas comprising a predominant number of sites in a specific land use category, i.e. residential sites for single households, constitute residential areas and are bounded by a bold, black line. To be included, the distance between plots used for the same purpose must be less than or equal to 30 metres. For blocks of flats, industrial buildings and institutions, distances between the sites may be up to 100 metres. Uncategorized areas contained within an area are counted as part of that area.

Table 10.3 shows that the population in residential areas has increased more than the total population of the urban settlement both in absolute and relative figures. The same applies to the areas of residential areas. However, the area of residential areas has grown more than the population, so that the population density within residential areas has shown a slight decline. The opposite is nonetheless true for the urban settlement as a whole, where the population density increased by 1.9 per cent between 1994 and 1998, in keeping with political objectives. The increase in the total area of residential areas is due both to the increase in residential area at plot level (table 10.2) and a greater concentration of the population in certain parts of the urban settlement.

Urban settlement centres

At the beginning of this chapter, we mentioned that strengthening town centre activity and settlement has been defined as an objective in the context of sustainable development of urban settlements. A dynamic centre can function as a meeting-place for people and for business, trade and culture. At the same time, the centre is easier to get to by public transport than the shopping centres outside the urban settlements where access is based on cars.

Figure 10.10. **Centre zones for inner Oslo**



Source: Dahlsett and Engelien (1999).

To monitor how far the objective of dynamic centres is being reached nationwide requires good indicators and a standardised delimitation of the centre. By delimiting the centre as a separate geographical unit, various aspects of centre activities can be measured and a comparison made between different urban settlements.

Regarding the centre as a geographical unit will also be useful in other environmental contexts, e.g. planning public communications or analysing commuter catchment areas.

In 1999 a national policy decision was made to call a temporary halt in the building of shopping centres outside the centres of towns and urban settlements because of the negative impact these shopping centres have on existing town and urban settlement centres (Ministry of the Environment 1999). Town centres are being drained of traditional trading activities, and this in its turn creates new urban settlement patterns and greater transport needs. The decision meant that there was an immediate need for an operative definition of the centre as concept so as to ensure a uniform implementation of the decision. A pilot project was launched to find out how this could be done. 124 centre zones were automatically delimited in Oslo and Akershus county. Figure 10.10 shows the delimita-

Table 10.4. **Retailers and contribution margin ratio in various service areas for selected centre zones in Oslo. 1999***

Centre zone	Retailers in centre zone			Contribution margin ratio for centre zone in nearby service areas, by distance from mid-point, as percentage of retail turnover		
	Number	Turnover (NOK thousands)	Employees	500 metres	1 500 metres	3 000 metres
Storo	45	513 021	388	925	60	14
Adamstuen	15	18 156	13	6	1	0
Inner Oslo	2 853	11 352 459	9 574	4 988	655	173

Source: Land use statistics, Statistics Norway.

tion of centres in the inner part of Greater Oslo.

By making use of geo-coded information about retail trade, population and revenues in a centre zone (see box 10.1) as one unit, calculations can be made of sales revenues in the centre zone in relation to the estimated purchasing power of people living at different distances from the mid-point of the centre zone. Table 10.4 gives information about retailers and the contribution margin ratio in the service area of selected centre zones in Oslo. The contribution margin ratio means the extent to which the necessary sales revenues can be provided by the population living within a given service area. In the table, contribution margin ratios have been calculated for service areas of 500, 1 500 and 3 000 metres from the mid-point of the centre zone. Retail trading in Adamstuen centre zone only accounts for 6 per cent of the purchasing power of the population living up to 500 metres from the mid-point of the centre zone. In contrast, retail trading in the centre zone of inner Oslo is over six times as great as the purchasing power of the population living up to 1 500 metres from the zone's mid-point and is also greater than the population living at a distance of up to 3 000 metres. Storo centre zone is different from the other two centre zones since sales revenues are over nine times as great as the purchasing power of the population living within 500 metres of the mid-point. If the population living up to 1 500 metres away is included, the situation is the reverse, with sales revenues accounting for only 60 per cent of the purchasing power of the population.

The selected examples show centre zones of different types: city centres (inner Oslo), centre zones containing a shopping centre (Storo) and centre zones where population density is high (Adamstuen). Because these centre zones are so different, comparisons between them at only one point in time are of limited value.

Box 10.1. Definition of centre zone

Firstly, a *centre core* is delimited according to the following criteria:

- Retail trade must take place there.
- It must contain either a public administration centre, a health and social centre or other social/personal services.
- More than three main industrial sectors must be represented.
- The maximum distance between the buildings where these undertakings are located must not exceed 50 metres.

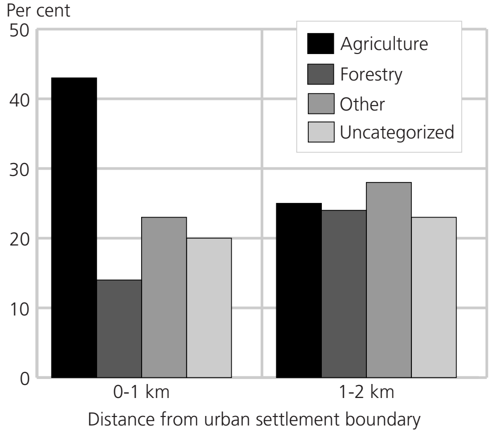
A 100-metre zone is added onto the centre core, and this zone + the centre core comprise the *centre zone*.

However, if it was possible to monitor trends over time, the comparisons would be of more value. The results of the project indicate that monitoring trends over time would give a useful tool so that the decision to halt the development of shopping centres could be effected as uniformly as possible for different centres and municipalities.

Land use statistics for areas adjacent to urban settlements

The authorities' general land-use policy objective is a development pattern that takes both natural assets and protection of land suitable for agriculture into account. Report No. 19 (1999-2000) to the Storting concerning Norwegian agriculture and food supplies includes clear environmental policy objectives relating to the administration of agricultural land and the protection of land suitable for agriculture. Agricultural land in use accounts for only 3 per cent of Norway's land area, mainly in eastern Norway, the area around the Trondheimsfjord on the north-western coast and the Jæren area in south-west Norway. Several of Norway's largest urban settlements are also located in these parts of the country and the surrounding agricultural areas are under great pressure from developers. In this context it is important not only to protect land suitable for agriculture but also to preserve areas adjacent to urban settlements as recreation areas for an increasingly urbanised population. In order to monitor land use trends and measure the effects of land use policy in areas adjacent to urban settlements, national statistics must be easily available. The areas adjacent to the urban settlement Fredrikstad/Sarpsborg were studied in a pilot project, the aim of which was to develop methods for the production of statistics for areas adjacent to urban settlements. In this project, an area up to 2 kilometres outside the urban settlement boundary was considered adjacent.

Figure 10.11. **Percentage distribution of areas designated for development. Areas adjacent to Fredrikstad/Sarpsborg urban settlements. 1994-1998***

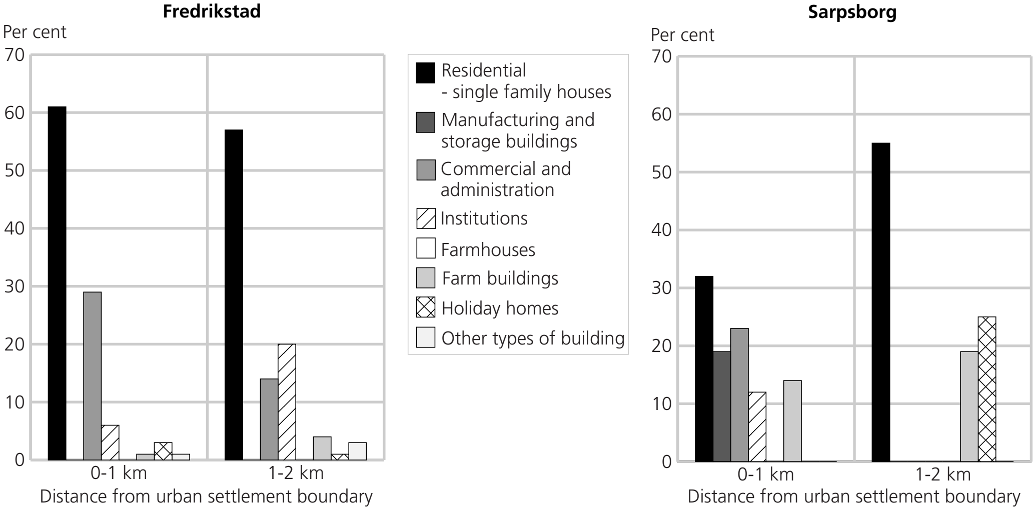


Source: Land use statistics, Statistics Norway.

From 1994 to 1998, most of the new developments took place within a zone stretching up to 1 kilometre from the old urban settlement boundary around Fredrikstad/Sarpsborg. The base area of these buildings, that is the actual area of land built on, took up a total of 3.9 hectares, while the corresponding figure for the 1-2 kilometre zone was 0.6 hectares. Calculated as a change in land use, this corresponds to 24.2 hectares of plots with buildings in the 0-1 kilometre zone and 4.1 hectares in the 1-2 kilometre zone.

Figure 10.11 shows that, relatively speaking, new developments have taken up a large proportion of agricultural land, particularly in the 0-1 kilometre zone. Over 40 per cent of the area in this zone that has undergone a change of use was once agricultural land.

Figure 10.12. **Developments in areas adjacent to Fredrikstad and Sarpsborg urban settlements, by purpose. 1994-1998***



Source: Land use statistics, Statistics Norway.

In order to be able to implement measures that might influence land use development, it is important to know about the forces that have brought about existing changes. Knowledge of the purpose of new buildings can provide information about the relative influence of economic sectors on land use. Figure 10.12 shows the types of buildings built around Fredrikstad and Sarpsborg in the period 1994-98 and their uses.

The most important reason for developing the areas adjacent to Fredrikstad urban settlement is to provide housing. Around Sarpsborg urban settlement, however, buildings are more varied, particularly in the 0-1 kilometre zone. While new industrial buildings and warehouses are absent around Fredrikstad, this type of building accounts for almost 20 per cent of the area of built-up plots in the 0-1 kilometre zone around Sarpsborg. New recreational buildings account for 25 per cent of the area of built-up plots in the 1-2 kilometre zone around Sarpsborg, while the same type of building near Fredrikstad urban settlement accounts for a far smaller percentage of the total built-up area in the zone.

Co-financed by: Ministry of the Environment, Ministry of Agriculture, Eurostat and the counties of Østfold, Akershus and Oslo.

More information may be obtained from: Tone Smith and Per Schøning.

11. Other analyses and research projects

11.1. Economic analyses

Natural resource rent and Norway's national wealth 1930-1995

The aim of this study was to calculate changes in Norway's national wealth from 1930 to 1995, focusing particularly on the contribution from natural resources. The national wealth may be divided into real capital (infrastructure, buildings and machinery), financial capital (claims or debt abroad), human capital (know-how, technology and health status) and the value of natural resources (agricultural land, forests, fish, hydropower, minerals, petroleum). In line with what is done in the national accounts, we ignored the value of the natural environment in other than monetary terms. We used figures from the national accounts to calculate the various components of the national wealth. For natural resources, more details will be found in Chapters 2-5.

Natural resource rent

The starting point for calculating the wealth from a particular natural resource is the resource rent that can be expected from it. This is the return on capital in excess of the normal rate of return that may arise because the resource is available in limited amounts, its quality varies or there are few owners.

In order to calculate the resource rent, we must first find the total income from the resource after all costs except wages and capital have been deducted. We also add subsidies and any taxes that do not apply to all goods and services. The net income found in this way is a measure of what the two factor inputs labour and capital have earned. The wage per man-year is calculated as the average wage in natural resource-based industries excluding the petroleum sector. Total remuneration of labour includes both employees and self-employed persons. The resource rent for an industry is found by subtracting wage costs and a return on capital of 7 per cent from the net income.

The large negative resource rent in *agriculture* described in Chapter 3 is related to the fact that this has been a protected industry. A political decision was made to maintain an active agricultural sector in larger parts of the country than would have been the case without protection. Various types of subsidies, which have a negative effect on the resource rent, were introduced to maintain production on small holdings and in marginal areas, and to ensure that income levels were reasonable. In addition, it was a political goal for agriculture to maintain employment levels in areas with a scattered population and few alternative forms of employment.

In *forestry*, the resource rent has generally been positive (see Chapter 4), and this may be because the industry has been less protected than agriculture. Another contributory factor may have been that natural conditions in Norway are more suitable for the production of timber than for food production.

The *fisheries*, like forestry, are dependent on trends in international markets. The fluctuations of the resource rent between positive and negative values described in Chapter 5 are related partly to over-exploitation of resources during certain periods, which resulted in crises and lower income in the industry. After such crises, the catch effort has often been transferred to new species or new areas, so that income has risen again. One of the developments that contributed to variations in income was the collapse of the herring stocks in the late 1950s and their recovery in the 1990s. Like agriculture, the fisheries were regulated as early as the 1930s, and subsidies were an important means of maintaining patterns of settlement in coastal regions and ensuring that fishermen had a reasonable income. One consequence has been that throughout the period studied, much of the industry has been small-scale, based on small vessels (less than 30 feet) that could be crewed by one man.

The *hydropower sector* has been an important source of electricity for energy-intensive industries such as the pulp and paper industry and the electrochemical and electrometallurgical industries throughout the period and even before the 1930s. For many years, these industries enjoyed favourable agreements and low electricity prices, which may explain the generally negative resource rent described in Chapter 2. At the end of the 1970s, it was decided to raise electricity prices for general consumption (Report No. 54 (1979-80) to the Storting). This, combined with the fact that a larger proportion of electricity was used for household consumption, can explain the steady decrease in the negative resource rent from the late 1970s.

Mining and quarrying can be divided into metal ore mining and extraction of other minerals. Fluctuations in export prices result in relatively large fluctuations in income, and this is reflected in the resource rent. There are also changes as a result of new finds or the exhaustion of mines. Up to 1976, the resource rent was between zero and NOK 1.5 billion, but from then until 1995 was generally negative, varying between zero and NOK –0.5 billion. The drop in the resource rent after the early 1970s may be explained by changes in subsidy levels. Subsidies rose from less than 5 per cent of the net product to about 50 per cent in the late 1980s, but have since dropped somewhat. Mining and quarrying was also important for employment in districts with few alternative sources of employment, and this was the reason why subsidies were so high.

For the *petroleum sector*, we have used the authorities' estimates of wealth instead of calculating the resource rent. The estimates are strongly dependent on changes in price expectations, costs and estimated resources. The estimates of petroleum wealth were particularly high before the drop in oil prices in 1986. During the 1990s, the estimated petroleum wealth has varied between NOK 500 and 600 billion (see Chapter 2).

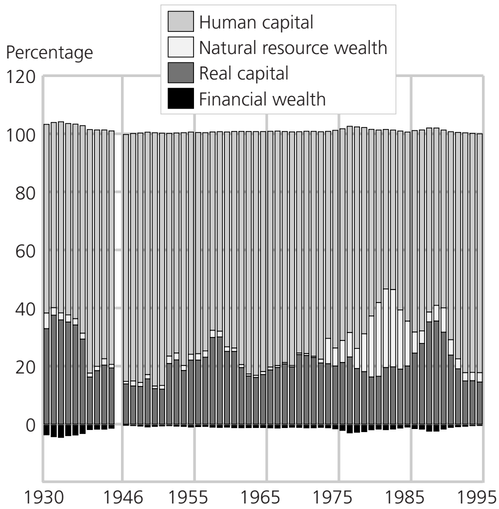
Trends in the various components of the national wealth

If the natural environment and other non-economic factors are excluded, the national wealth can be calculated as the current value of the future domestic product. We use a fixed discount rate of

7 per cent, which is the rate generally used in official Norwegian publications, and an estimated rate of technological progress[1]. When we have calculated the value of real capital, financial capital and natural resources, the remainder gives the value of human capital.

Resource wealth for a particular natural resource can be defined as the current value of a future resource rent. We assume that the future resource rent for all sectors except the petroleum sector is equal to the most recently observed resource rent. It may be unreasonable to ascribe a negative value to resource wealth for the various natural resources. In earlier calculations (Statistics Norway 1993), the wealth was set at zero when the economic rent was negative, since the resource may be used to satisfy other socio-economic goals.

Figure 11.1. **Estimate of the national wealth[1] 1930-1939 and 1946-1995 split by source**



[1] Figures for 1930-1960 from the old standard for the national accounts, 1961-1977 based on UN (1968) and 1978-1995 based on EU Commission et al. (1993).
Source: Lindholt (2000a).

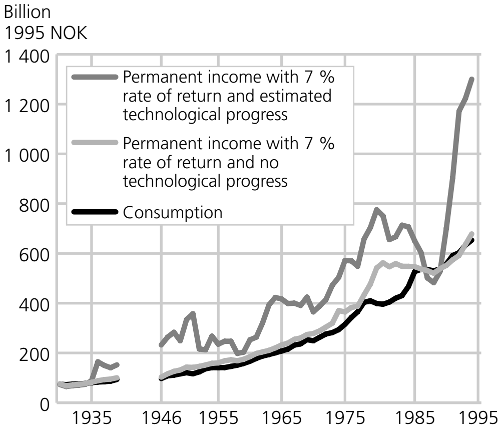
Figure 11.1 shows that financial debts accounted for less than 5 per cent of the national wealth throughout the period, except in the early 1930s, when it accounted for between 5 and 10 per cent. Natural resource wealth excluding petroleum never exceeded 2 per cent of the national wealth, and between 1975 and 1995 it was generally less than 0.5 per cent of the country's total wealth. Even though natural resources have been important for total income in Norway, the proportion of the national wealth that can be ascribed purely to these resources is very low if we ignore oil and gas resources. If the petroleum sector is included, natural resources accounted for between 15 and 29 per cent of the country's total wealth in the period 1979-1985, when oil prices were expected to remain high. From 1980 to 1984, estimates of petroleum wealth were in fact higher than the value of real capital.

The value of real capital has accounted for between 12 and 38 per cent of national wealth, but there is no clear trend over time. The proportion was lowest in periods when technological progress was rapid, for example 1946-1951 and the early 1990s[2]. Correspondingly, human capital made up a larger proportion of national wealth in periods when technological progress was rapid. From 1930 to 1985, it varied between 55 and 85 per cent of the total. Thus, human capital in the form of a highly-qualified labour force

[1] Technological progress is the part of annual economic growth that is not ascribed to a rise in the volume of real capital or man-years. It varies between - 0.5 and 4 per cent per year.

[2] If we assume that technological progress is 1 per cent per year throughout the period, the value of real capital accounted for between 20 and 30 per cent of the country's total wealth.

Figure 11.2. **Trends in permanent income and consumption. 1930-1939 and 1946-1995**



Source: Lindholt (2000b).

has been the country's most important economic resource throughout the period.

Sustainable management of the national wealth?

Estimates of wealth can be used as one starting point for a discussion of how a country's total income is used. The permanent income, which is the annual expected return on wealth, can be consumed without reducing national wealth or the basis for future consumption. In other words, the national wealth is maintained for future generations. If consumption is lower than the permanent income, national wealth and opportunities for consumption in the future will rise.

Figure 11.2 shows that the permanent income was higher than consumption in all years except 1931-1934 and 1988-1990. However, it should be noted that the figures for the permanent income are very uncertain, especially because of uncertainty in the estimate of the petroleum wealth and varying technological progress. When the return on wealth is so uncertain, it can be a sensible rule to keep consumption below this level. However, even if we ignore technological progress, consumption was below the permanent income except in the years specified above[3]. This leads to the conclusion that Norway's management policy has given future generations a good prospect of being able to consume more than the current generation. On the other hand, the potential for consumption has not been fully utilized for each generation.

Project financed by: Statistics Norway and Ministry of the Environment.

Project documentation: Lindholt (2000a and b).

Environmental costs in industry

Norwegian environmental policy and international commitments are incentives for industry to focus on environmentally-friendly production methods. The Government is currently establishing a result monitoring system for environmental policy. This will make it possible to follow trends and gauge the efficiency of environmental policy measures (Report No. 8 (1999-2000) to the Storting). Norway is also required under the terms of the EEA Agreement to report to Eurostat on environmental measures implemented in manufacturing industries. In 1998, Statistics Norway therefore carried out a pilot study to test and develop a tool that can be used to report on environmental protection expenditure in industry.

The pilot study covered six manufacturing industries: meat and meat products, beverages, textiles, pulp and paper, chem-

[3] The same conclusion is reached using a discount rate of 4 per cent.

icals and metals. They were chosen because Norway is required to report to Eurostat on these industries and because investigations in EU countries have shown that they have made relatively large investments in environmental measures. A questionnaire was sent to a sample of 251 enterprises with more than 49 employees, which account for between 45 and 93 per cent of total employment in these industries. Answers were received from 192 of these. Supplementary information from other sources was also collected.

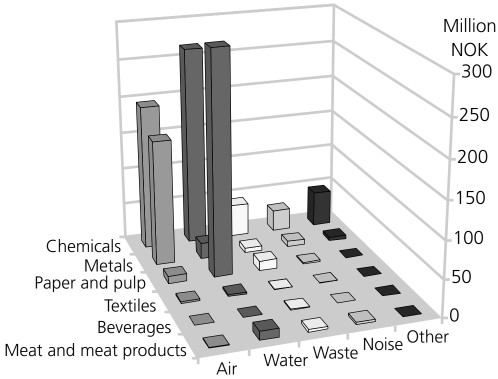
Three main types of information were collected:

- Environmental protection investments
- Environment-related current expenditure
- Revenues and cost savings related to environmental measures.

The enterprises were also asked to break down the data on each of these by environmental domain (air, water, waste, noise and other).

Environmental protection investments were split into two main types. The first was end-of-pipe equipment (equipment for treating and reducing emissions, e.g. waste water treatment plants, pipelines, stacks, flue gas treatment systems, incineration facilities, landfills and monitoring equipment). The second was process-integrated investments, i.e. investments in new or modified production processes, where environmental equipment is integrated with the rest of the production equipment. In many cases, enterprises estimated this type of investment, since it was difficult to separate out and quantify the environment-related part.

Figure 11.3. **Total environmental protection investments split by manufacturing industry and environmental domain. 1997**



Source: Hass et al. (2000).

Environment-related current expenditure include the costs of using consultants, use of equipment, waste and waste water management fees and wage costs for employees who work on environmental issues.

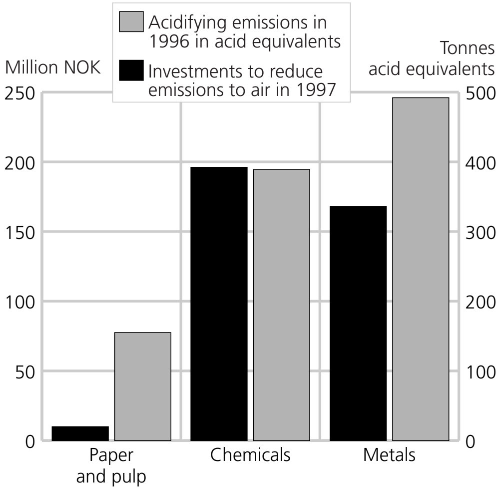
Revenues from environmental activities may include sales of sorted waste, recycled material and services, and cost savings include the difference between the market price of energy and the price of energy generated by recycling, and reductions in waste management fees obtained by delivering sorted instead of mixed waste.

The figures for environment-related current expenditure and revenues and cost savings are considered to be very uncertain. In the following presentation of the results, we have therefore focused mainly on environmental protection investments, particularly end-of-pipe investments. The figures presented are estimates for the whole of each industry, and may therefore contain errors resulting from the estimation method. The results must therefore be used with caution.

The study showed that the pulp and paper industry and the chemical industry made the largest environmental protection investments, 22 and 21 per cent of the total respectively (figure 11.3). The pulp and paper industry invested the largest amounts in end-of-pipe measures to purify waste water and reduce emissions to water. In all, about 90 per cent (NOK 137 million) of total environmental protection investments by this industry were used to reduce or remove discharges to water. Paper production results in emissions to both air and water. Waste water can for example be purified using microorganisms (biological treatment). This uses the same principle as natural purification, but polluting substances are broken down more rapidly. The chemical industry invested most in process-integrated solutions. Half of the total environmental protection investments were related to discharges to water. The metal industry ranked third as regards environmental protection investments. More than 80 per cent (NOK 115 million) of the end-of-pipe investments were used to reduce or remove emissions to air. The metal industry generates large emissions of the greenhouse gas CO_2 because carbon is essential in the reduction process used to manufacture metals.

If all six industries are considered together, 44 per cent of all environmental protection investments in end-of-pipe equipment were made to deal with emissions to water and the same amount to deal with emissions to air. The remaining 12 per cent were split between waste, noise and other measures.

Figure 11.4. **Environmental protection investments to reduce emissions to air (in million NOK) compared with emissions of acidifying substances (in tonnes acid equivalents) broken down by manufacturing industry. Here used as an indicator of investment needs**



Source: Hass et al. (2000).

Another Norwegian analysis (Ytterhus and Skjaker 1998) suggests that enterprises that make large total investments per employee also make the largest environmental protection investments per employee. The data from the current study showed no clear relationship between the environmental protection investments made by an enterprise and the variables total investments and employment. However, we cannot draw definite conclusions, since the figures are too uncertain at present.

The main aim of the pilot study was to test and develop methods for monitoring environmental protection expenditure in the future and to consider the types of data we can present once we have a representative sample and more reliable data. In future, Statistics Norway intends to focus most on end-of-pipe investments and investments in process-integrated solutions, and less on current expenditure, revenues and cost savings.

Relationships between investments and emission levels can be used as indicators for investment needs. Companies give investment data by environmental domain. As an example, figure 11.4 shows the relationship between emissions of acidifying substances to air and actual environmental protection investments (to deal with all types of emissions to air). Relationships between such variables can be estimated by means of regression analyses or other types of analyses.

However, since we currently only have figures for one year, it is not possible to demonstrate any effects of investments. Once we have time series covering several years, investments can be plotted against reductions in various types of emissions, and in this way be used as an indicator of the effects of investments.

Project financed by: Eurostat and Statistics Norway.

Project documentation: Hass et al. (2000).

An analysis of green taxes in the national accounts

In the report from the Green Tax Commission (NOU 1996:9), green taxes were suggested as a measure that could contribute to environmental improvements without the economy suffering. In this project, which forms part of NOREEA (NORwegian Economic and Environmental Accounts), we have used data from the national accounts to estimate the extent of green taxes, i.e. which goods and services are taxed and who pays the taxes. This is one of a series of similar projects that are being run by the OECD and Eurostat. One purpose of the project is to obtain more data on taxation structure in various countries, see Steurer (1998). It is still a matter of debate exactly which taxes should be classified as green taxes, but here we have kept to the principles used internationally in the projects we are involved in.

If a tax is to be classified as green, the tax base must be a physical variable (or an approximation to one) that has a recognized negative impact on the environment. On the basis of this criterion, a list of “green” tax bases has been drawn up. We have applied this to Norwegian conditions and concluded that the taxes listed in table 11.1 should be included.

In the period 1994-1997, the level of green taxation was relatively stable, both as a proportion of GDP and as a proportion of total taxation and social security contributions. Green taxes accounted for a somewhat higher proportion of total taxes in Norway than the average for the EU countries. In 1996, green taxes made up an average of 7.2 per cent of total taxation and social security contributions in the 15 member states of the EU. The exact proportion of green taxes may be adjusted after detailed analyses of taxation in the EU member countries, but the overall picture is unlikely to change much. In the EU, green taxes accounted for about 3.1 per cent of total GDP for the member states. Once again, the proportion in Norway was somewhat higher.

The largest group of green taxes is taxes on energy products. In Norway, these made up 54.6 per cent of green taxes in 1996. The proportion in the EU countries was much higher (74 per cent in 1996). Norway differs in having a large proportion of green taxes in the group “trans-

Table 11.1. **Green taxes in Norway. Total tax revenues in current prices. Million NOK**

	1994	1995	1996	1997
Total green taxes	31 040	32 572	35 110	38 066
Tax base:				
Emissions to air				
Tax on CO_2 emissions from petroleum activities on the continental shelf	2 557	2 559	2 787	3 043
Energy products				
Petrol tax	9 298	9 941	10 154	10 903
Autodiesel tax	1 659	2 706	2 912	3 406
Total tax on mineral oil			1 671	1 665
- Mineral oil, CO_2 tax	1 925	1 312	1)	..
- Mineral oil, SO_2 tax	110	88	1)	..
Tax on coal and coke	7	9	11	6
Production tax on electricity	1 286	1 519	1 533	1 471
Consumption tax on electricity	2 651	2 890	2 887	3 294
Transport				
Purchase tax on motor vehicles	7 022	7 575	8 945	9 771
Road tax on passenger cars	3 134	3 225	3 403	3 688
Weight-based road tax on heavy-duty vehicles	293	293	315	271
Tax per km driven[2]	560	1	-	-
Factor inputs in agriculture				
Environmental tax, commercial fertilizer	171	167	172	171
Environmental tax, pesticides	21	19	22	21
Waste				
Basic tax on disposable beverage containers	56	100	130	166
Other taxes on beverage containers[3]	234	108	106	127
Taxes on lubricating oils	56	60	62	63
Tax on environmentally harmful batteries [4]	0	0	0	-
Green taxes as a percentage of total taxes and social security contributions	8.48	8.25	8.03	8.12
Green taxes as a percentage of GDP	3.58	3.51	3.45	3.50*

[1] About the same figure as in 1995.
[2] Tax withdrawn in 1994.
[3] Taxation on packaging for beverages is made up of several different taxes.
[4] Tax withdrawn in 1997.
Sources: Report No. 3 to the Storting (several years) and National accounts, Statistics Norway.

port". In 1996, these accounted for 36.1 per cent of the total in Norway, but only 22.5 on average in the EU states. This difference is explained by the purchase tax on motor vehicles. Although the petrol tax is the green tax that brings in most revenue in Norway, the purchase tax on motor vehicles is almost as important.

The national accounts distinguish between taxes on products, taxes on production and income and wealth tax.

Table 11.2. **Green taxes by type and sectors that pay green taxes, 1995. Million NOK**

Paid by sector/industry	Green taxes total	Green taxes on production	Green taxes on products	Green taxes on investment
Total green taxes	32 640	6 268	22 557	3 815
Green taxes paid outside Norway	136	-	136	-
Green taxes paid by private households	16 962	2 664	14 298	-
Green taxes paid by business and industry, public sector and non-profit institutions serving households (NPISH), total	19 146	3 604	11 727	3 815
Of this:				
Primary industries	860	27	833	..
Mining and quarrying	2 642	2 559	83	..
Manufacturing	1 369	418	951	..
Construction, electricity and water supplies	727	44	683	..
Wholesale and retail trade, repair of motor vehicles and personal and household goods	1 483	319	1 164	..
Transport and communications	3 033	406	2 627	..
Other services	1 625	58	1 567	..

Sources: Sjølie and Sørensen (1999) and figures derived from the National accounts, Statistics Norway.

Product taxes vary with the production (or import) of specific products. Most green taxes belong to this group. Taxes on production, although related to industrial production, do not vary with production. The tax on commercial fertilizer is treated as a tax on the industrial production of certain chemicals. The only green tax that is classified as a tax on wealth and income is the road tax on motor vehicles, which is paid by private households.

The national accounts show directly who pays other taxes on production. In addition, the design of the Norwegian national accounts makes it possible to identify who pays taxes on products both directly and through the use of the taxed products.

If we consider the users of taxed products to be those who pay product taxes, our calculations show that households pay 52 per cent of the total green taxes. The remainder is paid by business and industry and the public sector. Within business and industry and the public sector, the sectors that pay most green taxes are transport and communication and extraction of energy-producing materials. Transport and communication pays about 9 per cent of total green taxes, and extraction of energy-producing materials (mainly oil extraction) about 8 per cent. Fishing is the sector that pays most green taxes as a proportion of gross product in the industry (about 5 per cent). For wholesale and retail trade and transport and communication, the purchase tax on motor vehicles is also important. In this project, the proportion of this product tax paid by business and industry is classified as a tax on investment, without any further split by sector. These figures cannot be found directly from the national accounts, but require further information.

In a market economy, green taxes will influence supply and demand for products. Enterprises that must pay green taxes will be able to shift a varying proportion of the extra costs to their customers. This will raise prices and result in lower demand, which in turn will affect the enterprises. Similarly, product taxes levied on consumers will also affect business and industry. Thus, our analysis of who pays green taxes does not give a complete picture of how the burden of these taxes is distributed.

Project financed by: Eurostat and Ministry of the Environment.

Project documentation: Sjølie and Sørensen (1999).

11.2. Analyses related to people's behaviour and attitudes to environmental issues

Environmental trends and people's concern and attitudes

The prospects of resolving environmental problems depend partly on the extent to which environmental considerations are given priority when politicians, business and industry, and the general public make choices about how to act. We may postulate that three conditions must be fulfilled:

1. We must *understand* that environmental problems exist (perception of the situation).
2. As a result, we must *want to do something* about the problems (attitudes and priorities).
3. And in response, we must actually *behave* in an environmentally-friendly way.

In this project, we looked at how people's perceptions of environmental problems have changed during the 1990s. We tested how well their views agreed with actual environmental trends by comparing people's concern about five specific environmental problems with actual trends in these problems. Next, we looked at trends in attitudes to environmental problems and what action people take. Finally, we investigated whether people who state that they are concerned about the environment and have a sympathetic attitude to environmental issues also reported more environmentally-friendly behaviour than other people.

Table 11.3. **Trends in concern about the environment and in environmental problems in the period 1989-1997**

Environmental problem[1]	Level of concern	Severity of problem
Environment in general	Dropping	..
Climate change	Dropping	Increasing
Depletion of the ozone layer	Dropping	Stabilizing
Acid rain	Dropping	Decreasing
Emissions from motor vehicles	Dropping	Decreasing
Household waste	Dropping	Uncertain[2]

[1] These problems are discussed in other chapters.
[2] The quantities have risen, which makes the problem more severe, but so has the proportion recycled, which makes the problem less severe.
Sources: Norsk Monitor, MMI and Environmental statistics, Statistics Norway.

Concern about environmental issues and actual trends

Since 1989, Norsk Monitor (a survey run by a Norwegian market research institute; MMI) has included a question on environmental issues requiring interviewees to choose between answers ranging from the pessimistic view that disaster is imminent to the view that environmental problems are being exaggerated. There has been a clear decrease in the extent to which people worry about environmental problems. Relatively few people choose the extreme alternatives. In 1989, the dominant view (61 per cent) was that *"The*

Table 11.4. **Trends in people's perception of and attitudes towards environmental issues in the period 1989-1997**

	Trend 1989-1997
Concern about the environment	Decreasing
What trend do you see in public-sector commitment to dealing with environmental problems	Decreasing to a variable degree
What trend do you see in your own sympathies?	Decreasing to a variable degree
What trend is there in your own behaviour?	Variable, but becoming more environmentally-friendly overall[1]

[1] Several questions were asked, and the trends vary.
Source: Norsk Monitor, MMI.

situation is serious. Immediate, drastic measures are needed if we are to solve the problems", whereas in 1997 the commonest answer (55 per cent) was that *"In the long run, patience and determination will allow us to reverse the tendency towards environmental degradation".* In other words, people were much less likely to believe in crisis and danger in 1997 than in 1989.

We find a similar trend in how much people worry about specific environmental problems. The level of concern varies from one problem to another, but in all cases concern is decreasing. We looked at whether this trend is linked with a real decrease in the severity of the problems. For the environmental problems that are included in the survey, the picture is generally positive, except in the case of climate change and to some extent waste generation (table 11.3).
The question on environmental problems in Norsk Monitor does not include important topics such as nuclear waste, gene technology, threats to biological diversity, the spread of hazardous chemicals or erosion. These have all shown generally negative trends during the 1990s (EU Commission 1999). Our hypothesis is that if we had been able to measure changes in people's concern about these problems, we would have found the same trend as for the problems that are included in the survey. This hypothesis is based partly on the steep drop in general concern about the environment, and partly on the fact that people are less concerned about climate change even though this is not justified by the facts.

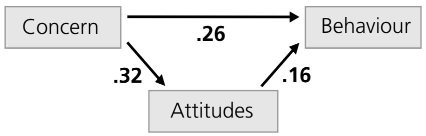
Are people less sympathetic towards environmental issues?

Does waning environmental concern coincide with less sympathy for and involvement in environmental issues? We investigated people's sympathies by looking at answers to various questions on attitudes and behaviour from Norsk Monitor. Some questions deal with what we might call people's opinions on public-sector commitment to dealing with environmental problems, and others with people's own sympathies. A third group of questions asks how people's behaviour reflects their sympathies: do they behave in an environmentally-friendly way in practice?

Concern about environmental problems and people's attitudes to them showed similar trends in the 1990s, whereas individual patterns of behaviour have shown a slight tendency to become more environmentally-friendly (table 11.4).

This contradiction may be partly explained by greater opportunities for such behaviour patterns: for example, collection systems for waste have been improved and the number of environmentally-friendly products on the market has risen.

Figure 11.5. **Factors that influence environmentally-friendly behaviour (regression coefficients)**[1]



[1] *Concern:* Index of concern about four problems (see table 11.3, waste excluded). *Attitudes*: index for questions on willingness to give environmental protection priority over economic growth and willingness to give up certain goods. *Behaviour*: index for four types of environmentally-friendly behaviour. All indexes are standardized 0-100.
Source: Norsk Monitor (surveys from 1995, 1996 (extra survey) and 1997 pooled), MMI.

The decrease in concern about environmental problems and waning sympathy for these issues may also be related to the following factors:

- The level of environmental concern was unusually high in 1989. Answers to other questions in Norsk Monitor also indicate this.
- During the 1990s, environmental considerations have been increasingly integrated into political decisions and the management systems of larger enterprises. This may result in a feeling that the people responsible for problems and who have an influence are doing something about them.
- Some local environmental problems that people experience directly, such as air and water pollution, have diminished during the 1990s.
- A materialistic attitude is becoming more common according to Norsk Monitor, and this is something that goes together with decreasing concern about environmental problems (Hellevik 1996).

What influences our behaviour?
Is there a relationship between concern about or sympathy for environmental issues and environmentally-friendly behaviour? The opposing trends we have found suggest that there is not. However, a comparison of time series does not provide a good basis for answering this question. Instead, we must look at the relationships between these three factors in individual people. As mentioned earlier, we based this study on a simple model in which concern is assumed to influence attitudes to environmental problems, which in turn influence our tendency to behave in an environmentally-friendly way.

Figure 11.5 shows that there are clear statistical relationships between the elements of this model, which may be interpreted as signs of their influence on each other[4].

In this analysis, concern decreased by 8.5 points from 1991 to 1997, which should have resulted in a 2.6 point drop in environmentally-friendly behaviour. In fact, the behaviour index showed a rise of 1.7 points, which means that factors outside the model must have changed in a way that outweighs the decrease in concern about environmental issues.

Many other factors in addition to concern about the environment and sympathy towards environmental issues have an

[4] The figures show how changes in the level of concern or in attitudes are expected to influence behaviour. If for example the level of concern in the population rises by 10 points, and the relationships between the three elements are as shown in figure 11.5, behaviour would move 3.1 points in a more environmentally-friendly direction (10 x 0.26 = 2.6 as a direct effect of concern on behaviour and 10 x 0.32 x 0.16 = 0.5 as an indirect effect of greater sympathy for environmental issues).

influence on behaviour, and this is reflected in the fact that these two factors only explain a total of 14 per cent of the variations in behaviour. If we look at social factors, sex and age have the largest influence on the probability that people will behave in an environmentally friendly way (women and older people score highest). If these factors are included in the model, 20 per cent of variations in behaviour are explained (sex and age alone account for 8 per cent). Place of residence and level of education, on the other hand, are not very important.

We have seen that there has been a positive trend in environmentally-friendly behaviour in practice, while the level of concern and attitudes to environmental issues indicate that people are less sympathetic towards environmental protection. Nevertheless, there is a statistical relationship between concern and attitudes on the one hand and practical behaviour patterns on the other. It is possible that opportunities to do something about the situation oneself also have an effect on the level of concern. If a disaster occurs, or factual information on worrying trends becomes available, this will raise the level of concern. But the opportunity to translate concern into practical efforts to behave in an environmentally-friendly way helps to moderate concern again. Thus, changes in behaviour can help to stabilize the level of concern.

Project financed by: Commission on Human Values.

Project documentation: Hellevik and Høie (1999).

Outdoor recreation

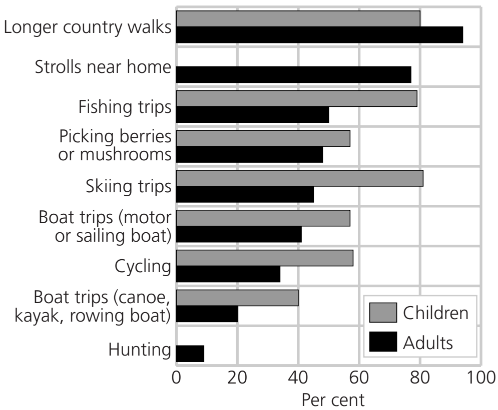
Outdoor recreation is very important to Norwegians, as shown by the fact that it has been defined as a separate priority area of the Government's environmental policy. Outdoor recreation is linked to environmental protection because it involves activities out-of-doors and in the countryside, and because the quality of outdoor recreation people experience is very dependent on environmental quality and undisturbed countryside.

We have analysed people's outdoor recreation habits using information from the 1997 Survey of Living Conditions by Statistics Norway, and looked at trends by comparing this with a survey of outdoor recreation made in 1971 (Statistics Norway 1971). We looked especially at participation by children in outdoor recreation activities, since one of the most important targets of the Government's outdoor recreation policy is to give children and young people opportunities to take part in such activities (Proposition No. 1 (1999-2000) to the Storting, Ministry of the Environment).

The 1997 Survey of Living Conditions shows that longer country walks and short strolls near home are the dominant outdoor recreation activities among adult Norwegians. More than nine of ten people have taken a longer country walk in the last twelve months, and more than three of four have gone for a stroll (figure 11.6). On average, each Norwegian goes for 42 strolls and makes 31 longer walks in the course of a year (figure 11.7).

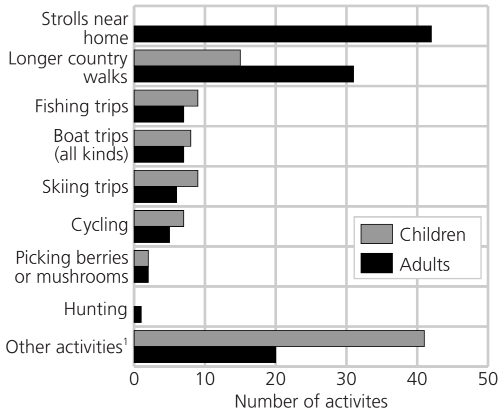
Many children go on country walks too, and considerably more children than adults go skiing. In general, a larger proportion of children than adults take part in the various activities, but the

Figure 11.6. **Percentage of the population who have taken part in various forms of outdoor recreation in the last 12 months. Children (6-15 years)[1] and adults (16-79 years). 1997**



[1] Children were not asked about strolls or hunting.
Source: Statistics Norway, 1997 Survey of Living Conditions.

Figure 11.7. **Average number of outdoor recreation activities during the past 12 months. Children (6-15 years) and adults (16-79 years). 1997**



[1] Mostly bathing in the sea or lakes.
Source: Statistics Norway, 1997 Survey of Living Conditions.

number of times they take part in them does not differ greatly from the figures for adults.

In total, adults take part in almost 122 outdoor activities in the course of a year. If we assume that each of these activities is on a separate day, each of us takes part in some form of outdoor recreation every third day throughout the year.

However, the idea that all Norwegians go cross-country skiing in winter appears to be a myth. Less than half of all Norwegians aged 16-79 years go skiing once or more during the year. On average, we go skiing six times a year. Children go skiing more often than adults, and eight of ten children in the age range 6-15 years ski. This applies to both boys and girls.
If we compare the figures from the 1997 Survey of Living Conditions with those from an earlier survey of outdoor recreation (Statistics Norway 1971), we can see that there has been a drop in the proportion of people who go walking and skiing in forested areas in the lowlands (table 11.5). There has also been a drop in the proportion who go skiing in the mountains, go on boat trips (using canoes, kayaks or rowing boats) and go fishing in fresh water. On the other hand, there has been a rise in the proportion of the population who go on mountain walks and who use motor or sailing boats. Other studies confirm several of these trends (Faye and Herigstad 1984).

These changes are not equally distributed among age groups. The rise in mountain walks, outdoor bathing and trips with motor or sailing boats applies to middle-aged and particularly to older people.

The drop in walking and skiing in the forest is particularly marked among younger people, but also in age groups up to the mid-sixties. The drop in freshwater fishing and boating using canoes, kayaks and rowing boats also applies to

Table 11.5. **Participation in various outdoor recreation activities in 1970 and 1997. Adults (16-74 years). Percentages**

	Never		1-2 times		3 or more times	
	1970	1997	1970	1997	1970	1997
Long mountain walks	75	67	10	14	15	19
Long walks in the forest	62	74	10	7	28	19
Long skiing trips in the mountains	72	80	6	8	22	12
Long skiing trips in the forest	71	90	4	4	25	6
Fishing, fresh water	66	71	7	9	27	20
Fishing, salt water	60	62	9	11	31	27
Hunting	94	91	2	2	4	7
Boat trips (motor or sailing boat)	64	58	11	14	25	29
Boat trips (canoe, kayak, rowing boat)	70	80	7	9	23	12
Picking berries or mushrooms	49	52	22	18	29	30

Sources: Statistics Norway, 1997 Survey of Living Conditions and Statistics Norway (1971).

younger people. Sea fishing and picking berries and mushrooms are activities that have become less popular with the youngest age groups and more popular among older people.

Thus, we can see clear signs that among young people, these activities have stagnated or become much less popular, whereas they have become considerably more popular among older age groups. This does not necessarily mean that young people have become more passive. It may equally well be that other activities that were not included in these surveys, such as snowboarding, rollerblading, etc., are taking over from traditional activities (Vaage 1999).

Swedish studies have also shown an increase in outdoor recreation activities among older people in the 1970s and 1980s (Statistics Sweden 1993). This has been explained by the fact that many people who have now reached these age groups were active when younger. They are still in good health and have retained their active lifestyle after becoming pensioners.

Other research (Scott and Willits 1998) shows that very often, people continue to take part in the outdoor activities they take part in and become accustomed to in their youth. This may be because people want continuity in their lives as regards activities, skills, surroundings, roles and ties. It all makes it easier for older people to accept negative physical and mental changes and cope with the ageing process. The outdoor activities enjoyed by older people may thus be similar to those they enjoyed as children and adolescents. This will probably also apply to people who are young today, and suggests that traditional Norwegian outdoor activities may experience a decline.

Project financed by: Ministry of Cultural Affairs.

Project documentation: Vaage (1999).

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Appendix A

Energy

Table A1. **Reserve accounts for crude oil. Fields already developed or where development has been approved. Million Sm³ o.e.**

	1992	1993	1994	1995	1996	1997	1998	1999
Reserves as of 1.1	1 354	1 496	1 473	1 477	1 654	1 795	1 858	1 810
New fields	117	5	34	131	315	84	-	36
Re-evaluation	152	107	124	212	11	166	131	24
Extraction	-127	-136	-154	-166	-186	-187	-179	-179
Reserves as of 31.12	1 496	1 473	1 477	1 654	1 795	1 858	1 810	1 692
R/P ratio	12	11	10	10	10	10	10	9

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.**

	1992	1993	1994	1995	1996	1997	1998	1999
Reserves as of 1.1	1 274	1 381	1 356	1 346	1 352	1 479	1 173	1 172
New fields	138	1	2	32	195	12	-	45
Re-evaluation	-2	2	18	5	-27	-271	47	81
Extraction	-29	-28	-30	-31	-41	-47	-48	-51
Reserves as of 31.12	1 381	1 356	1 346	1 352	1 479	1 173	1 172	1 247
R/P ratio	48	49	45	43	36	25	24	24

Sources: Norwegian Petroleum Directorate and Statistics Norway.

Table A3. **Norway's hydropower potential and developed and undeveloped hydropower[1] . GWh**

Year	Hydropower potential[2]	Developed as of 31.12.	Not developed					
			Under construction[3]	Licence granted	Applied for licence	Notification submitted	Permanently protected	Remainder
1988	171 209	105 578	3 778	..	8 674	4 415	20 947	27 817
1989	171 475	107 816	3 055	..	7 298	4 557	20 947	27 802
1990	171 366	108 083	3 494	..	6 609	4 890	20 947	27 343
1991	171 382	108 083	3 605	..	6 631	5 900	20 947	26 215
1992	176 395	109 457	2 913	..	4 767	3 318	22 246	33 695
1993	175 387	109 635	1 232	1 430	3 223	4 202	34 854	20 811
1994	177 745	111 850	799	1 585	3 124	4 529	35 259	20 599
1995	178 116	112 348	502	1 488	3 233	4 559	35 259	20 728
1996	178 302	112 701	161	1 532	2 774	2 180	35 258	23 694
1997	178 335	112 938	292	1 471	2 912	2 641	35 258	22 824
1998	179 647	113 015	332	1 446	3 132	2 920	35 321	23 481
1999	180 199	113 442	53	1 446	2 654	2 893	35 321	24 389

[1] Mean annual production capability.
[2] Plans for undeveloped hydropower are evaluated regularly, and this is why the hydropower potential changes from year to year.
[3] Includes the category "Licence granted " for all years before 1993.
Source: Norwegian Water Resources and Energy Directorate.

Table A4. **Extraction, conversion and use[1] of energy commodities. 1998***

	Coal and coke	Wood, wood waste, black liquor, waste	Crude oil	Natural gas	Petroleum products[2]	Electricity	District heating	Total	Average annual change 1976-1998	Average annual change 1997-1998
	PJ								Per cent	
Extraction of energy commodities	9	-	6053	1937	3113	419	-	8728		
Energy use in extraction sectors	-	-	-	-1 474	-15	-7	-	-169		
Imports and Norwegian purchases abroad	57	0	81	-	276	29	-	443		
Exports and foreign purchases in Norway	-11	0	-5 553	-1 728	-643	-16	-	-7 951		
Stocks (+decrease, -increase)	0	.	23	.	3	.	.	26		
Primary supplies	54	0	605	62	-68	424	-	1 077		
Oil refineries	7	-	-598	-	566	-2	-	-27		
Other energy sectors or supplies	-1	46	-	0	17	2	7	70		
Registered losses, statistical errors	-1	-	-6	-37	-28	-32	-2	-105		
Registered use outside energy sectors	60	46	0	25	487	393	5	1 015	1.0	4.4
Domestic use	60	46	-	25	323	393	5	851	1.6	4.1
Agriculture and fisheries	-	-	-	-	29	4	0	33	0.5	2.2
Energy-intensive manufacturing	45	0	-	24	55	121	0	246	1.9	10.1
Other manufacturing and mining	15	20	-	1	35	56	1	127	0.0	3.0
Other industry	-	0	-	-	132	87	3	223	2.3	2.4
Private households	0	25	-	-	73	124	1	223	1.7	0.8
International maritime transport	-	-	-	-	164	-	-	164	-1.2	5.8

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

Table A5. **Use of energy commodities outside the energy sectors and international maritime transport**

Energy commodity	1976	1985	1990	1993	1994	1995	1996	1997	1998*	1999*	Average annual change 1976-1998	Average annual change 1998-1999
	PJ										Per cent	
Total	606	731	734	745	767	781	805	817	851	853	1.6	0.2
Electricity	241	329	349	363	366	374	371	374	393	393	2.2	0.1
Firm power	232	312	324	335	347	348	357	352	368	:	2.1	.
Spot power	9	17	24	28	19	26	14	22	25	:	4.7	.
Oil, total	299	259	243	239	248	252	275	267	271	275	-0.5	1.6
Oil other than for transport	159	77	57	46	55	51	66	54	54	53	-4.8	-2.4
Petrol	9	0	0	0	0	0	0	0	0	0	-25.7	0.0
Kerosene	17	9	7	7	7	7	8	8	7	7	-4.0	-2.1
Middle distillates	66	43	36	28	31	30	39	31	31	31	-3.4	-1.0
Heavy fuel oil	66	25	14	11	17	14	18	16	16	16	-6.2	-5.3
Oil for transport	141	183	187	193	193	202	209	213	216	222	2.0	2.6
Petrol, aviation fuel, jet fuel	74	92	100	97	98	102	101	100	100	102	1.4	2.3
Middle distillates	64	83	84	96	94	99	108	112	116	119	2.8	3.0
Heavy fuel oil	3	7	4	1	0	1	1	1	1	1	-6.8	-31.6
Gas[1]	1	52	52	54	53	52	54	70	77	78	19.7	1.5
District heating	-	2	3	4	4	4	5	5	5	5	.	0.0
Solid fuel	64	89	88	86	95	99	99	102	106	102	2.3	-3.5
Coal, coke	47	57	50	48	54	58	58	58	60	56	1.1	-6.3
Wood, wood waste, black liquor, waste	17	31	38	38	41	41	42	44	46	46	4.6	0.1

[1] Includes liquefied natural gas. From 1990 also fuel gas and landfill gas, and from 1994 natural gas.
Source: Statistics Norway.

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

	1976	1980	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998*	1999*
Total	34	65	75	122	152	164	172	188	185	196	207	197	197
Of this:													
Electricity	4	6	8	7	8	8	8	11	10	7	11	9	9
Natural gas	12	30	45	79	113	118	125	137	140	150	154	147	146

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

Table A7. **Use of energy commodities outside the energy sectors and international maritime transport, by sector[1]. 1997. PJ**

	Coal and coke	Wood, wood waste, waste, black liquor	Crude oil	Natural gas	Petro-leum-products[2]	Elec-tricity	District heating	Total
Total	57.8	44.0	-	14.7	322.0	374.0	4.8	817.2
Manufacturing and mining	57.6	18.6	-	14.7	91.6	162.7	0.9	346.1
Oil drilling	-	-	-	-	4.8	-	-	4.8
Manufacture of pulp and paper	0.3	12.3	-	-	7.2	23.4	0.0	43.1
Manufacture of chemical raw materials	11.2	0.0	-	13.7	53.4	21.9	0.3	100.5
Manufacture of minerals[3]	9.6	0.0	-	-	7.9	4.7	0.0	22.2
Manufacture of iron, steel and ferro-alloys	25.2	-	-	-	0.5	24.2	0.0	49.9
Manufacture of other metals	7.1	0.0	-	0.7	3.6	62.2	0.0	73.6
Manufacture of metal goods, boats, ships and oil platforms	4.3	0.2	-	-	3.9	9.8	0.1	18.3
Manufacture of wood, plastic, rubber and chemical goods, printing	-	6.0	-	-	2.4	6.3	0.1	14.8
Manufacture of consumer goods	-	0.0	-	0.3	7.9	10.3	0.4	18.9
Other	0.2	25.4	-	-	230.4	211.3	3.8	471.1
Construction	-	0.1	-	-	8.6	2.3	-	11.0
Agriculture and forestry	0.0	-	-	-	6.8	3.9	0.1	10.8
Fishing, whaling and sealing	-	-	-	-	21.2	0.4	-	21.6
Land transport[4]	-	-	-	-	40.4	2.2	-	42.6
Sea transport, domestic	-	-	-	-	19.5	0.0	-	19.6
Air transport[4]	-	-	-	-	23.3	0.1	-	23.3
Other private services	-	-	-	-	28.5	51.0	1.3	80.9
Public sector, municipal	-	-	-	-	3.1	20.8	1.0	24.8
Public sector, state	-	-	-	-	6.6	8.4	0.5	15.5
Private households	0.1	25.3	-	-	72.3	122.3	1.0	221.0

[1] Includes energy commodities used as raw materials. See also tables F3 and F4, which give emission figures for the same sectors.
[2] Includes liquefied petroleum gas, fuel gas and methane. Petrol coke is included under coke.
[3] Includes mining.
[4] Norwegian purchases in Norway + Norwegian purchases abroad.
Source: Statistics Norway.

Table A8. **Electricity balance**

	1975	1980	1985	1990	1995	1996	1997	1998*	1999*	Average annual change 1990-1999*	Average annual change 1998-1999*
	TWh									Per cent	
Production	77.5	84.1	103.3	121.8	123.0	104.7	111.4	117.0	122.4	0.0	4.6
+ Imports	0.1	2.0	4.1	0.3	2.3	13.2	8.7	8.0	6.5	39.0	-19.6
- Exports	5.7	2.5	4.6	16.2	9.0	4.2	4.9	4.4	8.3	-7.2	87.6
= Gross domestic consumption	71.9	83.6	102.7	105.9	116.3	113.7	115.2	120.6	120.5	1.4	-0.1
- Consumption in pumped storage power plants	0.1	0.5	0.8	0.3	1.4	0.4	1.7	0.8	0.6	7.0	-26.9
- Consumption in power plants, losses and statistical differences	7.1	8.0	10.0	7.9	10.0	9.1	8.7	9.1	9.4	2.0	2.7
= Net domestic consumption	64.7	75.1	91.9	97.7	105.0	104.1	104.9	110.6	110.5	1.4	-0.1
- Spot power	3.2	1.2	4.8	6.7	7.5	4.1	6.2	4.9	4.3	-4.8	-13.0
= Net firm power consumption	61.4	73.9	87.1	91.0	97.5	100.0	98.7	105.7	106.2	1.7	0.5
- Energy-intensive manufacturing	26.2	27.9	30.0	29.6	28.4	28.2	28.7	30.5	31.1	0.6	2.1
= General consumption	35.2	46.0	57.1	61.5	69.1	71.8	70.0	75.2	75.1	2.3	-0.1
General consumption, corrected for temperature	36.3	45.1	54.6	65.4	69.6	70.6	71.6	76.0	77.4	1.9	1.9

Sources: Statistics Norway and Norwegian Water Resources and Energy Administration.

Table A9. **Average prices[1] for electricity[2] and some selected oil products. Energy supplied**

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998*	1999*
Heating products[3]					Price in øre[4]/kWh						
Electricity	43.5	45.7	46.5	46.6	47.8	46.8	49.7	52.4	55.0	50.3	50.3
Heating kerosene	28.3	33.9	40.1	37.4	37.8	37.1	37.7	41.6	43.8	42.6	47.6
Fuel oil no.1/light fuel oils[5]	21.6	26.6	31.9	28.3	28.0	28.2	29.6	34.0	37.0	34.3	39.9
Fuel oil no.2	20.7	25.7	30.8	27.2	26.9	27.1	..[5]	..	..	..	..
Transport products					Price in øre[4]/litre						
Petrol, leaded, high oct.	578.5	642.8	741.0	795.0	836.2	851	893	.	.	.	.
Petrol, unl. 98 octane	.	622.1	705.0	747.0	787.1	791	838	880	909	904	948
Petrol, unl. 95 octane	540.5	594.4	677.0	717.0	757.4	761	807	849	888	873	919
Auto diesel	233.0	285.9	341.0	326.0	403.0	649	701	757	779	781	827

[1] Including all taxes.
[2] Households and agriculture. For 1989-1992, prices are for firm power only. After this, both firm power and spot power.
[3] To find the price of utilized energy, we use the following figures for efficiency: electricity 1.0, kerosene 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 A10. **Total primary energy supply. World total and selected countries**

	1971	1978	1985	1990	1995	1997	Per unit GDP (1997)	Per unit GDP (1997)	Per capita (1997)
	Million toe						toe/1000 1990-USD	toe/1000 1990-USD PPP[1]	toe per capita
World total	5 477.8	6 978.7	7 719.9	8 615.4	9 146.6	9 521.5	0.37	0.29	1.66
OECD	3 372.5	4 065.7	4 118.3	4 494.1	4 867.6	5 067.5	0.25	0.27	4.63
Norway	13.9	18.5	20.3	21.5	23.5	24.2	0.16	0.24	5.50
Denmark	19.2	20.6	19.9	18.3	20.3	21.1	0.13	0.18	3.99
Finland	18.4	22.9	26.5	28.8	29.3	33.1	0.23	0.37	6.43
Iceland	1.0	1.3	1.8	2.1	2.1	2.3	0.33	0.44	8.60
Sweden	36.5	42.0	47.6	47.8	51.0	51.9	0.21	0.33	5.87
Belgium	39.9	46.9	44.7	48.4	52.4	57.1	0.26	0.30	5.61
France	154.5	182.0	200.2	227.6	241.4	247.5	0.19	0.22	4.22
Greece	9.2	15.2	18.6	22.1	23.7	25.6	0.27	0.22	2.44
Italy	114.1	134.8	135.5	153.3	161.5	163.3	0.14	0.16	2.84
Netherlands	51.3	65.5	61.6	66.6	73.4	74.9	0.22	0.25	4.80
Poland	87.4	120.0	124.8	100.1	99.3	105.2	1.41	0.43	2.72
Portugal	6.5	9.1	11.4	16.4	19.3	20.4	0.25	0.16	2.05
Spain	43.1	65.8	71.8	90.6	103.1	107.3	0.19	0.20	2.73
United Kingdom	211.1	209.4	203.8	213.1	224.5	228.0	0.21	0.22	3.86
Switzerland	17.1	19.7	23.0	25.0	25.2	26.2	0.11	0.18	3.69
Czech Republic	45.7	45.8	48.8	45.0	39.7	40.6	1.49	0.43	3.94
Turkey	19.5	31.9	38.9	52.5	62.2	71.3	0.35	0.16	1.12
Germany	307.9	353.8	361.3	355.7	339.9	347.3	0.19	0.24	4.23
Hungary	19.1	28.7	30.4	28.5	25.3	25.3	0.75	0.37	2.49
Austria	19.1	22.1	23.2	25.7	26.3	27.8	0.15	0.19	3.44
Canada	142.7	181.8	193.4	209.7	231.9	238.0	0.37	0.40	7.86
Mexico	45.6	79.8	111.4	124.2	132.7	141.5	0.44	0.20	1.51
USA	1 593.2	1 885.2	1 781.7	1 925.7	2 089.7	2 162.2	0.33	0.33	8.10
Japan	269.6	340.0	367.0	438.8	497.0	514.9	0.15	0.20	4.08
South Korea	16.5	34.5	53.4	91.4	148.2	176.4	0.43	0.31	3.83
Australia	52.2	67.2	73.9	87.2	94.5	101.6	0.28	0.29	5.48
Non-OECD	2 105.3	2 913.0	3 601.5	4 121.3	4 279.0	4 454.0	0.84	0.32	0.96
Romania	41.8	63.8	64.6	61.1	45.7	44.1	1.32	0.63	1.96
Russia	..	..	..	..	624.4	592.0	1.69	0.85	4.02
Egypt	7.8	13.0	25.5	31.9	35.3	39.6	0.49	0.15	0.66
Ethiopia	9.0	10.5	12.7	15.2	16.7	17.1	1.56	0.53	0.29
Nigeria	36.2	48.5	61.9	70.9	83.2	88.7	2.20	0.62	0.75
South Afrika	45.3	59.9	86.7	91.2	104.2	107.2	0.92	0.59	2.64
Argentina	33.7	38.9	41.4	43.3	56.1	61.7	0.29	0.22	1.73
Brazil	70.4	102.6	120.8	136.1	156.4	172.0	0.30	0.19	1.05
Guatemala	2.8	3.9	3.8	4.4	5.2	5.6	0.56	0.17	0.54
Venezuela	23.4	30.1	37.3	40.9	47.9	57.5	0.96	0.33	2.53
Bangladesh	10.8	13.8	17.3	20.9	23.8	24.3	0.81	0.18	0.20
India	183.8	227.8	292.3	359.9	436.7	461.0	1.03	0.35	0.48
Indonesia	36.3	54.6	73.3	98.9	124.9	138.8	0.74	0.18	0.69
China[2]	390.2	586.6	705.5	856.2	1 058.6	1 098.9	1.35	0.26	0.90
Thailand	14.1	21.5	26.6	43.7	70.8	80.0	0.59	0.20	1.32

[1] PPP (purchasing power parity): GDP adjusted for local purchasing power. [2] Hong Kong not included.
Sources: OECD/IEA (1999a and b).

Table A11. **Norway's net exports of energy commodities. Selected countries and regions. 1999*. Million NOK**

	Coal, coke and briquettes	Mineral oil and products	Gas, natural and manufactured	Electricity
Nordic countries	-39	16 757	445	155
EFTA	0	659	49	-
EU	-470	102 749	30 106	155
Developing countries	-167	4 999	98	-
Denmark	-1	3 980	-2	213
Finland	-2	3 079	23	1
Sweden	-36	8 815	424	-57
Belgium	-51	1 563	2 486	-
France	-9	11 042	9 157	-
Italy	0	2 222	124	-
Netherlands	-121	24 357	1 795	-
UK	-212	37 871	338	-
Germany	-33	5 740	13 846	-
Canada	-	15 417	-	-
USA	-59	13 760	193	-
China	-98	2 954	0	-

Source: External trade statistics, Statistics Norway.

Appendix B

Agriculture

Table B1. **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
1999*	10 378	3 343	647	4 883	1 504

Sources: Agricultural statistics from Statistics Norway.

Table B2. **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
1998/99*	110 083	14 135	10.6	1.4

Sources: Agricultural statistics from Statistics Norway and Norwegian Agricultural Inspection Service.

Table B3. **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	1529.3	138.4	38.7	1236.2	116.1	-	-	-	-	-
1988	1193.6	107.8	37.9	919.2	128.7	2.0	5.5	..	1.5	..
1989	1033.8	119.5	27.3	856.9	30.1	8.0	6.0	30.3	17.3	..
1990	1183.5	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	931.3	167.3	20.4	688.9	54.7	13.0	6.0	27.6	18.9	8.7
1996	706.2	139.7	15.8	503.2	47.4	15.5	7.0	32.3	21.8	10.5
1997	754.2	175.4	19.5	503.8	55.5	15.5	7.0	30.4	21.0	9.5
1998	954.6	263.3	22.8	544.3	124.3	15.5	9.0	37.9	24.1	13.8
1999	796.3	219.0	24.7	448.7	103.9	..	..	52.6	35.4	17.2

Sources: Norwegian Agricultural Inspection Service and Norwegian Agricultural Economics Research Institute.

Table B4. **Number of holdings and areas managed ecologically. Number of livestock on holdings managed ecologically and grants paid**

	Total grants to ecological farming	Conversion and acreage support	No. of holdings managed ecologically[1]	Area of agricultural land managed ecologically	Agricultural area under conversion to ecological farming	No. of milk cows	No. of sheep
	Million NOK			Decares			
1986	-	-	19	..	..	..	..
1987	-	-	41	..	..	..	..
1988	-	-	52	..	..	..	..
1989	5.1	-	89	..	..	..	..
1990	12.5	4	263	..	..	..	..
1991	20.4	6.6	410	18 145	6 288	237	3 007
1992	23.4	7.9	473	26 430	582	193	6 524
1993	22.2	5.8	501	32 343	5 444	294	7 102
1994	22.3	5.8	542	38 278	6 916	437	10 064
1995	23.4	5.9	670	44 596	13 082	572	10 628
1996	35.1	13.7	911	46 573	32 401	766	13 291
1997	35.4	20.6	1 278	73 921	43 143	1 816	18 895
1998	33.1	13.2	1 573	105 200	50 615	2 705	29 812
1999*[2]	52.9	37.2	1 707	149 510	37 824	2 998	18 393

[1] Includes all holdings approved for grants and/or to sell products labelled as ecologically produced.
[2] The rise was so large because funds were transferred from 1998.
Sources: Debio and Ministry of Agriculture.

Appendix C

Forest

Table C1. **Forest balance 1997. Whole country. 1 000 m³ without bark**

	Total	Spruce	Pine	Broad-leaved trees
Growing stock on 1.1	651 688	292 017	218 306	141 365
Total losses	11 514	7 662	2 223	1 629
Of which total roundwood cut	9 373	6 585	1 760	1 028
Sales, excl. fuelwood	8 043	6 223	1 656	164
Fuelwood, sales and private	1 128	208	61	859
Own use	202	155	42	5
Other losses	2 141	1 077	463	602
Logging waste	604	395	106	103
Natural losses	1 538	682	357	499
Total increments	22 303	11 362	5 953	4 987
Growing stock on 31.12	662 477	295 717	222 036	144 723

Sources: Forestry statistics from Statistics Norway and Norwegian Institute for Land Inventory. (Figures from inventories supplemented by calculations by Statistics Norway for Finnmark, where no inventory has been carried out.)

Table C2. **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
1994/98[1]	651 688	292 018	218 305	141 364	21 945	11 219	5 855	4 871
Region, 1994/98								
Østfold, Akershus/Oslo, Hedmark	182 061	94 253	67 976	19 832	6 672	3 715	2 127	830
Oppland, Buskerud, Vestfold	142 510	82 916	38 800	20 794	4 629	2 863	956	810
Telemark, Aust-Agder, Vest-Agder	113 573	37 193	51 409	24 971	3 381	1 328	1 246	807
Rogaland, Hordaland, Sogn og Fjordane, Møre og Romsdal	80 594	17 221	34 211	29 162	3 123	1 260	903	960
Sør-Trøndelag, Nord-Trøndelag	84 216	49 972	18 495	15 749	2 578	1 572	421	585
Nordland, Troms	45 765	10 462	5 183	30 120	1 484	481	140	863
Finnmark	2 969	1	2 231	736	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 D

Fishing, fish farming

Table D1. **Stock trends for some important fish species. 1 000 tonnes**

Year	North-East Arctic cod[1]	North-East Arctic haddock[1]	North-East Arctic saithe[2]	Green-land halibut[1]	Barents Sea capelin[3,5]	Norwegian spring-spawning herring[4]	North Sea herring[4]	North Sea cod[3]
1977	2 130	240	480	80	4 800	280	50	820
1978	1 800	260	470	70	4 250	350	70	810
1979	1 490	320	480	80	4 160	390	110	810
1980	1 200	250	550	70	6 720	470	140	1 020
1981	1 190	190	530	70	3 900	500	200	860
1982	1 000	110	480	70	3 780	500	290	840
1983	660	60	480	80	4 230	570	450	650
1984	780	50	400	70	2 960	590	720	720
1985	980	140	370	70	860	490	750	500
1986	1 320	290	350	70	120	410	770	680
1987	1 140	230	370	60	100	1 010	890	570
1988	920	160	360	60	430	3 270	1 140	430
1989	880	130	330	60	860	4 150	1 280	420
1990	980	130	390	50	5 830	4 850	1 170	330
1991	1 490	160	510	40	7 290	5 120	980	300
1992	1 970	240	640	30	5 150	5 020	720	410
1993	2 390	500	690	30	800	4 870	460	340
1994	2 180	550	640	30	200	5 600	510	430
1995	1 850	540	640	30	190	5 950	500	440
1996	1 740	470	590	40	500	6 650	490	400
1997	1 590	360	530	40	910	12 000	660	590
1998	1 300	250	540	40	2 050	11 140	880	390
1999	1 170	230	500	..	2 780	10 740	1 170	380

Table D1 (cont.). **Stock trends for some important fish species. 1 000 tonnes**

Year	North Sea haddock[3]	North Sea saithe[3,6]	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	630	1 110	480	60	..	..
1978	670	570	780	480	60	..	..
1979	670	590	950	470	50	..	..
1980	1 250	550	840	490	40	..	..
1981	670	650	640	490	50	3 210	..
1982	840	690	490	560	60	2 440	..
1983	760	820	510	550	70	1 700	..
1984	1 490	850	480	560	70	1 500	2 660
1985	860	720	440	550	60	1 760	2 630
1986	720	700	660	660	50	2 060	2 640
1987	1 070	510	540	640	60	1 760	2 620
1988	430	490	420	630	70	1 490	2 690
1989	400	470	560	590	100	1 410	2 730
1990	340	430	480	560	110	1 340	2 580
1991	740	470	460	470	100	1 770	2 910
1992	600	500	410	440	110	2 320	2 930
1993	860	530	380	390	100	2 220	2 750
1994	510	540	360	320	90	2 150	2 580
1995	950	620	370	310	70	1 930	2 800
1996	600	500	290	300	50	1 790	2 850
1997	680	450	230	290	60	2 000	3 100
1998	540	440	210	280	70	2 600	3 300
1999	372	490	270	430	80	2 920	3 750

[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.
[6] Including saithe west of Scotland.
Sources: ICES working group reports and Institute of Marine Research.

Table D2. **Norwegian catches by groups of fish species. 1 000 tonnes**

	1988	1989	1990	1991	1992	1993	1994	1995	1996*	1997*	1998*	1999*
Total	1 686	1 725	1 519	1 949	2 372	2 353	2 292	2 468	2 603	2 818	2 791	2 551
Cod	252	186	125	164	219	275	374	365	358	402	322	257
Haddock	63	39	23	25	40	44	74	80	97	106	79	53
Saithe	148	145	112	140	168	188	189	219	222	184	194	198
Tusk	23	32	28	27	26	27	20	19	19	14	21	23
Ling/blue ling	24	29	24	23	22	20	19	19	19	16	23	20
Greenland halibut	9	11	24	33	11	15	13	14	17	12	12	20
Redfish	25	27	41	56	38	33	29	22	30	23	29	31
Others and unspecified	29	29	30	44	43	57	31	27	32	39	35	26
Capelin	73	108	92	576	811	530	113	28	208	158	88	87
Mackerel	162	143	150	179	207	224	260	202	137	137	158	161
Herring	339	275	208	201	227	352	539	687	763	923	832	827
Sprat	12	5	6	34	33	47	44	41	59	7	35	22
Other industrial fisheries[1]	526	696	655	447	527	541	587	745	642	798	963	827

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

Table D3. **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
1999	591	25	-	494	-	-	7	65

Source: Norwegian Medicinal Depot.

Table D4. **Exports of some main groups of fish products. 1 000 tonnes**

	Fresh	Frozen whole	Fillets	Salted or smoked	Dried	Canned, etc.	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	486.0	637.5	238.7	79.0	84.9	19.1	154.4	38.2
1999*	491.6	795.4	249.5	63.4	66.0	17.8	153.1	48.5

Source: External Trade statistics from Statistics Norway.

Table D5. **Export of fish and fish products by important recipient country. Million NOK**

	Total	EU countries total	Of this				Other countries total	Of this	
			France	Denmark	United Kingdom	Germany		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	28 164.5	17 845.6	2 540.3	3 112.5	2 819.2	1 948.1	10 319.0	2 797.8	999.8
1999*	29 841.8	18 171.4	2 680.4	3 027.4	2 725.7	1 730.5	11 670.5	4 419.5	1 355.2

Source: External Trade statistics from Statistics Norway.

Table D6. **Export of salmon. 1000 tonnes and million NOK**

	Total		Farmed salmon. Fresh, chilled and frozen		Fresh and frozen fillets, smoked, gravlax, other salmon, etc.[1]	
	Quantity	Value	Quantity	Value	Quantity	Value
	1000 tonnes	Million NOK	1000 tonnes	Million NOK	1000 tonnes	Million NOK
1981	7.9	317.7	7.5	292.9	0.4	24.9
1982	9.6	422.7	9.2	395.3	0.4	27.4
1983	15.9	743.8	15.4	709.1	0.5	34.6
1984	20.4	998.5	19.6	944.8	0.7	53.7
1985	24.9	1 385.4	24.0	1 308.8	0.9	77.1
1986	40.1	1 773.4	38.9	1 663.7	1.2	109.7
1987	44.6	2 308.8	43.2	2 174.4	1.4	134.3
1988	66.9	3 175.7	66.0	3 079.7	1.0	96.0
1989	98.2	3 681.4	95.5	3 486.1	2.7	195.3
1990	132.9	5 043.3	130.7	4 834.9	2.2	208.4
1991	134.7	4 998.9	126.6	4 449.6	8.1	549.3
1992	133.3	5 117.8	122.1	4 399.9	11.1	717.9
1993	143.1	5 365.0	131.0	4 553.2	12.1	811.8
1994	170.3	6 476.4	153.8	5 425.3	16.4	1 051.1
1995	207.3	6 790.3	189.1	5 660.8	18.2	1 129.5
1996	238.1	6 991.6	214.1	5 692.9	24.0	1 298.7
1997	261.4	7 657.0	233.1	6 191.0	28.3	1 466.0
1998	282.0	8 761.9	252.3	7 135.9	29.7	1 626.0
1999*	338.1	10 770.7	296.7	8 423.2	41.4	2 347.5

[1] Mainly farmed salmon, but other categories are also included.
Source: External Trade statistics from Statistics Norway.

Table D7. **Catch quantities[1] and export value[2] of fish and fish products. Selected countries**

	1994		1995		1996		1997	
Country[3]	Catch quantity	Export-value	Catch quantity	Export-value	Catch quantity	Export-value	Catch quantity	Export-value
	1000 tonnes	Million USD	1000 tonnes	Million USD	1000 tonnes	Million USD	1000 tonnes	Million USD
World, total	91 398	47 205	91 558	51 802	93 177	52 857	93 329	51 376
China Main	10 867	2 320	12 563	2 835	14 222	2 857	15 722	2 937
Peru	11 999	978	8 937	870	9 515	1 120	7 870	1 342
Japan	6 617	743	5 967	713	5 936	709	5 882	889
Chile	7 721	1 304	7 434	1 704	6 691	1 697	5 812	1 782
USA	5 535	3 230	5 225	3 384	5 001	3 148	5 010	2 850
Russia	3 705	1 720	4 312	1 635	4 677	1 686	4 662	1 356
Indonesia	3 315	1 583	3 504	1 667	3 558	1 678	3 649	1 621
India	3 210	1 125	3 220	1 041	3 474	1 116	3 602	1 128
Thailand	3 012	4 190	3 013	4 449	2 963	4 118	2 912	2 350
Norway	2 352	2 735	2 525	3 123	2 639	3 416	2 857	3 399
Iceland	1 557	1 265	1 613	1 343	2 060	1 426	2 206	1 360
South Korea	2 358	1 411	2 320	1 565	2 414	1 513	2 204	1 376
Denmark	1 873	2 359	1 999	2 460	1 682	2 699	1 827	2 649
Philippines	1 845	533	1 860	502	1 784	437	1 806	435
Mexico	1 192	481	1 329	708	1 464	739	1 489	825

[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 1997.
Source: FAO (1999a and b).

Table D8. **Total catches[1] in world fisheries. 1997**

				1 000 tonnes	Per cent
Total catches				**93 329**	**100**
	By area:	Freshwater		7 739	8.3
		Marine areas		85 590	91.7
	By animal group:	Fish		79 531	85.2
		Crustaceans		5 841	6.3
		Molluscs		7 309	7.8
		Others		649	0.7
Catches in marine areas by various groupings	*Marine catches, total*			85 590	100
	By marine fishing areas:	Northern Atlantic		13 712	16.0
		Central Atlantic		5 378	6.3
		Mediterranean and Black Sea		1 493	1.7
		Southern Atlantic		3 821	4.5
		Indian Ocean		7 976	9.3
		Northern Pacific		27 356	32.0
		Central Pacific		10 612	12.4
		Southern Pacific		15 243	17.8
	By continents:	Africa		3 740	4.4
		North America		7 758	9.1
		South America		16 883	19.7
		Asia		38 795	45.3
		Europe		12 323	14.4
		Oceania		959	1.1
		Former USSR		5 051	5.9
		Others		82	0.1
	By species:	Anchoveta	*Engraulis ringens*	7 685	9.0
		Alaska pollock	*Theragra chalcogramma*	4 368	5.1
		Chilean jack mackerel	*Trachurus murphyi*	3 597	4.2
		Atlantic herring	*Clupea harengus*	2 532	3.0
		Chub mackerel	*Scomber japonicus*	2 423	2.8
		Japanese anchovy	*Engraulis japonicus*	1 667	1.9
		Capelin	*Mallotus villosus*	1 605	1.9
		Skipjack tuna	*Katsuwonus pelamis*	1 425	1.7
		Atlantic cod	*Gadus morhua*	1 362	1.6
		Largehead hairtail	*Trichiurus lepturus*	1 201	1.4
		Yellowfin tuna	*Thunnus albacares*	1 128	1.3
		European pilchard (Sardine)	*Sardina pilchardus*	1 031	1.2
		Argentine shortfin squid	*Illex argentinus*	959	1.1
		South American pilchard	*Sardinops sagax*	722	0.8
		European sprat	*Sprattus sprattus*	701	0.8
		Blue whiting	*Micromesistius poutassou*	698	0.8
		Round sardinella	*Sardinella aurita*	647	0.8
		Argentine hake	*Merluccius hubbsi*	634	0.7
		Japanese flying squid	*Todarodes pacificus*	603	0.7
		Gulf menhaden	*Brevoortia patronus*	598	0.7
		Atlantic mackerel	*Scomber scombrus*	566	0.7
		European anchovy	*Engraulis encrasicolus*	532	0.6
		Akiami paste shrimp	*Acetes japonicus*	495	0.6
		Atlantic horse mackerel	*Trachurus trachurus*	490	0.6
		Pacific cod	*Gadus macrocephalus*	444	0.5

[1] Not including farmed fish. Not including whales, seals and other sea mammals and aquatic plants. Source: FAO (1999a).

Appendix E

Transport

Table E1. **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	23	687	218	93	3	2 081	456
1952	6 524	3 893	1 584	24	1 847	291	171	9	2 115	507
1960	11 646	8 739	4 758	41	2 776	376	829	93	2 254	560
1961	12 721	9 846	5 676	45	2 929	386	855	103	2 199	573
1962	13 893	10 998	6 675	48	3 093	396	834	144	2 186	565
1963	14 642	11 824	7 724	53	2 866	403	831	185	2 093	540
1964	16 017	13 207	8 875	55	3 108	402	822	232	2 035	543
1965	17 384	14 512	10 053	58	3 263	398	798	280	2 020	572
1966	18 836	15 893	11 304	60	3 426	395	768	295	2 071	577
1967	20 185	17 088	12 495	62	3 452	399	742	423	2 088	586
1968	22 244	19 140	14 414	65	3 600	407	719	484	2 029	591
1969	23 939	20 833	16 001	67	3 707	423	702	558	1 932	616
1970	25 824	22 631	17 781	69	3 726	429	695	632	1 930	631
1971	28 734	25 344	20 452	71	3 770	441	681	758	1 970	662
1972	30 514	26 946	21 969	72	3 867	447	663	858	2 021	689
1973	32 826	29 218	24 207	74	3 907	463	641	916	1 991	701
1974	33 792	29 980	24 842	74	4 058	452	628	915	2 221	676
1975	35 305	31 353	26 311	75	3 963	475	604	1 021	2 271	660
1976	37 310	33 135	28 200	76	3 916	481	538	1 139	2 338	698
1977	39 172	34 824	29 760	76	3 987	538	539	1 286	2 377	685
1978	39 837	35 326	30 287	76	3 930	562	547	1 395	2 449	667
1979	41 229	36 458	31 169	76	4 124	613	552	1 482	2 636	653
1980	40 705	35 819	30 436	75	4 257	625	501	1 475	2 751	660
1981	40 518	35 582	30 146	74	4 297	621	518	1 535	2 767	634
1982	40 443	35 641	30 504	75	3 952	635	550	1 626	2 575	601
1983	41 100	36 160	31 112	76	3 811	665	572	1 797	2 530	613
1984	42 137	37 066	32 050	76	3 712	712	592	1 929	2 525	617
1985	47 657	42 300	36 884	77	3 948	838	630	2 147	2 567	643
1986	50 534	45 013	39 488	78	3 878	949	698	2 301	2 582	638
1987	52 404	46 704	41 243	79	3 743	1 002	716	2 505	2 563	632
1988	52 381	46 734	41 230	79	3 901	912	691	2 548	2 463	636
1989	52 707	47 136	41 684	79	3 956	792	704	2 469	2 459	643
1990	53 881	48 092	42 696	79	3 890	801	705	2 665	2 430	694
1991	53 556	47 648	42 252	79	3 935	760	701	2 699	2 573	636
1992	53 867	47 821	42 390	79	3 945	782	704	2 946	2 511	589
1993	54 987	48 578	43 128	78	3 927	815	708	3 204	2 588	617
1994	56 140	49 433	43 840	78	3 956	928	709	3 397	2 703	607
1995	56 132	49 206	43 659	78	3 752	1 071	724	3 567	2 681	678
1996	58 763	51 314	45 217	77	4 117	1 212	768	3 938	2 776	740
1997	59 367	51 602	44 934	76	4 248	1 580	840	4 029	2 941	795
1998	61 061	52 924	45 780	75	4 248	1 972	924	4 242	3 064	831

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

Table E2. **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	18 986	9 104	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	19 196	7 874	1 647	9 654	21	-	13 843
1996	21 925	9 419	1 835	10 651	20	-	18 509
1997	24 085	10 278	1 949	11 838	20	-	19 872
1998	24 780	10 191	1 934	12 636	19	-	20 200

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

Table E3. **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		1 000 tonnes							Tonnes	1 000 tonnes		kg	1 000 tonnes
1973	1.5	4.6	1.9	0.1	4.5	46.8	0.0	51.6	489	661	2.1	2.0	453	2.3
1980	1.9	5.9	2.3	0.1	4.9	61.3	0.0	63.5	599	554	2.7	2.6	597	2.9
1986	2.4	7.6	2.7	0.2	4.6	79.7	0.1	75.1	590	256	3.9	3.7	806	3.2
1987	2.5	7.9	2.8	0.2	4.9	82.9	0.1	77.4	586	261	4.1	3.9	853	3.3
1989	2.5	7.9	2.9	0.2	3.7	79.9	0.1	77.9	573	254	4.0	3.9	835	3.2
1990	2.5	7.9	2.8	0.2	3.6	76.6	0.2	75.7	555	210	4.0	3.8	813	3.1
1991	2.5	7.8	2.7	0.3	3.2	73.3	0.3	72.0	520	170	4.0	3.8	795	2.9
1992	2.5	7.9	2.7	0.3	3.3	72.2	0.4	71.3	513	139	4.3	4.1	823	2.8
1993	2.7	8.4	2.7	0.4	3.3	74.5	0.5	69.3	495	97	4.7	4.5	877	2.6
1994	2.6	8.2	2.7	0.5	2.3	68.1	0.6	65.5	467	16	4.2	4.0	796	2.5
1995	2.7	8.4	2.6	0.7	1.9	67.1	0.8	61.8	436	10	4.2	4.0	799	2.3
1996	2.8	8.9	2.6	0.8	1.8	65.9	1.0	57.7	404	3	4.0	3.9	799	2.1
1997	2.8	8.9	2.5	1.0	1.7	59.7	1.2	52.7	364	2	3.7	3.5	737	1.9
1998*	2.9	9.0	2.4	1.2	1.3	56.2	1.3	49.4	339	2	3.4	3.2	701	1.8

[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.
Sources: Bang et al. (1999) and Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table E4. **Road traffic: exhaust emissions and evaporation. Average of all vehicle categories, technologies and modes. 1998**

	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	0.061	0.19	0.08	0.04	0.01	0.98	0.05	1.59	11.9	0.09	0.02	0.02	0.01	0.06
Vans	0.100	0.31	0.09	0.04	0.02	1.41	0.04	1.98	16.3	0.14	0.02	0.02	0.01	0.09
Lorries	0.156	0.49	0.36	0.01	0.03	8.48	0.00	7.61	43.3	0.22	0.02	0.02	0.03	0.18
Buses	0.159	0.50	0.46	0.01	0.03	9.31	0.00	9.13	43.5	0.22	0.02	0.02	0.03	0.16
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	..	..
Motorcycles	0.039	0.12	0.20	0.00	0.01	0.28	0.00	4.75	28.0	0.06	0.01	0.01	..	..
Diesel														
Passenger cars	0.048	0.15	0.00	0.01	0.04	0.38	0.00	0.12	0.52	0.01	0.15	0.14	0.02	0.00
Vans	0.077	0.24	0.01	0.01	0.06	0.61	0.00	0.23	0.97	0.01	0.21	0.20	0.02	0.01
Light goods	0.128	0.41	0.02	0.01	0.10	3.98	0.00	0.49	1.98	0.02	0.24	0.23	0.06	0.01
Medium goods	0.172	0.55	0.03	0.01	0.14	5.58	0.00	0.63	2.28	0.02	0.39	0.37	0.08	0.01
Heavy goods	0.265	0.84	0.04	0.01	0.21	8.23	0.00	0.95	3.33	0.03	0.56	0.52	0.12	0.02
Buses	0.249	0.79	0.03	0.00	0.20	9.67	0.00	0.69	2.42	0.03	0.58	0.55	0.09	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.
Sources: Bang et al. (1999) and Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Appendix F

Air

Table F1. **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-equivalents
	Mill. tonnes	1000 tonnes		Tonnes											Mill. tonnes
GWP[1]	1	21	310	11700	650	2800	1300	3800	140	2900	7000	6500	9200	23900	
1950		131	7	-	-	-	-	-	-	-	..	..	..	..	..
1960		175	10	-	-	-	-	-	-	-	..	..	..	..	..
1973	30.1	216[2]	12[2]	-	-	-	-	-	-	-	..	..	..	..	..
1974	27.2	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1975	30.1	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1976	32.8	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1977	33.0	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1978	32.3	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1979	34.4	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1980	32.2	261	13	-	-	-	-	-	-	-	..	..	..	..	..
1981	31.4	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1982	30.5	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1983	31.5	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1984	33.5	..	..	-	-	-	-	-	-	-	..	..	..	..	..
1985	31.9	..	..	-	-	-	-	-	-	-	-	489	20	199	..
1986	34.6	..	..	-	-	-	-	-	-	-	-	479	20	240	..
1987	33.5	296	14	-	-	-	-	-	-	-	-	464	19	240	53.1
1988	35.4	296	15	-	-	-	-	-	-	-	-	443	18	223	54.6
1989	34.4	309	16	-	-	-	-	-	-	-	-	430	18	107	51.4
1990	35.1	315	17	-	-	-	-	-	0	-	-	441	18	92	52.1
1991	33.6	320	16	-	-	-	0	-	0	-	-	369	14	87	49.9
1992	34.3	327	14	-	-	-	0	-	1	-	-	294	11	29	48.2
1993	35.9	332	15	-	-	-	2	-	1	-	-	290	10	32	50.3
1994	37.9	340	15	0	0	0	5	0	1	-	-	251	9	32	52.4
1995	38.2	343	16	0	0	2	10	2	1	-	0	229	8	24	52.4
1996	41.1	346	16	0	0	5	17	4	1	0	0	214	5	25	55.3
1997	41.4	351	16	0	0	10	26	7	2	0	0	201	8	23	55.6
1998*	41.7	346	16	0	0	15	38	10	5	0	0	185	7	29	56.2
1999*	42.3	347	17	..	..	..	..	..	..	..	..	164	6	35	57.1

[1]Impact on greenhouse effect of emission of 1 tonne of the gas compared with that of 1 tonne CO_2.
[2] 1970 figure.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F2. **Emissions to air**

	SO_2	NO_X	NH_3	Acid equi-valents[1]	NMVOC	CO	Particu-lates[2]	Pb	Cd
	1000 tonnes							Tonnes	kg
1973	156	182	..	..	188	672	24	891	..
1974	150	178	..	..	179	632	23	834	..
1975	138	182	..	..	200	685	22	927	..
1976	147	180	..	..	202	729	21	763	..
1977	146	194	..	..	207	774	23	765	..
1978	143	186	..	..	167	798	21	787	..
1979	145	196	..	..	182	832	22	831	..
1980	137	188	23	9.7	175	822	19	624	..
1981	128	178	..	..	182	815	22	577	..
1982	111	182	..	..	189	824	20	651	..
1983	104	186	..	..	201	816	20	559	..
1984	96	201	..	..	212	842	21	401	..
1985	98	211	..	..	230	844	22	406	1143
1986	91	227	..	..	248	872	23	341	..
1987	73	226	23	8.6	255	832	22	294	..
1988	68	222	21	8.2	247	869	22	293	..
1989	58	221	23	8.0	275	823	22	276	1212
1990	53	219	23	7.8	300	820	23	228	1193
1991	44	210	24	7.4	298	759	22	183	1172
1992	36	208	25	7.1	329	750	22	149	1075
1993	35	216	25	7.3	343	745	24	105	1108
1994	35	213	25	7.2	354	737	25	20	618
1995	34	213	26	7.2	367	699	24	14	630
1996	33	221	27	7.4	368	669	25	7	629
1997	30	223	26	7.3	359	634	25	6	616
1998*	30	224	27	7.4	345	611	25	6	683
1999*	29	228	27	7.4	343	575	25	..	..

[1] Total acidifying effect of SO_2, NO_x and NH_3.
[2] Process emissions calculated for road dust only.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F3. **Emissions of greenhouse gases to air by sector. 1997**

	CO_2	CH_4	N_2O	HFC	PFC[1]	SF_6	CO_2-equivalents
	Mill. tonnes	1000 tonnes		Tonnes			Mill. tonnes
Total	41.4	351.2	15.5	45.5	208.6	23.1	55.6
Energy sectors	12.8	36.6	0.1	0.5	0.0	2.6	13.6
Extraction of oil and gas[2]	10.4	31	0.1	0.5	0.0	-	11.1
Extraction of coal	0.0	5.4	0.0	0.0	-	-	0.1
Oil refining	2.1	0.1	0.0	0.0	-	-	2.1
Electricity supplies[3]	0.3	0.1	0.0	0.0	-	2.6	0.4
Manufacturing and mining	12.3	31.1	4.9	8.2	208.5	18.3	16.3
Oil drilling	0.5	0.2	0.0	0.0	-	-	0.5
Manufacture of pulp and paper	0.6	12.6	0.1	0.0	-	-	0.9
Manufacture of chemical raw materials	3.0	1.0	4.8	0.0	-	-	4.5
Manufacture of minerals[4]	2.1	0.0	0.1	0.0	-	-	2.1
Manufacture of iron. steel and ferro-alloys	3.0	0.0	0.0	0.2	-	-	3.0
Manufacture of other metals	2.1	0.0	0.0	0.2	208.5	18.3	3.9
Manufacture of metal goods, boats, ships and oil platforms	0.3	0.0	0.0	4.4	-	0.0	0.3
Manufacture of wood plastic, rubber and chemical goods, printing	0.2	17.2	0.0	0.2	-	-	0.6
Manufacture of consumer goods	0.6	0.0	0.0	3.1	0.0	-	0.6
Other	16.4	283.5	10.4	36.7	0.0	1.9	25.7
Construction	0.7	0.1	0.1	0.6	-	-	0.7
Agriculture and forestry	0.7	108	8.6	0.5	-	-	5.6
Fishing, whaling and sealing	1.6	0.1	0.0	1.8	0.0	-	1.6
Land transport, domestic	3.0	0.2	0.1	2.7	0.0	-	3.0
Sea transport, domestic	1.4	0.1	0.0	1.0	0.0	-	1.5
Air transport[5]	1.0	0.0	0.0	0.2	-	-	1.0
Other private services	2.1	0.6	0.2	22.7	0.0	1.9	2.3
Public sector, municipal	0.3	164.2	0.5	1.2	0.0	-	3.9
Public sector, state	0.5	0.0	0.0	0.7	0.0	-	0.5
Private households	5.2	10.1	0.8	5.3	-	0.2	5.7

[1] Includes C_3F_8, CF_4 and C_2F_6.
[2] Includes gas terminal, transport and supply ships.
[3] Includes emissions from waste incineration plants.
[4] Including mining.
[5] Domestic air transport only, including emissions above 1000 m.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F4. **Emissions to air by sector. 1997**

	SO_2	NO_x	NH_3	Acid equi-valents[1]	NMVOC	CO	Par-ticu-lates[2]	Pb	Cd
	1000 tonnes							Tonnes	kg
Total	30.2	222.5	26.3	7.3	359.5	633.5	25.1	6.3	616
Energy sectors	3.1	49.0	0.0	1.2	221.5	8.3	0.5	1.3	43
Extraction of oil and gas[3]	0.4	45.0	0.0	1.0	203.5	7.2	0.3	0.0	1
Extraction of coal	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0
Oil refining	2.0	2.6	0.0	0.1	17.5	0.0	0.1	0.0	0
Electricity supplies[4]	0.7	1.4	0.0	0.1	0.5	1.0	0.2	1.3	42
Manufacturing and mining	21.7	30.9	0.3	1.4	24	51.5	1.0	2.0	400
Oil drilling	0.1	8.1	0.0	0.2	0.7	0.4	0.1	0.0	1
Manufacture of pulp and paper	2.4	1.8	0.0	0.1	0.3	2.5	0.3	0.2	23
Manufacture of chemical raw materials	6.8	5.0	0.3	0.3	2.3	37.5	0.1	0.1	4
Manufacture of minerals[5]	2.2	6.1	0.0	0.2	1.8	0.8	0.2	1.1	67
Manufacture of iron, steel and ferro-alloys	6.6	5.1	0.0	0.3	1.5	0.0	0.0	0.1	12
Manufacture of other metals	2.4	1.4	0.0	0.1	0.0	2.2	0.1	0.4	253
Manufacture of metal goods, boats, ships and oil platforms	0.2	1.0	0.0	0.0	2.8	1.0	0.1	0.0	2
Manufacture of wood, plastic,				0.0					
rubber, and chemical goods, printing	0.3	0.8	0.0	0.0	13.3	6.0	0.1	0.0	36
Manufacture of consumer goods	0.8	1.7	0.0	0.1	1.3	1.2	0.1	0.1	2
Other	5.4	142.5	26	4.8	113.9	573.7	23.5	3.0	173
Construction	0.2	6.3	0.0	0.1	13.0	5.5	0.7	0.0	2
Agriculture and forestry	0.2	6.2	24.9	1.6	3.0	4.8	0.8	0.0	1
Fishing, whaling and sealing	0.7	34.7	0.0	0.8	0.9	7.1	0.2	0.1	3
Land transport, domestic	1.1	25.3	0.0	0.6	5.1	21.6	3.0	0.2	6
Sea transport, domestic	1.3	29.6	0.0	0.7	1.7	1.4	0.3	0.1	4
Air transport[6]	0.1	1.5	0.0	0.0	1.5	2.1	0.1	0.3	0
Other private services	0.5	11.4	0.2	0.3	18.9	72.6	0.7	0.5	2
Public sector, municipal[7]	0.1	0.3	0.0	0.0	0.9	0.3	0.0	0.0	1
Public sector, state	0.1	2.3	0.0	0.1	1.4	0.7	0.0	0.0	1
Private households	1.2	24.8	0.9	0.6	67.4	457.6	17.7	1.8	153

[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] Including mining.
[6] Emissions under 1000 m only, including international air transport.
[7] Includes water supplies.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F5. **Emissions to air by source[1]. 1997**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Particulates	Pb	Cd
	Mill. tonnes	1000 tonnes								Tonnes	kg
Total	41.4	351.2	15.5	30.2	222.5	26.3	359.5	633.5	25.1	6.3	615.7
Stationary combustion	17.5	12.4	0.3	6.9	47.9	-	14.7	170.5	16.8	1.8	329.4
Process emissions	8.7	335.5	13.7	18.8	9.4	25.2	274.4	39.3	1.9	1.5	266.2
Mobile combustion	15.3	3.2	1.5	4.5	165.3	1.2	70.4	423.7	6.4	3.0	20.1
Stationary combustion, total	17.5	12.4	0.3	6.9	47.9	-	14.7	170.5	16.8	1.8	329.4
Oil and gas extraction	9.3	3.5	0.1	0.2	33.3	-	1.7	7.0	0.1	0.0	-
- Natural gas	7.1	2.8	0.1	-	19.1	-	0.7	5.2	-	-	-
- Flaring	1.1	0.1	0.0	-	5.3	-	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	5.1	10.8	-	1.9	9.0	0.8	0.5	141.4
- Refining	2.0	0.1	0.0	0.1	1.9	-	0.9	0.0	0.1	0.0	0.0
- Manufacture of pulp and paper	0.6	0.2	0.1	1.9	1.6	-	0.3	2.5	0.2	0.2	22.8
- 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	0.7	1.7	-	0.0	0.1	0.1	0.1	1.7
- Manufacture of metals	0.3	0.0	0.0	0.3	0.4	-	0.0	0.0	0.0	0.0	0.6
- Other manufacturing	1.0	0.1	0.0	1.6	1.4	-	0.6	6.3	0.3	0.1	49.4
Other industry	1.1	0.1	0.0	0.5	0.9	-	0.1	0.8	0.1	0.0	3.4
Dwellings, offices, etc.	1.0	8.1	0.1	0.9	1.9	-	10.6	153.6	15.8	0.0	152.2
Waste incineration	0.1	0.1	0.0	0.2	1.0	-	0.3	0.2	0.0	1.3	32.5
Process emissions, total	8.7	335.5	13.7	18.8	9.4	25.2	274.4	39.3	1.9	1.5	266.2
Oil and gas extraction	0.7	27.6	-	-	-	-	201.6	-	-	-	-
- Venting, leaks, etc.	0.0	9.1	-	-	-	-	4.2	-	-	-	-
- Oil loading at sea	0.6	17.8	-	-	-	-	173.9	-	-	-	-
- 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	18.8	9.4	0.3	20.1	39.3	-	1.5	266.2
- Refining	0.0	-	-	1.9	0.7	-	16.6	-	-	-	-
- 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	7.5	-	1.8	2.0	-	0.5	265.8
- - Iron, steel and ferro-alloys	3.7	-	-	9.1	6.8	-	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	-	-	-	-	-	7.0	-	-	-	-
Agriculture	0.2	108.0	8.4	-	-	24.9	-	-	-	-	-
Landfill gas	0.0	193.2	-	-	-	-	-	-	-	-	-
Solvents	0.1	-	-	-	-	-	45.7	-	-	-	-
Road dust	-	-	-	-	-	-	-	-	1.9	-	-
Other process emissions	0.0	0.4	0.5	-	-	-	-	-	-	0.0	-

Table F5 (cont). **Emissions to air by source[1]. 1997**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Particu-lates	Pb	Cd
	Mill. tonnes	1000 tonnes								Tonnes	kg
Mobile combustion, total	15.3	3.2	1.5	4.5	165.3	1.2	70.4	423.7	6.4	3.0	20.1
Road traffic	8.9	2.5	1.0	1.7	59.7	1.2	52.7	363.9	3.7	2.4	8.5
- Petrol engines	4.9	2.2	0.9	0.3	28.4	1.1	44.4	333.5	0.4	2.2	-
- - Passenger cars	4.3	2.0	0.9	0.2	24.6	1.1	39.5	295.1	0.4	1.9	-
- - Other light vehicles	0.6	0.2	0.1	0.0	3.0	0.1	4.2	34.3	0.0	0.3	-
- - Heavy vehicles	0.0	0.0	0.0	0.0	0.8	0.0	0.7	4.1	0.0	0.0	-
- Diesel engines	3.8	0.2	0.1	1.5	31.2	0.0	4.2	16.2	3.2	0.1	8.5
- - Passenger cars	0.4	0.0	0.0	0.1	1.0	0.0	0.3	1.4	0.4	0.0	0.8
- - Other light vehicles	0.9	0.0	0.1	0.3	2.5	0.0	0.9	3.7	0.9	0.0	2.0
- - Heavy vehicles	2.5	0.1	0.0	1.0	27.8	0.0	2.9	11.2	2.0	0.1	5.6
- Motorcycles, mopeds	0.1	0.1	0.0	00.	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	-
Snow scooters	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	12.1	0.0	3.9	25.7	1.4	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	2.3	89.7	-	3.1	9.2	0.8	0.2	9.7
- Coastal traffic etc.	2.2	0.2	0.1	1.5	47.3	-	1.7	2.0	0.5	0.1	5.4
- 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).
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F6. **Emissions to air by source[1]. 1998***

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Particulates	Pb	Cd
	Mill. tonnes	1000 tonnes								Tonnes	kg
Total	41.7	346.0	16.4	29.7	224.0	27.1	344.7	611.1	24.8	6.4	682.7
Stationary combustion	17.2	12.3	0.3	7.3	47.4	-	14.7	172.3	16.9	1.8	347.7
Process emissions	8.8	330.5	14.4	17.9	9.4	25.8	262.8	39.5	1.8	1.5	314.1
Mobile combustion	15.7	3.2	1.7	4.6	167.2	1.4	67.3	399.3	6.1	3.0	20.9
Stationary combustion, total	17.2	12.3	0.3	7.3	47.4	-	14.7	172.3	16.9	1.8	347.7
Oil and gas extraction	9.0	3.4	0.1	0.3	32.6	-	1.6	6.7	0.1	0.0	-
- Natural gas	6.8	2.6	0.1	-	18.2	-	0.7	4.9	-	-	-
- Flaring	1.2	0.1	0.0	-	5.7	-	0.1	0.7	-	-	-
- Diesel combustion	0.5	0.0	0.0	0.3	7.9	-	0.5	0.5	0.1	0.0	-
- Gas terminal	0.6	0.6	0.0	0.0	0.8	-	0.3	0.5	-	-	-
Manufacturing and mining	6.1	0.6	0.1	5.2	11.3	-	2.0	11.1	0.8	0.5	149.3
- Refining	2.0	0.1	0.0	0.1	1.9	-	0.9	0.0	0.1	0.0	0.0
- Manufacture of pulp and paper	0.6	0.2	0.1	1.7	1.6	-	0.3	2.6	0.2	0.2	23.1
- Manufacture of mineral products	0.9	0.0	0.0	0.6	3.8	-	0.0	0.1	0.1	0.1	63.0
- Manufacture of chemicals	1.2	0.1	0.0	0.6	1.9	-	0.1	0.6	0.1	0.1	3.9
- Manufacture of metals	0.3	0.0	0.0	0.3	0.4	-	0.0	0.2	0.0	0.0	1.4
- Other manufacturing	1.1	0.2	0.0	2.0	1.6	-	0.7	7.5	0.3	0.1	57.9
Other industry	1.1	0.1	0.0	0.7	0.8	-	0.1	0.8	0.1	0.0	3.1
Dwellings, offices etc.	1.0	8.1	0.1	1.0	1.8	-	10.6	153.6	15.8	0.0	152.3
Waste incineration	0.1	0.1	0.0	0.2	0.9	-	0.3	0.1	0.1	1.3	43.0
Process emissions, total	8.8	330.5	14.4	17.9	9.4	25.8	262.8	39.5	1.8	1.5	314.1
Oil and gas extraction	0.6	24.9	-	-	-	-	191.6	-	-	-	-
- Venting, leaks, etc.	0.0	8.3	-	-	-	-	4.0	-	-	-	-
- Oil loading at sea	0.5	16.0	-	-	-	-	168.5	-	-	-	-
- Oil loading, onshore	0.1	0.1	-	-	-	-	16.7	-	-	-	-
- Gas terminal	0.0	0.6	-	-	-	-	2.3	-	-	-	-
Manufacturing and mining	7.8	5.6	5.4	17.9	9.4	0.3	18.5	39.5	-	1.5	314.1
- Refining	0.0	-	-	2.0	0.8	-	14.8	-	-	-	-
- Manufacture of pulp and paper	-	-	-	0.6	-	-	-	-	-	-	-
- Manufacture of chemicals	0.9	1.0	5.4	2.8	1.2	0.3	0.9	39.2	-	-	-
- Manufacture of mineral products	0.9	-	-	0.9	-	-	-	-	-	1.0	-
- Manufacture of metals	6.0	-	-	11.7	7.4	-	1.9	0.3	-	0.5	314.1
- - Iron, steel and ferro alloys	4.0	-	-	9.0	6.7	-	1.9	-	-	0.1	12.0
- - Aluminium	1.7	-	-	1.8	0.7	-	-	-	-	0.4	102.0
- - Other metals	0.2	-	-	0.9	0.0	-	-	0.3	-	-	200.1
- Other manufacturing	0.0	4.6	-	-	-	-	0.9	-	-	-	-
Petrol distribution	0.0	-	-	-	-	-	7.2	-	-	-	-
Agriculture	0.2	109.6	8.4	-	-	25.4	-	-	-	-	-
Landfill gas	0.0	189.9	-	-	-	-	-	-	-	-	-
Solvents	0.1	-	-	-	-	-	45.5	-	-	-	-
Road dust	-	-	-	-	-	-	-	-	1.8	-	-
Other process emissions	0.0	0.4	0.5	-	-	-	-	-	-	0.0	-

Table F6 (cont.). **Emissions to air by source[1]. 1998***

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Particu-lates	Pb	Cd
	Mill. tonnes	1000 tonnes								Tonnes	kg
Mobile combustion, total	15.7	3.2	1.7	4.6	167.2	1.4	67.3	399.3	6.1	3.0	20.9
Road traffic	9.0	2.4	1.2	1.3	56.2	1.3	49.4	339.1	3.4	2.4	8.7
- Petrol engines	5.0	2.1	1.1	0.3	26.0	1.3	40.9	307.9	0.4	2.2	-
- - Passenger cars	4.3	1.9	1.0	0.2	22.5	1.3	36.4	272.6	0.4	1.9	-
- - Other light vehicles	0.6	0.2	0.1	0.0	2.7	0.1	3.8	31.6	0.0	0.3	-
- - Heavy vehicles	0.0	0.0	0.0	0.0	0.7	0.0	0.7	3.7	0.0	0.0	-
- Diesel engines	3.9	0.2	0.1	1.0	30.1	0.0	4.0	15.3	3.0	0.1	8.7
- - Passenger cars	0.4	0.0	0.0	0.1	1.1	0.0	0.3	1.4	0.4	0.0	0.9
- - Other light vehicles	1.0	0.0	0.1	0.3	2.5	0.0	0.9	3.9	0.8	0.0	2.2
- - Heavy vehicles	2.5	0.1	0.0	0.6	26.6	0.0	2.7	9.9	1.7	0.1	5.6
- Motorcycles, mopeds	0.1	0.1	0.0	0.0	0.1	0.0	4.4	16.0	0.0	0.0	-
- - Motorcycles	0.0	0.1	0.0	0.0	0.1	0.0	1.9	11.1	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	1.5	2.9	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	0.2	12.2	0.0	3.9	25.7	1.5	0.1	1.7
Railways	0.1	0.0	0.0	0.0	0.8	-	0.1	0.2	0.1	0.0	0.1
Air traffic[2]	1.2	0.0	0.0	0.1	1.7	-	0.5	2.3	0.1	0.3	-
- Domestic < 1000 m	0.4	0.0	0.0	0.1	1.2	-	0.5	1.9	0.0	0.3	-
- International < 1000 m	:	:	:	0.0	0.5	-	0.0	0.3	0.0	0.0	-
- Domestic > 1000 m	0.8	:	0.0	:	:	:	:	:	:	:	:
Shipping	4.4	0.4	0.1	3.0	95.2	-	3.2	9.5	0.8	0.2	10.3
- Coastal traffic etc.	2.5	0.2	0.1	1.9	52.7	-	1.9	2.2	0.5	0.1	6.0
- Fishing vessels	1.6	0.1	0.0	1.0	35.7	-	0.9	7.0	0.3	0.1	3.6
- Mobile oil rigs, etc.	0.3	0.1	0.0	0.2	6.8	-	0.5	0.3	0.1	0.0	0.7

[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).
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F7. **Emissions to air by county. 1997**

	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Particu-lates[1]	Pb	Cd
	Mill. tonnes	1000 tonnes								Tonnes	kg
Total	41.5	351.2	15.5	30.9	224.8	26.3	359.5	633.6	25.1	6.4	616.2
Of this, national emission figures	41.4	351.2	15.5	30.2	222.5	26.3	359.5	633.5	25.1	6.3	615.7
Of this, international sea traffic[2]	0.1	0.0	0.0	0.7	2.2	-	0.1	0.1	0.0	0.0	0.5
Østfold	1.6	15.6	0.7	3.3	6.2	1.7	9.3	36.5	1.7	1.4	36.1
Akershus	1.5	19.1	0.8	0.5	9.1	1.7	14.1	62.7	1.8	0.4	17.9
Oslo	1.2	5.0	0.2	0.6	6.4	0.1	11.7	38.6	1.0	0.8	9.5
Hedmark	0.8	20.6	1.0	0.3	5.2	2.4	6.6	37.1	1.9	0.1	24.8
Oppland	0.7	23.1	0.9	0.2	4.6	2.5	5.8	29.8	1.4	0.3	13.3
Buskerud	1.0	20.0	0.5	1.0	5.9	1.1	7.5	35.1	1.4	0.5	16.2
Vestfold	1.2	11.7	0.4	1.5	5.4	1.0	8.8	29.6	0.9	0.2	19.8
Telemark	3.5	11.5	3.2	1.3	7.0	0.8	6.7	27.3	1.2	0.2	49.7
Aust-Agder	0.6	7.8	0.1	2.4	2.2	0.3	3.7	50.7	1.0	0.1	11.3
Vest-Agder	1.1	12.5	0.3	2.0	3.7	0.6	5.1	21.7	1.0	0.1	17.3
Rogaland	2.8	39.1	1.2	1.5	8.8	3.4	15.4	42.1	1.5	0.2	49.6
Hordaland	3.5	30.7	0.6	2.2	10.0	1.4	46.9	49.3	2.1	0.3	169.7
Sogn og Fjordane	1.2	12.6	0.4	1.7	3.9	1.3	3.3	14.8	0.8	0.1	16.0
Møre og Romsdal	1.3	17.8	0.7	0.6	6.0	1.8	7.8	32.1	1.7	0.3	54.0
Sør-Trøndelag	1.4	17.6	0.7	3.2	6.4	1.8	7.0	35.7	1.2	0.3	33.4
Nord-Trøndelag	0.6	16.4	0.8	0.6	3.6	2.2	4.2	20.9	1.2	0.1	9.9
Nordland	2.5	20.8	2.4	4.0	8.8	1.5	6.5	25.0	1.1	0.4	40.3
Troms	0.7	9.1	0.3	1.1	3.7	0.6	3.9	17.1	0.8	0.1	7.5
Finnmark	0.3	4.6	0.1	0.2	2.2	0.2	2.6	11.0	0.5	0.1	3.8
Svalbard og Jan Mayen	0.1	5.4	0.0	0.4	0.2	0.0	0.1	0.2	0.1	0.0	7.4
Continental shelf	12.7	30.0	0.1	2.1	105.9	-	182.1	14.2	0.8	0.2	7.9
Airspace[3]	1.1	0.0	0.0	0.0	1.0	-	0.2	1.0	0.0	0.3	-
Open sea[4]	0.4	0.0	0.0	0.2	8.8	-	0.2	1.0	0.1	0.0	0.9

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

Table F8. **Emissions to air by municipality. 1997**

	CO_2	SO_2	NO_x	Particu-lates
	1000 tonnes	Tonnes		
Total	41536	30866	224778	25128
Of this, national emissions	41426	30160	222538	25107
Of this, international sea traffic[1]	109	706	2240	21
Østfold	1569	3279	6222	1734
Halden	101	236	548	208
Moss	262	412	1010	221
Sarpsborg	576	2021	1388	313
Fredrikstad	332	523	1456	411
Hvaler	14	3	87	36
Aremark	6	2	42	15
Marker	15	4	102	26
Rømskog	2	1	11	5
Trøgstad	16	5	103	37
Spydeberg	15	7	102	35
Askim	42	14	193	68
Eidsberg	40	11	247	73
Skiptvet	8	2	54	24
Rakkestad	29	9	173	58
Råde	35	9	247	58
Rygge	44	14	247	79
Våler	14	4	82	32
Hobøl	19	5	131	34
Akershus	1540	543	9056	1771
Vestby	52	12	357	66
Ski	68	16	391	83
Ås	72	16	470	76
Frogn	38	9	222	52
Nesodden	32	8	194	64
Oppegård	49	11	280	66
Bærum	306	79	1723	314
Asker	152	35	862	166
Aurskog-Høland	43	11	276	65
Sørum	56	15	366	65
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	85	37	584	110
Nannestad	22	5	133	35
Hurdal	10	2	67	16

	CO_2	SO_2	NO_x	Particu-lates
	1000 tonnes	Tonnes		
Oslo	1249	608	6436	1028
Hedmark	809	342	5219	1899
Kongsvinger	62	29	390	154
Hamar	81	27	415	178
Ringsaker	133	51	782	303
Løten	28	9	190	74
Stange	91	27	598	185
Nord-Odal	14	5	99	57
Sør-Odal	43	13	245	81
Eidskog	25	7	164	62
Grue	23	8	164	72
Åsnes	31	10	212	94
Våler	22	27	142	53
Elverum	66	21	406	159
Trysil	32	28	260	94
Åmot	29	37	173	59
Stor-Elvdal	31	9	248	55
Rendalen	16	5	130	37
Engerdal	9	7	71	23
Tolga	9	3	64	23
Tynset	30	9	217	61
Alvdal	17	5	135	32
Folldal	7	2	50	22
Os	8	3	63	23
Oppland	722	226	4618	1390
Lillehammer	73	26	420	142
Gjøvik	108	41	617	177
Dovre	22	6	164	33
Lesja	17	5	133	27
Skjåk	13	4	100	25
Lom	13	4	89	24
Vågå	18	5	126	35
Nord-Fron	25	7	171	53
Sel	32	9	209	55
Sør-Fron	15	5	104	31
Ringebu	26	7	183	46
Øyer	30	8	204	45
Gausdal	19	6	129	48
Østre Toten	45	15	272	100
Vestre Toten	49	13	244	88
Jevnaker	18	5	102	38
Lunner	29	8	195	55
Gran	43	12	280	91
Søndre Land	22	8	140	50
Nordre Land	22	7	152	55
Sør-Aurdal	15	4	113	33
Etnedal	7	2	54	16

Table F8 (cont.). **Emissions to air by municipality. 1997**

	CO_2	SO_2	NO_x	Particulates
	1000 tonnes	Tonnes		
Nord-Aurdal	31	8	203	56
Vestre Slidre	10	3	62	22
Øystre Slidre	13	4	89	26
Vang	8	2	61	17
Buskerud	1033	993	5853	1366
Drammen	169	47	862	146
Kongsberg	74	41	383	130
Ringerike	137	112	796	197
Hole	29	7	183	37
Flå	15	4	109	17
Nes	17	5	113	27
Gol	22	6	147	33
Hemsedal	11	3	76	15
Ål	19	9	102	42
Hol	23	7	155	37
Sigdal	15	6	107	31
Krødsherad	21	5	142	24
Modum	59	90	268	88
Øvre Eiker	84	81	470	114
Nedre Eiker	44	13	233	83
Lier	132	100	662	130
Røyken	32	9	172	69
Hurum	95	439	631	82
Flesberg	13	3	90	23
Rollag	8	2	59	15
Nore og Uvdal	13	4	93	26
Vestfold	1178	1478	5447	949
Borre	61	17	384	84
Holmestrand	89	12	257	46
Tønsberg	457	957	1554	152
Sandefjord	127	71	713	136
Larvik	166	208	1097	207
Svelvik	47	4	98	21
Sande	67	162	352	62
Hof	12	3	77	17
Våle	30	10	201	33
Ramnes	10	2	69	18
Andebu	12	3	76	22
Stokke	37	10	233	47
Nøtterøy	41	11	185	63
Tjøme	12	3	70	23
Lardal	12	4	82	17
Telemark	3463	1302	7021	1164
Porsgrunn	2447	947	3756	212
Skien	139	188	598	269
Notodden	45	12	269	91
Siljan	5	2	34	15
Bamble	600	18	964	90
Kragerø	43	41	260	86
Drangedal	12	4	86	36
Nome	35	55	154	72
Bø	14	4	85	35
Sauherad	18	5	117	38
Tinn	20	7	132	57
Hjartdal	8	2	54	17
Seljord	13	4	88	28
Kviteseid	13	4	88	27
Nissedal	8	2	51	14
Fyresdal	6	2	41	14
Tokke	13	3	89	25
Vinje	23	6	154	38
Aust-Agder	552	2438	2171	1050
Risør	24	12	143	73
Grimstad	53	17	316	154
Arendal	236	1476	625	368
Gjerstad	11	3	78	34
Vegårshei	6	2	41	23
Tvedestrand	24	7	155	74
Froland	13	4	94	48
Lillesand	110	888	245	91
Birkenes	27	6	133	49
Åmli	9	11	85	33
Iveland	2	1	19	12
Evje og Hornnes	14	4	87	41
Bygland	9	3	63	21
Valle	7	4	56	20
Bykle	6	2	31	10
Vest-Agder	1058	2002	3697	956
Kristiansand	422	1238	1589	362
Mandal	38	12	248	91
Farsund	155	285	327	59
Flekkefjord	30	9	193	59
Vennesla	116	406	366	98
Songdalen	16	4	104	35
Søgne	25	7	159	51
Marnardal	7	2	56	18
Åseral	5	1	42	9
Audnedal	5	2	39	13
Lindesnes	21	6	125	37
Lyngdal	27	7	161	48
Hægebostad	6	2	42	13
Kvinesdal	175	20	181	46
Sirdal	10	2	66	17

Table F8 (cont.). **Emissions to air by municipality. 1997**

	CO_2	SO_2	NO_x	Particu-lates
	1000 tonnes	Tonnes		
Rogaland	2758	1517	8763	1489
Eigersund	99	114	506	69
Sandnes	133	37	807	181
Stavanger	267	242	1963	339
Haugesund	60	17	331	109
Sokndal	30	39	187	31
Lund	16	4	119	23
Bjerkreim	17	4	107	18
Hå	43	11	264	62
Klepp	47	13	260	57
Time	39	9	189	51
Gjesdal	27	7	180	38
Sola	318	490	678	85
Randaberg	18	5	119	28
Forsand	8	3	81	7
Strand	25	8	140	40
Hjelmeland	18	6	171	22
Suldal	18	7	168	28
Sauda	314	86	57	26
Finnøy	17	7	115	16
Rennesøy	22	7	178	20
Kvitsøy	1	0	10	2
Bokn	7	3	74	7
Tysvær	627	10	856	49
Karmøy	565	382	1038	145
Utsira	1	0	6	1
Vindafjord	24	6	159	32
Hordaland	3451	2157	10001	2144
Bergen	543	189	2968	451
Etne	17	6	144	41
Ølen	11	3	69	30
Sveio	17	6	139	43
Bømlo	25	9	192	75
Stord	34	15	268	106
Fitjar	8	3	72	26
Tysnes	10	4	85	31
Kvinnherad	239	336	388	116
Jondal	4	2	35	13
Odda	326	101	441	77
Ullensvang	15	5	130	41
Eidfjord	9	3	78	14
Ulvik	5	2	47	13
Granvin	8	3	73	13
Voss	49	16	321	125
Kvam	234	666	747	84
Fusa	11	5	95	37
Samnanger	10	3	66	25
Os	31	11	224	96
Austevoll	11	5	110	29
Sund	11	4	79	31
Fjell	38	11	238	90
Askøy	51	81	283	112
Vaksdal	21	7	131	45
Modalen	1	1	14	4
Osterøy	17	7	133	59
Meland	10	3	62	37
Øygarden	104	2	203	21
Radøy	11	3	72	36
Lindås	1553	641	1944	178
Austrheim	7	3	64	20
Fedje	1	1	12	4
Masfjorden	8	3	74	21
Sogn og Fjordane	1192	1663	3866	771
Flora	42	37	339	62
Gulen	13	6	145	22
Solund	3	2	45	8
Hyllestad	5	2	41	13
Høyanger	137	223	163	35
Vik	9	3	83	21
Balestrand	11	4	90	17
Leikanger	8	3	75	21
Sogndal	26	8	167	43
Aurland	10	3	74	16
Lærdal	13	4	102	21
Årdal	417	457	277	49
Luster	13	4	92	40
Askvoll	8	3	74	23
Fjaler	8	3	62	20
Gaular	13	4	88	25
Jølster	15	4	103	26
Førde	34	10	180	60
Naustdal	7	2	52	18
Bremanger	270	806	735	29
Vågsøy	51	49	332	39
Selje	8	3	61	21
Eid	19	6	139	39
Hornindal	4	1	27	9
Gloppen	20	6	136	44
Stryn	29	9	183	51
Møre og Romsdal	1270	568	6034	1672
Molde	59	20	381	126
Kristiansund	35	12	213	92
Ålesund	111	56	808	211
Vanylven	21	36	123	35
Sande	9	4	83	23
Herøy	38	80	208	57
Ulstein	13	4	90	34

Table F8 (cont.). **Emissions to air by municipality. 1997**

	CO_2	SO_2	NO_x	Particulates
	1000 tonnes	Tonnes		
Hareid	10	4	81	28
Volda	18	7	152	56
Ørsta	31	12	242	72
Ørskog	9	3	65	19
Norddal	9	4	84	19
Stranda	16	7	122	36
Stordal	4	1	25	9
Sykkylven	16	7	122	48
Skodje	16	6	114	31
Sula	19	8	154	42
Giske	14	4	86	33
Haram	22	8	184	56
Vestnes	23	8	160	53
Rauma	33	10	260	70
Nesset	13	4	105	32
Midsund	6	2	56	15
Sandøy	3	1	31	10
Aukra	7	3	69	19
Fræna	25	8	174	66
Eide	11	4	89	24
Averøy	19	8	121	44
Frei	9	3	61	32
Gjemnes	11	3	78	27
Tingvoll	11	4	91	31
Sunndal	322	208	340	71
Surnadal	19	6	138	56
Rindal	7	2	47	20
Aure	263	4	711	26
Halsa	7	3	70	20
Tustna	4	2	39	10
Smøla	7	2	58	20
Sør-Trøndelag	1400	3213	6380	1243
Trondheim	476	765	2253	346
Hemne	248	806	682	32
Snillfjord	7	2	65	13
Hitra	10	4	89	32
Frøya	10	4	88	27
Ørland	14	5	90	29
Agdenes	6	2	52	17
Rissa	20	7	169	51
Bjugn	13	4	114	35
Åfjord	11	4	90	28
Roan	3	1	26	10
Osen	3	1	31	11
Oppdal	32	10	235	59
Rennebu	19	5	151	32
Meldal	12	4	75	34
Orkdal	332	1537	841	73
Røros	20	6	131	48
Holtålen	9	3	71	23
Midtre Gauldal	27	8	212	56
Melhus	51	14	367	100
Skaun	19	6	135	45
Klæbu	7	2	47	25
Malvik	34	9	247	70
Selbu	13	4	90	36
Tydal	4	1	31	9
Nord-Trøndelag	575	633	3582	1174
Steinkjer	72	23	500	189
Namsos	30	11	175	93
Meråker	86	405	248	30
Stjørdal	79	23	469	155
Frosta	7	2	43	22
Leksvik	10	3	69	32
Levanger	71	49	469	155
Verdal	49	16	315	116
Mosvik	3	1	19	10
Verran	8	3	56	29
Namdalseid	9	3	65	22
Inderøy	40	59	265	52
Snåsa	14	4	125	31
Lierne	7	2	58	18
Røyrvik	4	1	21	7
Namsskogan	11	3	97	18
Grong	19	6	151	34
Høylandet	8	2	53	15
Overhalla	14	4	90	34
Fosnes	3	1	29	8
Flatanger	3	1	29	13
Vikna	10	4	76	29
Nærøy	18	6	135	54
Leka	2	1	24	9
Nordland	2457	3981	8767	1062
Bodø	103	43	534	127
Narvik	51	25	328	77
Bindal	7	3	65	13
Sømna	6	2	55	11
Brønnøy	21	7	150	31
Vega	4	1	32	8
Vevelstad	3	2	44	4
Herøy	4	2	36	8
Alstahaug	16	6	117	24
Leirfjord	8	2	59	13
Vefsn	228	285	406	65
Grane	17	7	150	20
Hattfjelldal	6	4	41	11
Dønna	5	2	40	9

Table F8 (cont.). **Emissions to air by municipality. 1997**

	CO_2	SO_2	NO_x	Particulates		CO_2	SO_2	NO_x	Particulates
	1000 tonnes	Tonnes				1000 tonnes	Tonnes		
Nesna	5	2	57	9	Torsken	3	1	21	6
Hemnes	18	6	140	27	Berg	7	3	41	8
Rana	708	1714	1572	115	Lenvik	284	892	918	61
Lurøy	5	2	52	11	Balsfjord	31	10	198	46
Træna	1	0	12	2	Karlsøy	8	3	63	16
Rødøy	5	2	51	9	Lyngen	10	4	67	19
Meløy	16	18	400	27	Storfjord	11	3	73	17
Gildeskål	9	3	75	14	Kåfjord	10	4	71	20
Beiarn	3	1	27	8	Skjervøy	6	3	47	12
Saltdal	21	7	177	33	Nordreisa	17	6	112	33
Fauske	32	9	218	53	Kvænangen	6	2	44	12
Skjerstad	4	1	37	7					
Sørfold	456	1422	1342	19	**Finnmark**	318	168	2224	510
Steigen	10	3	68	17	Vardø	8	7	56	14
Hamarøy	13	4	103	17	Vadsø	22	12	181	31
Tysfjord	472	336	1027	13	Hammerfest	25	23	148	44
Lødingen	10	3	81	13	Guovdageaidnu-				
Tjeldsund	7	2	52	9	Kautokeino	20	8	190	33
Evenes	13	3	73	12	Alta	81	32	522	124
Ballangen	12	4	95	19	Loppa	3	2	32	10
Røst	2	1	15	2	Hasvik	3	2	24	7
Værøy	2	1	15	3	Kvalsund	11	4	77	15
Flakstad	4	1	30	6	Måsøy	4	2	30	9
Vestvågøy	28	8	180	40	Nordkapp	14	9	118	19
Vågan	24	8	171	30	Porsanger	24	9	147	38
Hadsel	23	8	172	32	Karasjohka-Karasjok	14	6	114	26
Bø	9	3	65	16	Lebesby	5	2	36	11
Øksnes	11	4	74	14	Gamvik	4	2	30	9
Sortland	28	9	183	36	Berlevåg	4	2	27	8
Andøy	20	6	124	22	Deatnu - Tana	18	7	121	31
Moskenes	3	1	23	4	Unjarga - Nesseby	8	3	56	12
					Båtsfjord	9	10	83	10
Troms	714	1063	3664	767	Sør-Varanger	41	26	232	58
Harstad	53	21	323	92					
Tromsø	135	59	830	208	**Other regions**	14 226	2 692	115 758	989
Kvæfjord	11	5	87	20	Spitsbergen	88	396	162	117
Skånland	13	5	87	24	Bjørnøya	0	-	-	-
Bjarkøy	2	1	27	5	Hopen	0	-	-	-
Ibestad	5	3	46	12	Jan Mayen	0	0	0	0
Gratangen	7	2	50	12	Continental shelf				
Lavangen	5	2	33	9	south of 62° N	10120	1020	64499	446
Bardu	21	7	121	29	Continental shelf				
Salangen	7	3	47	16	north of 62° N	2572	1068	41359	329
Målselv	39	14	204	48	Air space above				
Sørreisa	14	5	73	20	100 m	1055	41	963	35
Dyrøy	4	2	37	11	Fishing in				
Tranøy	6	2	45	13	distant waters[3]	391	167	8775	62

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

Table F9. **International emissions of CO_2 from energy use[1]. Million tonnes CO_2. Emissions per unit GDP and per capita**

	1980	1985	1990	1995	1997	Per unit GDP 1997[2]	Per capita 1997
	Mill. tonnes					kg/1000 USD	tonnes per capita
Whole world	18 307	19 090	20 870	21 668	22 561	..	3.9
OECD	10 956	10 628	11 176	11 725	12 235	629	11.1
Norway	30	28	30	32	34	336	7.7
Denmark	63	62	53	59	62	560	11.8
Finland	60	52	54	56	64	712	12.5
Sweden	73	62	53	56	53	341	6.0
France	485	385	378	361	363	320	6.2
Italy	374	361	408	424	424	409	7.4
Netherlands	157	150	161	179	184	639	11.8
Portugal	26	27	41	51	52	443	5.2
United Kingdom	593	569	585	567	555	518	9.4
Switzerland	42	42	44	42	45	294	6.3
Germany	1 083	1 032	981	884	884	597	10.8
Canada	430	401	428	455	477	771	15.7
USA	4 785	4 634	4 873	5 199	5 470	773	20.4
Japan	917	907	1 062	1 149	1 173	448	9.3

[1] The figures for Norway according to these data from the OECD differ somewhat from more recent Norwegian calculations of emissions.
[2] GDP 1997 expressed in 1991 prices.
Source: OECD (1999).

Table F10. **International emissions of SO_x[1]. Emissions per unit GDP and per capita**

	1980	1985	1990	1995	1997	Per unit GDP 1997[2]	Per capita 1997
	Mill. tonnes					kg/1000 USD	tonnes per capita
Norway	137	98	53	34	30	0.3	6.8
Denmark	454	363	217	150	109	1.0	20.7
Finland	584	382	260	96	100	1.1	19.5
Sweden	508	266	136	94	91	0.6	10.3
France	3 348	1 451	1 252	959	947[3]	0.8	16.2
Italy	3 757	1 901	1 651	1 322	..	..	..
Netherlands	495	254	202	145	125	0.4	8.0
Portugal	266	199	344	359	..	..	..
United Kingdom	4 894	3 759	3 764	2 351	2 028[3]	1.9	34.5
Switzerland	116	76	43	34	33	0.2	4.6
Germany	..	..	5 321	2 118	1 468	1.0	17.9
Canada	4 643	3 178	3 305	2 805	2 691	4.4	88.9
USA	23 501	21 072	21 482	17 408	18 481	2.6	69.0
Japan	1 277	..	..	903[3]	..	..	..

[1] The figures for Norway according to these data from the OECD differ somewhat from more recent Norwegian calculations of emissions. [2] GDP 1997 expressed in 1991 prices. [3] 1996 values. [4] 1992 values.
Source: OECD (1999).

Table F11. **International emissions of NO_x[1]. Emissions per unit GDP and per capita**

	1980	1985	1990	1995	1997	Per unit GDP 1997[2]	Per capita 1997
	Mill. tonnes					kg/1000 USD	tonnes per capita
Norway	188	210	218	212	222	2.2	50.4
Denmark	273	298	282	252	248	2.2	47.0
Finland	295	275	300	258	260	2.9	50.6
Sweden	448	..	388	354	337	2.2	38.1
France	1 646	1 400	1 886	1 729	1 698[3]	1.5	29.0
Italy	1 638	1 614	1 938	1 76Z	..	..	..
Netherlands	584	581	579	498	445	1.5	28.5
Portugal	165	..	309	373	..	..	..
United Kingdom	2 460	2 398	2 752	2 145	2 060[3]	1.9	35.0
Switzerland	170	179	166	136	129	0.8	18.0
Germany	..	..	2 709	2 007	1 803	1.2	22.0
Canada	1 959	2 044	2 106	1 999	2 011[3]	3.3	66.4
USA	22 558	21 302	21 258	21 561	21 394	3.0	79.9
Japan	1 622	1 322	1 476	1 409[3]	..	..	..

[1] The figures for Norway according to these data from the OECD differ somewhat from more recent Norwegian calculations of emissions. [2] GDP 1997 expressed in 1991 prices. [3] 1996 values. [4] 1992 values
Source: OECD (1999).

Appendix G

Waste

Table G1. **Quantities of municipal waste, by treatment and waste type. 1 000 tonnes**

	Total		Household waste		Industrial waste	
	Total	Recycled	Total	Recycled	Total	Recycled
1992[1,2]	2 223	186	1 012	86	1 211	99
1995[2]	2 722	373	1 174	213	1 549	160
1998	2 794	640	1 359	452	1 435	188
1999	2 650	781	1 397	524	1 253	257

[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.
[2] The figures have been adjusted downwards to correct for the intermixture of waste from industrial sectors.
Source: Waste statistics from Statistics Norway.

Table G2. **Quantities of household waste per capita, total and delivered for material recovery**

	Total	For recovery	Proportion recovered
	kg	kg	Per cent
1974	174	..	..
1985	200	..	..
1992[1]	237	20	8
1995[1]	269	49	18
1998	308	102	33
1999	314	118	38

[1] The figures have been adjusted downwards to correct for the intermixture of waste from industrial sectors.
Sources: Waste statistics from Statistics Norway and Ligård (1982).

Table G3. **Municipal waste delivered for material recovery, by material. 1995, 1998 and 1999. Tonnes**

Material	1995[1]			1998			1999		
	Total	House-hold waste	Industrial waste	Total	House-hold waste	Industrial waste	Total	House-hold waste	Industrial waste
Total	372 512	212 689	159 823	639 999	452 231	187 768	781 485	524 156	257 329
Paper and cardboard, total	169 608	122 161	47 447	244 892	208 444	36 448	278 295	247 133	31 162
Glass	17 967	14 912	3 055	26 333	23 254	3 079	29 879	28 432	1 447
Plastic	1 785	901	884	3 060	1 312	1 748	6 000	3 077	2 923
Iron and other metals	47 318	18 107	29 211	60 824	28 657	32 167	67 284	36 271	31 013
Food and organic waste, total	34 848	16 851	17 997	90 636	70 130	20 506	125 351	84 331	41 020
Wood waste	44 870	9 036	35 834	92 242	37 951	54 291	140 197	58 125	82 072
Park and garden waste	33 080	24 795	8 285	67 265	50 993	16 272	77 077	52 459	24 618
Textiles	4 101	3 716	385	7 568	7 225	343	7 865	7 810	55
Other	18 934	2 208	16 726	47 177	24 265	22 912	49 537	6 518	43 019

[1] The figures have been adjusted downwards to correct for the intermixture of waste from industrial sectors.
Source: Waste statistics from Statistics Norway.

Table G4. **Waste generated by building, rehabilitation and demolition in 1998, by waste type. Tonnes**

	Total	Construction	Restoration	Demolition
Total	1 542 800	209 500	372 200	961 100
Concrete and bricks	1 056 800	77 100	181 000	798 800
Wood	240 800	41 500	122 900	76 500
Metals	42 800	3 200	9 100	30 600
Plaster	37 100	14 100	21 000	2 200
Paper, board and plastic	16 800	8 000	2 400	6 500
Hazardous waste	7 700	200	2 900	4 700
Of this, asbestos	6 400	-	2 600	3 800
Mineral wool and EPS	6 400	3 500	1 900	1 000
Glass	4 700	1 100	2 100	1 700
Waste of unknown composition	130 200	61 300	29 300	39 600

Source: Waste statistics from Statistics Norway.

Table G5. **Waste from construction, restoration and demolition, by county. 1998. Tonnes**

	Total	Construction	Restoration	Demolition
Total	1 542 800	209 500	372 200	961 100
Østfold	86 400	8 000	21 300	57 200
Akershus	112 400	31 200	35 400	45 900
Oslo	233 800	13 100	35 100	185 700
Hedmark	94 100	9 900	17 200	67 100
Oppland	111 100	7 000	16 800	87 400
Buskerud	74 400	7 600	20 800	46 100
Vestfold	93 800	10 500	17 500	66 000
Telemark	56 200	8 100	16 900	31 300
Aust-Agder	33 900	5 300	9 100	19 600
Vest-Agder	37 200	8 200	13 500	15 600
Rogaland	140 900	22 900	32 100	86 000
Hordaland	127 100	17 400	33 000	76 800
Sogn og Fjordane	21 400	5 900	9 600	6 000
Møre og Romsdal	81 500	16 500	21 500	43 600
Sør-Trøndelag	50 900	10 600	21 700	18 700
Nord-Trøndelag	59 900	5 900	10 900	43 100
Nordland	55 400	10 300	20 100	25 100
Troms	58 000	9 400	13 900	34 700
Finnmark	15 400	2 800	6 700	6 100

Source: Waste statistics from Statistics Norway.

Table G6. **Hazardous waste delivered to the system for hazardous waste management, by category. 1990-1999[1]. Tonnes**

Category of hazardous waste	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999[1]
Total[2]	59 643	65 629	87 542	98 369	92 211	101 756	118 809	128 366	139 201	158 738
Waste oil	31 203	29 921	32 896	34 261	39 115	41 637	41 162	42 645	40 154	41 875
Other oil-contaminated waste	17 512	8 259	9 625	10 967	12 808	16 676	16 235	18 232	14 610	17 264
Stable oil emulsions	4 003	2 095	1 747	2 051	2 813	2 002	2 480	6 359	6 718	17 015
Waste solvent	1 530	2 379	2 485	3 022	4 884	4 319	3 989	3 894	3 628	4 939
Paints, glue, varnish and printing ink	2 047	2 308	2 849	2 820	2 782	3 580	4 060	3 995	3 517	5 022
Distillation residues	141	259	287	389	668	207	69	15		
Tars	1	31	0	17	220	253	673	362		
Waste containing mercury (Hg) or cadmium (Cd)	881	1 099	950	1 244	1 371	346	93	206	230	414
High priority metals or metal compounds that constitute a health or environmental hazard	-	-	-	-	19	1 883	3 262	3 637	17 158	19 586
Waste containing cyanide	6	19	8	33	22	13	14	19	28	20
Pesticides	16	16	12	45	52	72	87	45	38	195
Isocyanates and other very reactive substances	8	4	14	22	37	55	63	52	107	130
Corrosive substances and products	1 439	1 343	1 264	2 473	1 896	2 554	4 084	4 308	5 933	12 562
Waste brought ashore from oil-drilling/production	-	16 590	33 592	36 673	19 867	21 296	35 244	38 125	28 491	24 626
Other very toxic or environmentally hazardous substances	808	948	1 240	2 739	1 978	2 865	2 464	2 482	2 012	6 353
Waste containing PCBs	16	16	13	27	911	123	287	87	39	29
Photographic chemicals	8	312	527	1 554	2 682	3 838	4 488	3 510	3 839	3 754
Halons	-	-	-	-	-	3	2	130	6	4
CFCs	-	-	-	-	-	0	46	15	43	38
Asbestos	..	..	..	..	..	..	..	182	392	649
Lead accumulators[3]	..	..	..	..	..	..	12 653	12 350	13 554	14 169
Other unspecified waste	24	30	33	32	86	34	7	66	12 258	4 263

[1] Some of the figures for November and December 1999 are calculated.
[2] Lead accumulators not included.
[3] Source: AS Batteriretur.
Source: Norsas.

Table G7. **Hazardous waste delivered to the system for hazardous waste management, by county. Tonnes**

	1991[1]	1992[1]	1993[1]	1994[1]	1995	1996	1997	1998	1999[2]
Total	49 091	53 890	61 707	72 091	101 766	118 740	128 366	139 201	158 738
Østfold	1 990	2 226	3 100	5 993	5 998	6 133	5 956	9 622	14 100
Akershus	3 361	4 080	4 623	4 957	4 845	4 810	5 039	6 439	7 263
Oslo	3 261	2 987	3 744	5 597	5 532	6 938	8 807	10 687	16 776
Hedmark	1 010	1 155	1 230	1 534	1 401	2 101	1 836	2 086	2 155
Oppland	1 478	1 149	1 740	2 145	2 221	2 673	2 758	2 640	3 210
Buskerud	2 906	2 534	2 787	3 581	3 890	3 681	4 276	3 662	3 841
Vestfold	2 318	3 238	3 754	4 419	4 890	4 820	4 611	9 687	8 089
Telemark	2 563	2 393	2 200	2 191	3 428	3 743	3 462	4 829	5 522
Aust-Agder	647	700	655	859	960	1 001	1 317	782	1 171
Vest-Agder	2 019	1 799	2 689	2 544	1 959	2 445	3 278	2 575	3 346
Rogaland	5 816	8 290	9 060	10 258	14 095	17 201	18 245	15 399	14 998
Hordaland	10 518	10 251	10 681	12 693	26 571	27 824	20 814	25 623	26 253
Sogn og Fjordane	1 383	1 822	2 901	1 989	11 639	13 086	14 560	5 837	13 028
Møre og Romsdal	2 785	3 430	4 131	4 206	4 534	11 628	22 299	26 704	19 669
Sør-Trøndelag	1 761	2 125	1 985	2 248	2 616	2 738	2 818	3 961	3 554
Nord-Trøndelag	976	1 015	1 157	1 443	1 370	1 333	1 331	1 897	2 366
Nordland	2 395	2 539	2 994	3 133	3 366	3 362	3 507	3 379	8 087
Troms	1 086	1 398	1 560	1 517	1 756	2 250	2 114	2 222	4 320
Finnmark	789	718	674	747	656	874	1 288	1 011	974
Svalbard and Jan Mayen	29	41	42	37	40	48	50	22	16
Unknown	-	-	-	-	-	-	-	137	-

[1] Waste brought ashore from oil drilling/production not included.
[2] Some of the figures for Nowember and December 1999 are calculated.
Source: Norsas.

Table G8. **Quantities of waste paper, by product categories. 1 000 tonnes**

	1976	1980	1985	1990	1994	1995	1996	1997
Waste paper, total	682	687	829	907	929	926	921	990
Printed matter	276	319	436	441	474	489	519	544
Packaging	210	212	256	281	259	230	209	242
Building paper	1	0	1	2	2	2	2	2
Sanitary and household goods	34	50	70	95	79	75	75	77
Other	161	106	64	89	114	130	116	125

Sources: Waste statistics from Statistics Norway and Norwegian Food Research Institute (1994).

Table G9. **Quantities of waste paper by method of treatment or disposal. 1 000 tonnes**

	1976	1980	1985	1990	1994	1995	1996	1997
Waste 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: Waste statistics from Statistics Norway.

Table G10. **Waste paper by origin. 1 000 tonnes**

	1985	1990	1991	1992	1993	1994	1995	1996	1997
Waste paper, 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: Waste statistics from Statistics Norway.

Table G11. **Wood waste, by product types. 1 000 tonnes**

	1990	1991	1992	1993	1994	1995	1996	1997
Total	1 266	1 213	1 178	1 185	1 172	1 158	1 144	1 153
Furniture and fittings	87	95	101	105	110	115	123	128
Packaging	35	28	28	31	32	39	35	44
Construction products	205	196	196	182	191	198	209	226
Other products	22	21	20	21	21	20	21	21
Scrap from production	918	873	832	845	816	786	757	735

Source: Waste statistics from Statistics Norway.

Table G12. **Quantities of wood waste by method of treatment or disposal. 1996**

	1 000 tonnes	Per cent
Total	1 144	100
Material recovery	328	29
Incineration	496	43
Landfill	310	27
Other	11	1

Source: Waste statistics from Statistics Norway.

Table G13. **Wood waste by origin. 1 000 tonnes**

	1990	1991	1992	1993	1994	1995	1996	1997
Total	1 266	1 213	1 178	1 185	1 172	1 158	1 144	1 153
Households	77	78	80	88	95	94	98	111
Service industries	30	31	35	35	37	45	46	47
Construction	205	196	196	182	191	198	209	226
Other industries	0.4	0.5	0.5	0.5	0.6	0.6	0.6	0.6
Other wood waste from manufacturing	36	34	34	34	34	34	34	34
Scrap from production (manufacturing)	918	873	832	845	816	786	757	735

Sources: Waste statistics from Statistics Norway.

Table G14. **Quantities of wet organic waste calculated by the supply of goods and waste statistics methods. 1 000 tonnes**

	1990	1991	1992	1993	1994	1995	1996
Supply of goods	1 670	1 267	1 641	2 074	1 678	2 112	2 032
Waste statistics	1 062	1 149	1 273	1 372	1 444	1 526	1 510
Park and garden waste [1]	35	37	39	41	43	45	46

[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.
Source: Waste statistics from Statistics Norway.

Table G15. **Wet organic waste by origin and method of disposal. 1 000 tonnes**

	Total[1]	Private house-holds	Manu-facturing	Con-struction	Service industries	Fisheries	Fish farming	Other
Total 1993	1 413	358	464	3	69	462	37	20
Fodder	407	8	174	-	13	178	35	-
Compost	12	9	1	0	1	-	-	0
Incineration	92	66	10	1	11	-	-	4
Landfill	603	278	277	2	44	-	2	-
Dumped	268	-	-	-	-	268	-	-
Other/unspecified	34	-	2	-	-	16	1	16
Total 1994	1 487	376	440	3	74	530	42	22
Fodder	462	8	183	-	15	216	41	-
Compost	23	18	2	0	2	-	-	1
Incineration	98	70	11	1	12	-	-	4
Landfill	575	283	243	2	46	-	1	-
Dumped	297	-	-	-	-	297	-	-
Other/unspecified	37	-	2	-	-	17	1	17
Total 1995	1 572	394	417	3	79	602	53	24
Fodder	557	9	192	-	16	294	46	-
Compost	52	41	5	0	4	-	-	1
Incineration	104	74	12	1	13	-	-	5
Landfill	529	273	206	2	46	-	2	-
Dumped	287	-	-	-	-	287	-	-
Other/unspecified	46	-	2	-	-	21	5	18
Total 1996	1 556	397	393	3	80	596	63	24
Fodder	567	8	196	-	15	293	55	-
Compost	84	64	9	0	8	-	-	3
Incineration	156	111	18	1	20	-	-	7
Landfill	429	218	169	2	38	-	2	-
Dumped	282	-	-	-	-	282	-	-
Other/unspecified	44	-	2	-	-	21	6	15

[1] Park and garden waste included.
Source: Waste Statistics from Statistics Norway.

Table G16. **Plastic waste by product type. 1 000 tonnes**

	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997
Total	245	258	253	267	280	294	307	324	337	353	364	368
Consumer waste, total	225	238	233	243	258	271	285	300	307	316	320	322
Packaging	69	77	65	72	80	86	87	90	88	87	82	83
EE-products	36	37	39	39	41	43	44	45	44	45	44	45
Machinery and tools	5	5	5	5	5	6	6	6	6	6	6	6
Construction products	34	34	37	39	39	41	41	44	46	48	49	52
Sanitary/household products	18	20	22	25	27	31	38	43	49	56	62	63
Furniture and fittings	9	9	9	10	10	11	11	11	12	13	15	16
Means of transport excl. ships	15	15	16	15	16	16	17	18	20	21	22	21
Other products	40	40	41	38	38	39	41	42	42	40	40	37
Production waste, total	20	20	20	24	23	22	23	24	30	37	44	46

Source: Waste statistics from Statistics Norway.

Table G17. **Plastic waste by origin. 1 000 tonnes**

	1990	1991	1992	1993	1994	1995	1996	1997
Total	280	294	307	324	337	353	364	368
Households	150	159	160	168	172	176	187	188
Service industries	80	85	95	102	107	111	105	104
Manufacturing	34	33	33	34	41	47	54	56
Construction	9	8	9	8	8	8	8	9
Other industries	8	9	10	11	11	11	10	11

Source: Waste statistics from Statistics Norway.

Table G18. **Plastic waste by method of treatment or disposal. Per cent**

	1995	1996	1997
Material recovery	0	2	2
Incineration	15	15	14
Landfill	63	66	61
Export	2	3	3
Unknown treatment	20	14	20

Sources: Waste statistics from Statistics Norway and Plastretur AS.

Tabell G19. **Calculated quantities of glass waste by sector and product type. 1998. 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	131 145	55 131	1 203	245	13 672	185	44 791	15 918
Packaging	47 794	35 997	98	27	10 000	19	136	1 518
Windows	48 467	3 186	363	11	569	23	43 620	694
Vehicles and other means of transport	4 314	2 157	..	..	..	..	..	2 157
Furniture and fittings	1 592	796	37	10	116	7	51	574
Electrical and electronic products	7 802	3 499	190	53	804	37	265	2 955
Other products	21 177	9 497	515	144	2 183	99	719	8 020

Source: Waste statistics from Statistics Norway.

Table G20. **Quantities of metal waste by product type. Calculated according to the supply of goods method. 1 000 tonnes**

	1990	1991	1992	1993	1994	1995	1996
Total	1 321	1 602	1 767	1 939	1 947	1 970	2 131
Consumer waste	1 212	1 537	1 700	1 797	1 852	1 875	2 035
Buildings	50	52	53	55	57	59	64
Electrical/electronic	113	121	130	138	145	151	156
Packaging	48	42	44	43	43	42	40
Machinery and tools	147	150	164	175	181	183	195
Furniture	41	43	45	45	43	41	49
Ships and other large structures	100	107	113	120	128	133	148
Means of transport excl. ships	266	281	307	305	299	299	309
Roads and outdoor installations	34	36	39	41	44	46	53
Sanitary/household	9	9	10	10	11	11	13
Pipes and other products	403	696	795	863	901	909	1 008
Production waste[1]	109	65	67	143	96	96	96

[1] Production waste for 1994-1996 has been stipulated as the average of earlier years.
Source: Waste statistics from Statistics Norway.

Table G21. **Metal waste by origin and treatment. Calculated from the available waste statistics. 1 000 tonnes**

	Private households	Manufac-turing	Con-struction	Service industries	Other	Total
Total 1992	111	202	42	156	14	524
Re-use (car parts)	3	..	..	1	..	3
Material recovery[1,2]	51	174	28	44	9	407
Landfill or dumped	58	28	14	27	5	131
Exports[1]	..	..	..	84	..	84
Statistical errors[2]	.	.	.	.	.	102
Total 1993	115	182	39	107	16	459
Re-use (car parts)	3	..	..	1	..	3
Material recovery[1,2]	60	160	26	46	9	383
Landfill or dumped	52	22	13	28	7	..
Exports[1]	..	..	..	33	..	33
Statistical errors[2]	.	.	.	.	.	82
	0					
Total 1994	117	215	40	266	20	658
Re-use (car parts)	3	..	..	1	..	3
Material recovery[1,2]	61	193	27	49	12	400
Landfill or dumped	53	22	13	30	8	127
Exports[1]	..	..	..	186	..	186
Statistical errors[2]	.	.	.	.	.	58
Total 1995	126	221	43	98	18	..
Re-use (car parts)	3	..	..	1	..	4
Material recovery[1,2]	66	202	29	60	10	514
Landfill or dumped	57	19	14	34	8	133
Exports[1]	..	..	..	3	..	3
Statistical errors[2]	.	.	.	.	.	147
Total 1996	263	257	45	132	20	717
Re-use (car parts)	10	..	..	1	..	11
Material recovery[1,2]	127	238	30	71	12	548
Landfill or dumped	126	18	15	43	8	210
Exports[1]	..	..	..	17	..	17
Statistical errors[2]	.	.	.	.	.	69

[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 statistics on external trade. They do not agree with the total figures for material recovery reported in the waste statistics. The differences are given as statistical errors.
Source: Waste statistics from Statistics Norway.

Table G22. **Average standard waste management fees for household subscribers. Total fees collected. 1998. Excluding VAT**

	Average standard waste management fee for household subscribers	Total fees collected
	NOK	1 000 NOK
Whole country		
1995	981	1 993 748
1998	1 182	2 137 011
County		
Østfold	964	113 579
Akershus	1 029	168 389
Oslo	995	251 244
Hedmark	1 026	88 670
Oppland	1 018	87 561
Buskerud	1 047	103 710
Vestfold	1 246	113 803
Telemark	1 020	68 331
Aust-Agder	1 008	46 921
Vest-Agder	1 166	76 226
Rogaland	1 096	124 110
Hordaland	1 246	259 371
Sogn og Fjordane	1 418	61 987
Møre og Romsdal	1 188	119 895
Sør-Trøndelag	1 225	136 915
Nord-Trøndelag	1 357	67 175
Nordland	1 262	97 660
Troms	1 369	107 909
Finnmark	1 327	43 554

Source: Waste statistics from Statistics Norway.

Appendix H

Waste water treatment

Table H1. **Total inputs of phosphorus and nitrogen to the Norwegian coast. Tonnes**

	1985	1990	1992	1993	1994	1995	1996	1997	1998
Phosphorus (P)									
Total inputs	..	..	..	..	..	..	..	..	7 677
- of which anthropogenic[1]	3 563	2 711	2 673	2 727	2 609	2 450	2 392	2 200	6 431
Agriculture	744	719	697	677	664	659	662	662	663
Municipal waste water	2 490	1 728	1 753	1 745	1 713	1 562	1 489	1 281	1 310
Industry	600	464	464	304	230	229	240	257	233
Aquaculture[2]	..	..	..	..	..	..	..	..	4 225
Background runoff	1 246	1 246	1 246	1 246	1 246	1 246	1 246	1 246	1 246
Nitrogen (N)									
Total inputs	..	..	..	..	..	..	..	..	117 933
- of which anthropogenic[1]	46 664	46 584	45 049	46 664	46 584	46 034	46 435	45 049	62 918
Agriculture	22 470	22 020	21 992	22 470	22 020	21 959	21 992	21 992	21 992
Municipal waste water	20 788	21 503	22 485	21 253	21 358	20 855	20 534	18 495	18 265
Industry	2 939	3 205	4 562	2 939	3 205	3 220	3 908	4 562	2 375
Aquaculture[2]	..	..	..	..	..	..	..	..	20 286
Background runoff	55 015	55 015	55 015	55 015	55 015	55 015	55 015	55 015	55 015

[1] Anthropogenic sources are agriculture, municipal waste water and industry.
[2] Inputs from aquaculture not calculated before 1998.
Source: Norwegian Institute for Water Research (NIVA).

Table H2. **Inputs of phosphorus and nitrogen to the North Sea from Norway. Tonnes**

	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998
Phosphorus (P)										
Total inputs	..	..	..	..	..	..	..	..	..	975
- of which anthropogenic[1]	1 154	915	863	735	723	654	597	597	583	610
Agriculture	290	266	259	246	223	214	211	214	214	214
Municipal waste water	731	541	501	396	390	364	307	301	289	282
Industry	133	108	103	93	110	76	79	82	80	105
Aquaculture[2]	..	..	..	..	..	..	..	..	..	9
Background runoff	365	365	365	365	365	365	365	365	365	365
Nitrogen (N)										
Total inputs	..	..	..	..	..	..	..	..	..	37 180
- of which anthropogenic[1]	28 201	24 201	23 698	22 834	21 901	21 805	21 687	21 759	20 990	20 625
Agriculture	12 640	12 029	11 769	11 406	10 720	10 267	10 245	10 289	10 289	10 289
Municipal waste water	9 902	9 780	9 715	9 635	9 478	9 769	9 531	9 402	8 835	8 627
Industry	5 659	2 392	2 214	1 793	1 703	1 769	1 911	2 068	1 866	1 660
Aquaculture[2]	..	..	..	..	..	..	..	..	..	49
Background runoff	16 555	16 555	16 555	16 555	16 555	16 555	16 555	16 555	16 555	16 555

[1] Anthropogenic sources are agriculture, municipal waste water and industry.
[2] Inputs from aquaculture not calculated before 1998.
Source: Norwegian Institute for Water Research (NIVA).

Table H3. **Municipal waste water treatment. Hydraulic capacity (PE) and number of plants by size categories and treatment methods. 1998**

Treatment method	Total	Size by hydraulic capacity (PE) 50-99	100-499	500-1999	2000-9999	10000-49999	50000-
Total PE	6 273	45	316	582	1 199	1 475	2 657
Chemical/biological	1 643	2	32	111	152	71	1 275
Chemical	2 142	2	9	64	340	796	932
Biological	69	1	13	30	10	16	-
Other/unknown	116	15	47	17	36	-	-
Mechanical	1 669	21	164	216	438	441	390
Untreated	634	4	51	143	224	152	60
Number of plants, total	3 245	683	1 529	640	299	75	19
Chemical/biological	334	29	130	128	39	3	5
Chemical	253	26	36	66	76	39	10
Biological	117	17	62	34	3	1	-
Other/unknown	523	227	266	22	8	-	-
Mechanical	1 511	329	801	243	111	24	3
Untreated	507	55	234	147	62	8	1

Source: Waste water treatment statistics from Statistics Norway.

Table H4. **Hydraulic capacity by type of plant and per capita hydraulic capacity. By county. 1998**

Region/county	Hydraulic capacity Total	Chemical	Biological	Chemical/biological	Mechanical	Untreated discharges	Other	Proportion High-grade[1]	Other type[2]	Per capita capacity
	1 000 P.E.							Per cent		P.E.
Whole country (01-20)	6 272.8	2 141.8	69.3	1 642.6	1 669.2	633.6	116.3	61	39	1.42
North Sea counties (01-10)	3 490.2	1 590.5	35.7	1 550.2	226.8	7.7	79.4	91	9	1.44
Rest of country (11-20)	2 782.5	551.3	33.6	92.4	1 442.5	625.9	36.9	24	76	1.40
01 Østfold	350.2	325.7	0.5	22.0	1.0	0.1	1.0	99	1	1.44
02/03 Oslo og Akershus	1 378.0	196.5	0.3	1 179.7	0.0	0.0	1.4	100	0	1.45
04 Hedmark	221.8	86.5	0.9	106.6	2.1	0.0	25.8	87	13	1.19
05 Oppland	282.7	94.7	0.0	168.7	1.5	0.0	17.8	93	7	1.55
06 Buskerud	329.3	275.5	0.4	30.2	0.9	0.0	22.4	93	7	1.41
07 Vestfold	265.4	208.3	0.0	14.4	42.6	0.0	0.2	84	16	1.27
08 Telemark	248.1	215.8	11.5	12.4	2.4	0.0	6.0	97	3	1.51
09 Aust-Agder	197.6	34.4	20.5	8.1	132.0	0.0	2.6	32	68	1.95
10 Vest-Agder	217.1	153.1	1.7	8.2	44.4	7.6	2.2	75	25	1.42
11 Rogaland	601.7	303.4	1.8	1.5	222.0	64.9	8.2	51	49	1.65
12 Hordaland	482.5	63.5	3.2	27.6	367.1	19.7	1.4	20	80	1.13
14 Sogn og Fjordane	120.3	0.2	4.5	3.7	72.6	36.3	3.0	7	93	1.12
15 Møre og Romsdal	378.9	19.6	0.7	2.8	132.9	221.9	0.9	6	94	1.57
16 Sør-Trøndelag	406.4	133.3	4.3	19.8	228.6	17.2	3.2	39	61	1.57
17 Nord-Trøndelag	187.2	23.1	12.3	12.7	132.4	3.3	3.4	26	74	1.48
18 Nordland	327.0	2.5	5.8	1.9	176.2	137.5	3.2	3	97	1.37
19 Troms	173.1	3.7	0.9	11.0	81.3	66.5	9.8	9	91	1.15
20 Finnmark	105.5	2.1	0.1	11.5	29.3	58.6	3.9	13	87	1.41

[1] High-grade plants are those providing chemical and/or biological treatment. [2] The category "Other type" includes mechanical, unconventional and other treatment, and in addition untreated discharges.
Source: Waste water treatment statistics from Statistics Norway.

Table H5. **Quantities of phosphorus and nitrogen discharged and removed from waste water at waste water treatment plants. Calculated treatment efficiency. County. 1998**

	Discharged from plants		Removed from waste water		Calculated treatment efficiency	
	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen
	Tonnes		Tonnes		Per cent	
Whole country (01-20)	816	13 554	1 576	4 110	66	23
North Sea counties (01-10)	119	7 134	1 285	3 109	91	31
Rest of the country (11-20)	698	6 420	291	1 001	29	13
01 Østfold	12	811	114	100	91	11
02/03 Akershus and Oslo	28	2 517	660	1 978	96	44
04 Hedmark	8	510	97	191	92	27
05 Oppland	5	478	88	235	95	33
06 Buskerud	10	629	108	100	92	14
07 Vestfold	11	629	66	154	85	20
08 Telemark	9	505	83	87	90	15
09 Aust-Agder	20	243	23	86	53	26
10 Vest-Agder	15	813	45	178	75	18
11 Rogaland	83	1 144	103	226	55	17
12 Hordaland	149	1 338	40	237	21	15
14 Sogn og Fjordane	44	328	7	40	13	11
15 Møre og Romsdal	94	735	29	60	24	7
16 Sør-Trøndelag	80	917	57	180	41	16
17 Nord-Trøndelag	45	396	22	79	33	17
18 Nordland	97	735	15	98	14	12
19 Troms	66	502	12	61	16	11
20 Finnmark	40	324	7	21	14	6

Source: Waste water treatment statistics from Statistics Norway.

Table H6. **Number of people connected to municipal and separate waste water treatment plants, and the proportion connected. County. 1998**

	No. of people connected to municipal sewerage systems			No. of people connected to separate treatment plants	Proportion connected to municipal sewerage system
	Total	Treatment plants	Untreated discharges		
					Per cent
Whole country	3 514 590	3 173 792	340 798	912 966	79
North Sea counties (01-10)	1 981 468	1 976 569	4 899	409 315	83
Rest of country (11-20)	1 533 122	1 197 223	335 899	503 651	75
01 Østfold	210 130	210 130	-	33 775	86
02/03 Akershus and Oslo	883 357	883 357	-	58 932	94
04 Hedmark	123 637	123 637	-	77 270	62
05 Oppland	107 633	107 633	-	70 098	61
06 Buskerud	182 215	182 215	-	45 012	80
07 Vestfold	164 761	164 761	-	42 694	79
08 Telemark	126 644	126 644	-	32 942	79
09 Aust-Agder	71 099	71 099	-	24 383	74
10 Vest-Agder	111 992	107 093	4 899	24 209	82
11 Rogaland	288 751	257 778	30 973	47 749	86
12 Hordaland	353 916	328 381	25 535	110 462	76
14 Sogn og Fjordane	72 684	50 320	22 364	42 092	63
15 Møre og Romsdal	170 773	81 206	89 567	78 006	69
16 Sør-Trøndelag	191 008	182 428	8 580	55 595	77
17 Nord-Trøndelag	83 350	80 767	2 583	35 757	70
18 Nordland	177 880	123 686	54 194	67 037	73
19 Troms	127 330	70 410	56 920	51 518	71
20 Finnmark	67 430	22 247	45 183	15 435	81

Source: Waste water treatment statistics from Statistics Norway.

Table H7. **Number of separate waste water treatment plants (scattered settlements). County. 1998**

County/region	Total	Type of plant							
		Untreated discharges	Sludge separator	Mini wwtp without precipitation	Mini wwtp with precipitation	Infiltration	Sandfilter	Separate toilet systems	Sealed tank
Whole country (01-20)	346 365	24 682	152 220	3 267	3 184	109 722	33 321	14 441	5 529
North Sea counties (01-10)	160 564	6 212	48 974	2 840	2 250	72 223	12 515	10 947	4 603
Rest of country (11-20)	185 801	18 470	103 246	427	934	37 499	20 806	3 494	926
01 Østfold	13 533	487	8 407	58	428	476	974	2 395	308
02/03 Oslo og Akershus	23 202	2 029	9 857	848	964	4 864	3 143	310	1 187
04 Hedmark	30 661	345	5 632	4	217	18 853	2 002	3 436	172
05 Oppland	27 764	174	1 922	4	21	22 528	362	2 448	305
06 Buskerud	17 815	429	5 172	57	138	9 397	927	885	810
07 Vestfold	16 373	1 933	9 114	1 801	200	927	1 179	234	985
08 Telemark	12 926	122	4 569	44	65	5 285	2 362	38	441
09 Aust-Agder	9 128	530	2 366	13	117	4 729	1 024	184	165
10 Vest-Agder	9 162	163	1 935	11	100	5 164	542	1 017	230
11 Rogaland	16 776	768	11 230	41	187	3 079	995	332	144
12 Hordaland	40 997	1 615	22 163	87	541	8 733	7 496	202	160
14 Sogn og Fjordane	15 001	1 149	5 461	22	3	6 069	2 260	6	31
15 Møre og Romsdal	26 670	4 100	15 846	7	13	2 485	2 240	1 840	139
16 Sør-Trøndelag	21 055	2 368	8 517	64	79	6 001	3 048	849	129
17 Nord-Trøndelag	12 681	915	5 844	161	94	1 632	3 615	173	247
18 Nordland	25 765	4 332	16 911	45	14	3 198	1 114	78	73
19 Troms	21 141	2 485	15 173	0	1	3 452	14	14	2
20 Finnmark	5 715	738	2 100	0	2	2 849	25	0	1

Source: Waste water treatment statistics from Statistics Norway.

Table H8. **Gross investments in the municipal waste water sector. Planned investments and investments per subscriber. By county. 1998**[1]

County/region	Actual investments	Planned investments in 1998	Proportion carried out	Number of subscribers	Investment per subscriber
	1 000 NOK		Per cent		NOK
Whole country	1 908 726	2 043 367	93	1 544 889	1 236
North Sea counties	1 012 788	1 135 818	89	888 619	1 140
Rest of country	895 938	907 549	99	656 270	1 365
Østfold	139 435	163 614	85	85 409	1 633
Akershus	143 404	102 924	139	160 774	892
Oslo	251 407	245 700	102	259 931	967
Hedmark	64 482	81 780	79	58 034	1 111
Oppland	86 703	106 624	81	56 434	1 536
Buskerud	57 985	91 765	63	68 745	843
Vestfold	83 062	93 305	89	71 865	1 156
Telemark	60 384	76 865	79	50 475	1 196
Aust-Agder	41 960	115 505	36	30 601	1 371
Vest-Agder	83 966	57 736	145	46 352	1 811
Rogaland	181 838	138 000	132	132 766	1 370
Hordaland	300 656	254 658	118	144 747	2 077
Sogn og Fjordane	25 027	46 450	54	26 229	954
Møre og Romsdal	81 001	95 544	85	70 705	1 146
Sør-Trøndelag	59 071	93 177	63	105 049	562
Nord-Trøndelag	72 517	108 078	67	42 859	1 692
Nordland	97 729	87 242	112	60 273	1 621
Troms	63 013	61 454	103	52 144	1 208
Finnmark	15 086	22 946	66	21 499	702

[1] Some counties did not report these figures, and in these cases estimates have been used.
Source: Waste water treatment statistics from Statistics Norway.

Table H9. **Total fees collected and annual costs in current NOK. Ratio between fees and annual costs in the municipalities (income-to-cost ratio)**

	Fees collected				Annual costs[1]				Income-to-cost ratio[1]			
County/region	1995	1996	1997	1998	1995	1996	1997	1998	1995	1996	1997	1998
	Million NOK								Per cent			
Whole country	2 957	3 094	3 139	3 455	3 202	3 248	3 088	3 621	92	95	102	95
North Sea counties	1 942	2 014	2 017	2 241	2 120	2 161	2 037	2 337	92	93	99	96
Rest of country	1 016	1 080	1 122	1 213	1 082	1 087	1 052	1 285	94	99	107	94
Østfold	223	236	247	252	233	243	239	258	96	97	103	98
Akershus	318	334	341	391	377	386	338	427	84	86	101	92
Oslo	498	498	459	538	417	438	401	432	120	114	114	125
Hedmark	136	133	143	149	163	153	158	177	83	86	90	84
Oppland	132	135	141	152	186	197	190	203	71	69	74	75
Buskerud	185	185	192	209	225	218	208	226	82	85	92	92
Vestfold	147	164	171	188	151	155	151	183	98	106	114	103
Telemark	120	134	125	144	138	136	131	155	86	99	95	93
Aust-Agder	78	87	90	96	97	100	96	114	81	87	93	84
Vest-Agder	106	108	109	122	132	133	124	162	80	81	88	75
Rogaland	226	232	234	252	269	260	242	291	84	89	96	87
Hordaland	251	272	286	302	228	237	237	295	110	114	121	102
Sogn og Fjordane	37	42	42	46	45	46	41	53	82	90	101	87
Møre og Romsdal	98	107	112	120	112	113	112	131	88	95	101	91
Sør-Trøndelag	137	143	157	160	145	144	139	163	95	99	113	98
Nord-Trøndelag	74	76	81	89	82	80	83	107	91	95	98	83
Nordland	89	97	99	113	98	104	97	124	91	93	103	91
Troms	75	81	91	99	73	67	80	84	103	121	113	118
Finnmark	29	31	20	33	32	34	20	37	93	91	101	89

[1] Municipalities that did not report investments or that reported no investments in 1997 omitted.
Source: Waste water treatment statistics from Statistics Norway.

Table H10. **Annual costs per subscriber and average fees quoted by municipality. Current NOK**

	Annual costs per subscriber[1]			Connection fee				Annual fee per 140 m² dwelling			
County/region	1996	1997	1998	1996	1997	1998	1999	1996	1997	1998	1999
Whole country	2 081	2 075	2 344	11 151	11 324	11 690	12 267	1 517	1 668	1 770	1 934
North Sea counties	2 632	2 393	2 629	14 158	14 260	14 647	15 717	2 072	2 247	2 343	2 543
Rest of country	1 470	1 662	1 958	9 143	9 378	9 860	9 936	1 176	1 314	1 390	1 536
Østfold	2 841	2 826	3 024	8 015	7 916	8 248	8 252	2 242	2 456	2 576	2 706
Akershus	2 378	2 255	2 656	15 358	15 395	25 809	20 786	2 317	2 403	2 410	2 476
Oslo	2 075	1 567	1 661	18 300	18 300	26 117	32 893	1 128	1 128	1 877	2 066
Hedmark	2 725	2 803	3 046	17 522	17 931	19 147	18 539	2 077	2 333	2 449	2 684
Oppland	3 755	3 467	3 594	22 274	22 891	22 853	23 895	2 288	2 413	2 447	2 726
Buskerud	3 240	3 058	3 282	10 731	11 544	9 642	11 584	2 353	2 434	2 316	2 497
Vestfold	2 332	2 217	2 543	19 379	17 942	20 286	21 094	1 686	1 909	2 023	2 163
Telemark	2 893	2 874	2 956	7 539	6 286	6 146	5 948	2 073	2 359	2 567	2 747
Aust-Agder	3 538	3 377	3 735	11 148	11 889	12 204	12 866	1 738	1 864	2 041	2 393
Vest-Agder	3 035	3 020	3 502	11 017	11 658	12 371	12 769	1 606	1 861	2 094	2 351
Rogaland	1 959	1 958	2 102	10 401	11 257	11 024	11 359	1 111	1 162	1 269	1 386
Hordaland	1 566	1 646	2 040	10 140	10 742	11 132	11 590	1 098	1 217	1 284	1 442
Sogn og Fjordane	1 916	1 772	2 016	11 735	11 841	11 954	11 946	1 207	1 417	1 469	1 584
Møre og Romsdal	1 564	1 545	1 792	9 427	9 227	9 247	10 248	1 108	1 242	1 288	1 406
Sør-Trøndelag	1 337	1 366	1 556	12 313	12 116	13 074	12 299	1 475	1 579	1 664	1 856
Nord-Trøndelag	2 154	2 092	2 487	8 230	9 000	10 734	10 867	1 759	1 899	1 953	2 181
Nordland	783	1 608	1 844	7 124	7 698	8 060	7 823	1 088	1 248	1 324	1 470
Troms	1 335	1 648	1 605	4 349	4 431	4 573	4 786	928	1 044	1 101	1 240
Finnmark	1 137	1 124	1 305	9 524	8 574	9 419	8 922	910	1 131	1 264	1 363

[1] Reported figures for subscribers in 1997 adjusted using estimated figures for municipalities that did not provide reports.
Source: Waste water treatment statistics from Statistics Norway.

Table H11. **Comparison of physical and economic data for the waste water treatment sector for Norway's four largest towns. 1998 unless otherwise stated**

	Oslo	Bergen	Trondheim	Stavanger
Proportion connected	ca. 100%	ca. 94%	ca. 96%	ca. 100%
Treatment method				
Chemical/biological	100 %	20 %	60 %	80 %
Chemical	-	20 %	40 %	80 %
Mechanical	-	80 %	40 %	20 %
Treatment efficiency				
Phosphorus	97 %	23 %	41 %	77 %
Nitrogen	50 %	16 %	17 %	19 %
Investments				
Total (1 000 NOK)	251 407	236 200	39 982	26 236
Per subscriber (NOK)	967	2 346	500	500
Annual costs				
Total (1 000 NOK)	431 621	197 223	93 364	125 328
Operating, management and maintenance costs (1 000 NOK)	241 917	71 519	52 515	71 580
Capital costs (1 000 NOK)	189 704	125 704	40 849	53 748
Per subscriber (NOK)	1 661	1 959	1 213	2 546
Fees collected				
Total (1 000 NOK)	537 850	225 547	101 815	93 700
Per subscriber (NOK)	2 069	2 241	1 322	1 904
No. of subscribers	259 931	100 667	77 000	49 224
Income-to-cost ratio	125 %	114 %	109 %	75 %
Fees for 1998 (NOK)				
Connection fee	26 117	7 812	8 898	14 097
Annual fee	1 877	2 143	2 114	1 456
Fees for 1999 (NOK)				
Connection fee	32 893	3 906	10 053	14 097
Annual fee	2 066	2 143	2 388	1 456

Source: Waste water treatment statistics from Statistics Norway.

Appendix I

Urban settlements

Table I1. **Area[1] and population in urban settlements. Whole country and counties. 1999***

County	Area: km²	Area: Percentage of total area	Population in urban settlements as of 1 January 1998: Residents	Percentage of total population	Residents per km²
Whole country	2 119.9	0.7	3 344 427	75.2	1 578
01 Østfold	141.7	3.6	200 743	81.6	1 417
02 Akershus	236.3	5.2	401 051	87.1	1 697
03 Oslo	134.0	31.4	500 973	99.6	3 738
04 Hedmark	92.9	0.4	96 520	51.8	1 039
05 Oppland	94.6	0.4	93 401	51.3	988
06 Buskerud	129.6	0.9	177 763	75.6	1 372
07 Vestfold	123.0	5.7	173 474	82.3	1 410
08 Telemark	90.6	0.6	119 771	72.8	1 321
09 Aust-Agder	60.9	0.7	66 435	65.5	1 090
10 Vest-Agder	75.8	1.1	117 824	76.5	1 554
11 Rogaland	171.2	2.0	304 280	82.4	1 778
12 Hordaland	208.3	1.4	322 015	74.6	1 546
14 Sogn og Fjordane	50.5	0.3	52 827	49.1	1 046
15 Møre og Romsdal	131.0	0.9	156 984	64.7	1 198
16 Sør-Trøndelag	109.6	0.6	192 695	73.9	1 758
17 Nord-Trøndelag	55.0	0.3	66 458	52.4	1 209
18 Nordland	111.0	0.3	152 827	64.1	1 376
19 Troms	63.6	0.3	94 911	63.2	1 492
20 Finnmark	40.3	0.1	53 474	72.2	1 326

[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 from Statistics Norway.

Table I2. **Road area and the base area of buildings and dwellings in urban settlements. Whole country and counties. 1998***

County	Total base area of all buildings[1]	Base area of all dwellings[1]	Road area[2]	Base area of buildings as proportion of settlement area	Base area of dwellings as proportion of settlement area	Road area as proportion of settlement area
	km²			Per cent		
Whole country	177.3	87.8	308.4	8.6	4.2	14.9
01 Østfold	12.0	6.0	20.4	8.6	4.3	14.7
02 Akershus	20.4	10.2	32.8	8.9	4.4	14.3
03 Oslo	20.2	8.8	15.8	15.3	6.6	12.0
04 Hedmark	7.3	3.3	13.8	8.1	3.6	15.2
05 Oppland	6.5	3.0	14.9	7.0	3.3	16.1
06 Buskerud	10.3	5.1	19.5	8.1	4.0	15.2
07 Vestfold	10.1	5.5	18.7	8.3	4.5	15.4
08 Telemark	6.6	3.4	13.5	7.3	3.8	15.0
09 Aust-Agder	3.8	2.0	8.0	6.5	3.5	13.7
10 Vest-Agder	5.9	3.1	11.4	8.0	4.2	15.4
11 Rogaland	17.3	8.4	26.7	10.3	5.0	15.9
12 Hordaland	14.4	8.0	32.0	7.2	3.9	15.9
14 Sogn og Fjordane	3.7	1.7	7.7	7.5	3.5	15.8
15 Møre og Romsdal	9.7	4.7	17.5	7.7	3.7	13.9
16 Sør-Trøndelag	8.8	4.5	14.1	8.3	4.2	13.2
17 Nord-Trøndelag	4.1	1.9	8.4	7.8	3.6	15.9
18 Nordland	8.2	4.3	17.1	7.5	3.9	15.7
19 Troms	4.8	2.4	10.1	7.8	3.9	16.3
20 Finnmark	3.2	1.7	6.0	8.1	4.2	15.1

[1] The data on area in the GAB register is incomplete, particularly for older buildings. The figures for these areas are therefore very uncertain.

[2] Road area is calculated on the basis of standard road widths. There is therefore some uncertainty associated with the calculated road areas.

Source: Land use statistics from Statistics Norway.

Table I3. **Road area and the base area of buildings and dwellings in urban settlements by population size. 1998***

Size group	Total base area of all buildings[1]	Base area of all dwellings[1]	Road area[2]	Base area of buildings as proportion of settlement area	Base area of dwellings as proportion of settlement are	Road area as proportion of settlement area
	km²			Per cent		
Total	177.3	87.8	308.4	8.6	4.2	14.9
200 - 499	10.4	4.5	24.6	6.1	2.6	14.3
500 - 999	12.2	5.4	28.0	6.5	2.9	15.0
1 000 - 1 999	13.5	6.6	29.7	6.9	3.4	15.3
2 000 - 19 999	53.6	26.9	101.9	8.2	4.1	15.5
20 000 - 99 999	35.2	18.5	60.5	9.0	4.7	15.4
100 000 -	52.4	25.9	63.6	11.3	5.6	13.7

[1] The data on area in the GAB register is incomplete, particularly for older buildings. The figures for these areas are therefore very uncertain.
[2] Road area is calculated on the basis of standard road widths. There is therefore some uncertainty associated with the calculated road areas.
Source: Land use statistics from Statistics Norway.

Table I4. **Road area and the base area of buildings and dwellings in the 10 largest urban settlements in Norway. 1998***

Urban settlement	Total base area of all buildings[1]	Base area of all dwellings[1]	Road area[2]	Base area of buildings as proportion of settlement area	Base area of dwellings as proportion of settlement area	Road area as proportion of settlement area
	km²			Per cent		
Oslo	32.4	15.0	33.0	12.4	5.7	12.6
Bergen	7.0	4.3	14.3	8.1	5.0	16.7
Stavanger/Sandnes	7.8	3.7	9.6	12.7	6.0	15.6
Trondheim	5.3	2.9	6.8	9.3	5.1	12.0
Fredrikstad/Sarpsborg	5.9	2.8	9.2	9.3	4.4	14.5
Porsgrunn/Skien	4.0	2.2	7.6	7.5	4.2	14.3
Drammen	3.9	1.9	6.2	10.3	5.2	16.5
Kristiansand	2.7	1.5	4.5	9.6	5.3	15.9
Tromsø	1.8	1.0	3.4	9.5	5.2	17.7
Tønsberg/Åsgårdstrand	2.7	1.5	4.8	8.4	4.8	14.7

[1] The data on area in the GAB register is incomplete, particularly for older buildings. The figures for these areas are therefore very uncertain.
[2] Road area is calculated on the basis of standard road widths. There is therefore some uncertainty associated with the calculated road areas.
Source: Land use statistics from Statistics Norway.

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