Natural Resources and the Environment 2001

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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.

An important objective is to ensure that this publication presents the environmental situation so that it can be readily understood while at the same time including considerable detail. *Natural Resources and the Environment 2001* starts with an updated presentation of key figures or indicators (Chapter 1). This is followed by detailed descriptions of the various topics, which include both statistics and analyses. 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 2001*.

The report is a joint publication by the Division for Environmental Statistics, Department of Economic Statistics, and the Division for Resource and Environmental Economics, Research Department, and was edited by Olav Skogesal. The other members of the editorial committee were Iulie Aslaksen, Karine Nyborg and Eirik Lund Sagen. Alison Coulthard and Veronica Harrington Hansen have translated the Norwegian version into English.

Statistics Norway,
Oslo/Kongsvinger 28 September 2001

Svein Longva

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1. Status and important trends

The state of the environment is of crucial importance to people's welfare. Issues related to the management of the environment and natural resources frequently make the headlines and occupy an important place in the public debate. In Norway, for example, a heated debate on whether to build gas-fired power plants led to a change of government in 2000. Management of the large predators, especially wolves, and livestock diseases are other issues that have received a great deal of attention during the past year. And people have strong opinions on other issues too – private cars versus public transport, waste management and how to maintain public access to the shoreline, to mention only a few. All this shows the importance of environmental issues and the way we use our natural resources to Norwegian society as a whole and to individual Norwegians. Why is this the case? Is the environment under threat? Are we using our natural resources unwisely? We hope that the sound factual basis we provide in this publication can go some way towards answering these questions.

1.1. Introduction

The state of the environment depends on a complex variety of biological and physical processes that interact with human behaviour and the pressures this exerts. One example is provided by greenhouse gas emissions, which are generated by various processes including the combustion of fossil fuels such as coal, oil and natural gas. These gases reduce the amount of infrared radiation (heat) escaping through the atmosphere, thus causing the global temperature to rise. The effects of a rise in temperature will include climate change and a rise in sea level. This in turn will alter living conditions for all kinds of organisms, including people: some individuals and species will benefit, whereas others will meet more difficult conditions or even become extinct. Factors that affect greenhouse gas emissions include the prices of fuel and energy, which are therefore also important factors to consider. In addition, we know that economic and technological developments can have a major effect on the consumption of raw materials, and thus on the volume of emissions. In order to find effective measures to deal with an environmental problem, we need a thorough knowledge of the processes involved.

As the examples above show, we need environmental statistics that describe the state of the environment and environmental trends in a way that clearly illustrates the most important processes and linkages between them. Environmental indicators are being developed as a tool for this purpose (see box 1.1).

Box 1.1. Environmental indicators

Information on the environment includes a variety of topics, and it can be difficult to interpret trends. Indicators or key figures have therefore been developed to describe environmental phenomena in a way that is clearer and easier to grasp than detailed statistics. Indicators are used to monitor environmental trends and provide a basis for evaluating action that needs to be taken. A great deal of work is being done at national and international level to develop good environmental indicators.

An indicator is often a simplified description of a 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.

Environmental policy focuses on environmental problems that are caused by human activity. These 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 be linked to such socio-economic factors. One way of structuring environmental indicators that is generally recognized is the PSR model (Pressure-State-Response), which was developed by the OECD (e.g. OECD 1994, 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, adverse effects on human health, reduction in crop yields or species extinction. At some point, society can react by making 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 various aspects of 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, so that it is possible to show which types of activities exert the strongest pressures on the environment. Indicators are also important in the context of linking environmental statistics to economic models, analyses and projections.

The next two sections of this chapter describe some indicators or key figures that can be used to describe the state of the environment and environmental pressures in Norway. In section 1.4, we describe some economic trends in Norway and discuss how these affect the environment and natural resources.

The book continues with descriptions of statistics and analyses related to Norway's natural resources and resource policy issues in Chapters 2 – 6. Chapters 7 – 10 focus on important environmental problems, and Chapter 11 describes some specific analyses and research projects. Finally, the appendix provides more detailed statistics on various aspects of

Box 1.2. Priority areas of Norwegian environmental policy

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 provide the basic structure for the result monitoring system used by the environmental authorities. *Strategic objectives* and *national targets* have been set for each of the priority areas. The results are to be monitored by means of *key figures* for each of the priority areas (see Report No. 8 (1999-2000) to the Storting, Report No. 24 (2000-2001) to the Storting).

Natural Resources and the Environment 2001 describes environmental pressures in several of the priority areas of environmental policy and presents several of the key figures that have been selected.

the environment and natural resources in the form of tables.

The statistics presented in this publication are mainly from Statistics Norway, but in some cases we have also used figures from other institutions to give a more complete picture. The descriptions in this Chapter are to a large extent based on Report No. 24 (2000-2001) to the Storting and the website *State of the Environment Norway* (Norwegian Pollution Control Authority 2001b).

1.2. The state of the environment in Norway

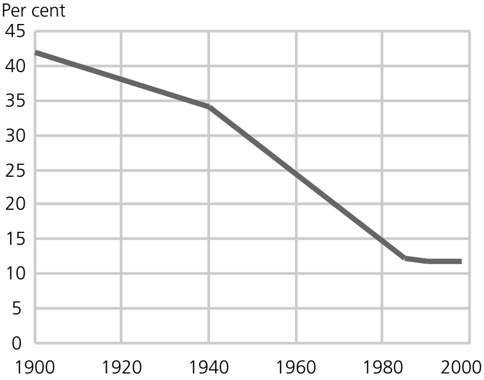
This section is structured according to the priority areas of environmental policy defined by the environmental authorities (see box 1.2). Some of the priority areas are described in more detail than others because more statistical material is available. In other areas, the environmental statistics do not provide a good enough basis for describing the current status or trends. In addition to the priority areas, some indicators for the resource situation in Norway have been included.

Priority area 1: Conservation and sustainable use of biological diversity

Wilderness-like areas

The diversity of life forms and habitats and their interactions are the essential basis for the survival of both people and other organisms. However, human activities are threatening biological diversity in many different ways, and calculations show alarmingly high figures for losses of both species and habitats (SSB/SFT/DN 1994). Such losses may be a direct result of various forms of development or overexploitation, or they may be caused indirectly when our activities cause pollution or result in climate change and thus in a deterioration of conditions for animals and plants.

Figure 1.1. Wilderness-like areas[1] as a percent age of Norway's total land area[2]

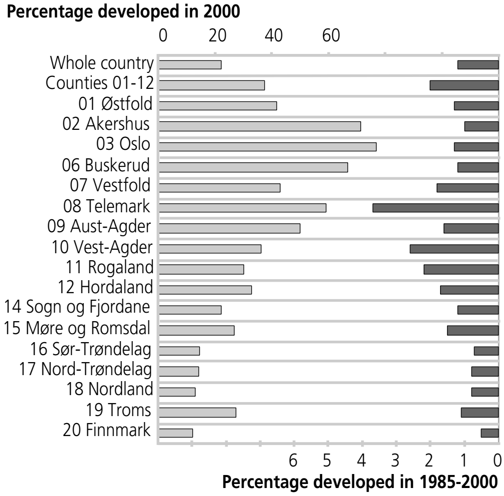


[1] Wilderness-like areas are defined as lying at least 5 km from the nearest major infrastructure development.
[2] Excluding Svalbard and Jan Mayen.
Source: Directorate for Nature Management.

It is difficult to monitor trends in such a complex and multi-faceted field as biological diversity. Nevertheless, there are some indicators that can be used to illustrate aspects of this priority area. We have chosen to use trends in the area of wilderness-like habitat in Norway as an indicator of pressure on biological diversity. In this context, wilderness-like areas are defined as areas more than 5 km from major infrastructure developments such as roads, buildings or hydropower plants. In such areas, pressure from human activity is low, and there is little disturbance of the original biological diversity.

Figure 1.1 shows that the proportion of wilderness-like areas in Norway fell dramatically from 1900 to 1985, especially in the period 1940 – 1985. Since 1985, the loss of wilderness-like habitat has continued, but at a much slower pace. However, the remaining areas are small (totalling 11.7 per cent of Norway's land area).

Figure 1.2. Proportion of the coastline less than 100 m from the nearest building in 2000. Changes from 1985 to 2000



Source: Statistics Norway.

For more information see section 10.2.

Priority area 2: Outdoor recreation

Access to the coast
The coastal zone is very valuable, offering opportunities for outdoor recreation and experiencing the countryside and for activities such as bathing, fishing, walking and boating. Strict restrictions have therefore been placed on building less than 100 m from the shoreline, and the general right of public access to uncultivated land also applies along the coast. Even so, access is restricted by buildings near the shoreline. Figure 1.2 shows that large parts of the coastline have already been developed. The proportion is highest in the counties Akershus, Oslo and Buskerud, where more than two thirds of the coastline is less than 100 m from the nearest building. For the country as a whole, 22 per cent of the coastline is less than 100 m from the nearest building, and the corresponding figure for the

coast from Østfold to Hordaland is 38 per cent.

Since 1965, the Planning and Building Act has restricted developments along the shoreline. In recent years, tighter restrictions have been introduced, for example through the National Policy Guidelines for planning in coastal and marine areas in the Oslofjord region. Despite this, there has been some development of the coastal zone. From 1985 to 2000, buildings were constructed or altered along 1.2 per cent of the shoreline. The greatest changes took place in the southern parts of the country, where the largest proportion of the coastline was already developed. The largest percentage changes were in Telemark (3.7 per cent), Vest-Agder (2.6 per cent) and Rogaland (2.2 per cent).

For more information see Chapter 10.

Priority area 3: The cultural heritage

Our cultural heritage is a source of knowledge about people's lives and activities throughout history. It can improve our understanding of the links between history and the present day, the natural environment and different cultures. We can use our heritage to rediscover lost knowledge and skills and to find answers to new questions that arise in connection with sustainable development.

Cultural monuments and sites and cultural environments are often damaged by changes in land use. We have therefore chosen the *area of land converted for other purposes by new cultivation, road construction and building* as an indicator of the pressure on the cultural heritage. 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 purposes that may threaten the cultural heritage has been reduced (figure 1.3). 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.

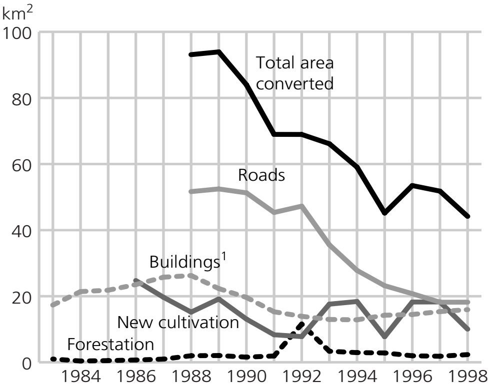
More information: the indicator is not discussed further in this publication, but there is some relevant material on cultural environments in Chapter 3.3 and background material in chapter 10.

Priority area 4: Eutrophication and oil pollution

Eutrophication of fjords and marine waters
Discharges of nitrogen and phosphorus from industry, agriculture, households/ municipal waste water and other sectors cause eutrophication and may result in excessive algal growth in waters along parts of Norway's coast.

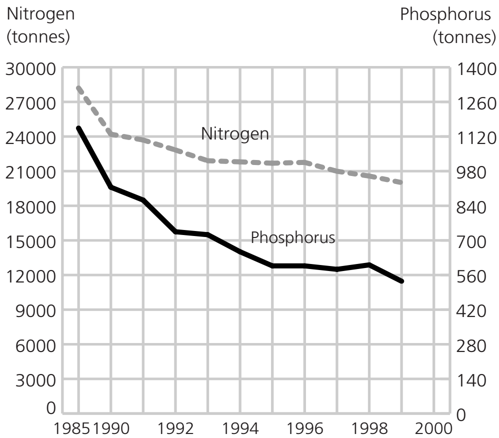
Anthropogenic discharges of nitrogen and phosphorus to the whole Norwegian coastline were reduced by 8 and 41 per cent respectively from 1985 to 1999. In the North Sea region (from the border with Sweden to Lindesnes at the southernmost tip of Norway), where the

Figure 1.3. Annual conversion of land for roads, new buildings[1] and new cultivation



[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.
Source: Statistics Norway, Norwegian Agricultural Economics Research Institute and Directorate of Public Roads.

Figure 1.4. Discharges of phosphorus and nitrogen to the North Sea basin (from the border with Sweden to Lindesnes at the southernmost tip of Norway)



Source: Norwegian Institute for Water Research.

measures taken to reduce discharges have been more extensive than in the rest of the country, inputs of nitrogen and phosphorus to the North Sea have been reduced by 17 and 67 per cent respectively in the same period (figure 1.4). The steeper reduction in phosphorus discharges is mainly a result of more efficient treatment of waste water from industry and private households. Changes in soil management routines in the agricultural sector have also had some effect. It has proved more difficult to reduce nitrogen discharges.

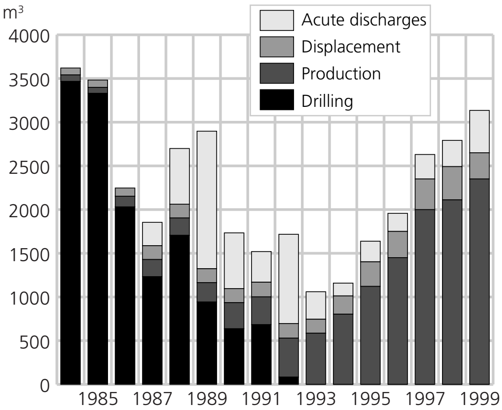
For more information see Chapter 9.3.

Eutrophication of lakes
In fresh water bodies, inputs of phosphorus from agricultural activities are the main cause of eutrophication. In general, eutrophication of lakes is not a major problem in Norway in comparison with the situation in Europe as a whole, but can be a significant problem locally in low-lying areas. Conditions in over 90 per cent of all the lakes in Norway are classified as "good" or "fair" with respect to the phosphorus concentration. Only in about 2.5 per cent of all the country's lakes are conditions classified as "bad" or "very bad". Nevertheless, this classification applies to around 800 lakes. A study of 27 eutrophicated lakes in the period 1995 -1999 showed that water quality was improving in 14 of them, but deteriorating in another four. In the remaining nine lakes, there was no clear trend. Thus, the overall results indicate an improvement as regards eutrophication of lakes in Norway.

For more information see Chapter 9.4.

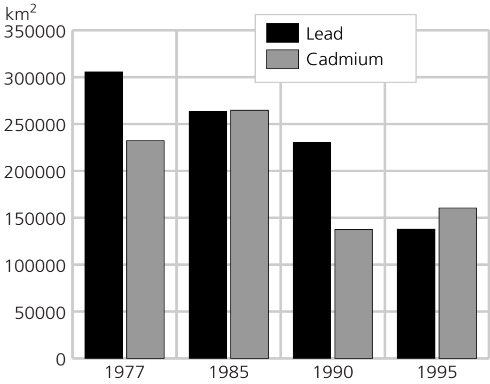
Oil pollution
Discharges of oil and chemicals from shipping, the petroleum industry and onshore activities can damage organisms and ecosystems in the open sea, on the sea floor, in the littoral zone and on land.

Figure 1.5. Discharges of oil from petroleum activities



Source: Norwegian Pollution Control Authority.

Figure 1.6. Heavy metals: lead (Pb) and cadmium (Cd) in the moss *Hylocomium splendens* in Norway. Area (km^2) where concentrations exceed 5 ppm (lead) or 0.1 ppm (cadmium)



Source: Norwegian Pollution Control Authority.

Pollution of coastal areas also reduces their value as recreation areas and for other purposes.

The authorities have satisfactory data on discharges of oil from petroleum activities, but the figures for discharges from onshore sources and shipping are incomplete, particularly as regards illegal discharges.

Oil production results in both uncontrolled (acute) discharges and legal, licensed (operational) discharges. Operational discharges are the largest category, and have risen considerably since 1992 as oil production has increased (figure 1.5). Acute discharges from oil production and other activities vary widely, but there has been an overall decrease in recent years.

For more information see Report No. 24 (2000-2001) to the Storting.

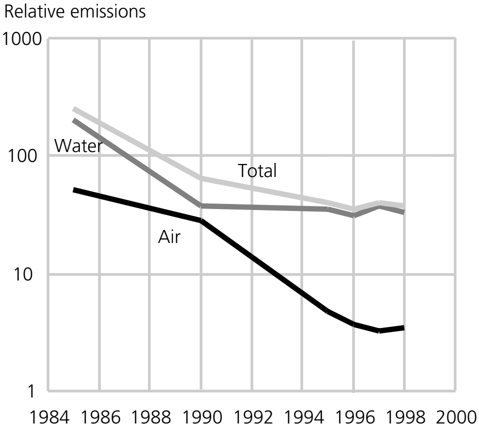
Priority area 5: Hazardous substances

Our use of hazardous chemicals and emissions of these substances are responsible for one of the most serious environmental threats facing the world. A number of chemicals break down very slowly in the environment and can therefore accumulate in food chains. They are a serious threat to biological diversity, food supplies, our health and the health of future generations. The most harmful chemicals, including persistent organic pollutants (POPs) such as PCBs and dioxins, can cause damage even at very low concentrations.

Hazardous chemicals in the environment

A large proportion of the hazardous chemicals that are found in the Norwegian environment originate from long-range pollution carried by winds. Mosses absorb their nutrition from precipitation, and the heavy metal content of mosses is therefore a good indicator of trends in long-range transport of pollutants (figure 1.6). The highest concentrations of heavy metals are found in the southern half of Norway. In the period 1977-1990, concentrations of heavy metals in mosses dropped markedly. The lead

Figure 1.7. Index for emissions of chemicals on the priority list weighted by how dangerous they are



Source: Norwegian Pollution Control Authority.

concentration in mosses dropped further from 1990 to 1995, whereas the concentrations of other heavy metals remained at about the same levels.

Emissions of hazardous substances
Emissions of the most dangerous chemicals from Norwegian industry have been reduced, but the total consumption of chemicals is rising, and it is therefore uncertain whether the overall impact on health and the environment has been reduced. A graph of emissions of the chemicals that are on the Norwegian environmental authorities' priority list weighted according to how dangerous they are considered to be (figure 1.7) shows a positive trend in the last 15 years. However, emissions must be further reduced to meet the authorities' targets.

For more information see Chapter 7.

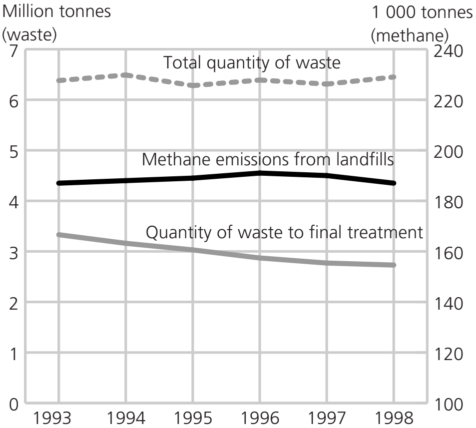
Priority area 6: Waste and recycling
Waste gives rise to environmental problems because waste treatment generates emissions of pollutants. Landfilling of waste generates emissions of methane, which is a greenhouse gas. In addition, landfills contain various kinds of hazardous chemicals and other substances that can cause pollution if they are released into the environment. This problem is most serious at older landfills. Incineration is a method of waste treatment that eliminates methane emissions and other problems associated with landfilling, but generates emissions of various pollutants to air. New incineration technology has made it possible to reduce such emissions considerably. Waste contains both energy and materials that can be recovered and replace other energy sources or virgin raw materials.

One of the authorities' targets as regards waste (Report No. 24 (2000-2001) to the Storting) is that the growth in the quantity of waste generated is to be considerably lower than the rate of economic growth. Another is that the quantity of waste delivered for final treatment (i.e. landfilling or incineration without energy recovery) is to be reduced to about 25 per cent of the total quantity of waste generated by 2010.

Figure 1.8 shows that the total quantity of waste generated has been fairly stable in the period 1993 – 1999, and so has the quantity of methane released from landfills. The proportion of waste delivered for final treatment has dropped from 52 to 42 per cent in the same period, but there is still a long way to go before the target of 25 per cent is reached. Nevertheless, the reduction in the quantity of waste delivered for final treatment is enough to result in a certain drop in methane emissions over time.

For more information, see Chapter 8.

Figure 1.8. Methane emissions from landfills and total quantity of waste generated and delivered for final treatment[1]



[1] Final treatment means landfilling or incineration without energy recovery.

Source: Statistics Norway.

Priority area 7: Climate change, air pollution and noise

The greenhouse effect

Concentrations of greenhouse gases in the atmosphere are rising as a result of human activity. The most important reason for this is emissions of carbon dioxide (CO_2) from combustion of fossil fuels, which have already resulted in the highest CO_2 concentrations in the atmosphere for 160 000 years. As concentrations of greenhouse gases rise, the atmosphere retains more of the thermal radiation from the earth, which will cause the global mean temperature to rise and result in climate change. This phenomenon is called the anthropogenic greenhouse effect.

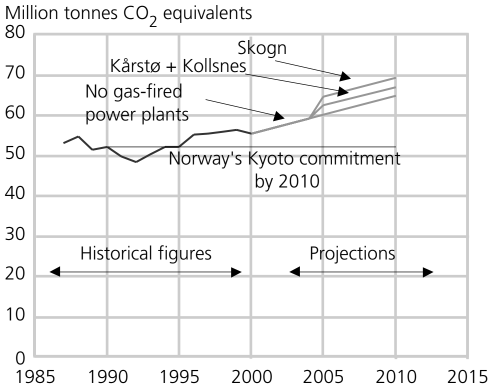
The global mean temperature has risen by between 0.3 and 0.6 °C since accurate measurements began in 1860. Some of this rise may be explained by natural variations, but the UN Intergovernmental Panel on Climate Change (IPCC) has concluded that there has been a discernible human influence on the global climate.

If greenhouse gas emissions continue to rise, we risk extensive and damaging climate change in the course of the next 100 years. To solve the problem will require a complete reorganization of world energy use. The Kyoto Protocol is an important step forward in international climate policy, but according to the most recent white paper on the Government's environmental policy and the state of the environment in Norway (Report No. 24 (2000-2001) to the Storting), it is not ambitious enough in relation to the climate problems the world is facing. However, recent political developments, including the negative views expressed by the US President on the Kyoto Protocol, indicate that even moderate reductions in emissions may be difficult to achieve.

Norwegian greenhouse gas emissions rose by more than 6 per cent from 1990 to 2000 (figure 1.9). According to the Kyoto Protocol, Norwegian emissions may only rise by 1 per cent from 1990 to 2010. Projections show that Norway's aggregate emissions of greenhouse gases may rise by about 24 per cent from 1990 to 2010 unless steps are taken to reduce them. Construction of the three planned gas-fired power plants at Kårstø, Kollsnes and Skogn will cause a further rise in emissions, by about 12 per cent compared with 1990.

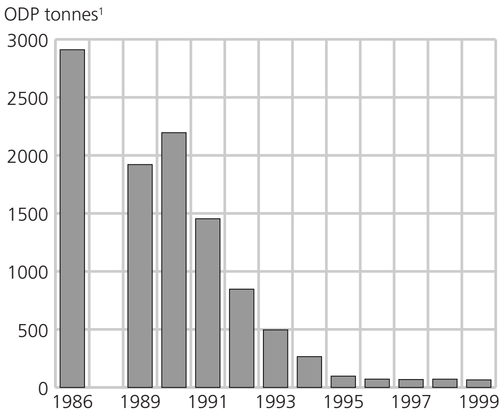
The Kyoto Protocol allows for a proportion of countries' commitments to reduce emissions to be achieved through measures in other countries using the Kyoto mechanisms, but it is uncertain how large a proportion will be permitted.

Figure 1.9. Greenhouse gas emissions in Norway. Historical figures and projections



Source: Statistics Norway and Norwegian Pollution Control Authority.

Figure 1.10. 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.

For more information, see Chapter 7.2.

Depletion of the ozone layer

Emissions of gases containing chlorine and bromine, such as CFCs, HCFCs and halons, deplete the atmospheric ozone layer, which protects the earth against harmful UV radiation from the sun. Excessive UV radiation may damage people, plants and animals and marine ecosystems. Polar marine ecosystems are found in the areas where UV radiation is expected to rise most as a result of depletion of the ozone layer.

Measurements throughout the world have shown depletion of the ozone layer in the past 20 years. The largest reductions in ozone concentrations have been registered in the Antarctic. Over Oslo, records have shown an average annual reduction of 0.39 per cent in the thickness of the ozone layer.

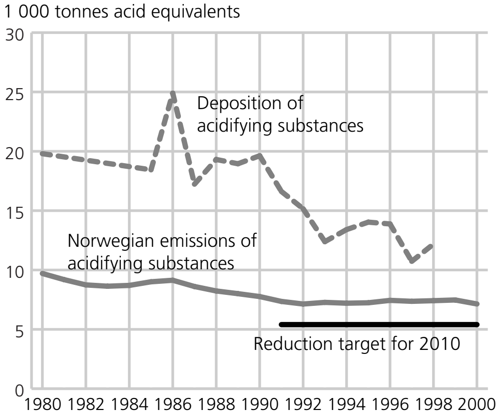
In 1987, an international agreement, the Montreal Protocol, was drawn up with the aim of reducing global production and consumption of ozone-depleting substances. If all countries comply with the requirements of the agreement, the ozone layer is expected to return to normal in 2050. Norway is well on the way to achieving the targets for phasing out ozone-depleting substances both under the Montreal Protocol and under the new EU directive that entered into force in September 2000. Figure 1.10 shows that imports of ozone-depleting substances to Norway have been very low in recent years. Nevertheless, there are still substantial emissions in connection with the use and replacement of old products that contain ozone-depleting substances. But these emissions are dropping, and will approach zero as old products are phased out.

For more information, see Chapter 7.5.

Long-range air pollution

Acid rain is still one of the most serious environmental problems in Norway, even though reductions in emissions have reduced the extent of acidification. Acid

Figure 1.11. Emissions and deposition of acidifying substances (NO_x, SO_2 and NH_3) in Norway



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

rain is caused by emissions of sulphur and nitrogen compounds to air. In the atmosphere, sulphur and nitrogen react chemically with water vapour to form sulphuric acid and nitric acid. Acid rain can be transported over long distances, and emissions from other countries in Europe account for about 90 per cent of acid deposition in Norway. The southern half of the country is particularly severely affected by acid rain. The most obvious effect is damage to fish stocks, but acidification can also cause forest damage. Inputs of nitrogen oxides and ammonia can also cause eutrophication.

The international agreements on reductions in emissions of long-range pollutants are now showing results. Figure 1.11 shows that the deposition of acidifying substances in Norway has dropped considerably in the last 10 years. However, Norway's emissions have not been significantly reduced, and the authorities' target for 2010 has not yet been reached. Nevertheless, acidification has been reduced, mainly as a result of the lower inputs from abroad. The areas of Norway where critical loads for acidification are exceeded have been reduced by more than 30 per cent since 1985. In 1994, critical loads were exceeded across 19 per cent of the total area of Norway. The situation has improved further since 1994, and the greatest improvements have occurred in Eastern Norway. Both the area where critical loads are exceeded and the degree to which they are exceeded have been reduced.

For more information, see Chapter 7.4.

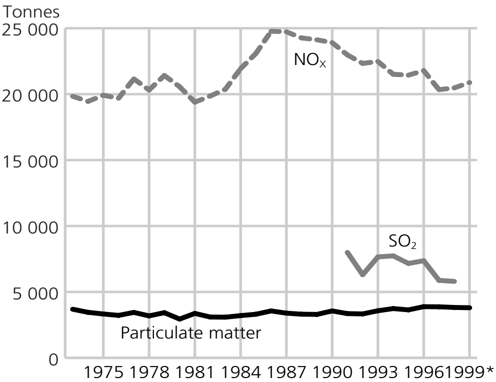
Local air quality

Clean air is important for people's health and quality of life. At times, local air pollution causes serious health and welfare problems in the largest towns and built-up areas in Norway. In the largest towns, a substantial proportion of the population is exposed to concentrations of pollutants that increase the risk of premature death and health problems such as respiratory infections, lung disease and cancer.

Some important pollutants that contribute to local air pollution are particulate matter (PM_{10} and $PM_{2.5}$), nitrogen dioxide (NO_2), sulphur dioxide (SO_2), ground-level ozone (O_3), carbon monoxide (CO), polycyclic aromatic hydrocarbons (PAHs), benzene (C_6H_6) and other aromatic compounds.

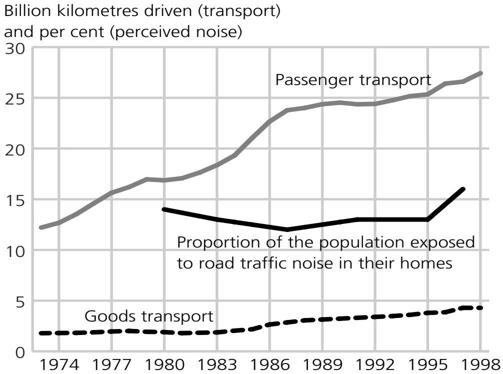
It has been calculated that in 1995, an estimated 700 000 people in Norway were exposed to levels of air pollution that entailed a health risk. The socio-economic costs of the health damage caused by local air pollution are estimated at NOK 3.8 billion per year. Figure 1.12 shows trends in emissions in the 10 largest towns in Norway. There has been

Figure 1.12. Emissions of particulate matter, SO_2 and NO_x in the 10 largest towns in Norway



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

Figure 1.13. Growth in transport work by road and proportion of the population exposed to noise



Source: Surveys of living conditions from Statistics Norway and Institute of Transport Economics.

a certain reduction in emissions of NO_x and SO_2 in the last 10 years, but emissions of particulate matter have risen somewhat.

The most important causes of local air pollution today are road traffic and fuelwood use. Even with the projected growth in road traffic, emissions from this source will probably be gradually reduced in future because considerable reductions in emissions from individual vehicles are expected. Nevertheless, it may be difficult to achieve the national air quality target for nitrogen dioxide (NO_2) in 2010 in certain towns unless measures are introduced to reduce traffic.

For more information, see Chapter 7.8.

Noise

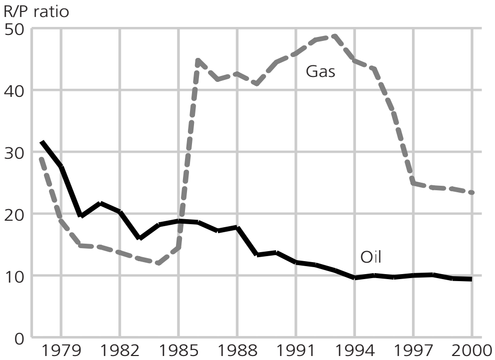
Noise is one of the environmental problems that affects the largest number of people in Norway. About 1.5 million people are exposed to noise in their homes, and of these, more than 600 000 are exposed to noise levels exceeding a 24-hour average of 60 dBA. Surveys of living conditions carried out by Statistics Norway show that 5 per cent of the population has sleep problems as a result of noise. Figure 1.13 shows that road traffic has increased considerably, but the proportion of the population who report that they are annoyed by noise has remained relatively constant. However, the figures for annoyance from noise are uncertain, and work is in progress to improve the statistics on annoyance caused by road traffic noise.

For more information, see Chapter 6.

1.3. Natural resources

Natural resources are society's raw materials. Some of them are also of crucial importance for biological diversity. It is therefore essential that natural resources are managed sustainably and are not over-exploited. In this section, we consider some important natural resources that Norway is responsible for managing

Figure 1.14. Life span[1] of Norwegian oil and gas reserves (R/P ratio)



[1] The life span is expressed as the R/P ratio, or the ratio between reserves and production.
Source: Energy statistics from Statistics Norway and Norwegian Petroleum Directorate.

– oil and gas, fish stocks, agricultural land and forests.

Oil and gas resources

Given the present rate of production, the total known oil resources on the Norwegian continental shelf will be exhausted after 23 years, and the natural gas resources after 119 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 23 years for gas. The ratio between reserves and annual production (the R/P ratio) will change with time, depending on new estimates of resources, decisions to develop new fields, changes in the rate of extraction and the development of new technology. This is illustrated by figure 1.14, which shows historical trends in the R/P ratio. The R/P ratio for natural gas dropped sharply from 1995 to 1997 because the large gas field Troll East went on stream in 1996 and the estimates of reserves were reduced.

Norway's oil and gas reserves correspond to 1.1 and 0.9 per cent respectively of the world's petroleum reserves. The R/P ratio for the world's reserves indicates that the crude oil reserves will be exhausted after 42 years and the natural gas reserves after 63 years.

For more information, see Chapter 2.

Fish stocks

In its annual report on marine resources (Iversen 2001), the Institute of Marine Research states that great caution must still be shown in harvesting several of Norway's important fish stocks. This is particularly the case for demersal fish stocks: the pelagic stocks are generally in a better state. The North Sea cod stock is at a particularly low level. This stock has been and is still being very heavily exploited.

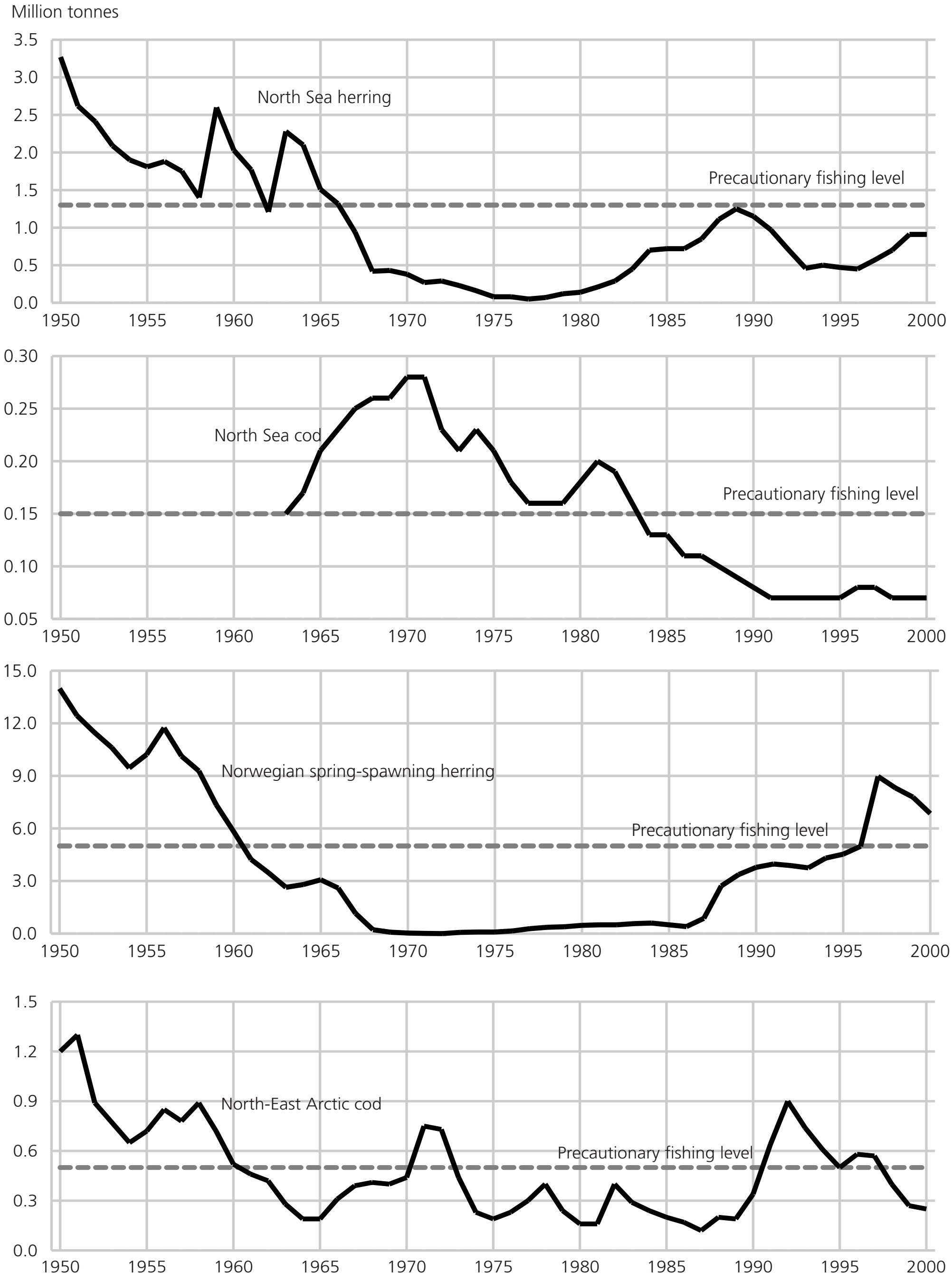
Figure 1.15 shows trends in spawning stocks of four selected fish stocks since the 1950s in relation to the precautionary fishing level that has been calculated for these stocks. The precautionary fishing level is primarily intended as a warning level. If the spawning stock is below this level, extra measures should be taken to raise the stock to a safer level again. Of the four stocks illustrated here, only Norwegian spring-spawning herring is currently well above the precautionary fishing level.

For more information, see Chapter 5.

Agricultural areas

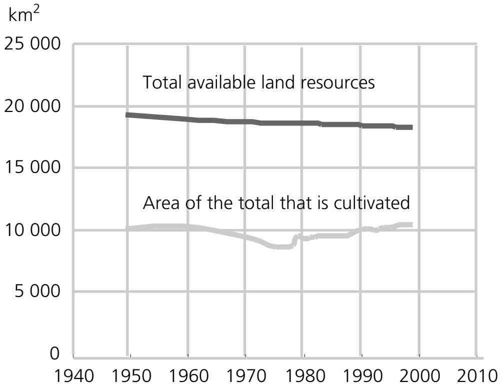
Norway has only limited land resources that are suitable for agricultural production. About 3 per cent of the country is cultivated, as compared with over 10 per cent in the world as a whole. The scarcity of land resources means that the current

Figure 1.15. Spawning stocks and precautionary levels for four important fish stocks



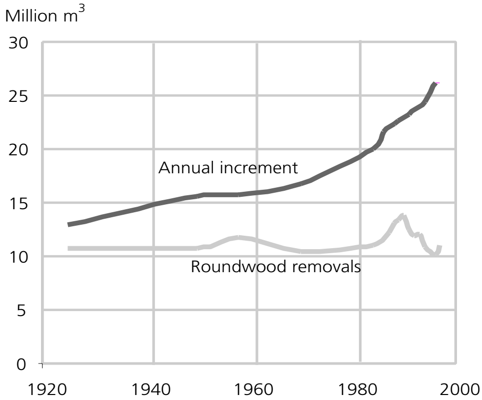
Source: ICES and Institute of Marine Research.

Figure 1.16. Land resources in Norway



Source: Grønlund and Høie (2001).

Figure 1.17. Roundwood removals and annual increment[1] in Norwegian forest



[1] Annual increment including bark.
Source: Statistics Norway and Norwegian Institute for Land Inventory.

self-sufficiency rate is between 40 and 50 per cent.
The cultivated area of Norway has remained fairly constant for the past 100 years. The largest area (11 200 km^2) was registered in the late 1930s. After this, the cultivated area gradually dropped, and reached its lowest level, 8 700 km^2, in the 1970s. Since then, the cultivated area has risen again to 10 382 km^2 (figure 1.16).

The available land resources (cultivated and cultivable area) have dropped by almost 1000 km^2 or 5 per cent from 1949 to 1999 as a result of irreversible conversion of agricultural land to non-agricultural uses. The proportion of the available resources actually cultivated was 57 per cent in 1999, as compared with 52 per cent in 1949.

For more information, see Chapter 3.

Forest resources

Since the early 1920s, roundwood removals in Norway have been less than the annual increment (figure 1.17). In recent years, only 50 to 60 per cent of the annual increment has been harvested. As a result, the volume of the growing stock has nearly doubled since the 1920s.

The volume of the growing stock of forest has risen a great deal in the past century, resulting in an increase both in timber resources and in the potential value of forest as a CO_2 sink (although this is not included in the Kyoto Protocol). The type of forest has also changed greatly during this period. Clear-cutting, silviculture, drainage, the construction of forest roads, the introduction of alien species and pollution are some of the factors that have had an impact on the forest as a natural resource and on biological diversity in forests.

The Norwegian monitoring programme for forest damage shows that in recent years, there has been a slight improvement in the health of forests measured as crown condition.

For more information, see Chapter 4.

1.4. Economic trends and the environment

There is a relatively close relationship between economic activity and many environmental problems. Pollution and disturbance of the natural environment are often side effects of production and/ or consumption, and such effects result in growing pressure on the environment as the economy grows. For example, energy use and greenhouse gas emissions show a tendency to rise with economic growth. However, this relationship is not at all clear-cut (Bruvoll et al. 2000a). Certain kinds of technological progress lead to a reduction in resource consumption and emissions: for example, electronic communications can be used to replace physical journeys. This type of technological progress can both result in economic growth and help to reduce pressure on the environment.

Moreover, with economic growth there will be changes in the needs to which people give priority. As income levels rise, people may feel that they can afford to give higher priority to better environmental quality, and this in turn will make it politically feasible to pursue an ambitious environmental policy. Analyses show that environmental problems that can be dealt with relatively easily at local level, for example local water pollution, tend to increase with economic growth as long as economic activity is fairly low, but are instead reduced with economic growth once this exceeds a certain level.

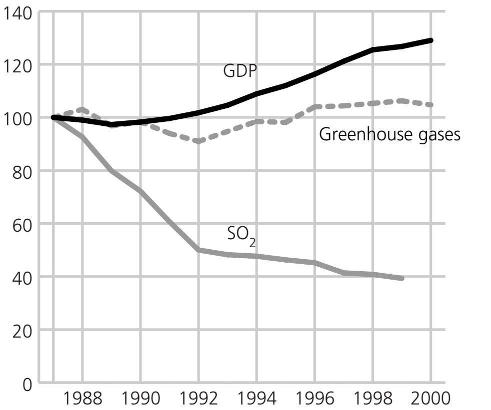
Measured in fixed prices, Norway's gross domestic product (GDP) has risen every year for the past ten years. The Norwegian economy passed a cyclical peak in 1998, and since then its growth has been weaker than it was in the mid-1990s. According to preliminary figures from the national accounts, GDP for mainland Norway rose by 1.8 per cent in 2000, measured in fixed 1997 prices. However, almost one third of the growth in the mainland economy in 2000 is a result of the sharp rise in electricity production, explained by the high precipitation level in 2000. Otherwise, growth in both demand and production in mainland Norway was relatively weak.

Production in manufacturing and mining and quarrying dropped both in 1999 and in 2000. This in itself may have reduced some environmental problems associated with emissions of pollutants. On the other hand, production rose in service industries, which are not associated with pollution problems to the same degree. Production in the post and telecommunications sector measured in fixed prices has risen by more than 14 per cent per year for the past three years. However, production has also risen steeply in domestic passenger transport and land transport. These sectors are major contributors to greenhouse gas emissions and local air pollution problems.

Figure 1.18 shows the relative growth in mainland Norway's GDP, greenhouse gas emissions and sulphur dioxide emissions from 1987 onwards. The figures for each year are expressed as a percentage of the 1987 level (used as an index). For example, the figure shows that in 1999, sulphur emissions were only 39 per cent of the 1987 level.

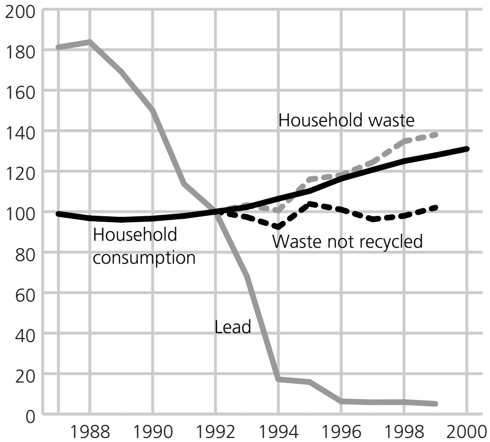
Greenhouse gas emissions tend to follow the same path as economic trends. This is because there is a close relationship between economic growth and trends in energy use. A large proportion of the energy used is extracted from fossil fuels, and their use results in carbon emissions that are difficult to reduce. Nevertheless,

Figure 1.18. Relative trends in gross domestic product and emissions of greenhouse gases and SO_2. Indices, 1987=100. (GDP for mainland Norway, fixed prices. Greenhouse gas emissions are measured in CO_2 equivalents.)



Source: Statistics Norway.

Figure 1.19. Household consumption (fixed prices), total generation of household waste, unsorted household waste and emissions of lead to air. Indices, 1992=100



Source: Statistics Norway.

the figure shows that greenhouse gas emissions have risen rather less than GDP since 1987.

Sulphur dioxide, on the other hand, is an example of a pollutant whose emissions are not related to economic developments in the same way. A large proportion of sulphur emissions are generated by the combustion of heavier oil types, and the sulphur content of such oils has been greatly reduced over the years. There are also technically and economically feasible ways of reducing sulphur emissions from major sources, and it has thus been possible to reduce industrial emissions. In addition, large point sources such as industrial enterprises used to generate a large share of sulphur emissions, and total emissions have been strongly dependent on what happens to precisely these enterprises.

Some environmental problems are closely related to household consumption, but the picture is mixed here as well. Figure 1.19 shows indices for consumption by Norwegian households, total generation of household waste and household waste not separated for recycling, and for lead emissions to air. It should be noted that the base year for the indices is 1992, since no earlier figures are available for quantities of household waste.

The total quantity of household waste generated follows much the same pattern as trends in consumption, but has grown even more strongly. Household consumption rose by almost 30 per cent from 1992 to 1999, but the quantity of household waste generated rose by almost 40 per cent in the same period. Nevertheless, it is possible that the composition of household consumption can over time change in a way that generates less waste, for example if we use less money on purchasing goods that generate waste and more on purchasing services that do not.

Since 1992, a rising proportion of household waste has been separated for material recovery or incinerated with energy recovery. The quantity of household waste delivered for final treatment (landfilling or incineration without energy recovery) has therefore remained relatively constant in the period 1992-1999, and is about 45 per cent of the total.

There are also examples of environmental problems that are closely related to private consumption, but that have shown very different trends. Emissions of lead to air are largely generated by motor vehicles. Households' use of vehicles is included in private consumption, but as figure 1.19 shows, lead emissions have shown a very different trend from consumption. This is largely because the use of leaded petrol has been phased out.

The remaining chapters of this publication and the appendix of tables provide further information on Norway's natural resources and the environment and describe how they are affected by the activities of various economic operators.

2. Energy

2000 was a record year for energy production in Norway. Oil and gas extraction reached a new peak while electricity production was higher than ever before. Energy use, on the other hand, decreased for the first time in many years. All in all, this resulted in record exports, almost 90 per cent, of energy commodities in 2000.

The high level of energy production in Norway is mainly accounted for by the extraction of oil and gas. Given the current rate of extraction, the calculated petroleum resources on the Norwegian continental shelf will be exhausted in 23 years and the gas resources in 119 years. Petroleum extraction accounted for about 23 per cent of Norway's GDP and 46 per cent of export income in 2000. These percentages are the highest ever recorded and are mainly due to a rise in prices.

Electricity production totalled 143 TWh in 2000, the highest level ever reached. Production showed a 17 per cent increase on the previous year and was 21 per cent higher than the expected level of production in a hydrologically normal year. The total surplus for export was 19.1 TWh, making Norway a net exporter of electricity for the second time in a row.

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. Hydropower developments also 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

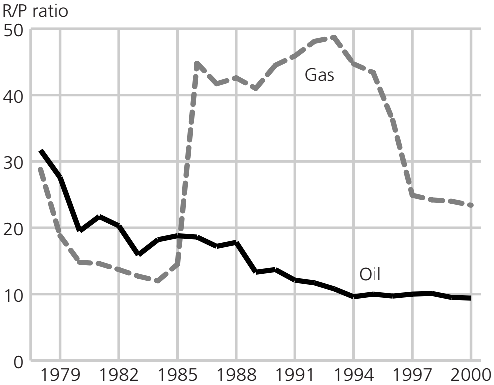
In the context of oil and gas activities, the Norwegian Petroleum Directorate distinguishes between resources and reserves. Resources include all more or less definitely proven deposits. Reserves are recoverable resources in fields that are already developed or where development has been approved. As of 1 January 2001, the remaining Norwegian reserves of crude oil totalled 1.77 billion standard cubic metres oil equivalents (Sm^3 o.e.), which corresponds to 1.1 per cent of the world's crude oil reserves (table 2.1). Reserves of natural gas totalled 1.26 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.

Table 2.1. World reserves[1] of oil and gas as of 1 January 2001

	Oil		Gas	
	Billion Sm^3 o.e.	Per cent	Billion Sm^3 o.e.	Per cent
World	163.5	100.0	149.5	100.0
North America ..	4.2	2.6	6.5	4.3
Latin America	19.6	12.0	7.8	5.2
Western Europe (incl. Norway)	2.7	1.7	4.5	3.0
Eastern Europe ..	9.4	5.7	56.7	37.9
Middle East	108.7	66.5	52.5	35.1
Africa	11.9	7.3	11.2	7.5
Asia and Oceania	7.0	4.3	10.3	6.9
OPEC	129.5	79.2	66.4	44.4
Norway	1.8	1.1	1.3	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.
Source: Oil & Gas Journal (2001) 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



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

The Norwegian Petroleum Directorate has calculated that the remaining Norwegian petroleum resources total 4.4 billion Sm^3 o.e. crude oil (including wet gas) and 6.4 billion Sm^3 o.e. natural gas. Of this, 41 and 20 per cent respectively are defined as reserves (see above), and 19 and 35 per cent respectively are resources for which development has not been approved. The remainder, i.e. 40 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 23 years, and the natural gas resources after 119 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 23 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.

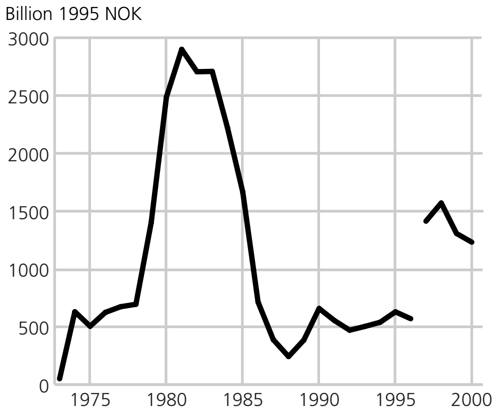
Norway's proven oil reserves are larger than those of any other European country except Russia. Russia also has the world's largest gas reserves, a third of the total, and the Netherlands and Norway have the largest reserves otherwise in Europe. In Western Europe, 55 per cent of the oil reserves and 28 per cent of the gas reserves are on the Norwegian continental

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.

shelf, according to figures from the Oil & Gas Journal. For the world as a whole, 79 per cent of the oil reserves and 44 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 35 per cent of its gas reserves. At the end of 2000, the R/P ratio indicated that the world's petroleum reserves will be exhausted after 42 years and its natural gas reserves after 63 years.

Figure 2.2. Estimates[1] of Norway's petroleum wealth



[1] The estimates are made at the beginning of each year. For the years 1997-2000, 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 (1990) and various long-term programmes and national budgets, Ministry of Finance.

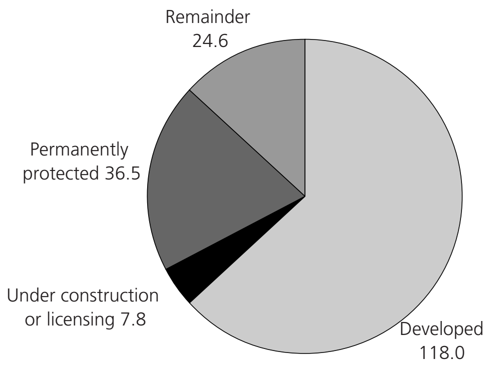
Figure 2.2 shows estimates of Norway's petroleum wealth for the years 1973-2000. The estimated value of Norway's petroleum wealth has changed a great deal in this period because of changes in expected future prices, costs and the resource base. Changes in expected prices have clearly been most important, 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, almost two years before oil prices collapsed, Norway's petroleum wealth was revised downwards 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 2001, Norway's economically exploitable hydropower resources totalled 187.0 TWh (expressed as mean annual production capability, i.e. the production capacity of the power stations

Figure 2.3. Hydropower resources as of 1 January 2001. TWh per year



Source: Norwegian Water Resources and Energy Directorate.

in a year with normal precipitation). Hydropower resources are divided into developed reserves, reserves that have been approved for development or are in the various stages of being considered for licensing, protected river systems and the remaining river systems. As of 1 January 2001, 118.0 TWh was developed and 36.5 TWh permanently protected (Appendix, table A3). The figures for hydropower resources are not comparable with figures from previous years since the Norwegian Water Resources and Energy Directorate has now decided to base calculations of the normal water inflow on the period 1970-1999.

Hydropower developments 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 river (Finnmark). Any future hydropower developments will be based on the Master Plan for Water Resources and the Protection Plans for Water Resources. 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. Environmental restrictions and the need to consider cost-effectiveness make it uncertain how much of the remaining hydropower potential (see figure 2.3) is likely to be developed in the future. The Government bases its policy on the conclusion that the era of major hydropower developments is over (Stoltenberg 2001). 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, discharges to river systems, 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 2000, Norway's coal resources on Svalbard were about 54 million tonnes, defined partly as certain and partly as probable deposits. At the end of 2000, 10 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 30.5 million tonnes at the end of 2000. At the 2000 rate of extraction, the estimated quantity of coal for sale will last for 48 years. This figure may be somewhat lower in the years ahead if the plans presented by Store Norske Spitsbergen Kulkompani to increase extraction are approved (see more details in section 2.2). At the end of 1999, the world's exploitable coal resources were 984 billion tonnes (BP 2000). At the current rate of extraction, they will

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 (2000)[2]	40.4 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 oil, gas oil and light fuel oil	43.1 GJ/tonne = 36.2 GJ/m^3	0.84 tonnes/m^3	0.80	0.30	0.70
Heavy distillate	43.1 GJ/tonne = 36.2 GJ/m^3	0.88 tonnes/m^3	0.80	0.30	0.70
Heavy fuel oil	40.6 GJ/tonne = 39.8 GJ/m^3	0.98 tonnes/m^3	0.90	0.30	0.75
Methane	50.2 GJ/tonne	..	..	..	..
Wood	16.8 GJ/tonne = 8.4 GJ/solid m^3	0.5 tonnes/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).
Source: 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	1.047	0.040
1 Mbarrel	5.65	1.57	0.13	1	0.16	0.140	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	40.4	11.2	1.0	7.2	1.12	1	0.038
1 quad	1053	292.5	24.9	186.4	29.29	26.06	1

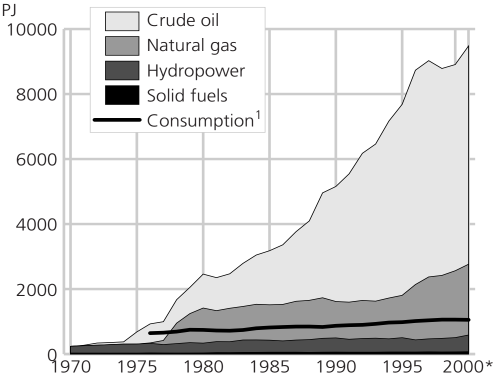
1 Mtoe = 1 mill. tonnes (crude) oil equivalents
1 Mbarrel = 1 mill. barrels crude oil (1 barrel =0.159 m^3)
1 MSm^3 o.e. oil = 1 mill. Sm^3 oil
1 MSm^3 o.e. gas = 1 billion Sm^3 natural gas
1 quad = 10^{15} Btu (British thermal units)

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

Prefixes

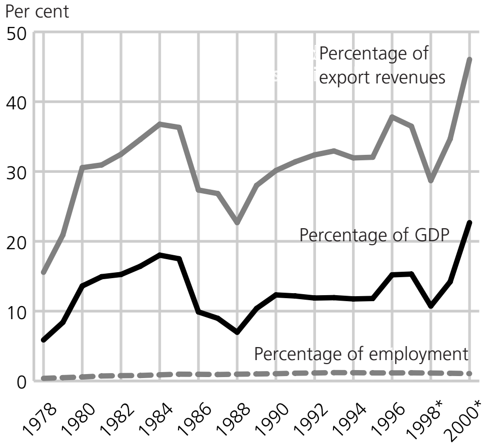
Name	Symbol	Factor
Kilo	k	10^3
Mega	M	10^6
Giga	G	10^9
Tera	T	10^{12}
Peta	P	10^{15}
Exa	E	10^{18}

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



[1] Including the energy sectors, excluding international maritime transport.
Source: Energy statistics, Statistics Norway, Norwegian Petroleum Directorate and Norwegian Water Resources and Energy Directorate.

Figure 2.5. Oil and gas extraction. Percentage of exports, gross domestic product (GDP) and employment



Source: National Accounts, Statistics Norway.

last for 230 years. The largest resources are found in the United States, Russia and China, which account for 25, 16 and 12 per cent respectively of the total.

2.2. Extraction and production

Total extraction of energy commodities in Norway rose by over 6 per cent from 1999 to 2000. Hydropower production showed the strongest growth, increasing by 16.6 per cent as a result of unusually high inflow to the reservoirs.

Since 1976, total energy extraction has risen by an average of as much as 10.2 per cent per year as a result of the growth in oil and gas extraction in the North Sea (figure 2.4). In comparison, total consumption of energy commodities in Norway has only risen by 2 per cent per year in the same period. Total energy extraction has also risen in the last decade by an average of 6.3 per cent per year. 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 2000, extraction of primary energy commodities was almost 9 times higher than consumption, so that almost 90 per cent of all energy extracted was exported. Table A11 in the Appendix shows the value of Norway's net exports of energy commodities to other countries in 2000.

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 2000, exports of crude oil and natural gas rose by 85 per cent on the year before, and totalled NOK 300 billion, or 46 per cent of the country's total exports (figure 2.5). The large variations in export revenue in recent years are due to the very low crude oil prices in 1998 and very high prices towards the end of 1999. The industry accounted for 23 per cent of GDP, but only about 1 per cent of total

Table 2.2. World production of crude oil and natural gas in 2000

	Oil		Gas	
	Million Sm^3 o.e.	Per cent	Million Sm^3 o.e.	Per cent
World	3 891.0	100.0	2 360.6	100.0
OPEC	1 634.7	42.0	287.9	12.2
North America	459.3	11.8	753.1	31.9
Latin America	542.8	13.9	135.3	5.7
Western Europe	370.6	9.5	281.8	11.9
Eastern Europe	450.0	11.6	705.8	29.9
Middle East	1 253.8	32.2	134.4	5.7
Africa	387.9	10.0	92.8	3.9
Asia and Oceania	426.6	11.0	257.4	10.9
Saudi Arabia	478.2	12.3	31.9	1.4
Former Soviet Union	437.9	11.3	675.4	28.6
United States	339.4	8.7	555.2	23.5
Iran	213.3	5.5	30.3	1.3
China	188.3	4.8	26.5	1.1
Norway[1]	185.8	4.8	49.0	2.1
Venezuela	176.2	4.5	23.8	1.0
Mexico	175.1	4.5	48.5	2.1
Iraq	156.0	4.0	6.9	0.3
UK	145.8	3.7	114.0	4.8
United Arabian Emirates	129.3	3.3	23.2	1.0
Kuwait	121.5	3.1	5.7	0.2
Canada	119.8	3.1	197.8	8.4
Nigeria	117.7	3.0	3.5	0.1
Libya	82.1	2.1	6.1	0.3
Indonesia	73.8	1.9	74.1	3.1
Brazil	65.1	1.7	4.7	0.2
Algeria	46.8	1.2	65.3	2.8
Netherlands	2.6	0.1	68.5	2.9

[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).

labour input was directly related to oil and gas extraction.

In 2000, production of petroleum on the Norwegian continental shelf totalled 243.2 million Sm^3 o.e. This was a rise of 7.1 per cent from 1999. Oil production (excluding NGL[1] and condensate) was 181 million Sm^3 o.e. in 2000, 6.8 per cent higher than the year before. Norway's crude oil production corresponded to 4.8 per cent of world production in 2000 (see table 2.2).

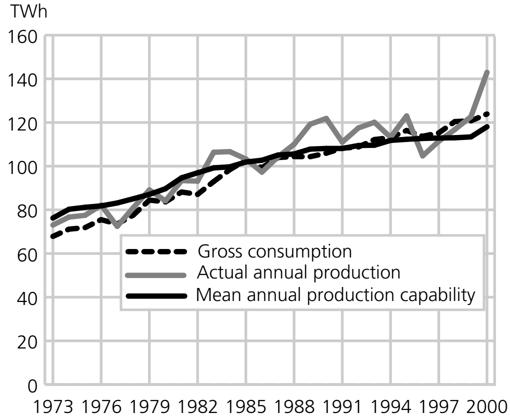
When Troll C went on stream at the end of 1999, oil production on the Troll oil field increased by 31.3 per cent in 2000, bringing production almost up to the same level as in the leading field, Ekofisk. Oil production on Ekofisk rose by 13.9 per cent in 2000. The Oseberg and Gullfaks fields were the third and fourth largest oil producers respectively in 2000. Together, these four fields accounted for 35.9 per cent of total oil production on the Norwegian continental shelf in 2000.

Production of natural gas reached a record high of 49.9 million Sm^3 o.e. in 2000, which is 5 per cent higher than in 1999. This corresponded to 2.1 per cent of total world production of gas in 2000 (see table 2.2). Norway has undertaken to deliver more than 70 million Sm^3 o.e. natural gas in 2005. Gas production is therefore expected to rise in the next few years, as it did from 1998 to 2000. Production of NGL and condensate was about 2.4 million Sm^3 higher in 2000 than in 1999.

Troll East and Sleipner East are the two most important fields for natural gas production. Troll East alone accounted for almost 50 per cent of total natural gas production on the Norwegian shelf in 2000.

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

Figure 2.6. Mean annual production capability, actual hydropower production and gross consumption of electricity in Norway



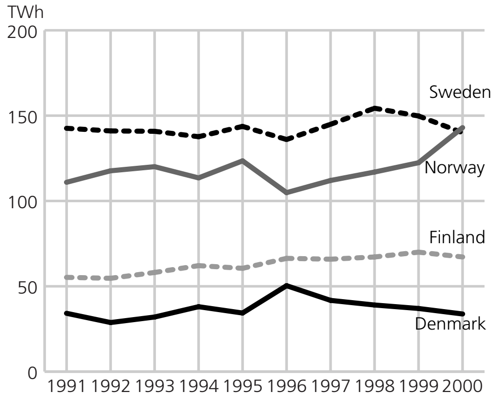
Source: Norwegian Water Resources and Energy Directorate and Energy statistics, Statistics Norway.

Electricity

Electricity production in Norway in 2000 totalled 143 TWh, an increase of 17 per cent on the year before and the highest level ever reached (see figure 2.6 and Appendix, table A8). Given the production capacity available at the end of 2000, production in a year with normal precipitation is calculated to be 119 TWh (including 0.8 TWh thermal power). The high level of production in 2000 was a result of ample rainfall and high inflow to the reservoirs. The net surplus for export for 2000 was 19.1 TWh, making Norway a net exporter of electricity for the second year in a row.

Norway's high level of export affects electricity production in the other Nordic countries. Figure 2.7 shows that electricity production in Denmark, Finland and Sweden fell from 1999 to 2000. At the same time, net exports by Nordic coun tries to countries outside the Nordic region increased by 2 TWh.

Figure 2.7. Electricity production in the Nordic countries



Source: Nordel's secretariat (various years).

Coal

Coal production on Svalbard in 2000 totalled 632 000 tonnes, which corresponds to just under 17.8 PJ. This is the highest level of production Store Norske Spitsbergen Kulkompani has ever achieved; as much as 56 per cent higher than in 1999. The reason for this large increase is the test production that was started at the new Svea Nord mine in Sentralfeltet, which contains the largest coal deposits found so far on Svalbard. Coal extraction on Svalbard has been the subject of political controversy, and its future has been uncertain for some time. On the basis of positive results from test extraction in Svea Nord, Store Norske Spitsbergen Kulkompani wants to increase production to a level three times higher than the 1990s level. With this level of production, operation will be profitable and no longer dependent on the government support on which it has been based so far. The Ministry of Trade and Industry supports these plans and the matter will be considered by the Storting (Norwegian parliament) in the course of autumn 2001. Total Norwegian coal production on Svalbard from 1916, when Store

Norske Spitsbergen Kulkompani was established, up to the end of 2000 was 25 million tonnes.

A small proportion of Svalbard coal is used for residential heating, while the rest is used for the production of electricity and for industrial purposes, especially cement manufacturing. In 1999 exports made up 70 per cent of total sales – mostly to Germany, but also to the UK and Iceland.

World coal production in 1999 was 2 104 Mtoe or, in energy units[2], 89 EJ (BP 2000), a decline of 6 per cent on last year's figures. Production in China declined most in 1999, dropping as much as 18 per cent compared with 1998 and leaving the United States to take over the position as the world's largest coal producer. In 1999, the United States and China accounted for 28 and 24 per cent respectively of world coal production. Europe excluding the former Soviet Union accounted for 12 per cent of the total, and more than half of this was produced in Poland and Germany. Brown coal accounted for almost four fifths of production in Germany, which is the world's largest brown coal producer. On a global basis, about one fifth of total production is brown coal, while the rest is black coal.

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, almost doubled from 1980 to 1990 but has only increased by 11 per cent since then. In 2000 consumption was 57 PJ per year, equivalent to about 10-15 per cent of energy production from hydropower. The figure is uncertain because the data are incomplete. In 1999, energy equivalent to about 5 PJ was generated for district heating by waste incineration, and about 90 per cent of this may be classified as bioenergy. In 1999, 211 621 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, 23 626 tonnes (1.2 PJ) was extracted.

The use of fuelwood contributes substantially to local air pollution, especially to emissions of particulate matter (see Chapter 7, Air pollution and climate). Bioenergy installations have been exempted from investment tax to promote the use of renewable energy sources.

Wind power

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 the county of Sogn og Fjordane.

2.3. Environmental problems associated with the extraction and use of energy

One of the Government's objectives is to limit the extent to which the energy sectors contribute to the environmental problems mentioned in box 2.3,

[2] See box 2.2 for an explanation of energy units.

Environmental pressures caused by the extraction and use of energy, and a number of policy instruments are being used to achieve this objective. 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 as to 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).

Table 2.3. Emissions to air from the energy sectors. 1999*

Pollutant	Emissions from the energy sectors	Share of total emissions in Norway
	Tonnes	Per cent
Carbon dioxide (CO_2)	12 775 536	30.7
Methane (CH_4)	26 456	7.8
Nitrous oxide (N_2O)	118	0.7
Sulphur dioxide (SO_2)	3 458	12.1
Nitrogen oxides (NO_X)	57 188	24.8
Ammonia (NH_3)	2	0.0
Non-methane volatile organic compounds (NMVOCs)	218 349	62.3
Carbon monoxide (CO)	8 155	1.4
Particulate matter	665	2.9
Lead (Pb)	1	10.7
Cadmium (Cd)	0.05	5.2

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

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. These can result in climate change, acidification, the formation of ground-level ozone and local air pollution (see Chapter 7). Emissions to air from the energy sectors in 1999 are shown in table 2.3.

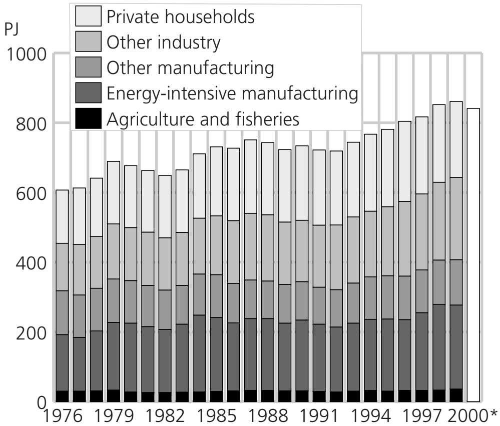
Discharges of oil and chemicals to the sea occur during the extraction and transport of oil and gas products. They may injure fish, marine mammals and birds and reduce the yield from fisheries etc.

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. Hydropower production also results in variable water levels in reservoirs and changes in discharge volumes in rivers. These developments can have an impact on biological diversity and the value of cultural monuments, the cultural landscape and recreational areas.

- 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). Like hydropower developments, wind power developments can result in environmental problems. Wind farms disturb habitats for

Figure 2.8. Domestic energy use by consumer group



Source: Energy statistics, Statistics Norway.

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, Air pollution and climate, and those intended mainly to reduce emissions from transport are discussed in Chapter 6, Transport.

2.4. Energy use

In 2000, Norway's total energy use (excluding international maritime transport), was 1 053 PJ. Energy use in the energy sectors accounted for 20 per cent of this.

Consumption of energy commodities, excluding the energy sectors and international maritime transport, totalled 861 PJ in 1999 and 841 PJ in 2000, a decrease of 2.3 per cent (preliminary figure) (figure 2.8 and Appendix, table A5). Energy use rose by an average of 1.1 per cent per year from 1979 to 1999. 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 increased from 198 PJ in 1999 to 212 PJ in 2000 (preliminary figures). Electricity generation from natural gas in connection with oil and gas extraction, which accounts for most of this, increased from 146 PJ in 1999 to 160 PJ in 2000 (see Appendix, table A6), a rise of 9.5 per cent. In the period 1976-1997, energy use for this purpose rose by an average of 9 per cent per year, then dropped somewhat before rising again in 2000. Most of the natural gas is used for combustion for energy purposes, but in 2000, about 18 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 previous 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). However, extraction of both oil and gas has risen in the past year. 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 on average per year, in the same period (figure 2.9 and Appendix, table A5). Preliminary figures now show a decline from 1999 to 2000 for most types of distillate, including transport oils. However, since the calculations are based on sales figures, consumption may not in reality have declined as much as is indicated by these figures. The decline is probably partly due to the decision to reduce fuel taxes from 1 January 2001. Transport now accounts for 85 per cent of total oil consumption, as compared with 47 per cent in 1976. Rising air traffic both within Norway and to other countries resulted in growing consumption of aviation fuel for several years. Now it appears that a reduction in the number of flights and scheduled routes has halted this trend. There has been a slight drop in sales of petrol in the past two years. Consumption of heavy fuel oil excluding international maritime traffic has dropped since the mid-1980s.

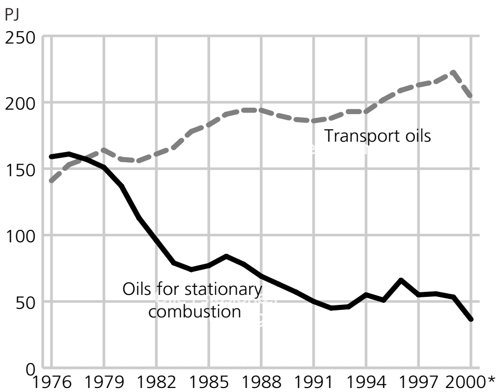
Consumption of oil for stationary purposes had dropped to less than one third of the 1976 level by 1992. Since then, the figures have fluctuated, but there has been a downward trend in the 1990s. From 1999 to 2000, there was a drop of 31.4 per cent (preliminary figures). The heating season in 2000 was very mild and electricity prices low. Sales of both heating kerosene and light fuel oil fell by 23 per cent from 1999 to 2000, whereas sales of heavy fuel oil fell by 41 per cent (figure 2.10). 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 due to 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 2.5.

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

Electricity consumption

Net domestic consumption of electricity was 112.8 TWh in 2000, 1.8 per cent higher than the year before (figure 2.10 and Appendix, table A8). This is the highest level of consumption ever recorded, and in the period 1990-2000 con-

Figure 2.9. Consumption of oil products

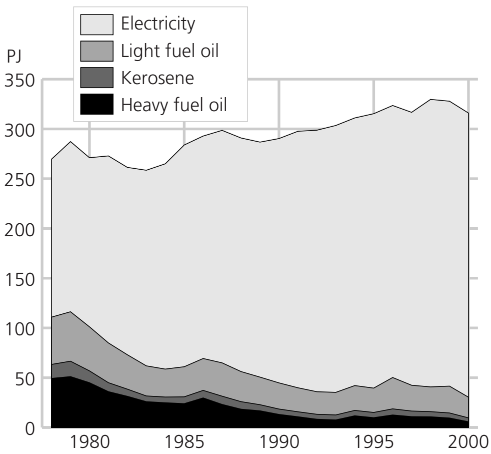


Source: Energy statistics, Statistics Norway.

sumption rose by an average of 1.4 per cent per year. Electricity prices have been considerably lower in 1998, 1999 and 2000 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 33.4 TWh in 2000, an increase of 2.3 TWh from the year before and about 4.9 TWh more than the average for 1990-1998. 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 73.8 TWh in 2000, see table A8 in the

Figure 2.10. Electricity consumption (excluding energy-intensive manufacturing) and sales of fuel oils and kerosene as utilized energy



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

Appendix. This is a slight decrease from 1999, partly because the weather was milder in 2000 than in 1999. 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 77.9 TWh. This corresponds to a rise of about 0.6 per cent from 1999.

World energy use

The increase in world energy use in 1999 held a slow pace for the second year in a row, rising by only 0.2 per cent from the previous year, while the average increase for the last 10 years was 0.9 per cent (BP 2000). The reason for this slow pace is a lower level of consumption in countries with less developed economies: in OECD countries, consumption rose by 1.4 per cent, consistent with the trend over the last ten years. Particularly striking was China's 16.8 per cent decline in coal consumption, resulting in a total decrease for China of 10.7 per cent. Romania showed the largest overall decrease (12.4 per cent), while South Korea showed the largest increase (9.3 per cent).

In 1998, Norway, which has about 0.075 per cent of the world's population, accounted for 0.27 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, see table A10 in the Appendix). The OECD countries together accounted for 54 per cent of this. Per capita energy use in Norway was 24 per cent higher than the average for the OECD countries and more than 3.5 times the world average. This is due to 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 United States and Canada. Average per capita energy use in OECD member countries is 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 92 per cent of the OECD average.

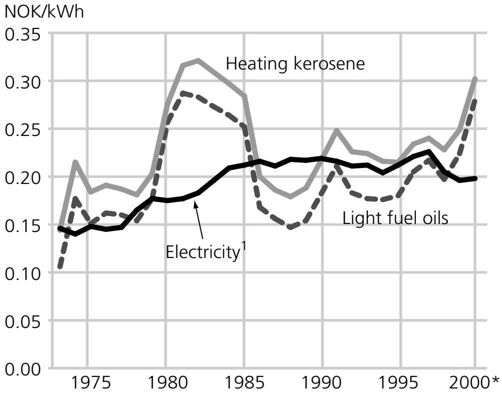
The energy mix varies between continents. Oil, natural gas and coal are important energy commodities in all continents, whereas nuclear power is used particularly in some industrial countries (BP 2000). On a global basis, about 65 per cent of energy use is in the form of oil and natural gas, while coal accounts for about 25 per cent. The United States, France and Japan account for about 60 per cent of nuclear power used. The proportion of energy use based on nuclear power is highest in Sweden and France, while Norway uses the highest proportion of hydropower.

2.5. Energy prices

Electricity

The spot price for electricity on the Nord Pool power exchange fell from NOK 0.112 per kWh in 1999 to NOK 0.103 per kWh in 2000 because of the high level of hydropower production in 2000. As a result of the lower price on the exchange,

Figure 2.11. Price trends for fuel oils and electricity for heating[1] (as utilized energy), in fixed 1980 prices including all taxes and tariffs



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

electricity prices excluding transmission charges and taxes also fell for all consumer groups. However, since the electricity tax rose from NOK 0.0594 to NOK 0.0856 per kWh from 1999 to 2000, there was an increase in the total price paid by the consumer. Nonetheless, figure 2.11 shows that electricity prices have not been as low as in 1999 and 2000 since 1983, when prices are corrected for the general increase in prices.

Fuel oils

In 2000, 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 29 and 25 per cent respectively to NOK 0.515 and 0.595 per kWh, see table A9 in the Appendix. As a result of higher prices for oil products and relatively low prices for electricity, combined with warm weather last year, sales of fuel oil fell sharply from 1999 to 2000.

Sales of heating kerosene, light fuel oils and heavy distillates dropped by 22-25 per cent. Sales of heavy fuel oils decreased by as much as 40 per cent. Figure 2.11 shows trends in the price of utilized energy (i.e. corrected for efficiency) in fixed 1980 prices from 1973 to 2000. Table A9 in the Appendix shows the prices of heating products measured as energy supplied. Consumption of heavy fuel oil is very low despite low prices (Appendix, table A5). This is because permits and technical considerations greatly restrict their use. Heavy fuel oils are mainly used in manufacturing and international maritime transport.

2.6. Power and generation capacity shortages in the Norwegian electricity market?

Is there enough generation capacity in the Norwegian electricity market today, and will there be sufficient capacity in the future? Is the market organized in the best possible way or is it possible to improve the way it functions?

After deregulation of the Norwegian electricity market in 1991, investments in capacity have been lower than the growth in consumption. This has resulted in a gradually tighter balance in the Norwegian power market. However, prices are still low and there are still good possibilities for import of surplus capacity from neighbouring countries. Because of the growth in consumption and low investment activity, actors in the electricity market are concerned about the power balance in the years ahead. Several actors also seem to feel that capacity is dropping too low to maintain a regular supply in a dry year or over two consecutive dry years.

In this project (Johnsen et al. 2000) we took our point of departure in today's situation, and addressed how shortages are handled in the context of the regulations and markets that exist today. Then we looked at the theoretical aspects of handling shortages and rationing. We then identified some unfortunate aspects of the organization of the Norwegian market that are relevant to the ability to handle shortage situations. There is an upper limit for the supply of power, defined by the possibilities for domestic production and for import via transmission connections to other countries. It is therefore important to know to what extent consumers reduce their use of electricity when the price of electricity is high and supplies are short. If the consumers react to price signals, even when they change from hour to hour, it can be assumed that shortage situations can be managed by means of a reduction in use. We discussed and have presented statistics for the reaction of various consumer groups to higher electricity prices. We also presented various technical solutions that may be used to reduce electricity use when supplies are short. It is very uncertain how the Nordic electricity market will develop. We used Statistics Norway's Nordic electricity market model, Normod-T, to simulate a development path for the power market up to 2010. We also studied how dry years would affect the market balance.

We have identified a number of imperfections that can aggravate an electricity shortage and reduce the ability of the market to handle these situations by means of an increase in supply and/or a reduction in consumption:

- In the short-term physical electricity market, the market is cleared hour by hour in the Nord Pool day-ahead, or spot market. In this market, supply and demand bids are cleared once every twenty-four hours. Electricity prices for each of the next day's 24 hours are made available every day at 1400. Transmission constraints (bottlenecks in the grid) are reflected in regional markets (price zones) with their own prices, or Statnett carries out market operations, using sales and purchases in the regulatory market to remove transmission constraints (special regulation). As of 2000, the Norwegian Water Resources and Energy Directorate has permitted the introduction of fixed price areas, i.e. a system whereby Statnett can make greater use of special regulation to remove bottlenecks. This means that regional shortages are reflected to a lesser extent than previously in regional price differences in the spot market. In our opinion, bottlenecks in the grid should be reflected in separate price areas with prices that reflect the real shortage in the market. This would give consumers a correct price signal, so that anyone who had something to gain by reducing their consumption would do so. Market-based power trading is founded on the principle that prices are used to clear supply and demand. This should also apply in a regional context. Regional shortages should be reflected in the prices. This would also help to mitigate national shortages.

- All Norwegian energy utilities are regulated by the Norwegian Water Resources and Energy Directorate, which determines an upper limit for each company's annual income. The limit is determined on the basis of past cost figures, the quantity of energy supplied and efficiency requirements. In addition, the Directorate issues guidelines to be used by energy utilities when setting their charges. It is important that the Directorate's regulation does not hinder profitable investments aimed at increasing consumers' price sensitivity. Investments should be made so as to give the best yield in macroeconomic terms irrespective of the grid's structure of ownership. It may be cheaper for the owner of a regional grid to invest in measures to prevent greater price sensitivity in end-users in a distribution grid rather than increasing capacity in the regional grid. In other words, cooperation should be encouraged and any income should be transferred between grid owners so that any gains from measures implemented are transferred to the parties responsible for the investments, giving the highest profits in economic terms.
- The fixed charges in the central grid tariff system should not affect decisions on input or withdrawal of generation capacity. The sole function of the fixed charges is to generate income, and intervention should be kept to a minimum. New generation capacity may be exempted from the fixed charge and owners may be instructed to continue to pay the fixed charge for the net capacity withdrawn.

We believe there is sufficient capacity on the market, that is the price ensures that demand does not exceed supply. Our main conclusions are therefore as follows:

- The price mechanism should be used to clear supply and demand. High prices will have the effect of maintaining or increasing generation capacity instead of reducing consumption. Increasingly frequent power shortages may require very high peak-load prices in the day-ahead market - high prices will lead to increased imports, reduced domestic consumption and export, and trigger investments on the demand and on the supply side. Market systems must allow for periodically very high prices.

- High prices will, first of all, make the power trading companies aware of the size of the potential loss involved in purchasing power on the day-ahead market for resale at fixed prices. Secondly, power trading companies purchasing power on long contracts with fixed prices will be aware of the potential profits involved in being able to sell power into the market at hours when the prices are extremely high. Thirdly, high prices will demonstrate to producers who sell power on fixed price contracts that there is potential profit in being able to release power for sale on the day-ahead market.
- It must be made quite clear to the market participants that very high prices may occur at individual hours, and that Nord Pool, Statnett or the authorities will not prevent these prices from occurring if they are necessary to clear the market. If Nord Pool, Statnett or the authorities take on the role of solving shortage problems, or immobilizing market mechanisms in the case of extreme shortages, the market will not regard the risk mentioned or the potential for profit as real. Consequently, the market participants will not make the required adjustments within a system of market-based power trading.

Financing and project concept: Statnett SF.

Project documentation: Johnsen, Aune and Vik (2000).

2.7. Uncertainty and investment decisions in the electricity sector

In assessing trends in the power market, the effect of uncertainty on investments in generation capacity is important. The deregulation of the electricity market in 1991 has altered the way in which uncertainty related to investments is assessed. Under the regulated regime, the local power producers held a monopoly and could pass on the costs related to uncertainty to the consumers by raising prices. In today's situation, however, customers are free to choose their own supplier, and producers can lose customers if they mark up the price of electricity as a result of unprofitable investments.

In a deregulated market where producers compete for the customers, it is more important for a producer to make thorough assessments related to investments because the cost of any over-investment must be borne by the investor. Investments in power production are irreversible in the sense that once investments have been made, they have no, or very little value, for others. The invested capital is tied up because good second-hand markets for turbines and reservoirs do not exist. The traditional rule of investing when price is equal to marginal cost is not an optimal solution when there is uncertainty and irreversibility.

These issues have been studied within a theoretical model for investments under uncertainty. We have also illustrated this with empirical estimates of decisions on investments in power projects when future power prices are assumed to be uncertain. Our calculations are based on data for the Nordic electricity market.

The results show that when there is uncertainty and irreversibility, the optimal solution is to postpone the construction of power plants. The empirical estimates show that for the investment to be profitable, the price of electricity must be up to 13 per cent higher than the long-term marginal cost.

Project financing: Statistics Norway.

Project documentation: Larsen (2000).

General documentation: Statistics Norway (2001b).

Further information on energy in general: Pål Marius Bergh, Lisbet Høgset, Tor Arnt Johnsen and Trond Sandmo.

3. Agriculture

Agriculture has significant positive and negative impacts on the environment. The total size of agricultural areas in use has remained stable at a time when the importance of agriculture to the national economy is declining, and when there have been major structural changes in farming. The cultural landscape has largely been created by farming, and in recent years there has been increasing focus on the importance of farming to the landscape, while production objectives have been toned down. Agriculture contributes to pollution, and particular attention has been focused on eutrophication of water bodies caused by nutrient enrichment.

Agriculture interacts with the environment in many ways. Farming results in environmental changes both to farmed land, such as alterations in biotopes and landscapes, and to adjacent areas in the form of runoff of nutrients into water bodies and emissions to air from agricultural processes. At the same time farming areas are also affected by outside environmental pressures such as pollution, in the form of ozone and heavy metals, and demand for farmland, resulting in conflicts over land use. The agricultural sector manages substantial biological and cultural assets in the form of cultivated animal and plant resources, buildings and types of landscapes. These have a positive environmental impact in the form of genetic diversity and cultural assets.

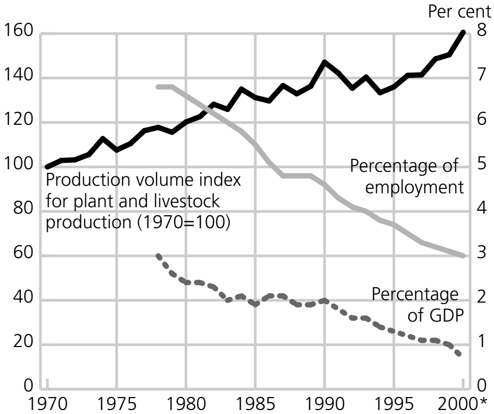
One of the most important objectives of farming is to safeguard the national food supply (Report No. 19 (1999-2000) to the Storting). Since Norway aims for a high capacity for self-sufficiency, the most critical factor in Norway is access to land resources. Another important environmental perspective is the impact farming methods have on the quality of farm products and thereby on human health, whether in the sense of the nutritional content of food, pesticide residues or animal diseases transmissible to humans.

This chapter cannot deal with all the various interactions between agriculture and the environment. We will base the chapter on the economic importance of agriculture as an industry and focus on the natural resource base (land resources) and activities in the agricultural sector that have an environmental impact in the form of changes in the landscape and emissions to water and air.

3.1. Agriculture in an economic perspective

The importance of agriculture in economic terms continues to decline. According to the Norwegian National Accounts, the agricultural sector's share of total

Figure 3.1. Trends in agricultural sector's share of total employment and GDP and in level of agricultural production (index 1970=100)



Source: Budget Committee for Agriculture (2000) and Norwegian National Accounts, Statistics Norway.

employment (measured as full-time equivalent persons) sank from 6.8 to 3.0 per cent from 1978 to 2000 (figure 3.1). In absolute figures, the drop was from 111 500 to 59 000 full-time equivalent persons (preliminary figures). The share of gross domestic product (GDP) derived from agriculture dropped from 3.0 per cent to 0.7 per cent in the same period. However, agricultural production measured according to the production volume index used by the Budget Committee for Agriculture rose by about 60 per cent from 1970 to 2000 (Budget Committee for Agriculture 2000).

3.2. Land resources

Resource base

Norway has limited land resources suitable for farming. About 3 per cent of the area of Norway is cultivated land, as against over 10 per cent on a global basis (SSB/SFT/DN 1994). The scarcity of land resources means that the current self-sufficiency rate is between 40 and 50 per cent. Nevertheless, potential crop yield for the most productive areas is relatively high compared with most other countries for crops that can be cultivated in this country. Crop yields for cereals in Norway are slightly lower than in Sweden and Denmark, but higher than average for the OECD countries. One important reason for the high crop yield in the Nordic countries is good access to water. In a global context, lack of access to water is one of the most important factors restricting plant production. The cold climate in the Nordic countries also means there is less risk of disease and pests.

Potential crop yield varies greatly with the quality of land resources. Grouping land resources according to quality will give a more detailed picture of the land resources lost as a result of conversion of agricultural land for other purposes, and provide a basis for assessing the quality of the remaining land (cultivable land) in relation to the resources already in use (cultivated land). There is an important distinction in quality between land that is suitable for cereal farming and land that is not. Land suitable for cereal farming can to a great extent be used for the direct production of food, while land that is not suitable for cereal farming must largely be used for coarse fodder production.

Grønlund and Høie (2001) has grouped land resources according to their suitability for cereal farming on the basis of three characteristics:

- climate zone
- depth of soil
- quality of terrain.

The results show, as expected, that a lower percentage of uncultivated land

Table 3.1. Area of cultivated and cultivable land (km²) in Norway calculated on the basis of economic mapping. Status as of 1975

	Total area	Potential cereal acreage of total	
	km²	km²	Per cent
Cultivated	10 608	5 871	55
Cultivable	8 350	3 217	39

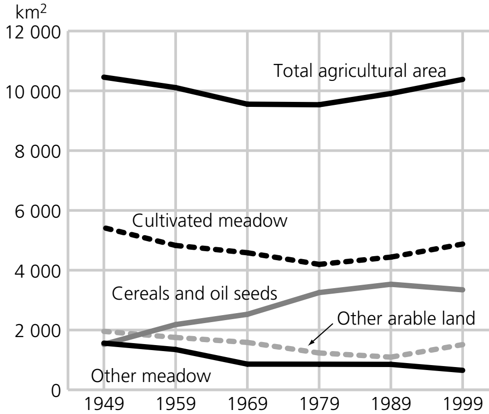
Source: Grønlund and Høie (2001).

resources is suitable for cereal farming compared with land that has already been cultivated. In other words, unused land resources are of generally poorer quality than land already cultivated. However, the results indicate that there is considerable variation between counties as regards the quality of cultivable land.

Use of cultivated land

In 1949, the area of agricultural land in use was just under 10 500 km². The area then gradually decreased until it reached its lowest level of about 8 700 km² in the 1970s[1]. The area has since increased, reaching 10 382 km² in 1999 (figure 3.2 and Appendix, table B 1). The increase in agricultural area over the last few years consists largely of "other meadow", comprising surface cultivated meadow and fertilized pasture. This is probably related to stricter requirements with regard to the area suitable for manure spreading and the transition from support based on production to support based on the area farmed. The introduction of stricter requirements with regard to the area suitable for manure spreading has forced livestock farmers to increase this area to avoid having to reduce their livestock production. An acreage and cultural landscape support scheme was introduced in 1989. Grants under this scheme have made it more worthwhile for farmers to use marginal areas (Budget Committee for Agriculture 1997). One of the reasons for reorganizing the grants system in this way is that collective goods such as the country's emergency preparedness and environmental benefits related to agriculture have been given more prominence in agricultural policy targets (Report No. 19 (1999-2000) to the Storting). In the light of this reorganization, there is reason to believe that some of the increase indicated in the statistics is due to improved registration.

Figure 3.2. Agricultural area in use



Source: Agricultural statistics, Statistics Norway.

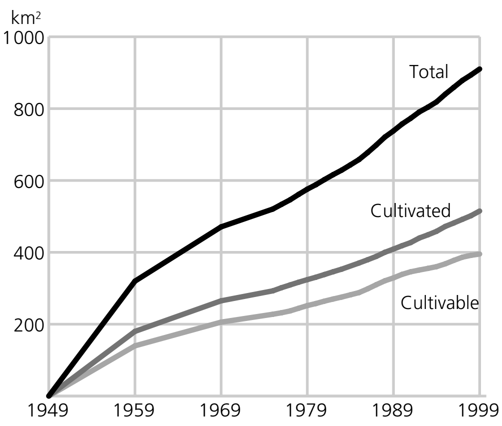
In 1999, cereal and oil-seed acreage made up 32 per cent of the agricultural area in use, and cultivated meadow 47 per cent. The acreage of cereals reached a peak in 1991, and has since dropped by about 10 per cent. The area of cultivated meadow was at its lowest level in 1980, since when it has risen by about 17 per cent.

[1] The registered agricultural area decreased in the 1970s, which was due (at least partially) to methodological deficiencies in the background data.

Conversion of agricultural land resources for other uses

Maintaining the country's capacity for self-sufficiency, so that the level of self-sufficiency can be increased at need, in a trade crisis, for instance, is an express political objective (Report No. 19 (1999-2000) to the Storting). With Norway's limited land resources, changes in land resources can quickly affect the country's capacity for self-sufficiency. One of the most important means of avoiding this is to protect agricultural land resources. The most important threat to agricultural land resources is its conversion for purposes that prevent future agricultural production, such as roads and housing. From 1949 and up to the end of 1999, an estimated 910 km^2, or about 4.7 per cent of the total area suitable for agriculture in 1949, has been converted for such purposes (figure 3.3). The rate at which agricultural land resources were 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 converted land are uncertain, and have most probably been underestimated. This is because the official reports on which the statistics are based do not include all conversion of cultivated and cultivable land (see also table 3.1). No overall survey of the quality of converted land resources has been carried out. However, since most of the development has taken place in urban settlements and adjoining areas, there is reason to assume that the quality of converted land has been generally higher than that of the remaining areas.

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



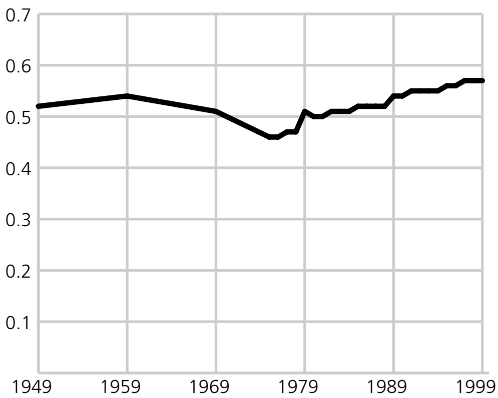
[1] For the period 1949-1976 data is only available for cultivated areas that were converted. The area of cultivable land converted in this period has been estimated on the basis of the ratio between cultivable and cultivated land converted 1976-97.
Source: 1999 Agricultural Census, Statistics Norway and the Ministry of Agriculture.

Indicator for degree of utilization of agricultural land resources

The percentage of the total agricultural land resources utilized indicates how vulnerable the capacity for self-sufficiency is to irreversible conversion of land suitable for agriculture. The total agricultural land resources are defined as the sum of cultivated and cultivable area. The degree of utilization is thus the percentage of this area that has been cultivated. New cultivation means that cultivable area is cultivated. This does not affect the size of the total resources, but increases the degree of utilization. We can therefore assume that the total agricultural land resources are only affected by irreversible conversion. Data on irreversible conversion are available from 1949. The total area of cultivated and cultivable land has therefore been calculated as the area in 1949 minus the area irreversibly converted since then.

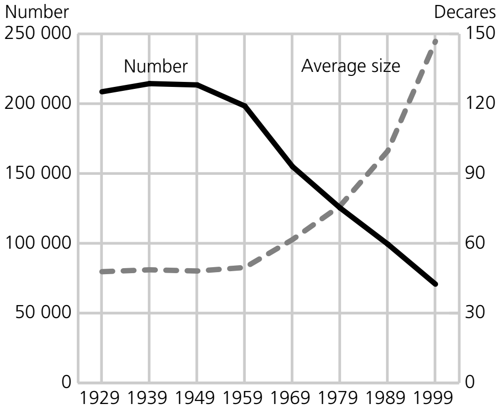
This indicator shows the proportion of the total agricultural land resources that are in use at any given time. The indicator value lies between 0 and 1. A value close to 0 means that only a small

Figure 3.4. Degree of utilization of agricultural land resources in Norway



Source: Grønlund and Høie (2001).

Figure 3.5. Number of holdings and their average size (decares)



Source: 1999 Agricultural Census, Statistics Norway.

proportion of the total land resources are in use and that there are large land reserves that can be cultivated to compensate for cultivated land that has been irreversibly converted for other purposes. A value near 1 means that virtually all the agricultural land resources are in use and that there is little available land for cultivation to compensate for irreversible conversion of cultivated land.

Figure 3.4 shows that in the period from 1949 to 1976 there was a net decline in the degree of utilization of the agricultural land resources from 0.52 to 0.46. This is because agricultural area diminished in this period. In the period 1977 to 1995, utilization rose from 0.46 to 0.57, an increase of 22 per cent. Most (19.5 per cent) of this increase is due to the fact that agricultural area increased in the same period through cultivation of previously uncultivated land and utilization of other cultivable areas. The remaining increase of 2.5 percentage points is due to a reduction in available land resources as a result of irreversible conversion.

3.3. Size of holdings and cultural landscape

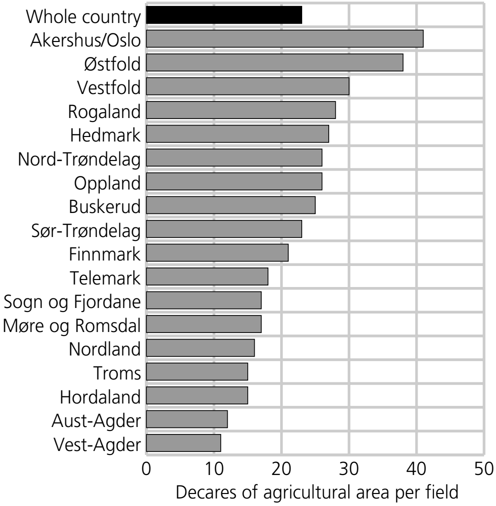
Major structural changes have taken place in agriculture over the last few decades, and they have followed three distinct trends:

- the agricultural area is divided among fewer and larger holdings
- each holding produces fewer products (specialization at holding level)
- production of important products is concentrated to a greater extent in certain regions (specialization at regional level).

All these trends have changed the conditions for nutrient cycles in the agricultural system and the way farming shapes the cultural landscape. Requirements relating

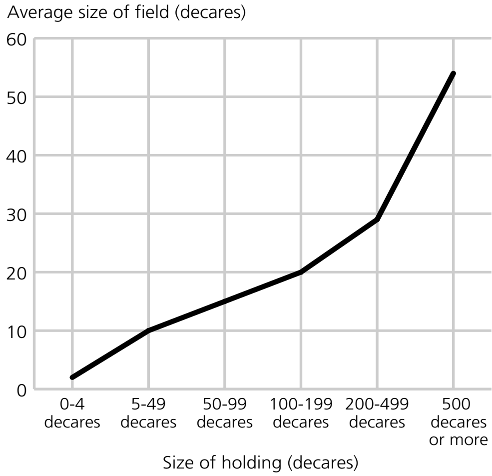
[2] There was an increase in agricultural area in the 1990s that was partly due to the introduction of acreage support. This meant that previously unrecorded area was now included in the statistics.

Figure 3.6. Average size of fields by county



Source: 1999 Agricultural Census, Statistics Norway.

Figure 3.7. Average size of fields by size of holding



Source: 1999 Agricultural Census, Statistics Norway.

to the means of production have also been affected, including buildings, which are an important part of Norway's cultural heritage.

The number of holdings in Norway has been reduced to nearly a third since 1960, and as a result the average size has almost trebled, since the total agricultural area in use has hardly changed at all (figure 3.5). These structural changes have not yet stabilized. Much of the land on abandoned holdings has been taken over as additional land by the remaining holdings, often as rented area.

Increasing the size of holdings means a potential improvement in the organizational basis for more efficient operation. Coupled with today's technological advances and greater pressure to increase earnings, this may lead to an increase in the size of fields. An increase in the size of fields will reduce the length of ecotones and result in less variation in the landscape within a given area. This will reduce biological diversity and give the agricultural landscape a more monotonous appearance. However, there are insufficient statistics and surveys that can confirm to what extent this trend actually exists. A question about the division of holdings into parcels and fields[3] was included for the first time in the 1999 Agricultural Census. The size of fields within an area can give an indication of how varied the landscape in that area is. Figures from the 1999 Agricultural Census show that there was considerable variation from county to county with regard to the average size of fields (figure 3.6). In the counties around the Oslofjord, the agricultural area is divided among the largest fields, while southern

[3] In this context, a parcel is defined as the area delimited by other property, while a field is an area delimited by natural boundaries such as roads, forests, streams, etc.

Norway has on average the smallest fields. The differences are to a great extent due to the geomorphological conditions. In hilly areas such as Agder in southern Norway, most of western Norway and northern Norway, the size of fields will be naturally delimited by the terrain.

How the size of the fields varies with the size of the holding can give some indication of whether the size of the holding affects the size of the fields. Figure 3.7 shows that there is a clear connection between holding size and field size. If it is assumed that field size is dependent on operational organization in addition to terrain as mentioned above, there is reason to believe that the structural changes shown in figure 3.5, whereby holdings are fewer in number and larger in size, have played a role in increasing the size of the fields. When this survey is repeated, more information will be available about the trends in field size and the underlying reasons for these trends.

3.4. Pollution from the agricultural sector

Farming results in air and water pollution. In particular, agriculture is a major contributor to discharges of nutrients to water (nitrogen and phosphorus) (see further details in Chapter 9). Farming also makes a substantial contribution to emissions to air, in the form of ammonia (NH_3) and greenhouse gases such as methane (CH_4) and nitrous oxide (N_2O) (see paragraph below, Chapter 7 and Appendix, tables F3-F5). The use of pesticides in farming also results in significant emissions of hazardous substances.

The following paragraphs describe the extent of emissions to air from farming and the activities that are important in relation to discharges of nutrients and pollution from pesticide use.

Emissions to air

Agriculture contributes particularly to ammonia, methane and nitrous oxide emissions. Emissions of ammonia result in acid rain, while methane and nitrous oxide are greenhouse gases (see also Chapter 7, Air pollution and climate). 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 to air.

Emissions of *ammonia* (NH_3) from the agricultural sector account for 93 per cent of the total ammonia emissions in Norway (table 3.2). 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 67 per cent of the total.

Livestock are the most important source of *methane* emissions (CH_4) in the

Table 3.2. Emissions to air from agriculture. Pollutants for which the sector is an important source. Tonnes and percentage of total emissions in Norway. 1999*

Pollutant	Tonnes	Percentage of total emissions in Norway
All greenhouse gases		
(in CO_2 equivalents)	5 480 917	10
CO_2	554 877	1.3
Nitrous oxide (N_2O)	8 440	49
Methane (CH_4)	109 976	33
Acidifying substances	1 567 [1]	21
Ammonia (NH_3)	24 803	93

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

agricultural sector. Methane is released directly in the form of intestinal gas and indirectly via manure. Livestock account for about 33 per cent of total methane emissions in Norway, of which 28 per cent is from intestinal gas and 5 per cent from manure.

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 is responsible for 50 per cent of total nitrous oxide emissions in Norway. Calculations of nitrous oxide emissions from agriculture show a high level of uncertainty (see Chapter 7).

Emissions to water

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 Chapter 9, Water resources and water pollution. Eutrophication is a particularly serious problem locally in water recipients where much of the surrounding land is agricultural.

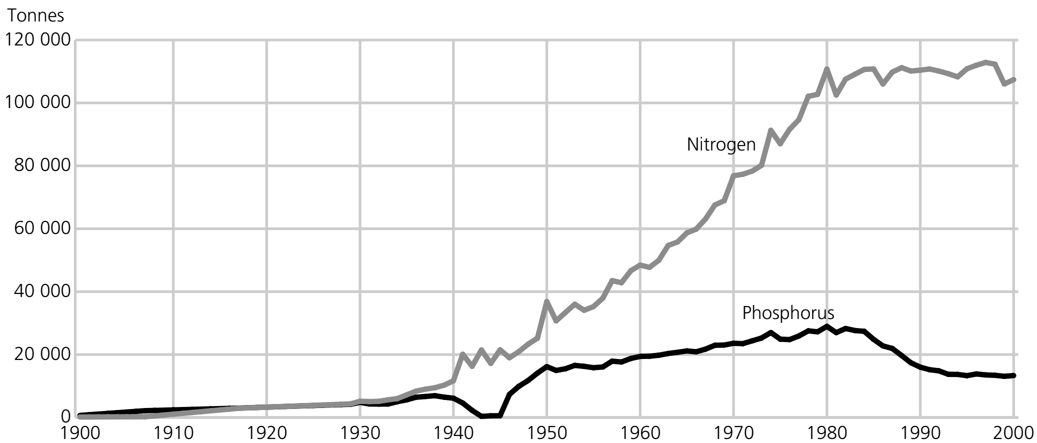
Measures to limit runoff of nutrients can be divided into three main groups:

- better fertilizer management to reduce the surplus of nutrients in soils
- better cultivation systems to protect soils against erosion
- technical measures.

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 only took off in the second half of the twentieth century (figure 3.8). 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

Figure 3.8. Sales of nitrogen and phosphorus in commercial fertilizers



Source: Statistics Norway and Norwegian Agricultural Inspection Service.

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

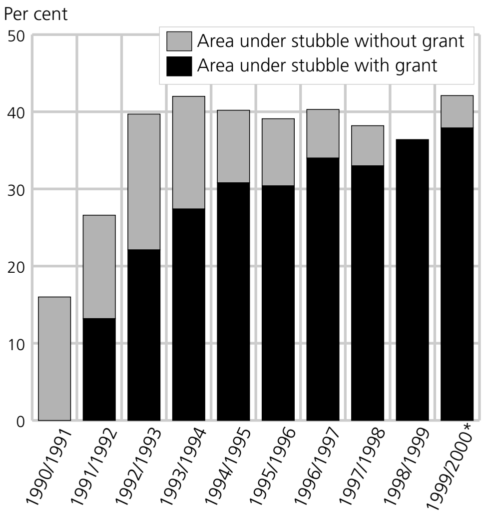
If livestock numbers are high in relation to the agricultural area in use, there may be an excess of manure and thus a risk of pollution. Total livestock numbers, and therefore the amount of manure produced, have changed little since 1985. The amount of nitrogen in animal manure available for plant growth (fertilization value) is about 35 000 tonnes (Bye, Mørk et al 2000). The corresponding figure for phosphorus is 12 000 tonnes. The total amount of nitrogen and phosphorus in animal manure is considerably larger, but much of it is bound in such a way that these substances are not immediately accessible as plant nutrition.

The proportion of the manure applied during the growing season, expressed as nitrogen, was 80 per cent in 1989 and has been about 87 per cent in recent years. Application during the growing season is important to ensure efficient utilization of the manure.

Soil management

A large proportion of pollution from the agricultural sector is a result of erosion, i.e. transport of soil with surface water runoff from fields. Most erosion takes place on fields that are ploughed in autumn. With this method, fields 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.

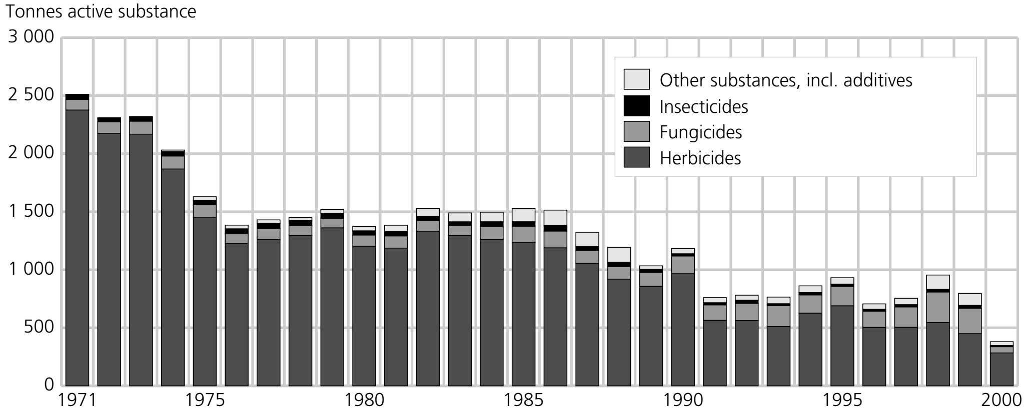
Figure 3.9. Proportion of cereal acreage left under stubble in autumn



Source: Agricultural statistics, Statistics Norway and Ministry of Agriculture,

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 these 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

Figure 3.10. Sales of chemical pesticides, measured in tonnes of active substance



Source: Norwegian Agricultural Inspection Service.

is granted has risen year by year and was 86 per cent in 1997-98.

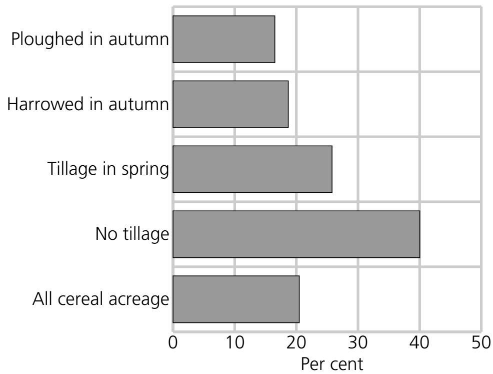
Use of pesticides

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 the weight of the active ingredients, were greatly reduced in the first half of the 1970s, then, following a slight increase, were almost halved from 1985 to1991. Consumption rose again slightly until 1999, then halved from 1999 to 2000 (figure 3.8 and Appendix, table B 3). Sales trends over the last three years must be seen in the context of an increase in taxes on pesticides in 2000. This probably meant that stocks were built up before the year 2000, and that these stocks were then used in 2000 (Norwegian Agricultural Inspection Service 2001).

There is no clear connection between the sale and use of pesticides. The amount sold is therefore only an indicator of the amount used. As mentioned above, there may be a lapse of time between sale and use, and this can result in annual statistics that are misleading. There has also been a gradual transition to low dosage pesticides. This means that even though the amount sold in kilogrammes of active substance is reduced, there will not be a corresponding reduction in the extent of

Figure 3.11. Proportion of cereals acreage sprayed for couch grass after various forms of soil management. Average for the period 1992/93-1997/98



Source: Resultatkontroll jordbruk, Statistics Norway.

Box 3.1. Ecological farming

Ecological farming 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 producti on 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. Requirements relating to 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 181 km^2 in 1999 (see Appendix, table B 4). Including area in the process of conversion, about 2.0 per cent of the total agricultural area is farmed ecologically. Table 3.3 shows ecological farming by county in 2000.

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.

spraying. There is even more uncertainty attached to the use of sales figures as an indicator of the environmental impacts of spraying because the degradation rates of different pesticides vary widely, as do their selectivity, mobility and toxicity.

Perennial weeds, especially couch grass, are the most serious problem in cereal production. They are controlled either by tilling or by using herbicides. Over the past few 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

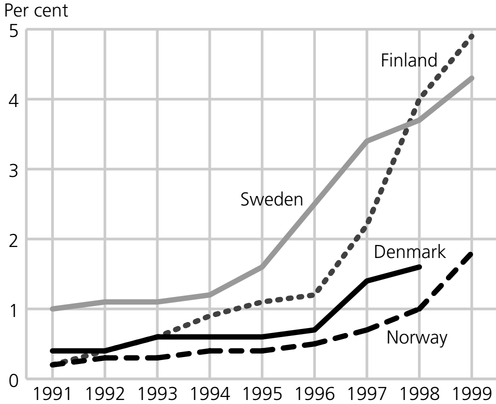
Table 3.3. Holdings and areas farmed ecologically or in the process of conversion. By county. 2000

County	No. of holdings	Ecologically farmed area	Area in the process of conversion	Percentage of total agricultural area
		Decares		
Whole country ...	**1 823**	**180 841**	**24 387**	**1.99**
Østfold	63	6 076	940	0.92
Akershus og Oslo	129	15 307	2 376	2.21
Hedmark ..	177	20 750	2 381	2.17
Oppland ...	205	20 737	1 915	2.20
Buskerud ..	152	11 732	1 763	2.61
Vestfold ...	78	8 416	1 042	2.21
Telemark ..	80	7 640	1 254	3.45
Aust-Agder	39	2 634	324	2.52
Vest-Agder	52	4 908	1 118	3.02
Rogaland ..	45	5 473	378	0.60
Hordaland	109	7 472	673	1.75
Sogn og Fjordane ...	178	16 330	1 625	3.78
Møre og Romsdal ...	93	7 421	1 605	1.48
Sør-Trøndelag	149	16 504	2 259	2.46
Nord-Trøndelag	116	11 616	2 534	1.60
Nordland ..	107	11 121	1 663	2.19
Troms	45	6 151	426	2.44
Finnmark ..	6	556	111	0.63

Source: Debio (1999).

of the soil is reduced or postponed, the larger the proportion of the area that is sprayed. In the area under cereals that was *sown directly*, i.e. no tillage at all and therefore minimal risk of erosion, 40 per cent on average was sprayed against perennial weeds, whereas in the *area ploughed in autumn* (with maximum potential for erosion) only 17 per cent was sprayed (figure 3.11). When tillage is reduced, soil loss and pollution by nutrients is reduced, but larger amounts of pesticides are used. This means that given current agricultural practice, the

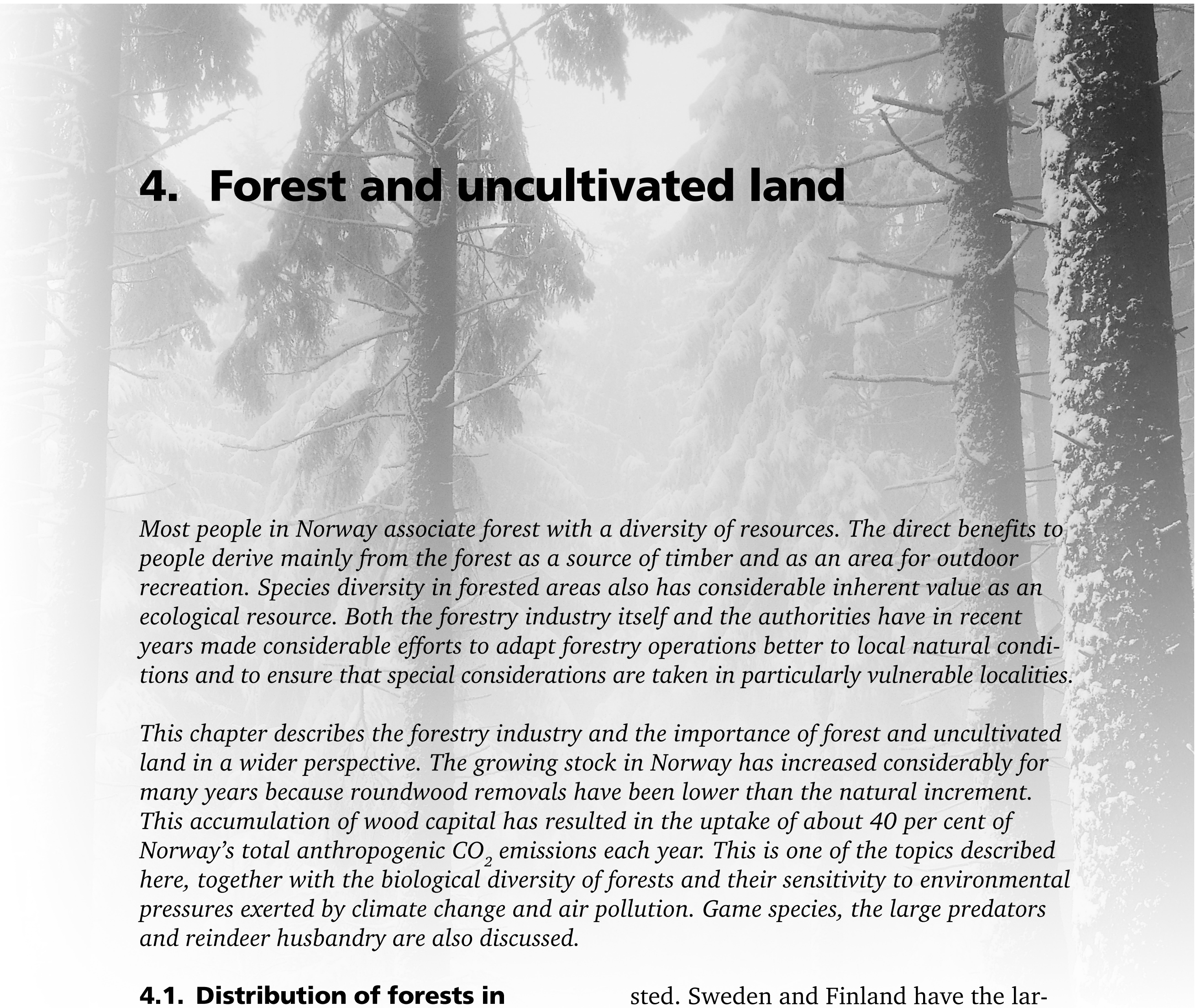
Figure 3.12. Areas farmed ecologically or in the process of conversion in the Nordic countries[1]. Percentage of total agriculture area



[1] In the case of Sweden, permanent grazing land 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.
Source: Norway: Debio (1999), Denmark: Miljø- og energikontoret, Statistics Denmark, Sweden: KRAV Ekonomisk Förening, Finland: Agricultural Economics Research Institute.

environmental cost of reducing soil loss by limiting tillage is greater use of pesticides.

Further information may be obtained from: Henning Høie, Anne Snellingen Bye and Svein Erik Stave.



4. Forest and uncultivated land

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. Species diversity in forested areas also has considerable inherent value as an ecological resource. Both the forestry industry itself and the authorities have in recent years made considerable efforts to adapt forestry operations better to local natural conditions and to ensure that special considerations are taken in particularly vulnerable localities.

This chapter describes the forestry industry and the importance of forest and uncultivated land in a wider perspective. The growing stock in Norway has increased considerably for many years because roundwood removals have been lower than the natural increment. This accumulation of wood capital has resulted in the uptake of about 40 per cent of Norway's total anthropogenic CO_2 emissions each year. This is one of the topics described here, together with the biological diversity of forests and their sensitivity to environmental pressures exerted by climate change and air pollution. Game species, the large predators and reindeer husbandry are also discussed.

4.1. Distribution of forests in Norway and Europe

There is about 75 000 km^2 of productive forested area in Norway (Norwegian Institute for Land Inventory 1999) Productive forest accounts for 24 per cent of the total land area of Norway. According to the Agricultural Property Register, as of January 2001 there were almost 119 000 forest properties in Norway with more than 25 decares[1] of productive forest. 43 per cent of the forest area on these properties is managed in combination with agricultural operations.

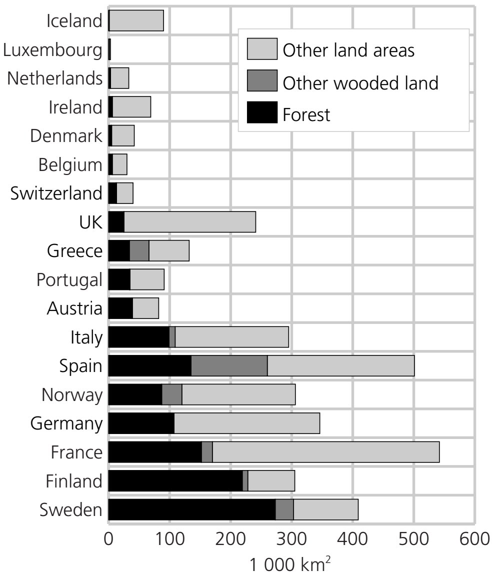
About 1.1 million km^2 or 36 per cent of the total area of the EU countries is forested. Sweden and Finland have the largest areas of forest (see figure 4.1, Eurostat 2001). Forestry and forest industries employ 2.2 million persons in the EU area today (UN/ECE-EC 2000a).

4.2. Forestry

The main economic importance of forest today 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. This provides a basis for making use of the resources of uncultivated areas for

[1] 1 decare = 0.1 hectare.

Figure 4.1. Forest area and total land area in EU and EFTA countries



Source: UN-ECE FAO (1995).

tourism as well. More and more importance is now being given to multi-use considerations in forest industry.

International market

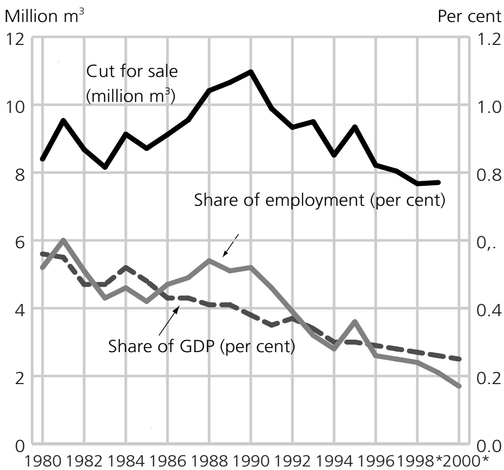
Forestry in Norway competes directly on the world market and is thus affected by international trade cycles. In 2000, the timber market in Europe was disrupted by an over-supply of roundwood as a result of the severe damage caused by storms in December 1999 (UN/ECE-EC 2000b). The volume of windthrown timber totalled 190 million m^3, mainly in France, Germany and Switzerland. In France and Switzerland, the storm damage corresponded to three years of normal harvests. Several steps were taken to reduce the effect of the large supplies of windthrown timber, such as reducing felling in areas that were not affected by the storms, exporting to new markets (including China) and developing the market for fuelwood. Nevertheless, the price of timber fell sharply in the areas that were affected.

The demand for forest products was high in both Europe and North America in 2000. In the countries of the former Soviet Union, a weak market for these products began to improve (UN/ECE 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, pressure on local prices and a poorer local market for timber.

Economic importance

In 2000, labour input in forestry was 5 000 full-time equivalent persons, or 0.25 per cent of total employment (figure 4.2). According to the national accounts, forestry's share of total employment was more than halved from 1980 to 2000. Forestry's share of Norway's GDP dropped from 0.52 per cent in 1980 to 0.17 per cent in 2000. The gross value of the

Figure 4.2. Forestry: share of employment and GDP. Annual roundwood removals



Source: National accounts and forestry statistics, Statistics Norway.

roundwood removed for commercial purposes in 1999 was NOK 2.7 billion.

In 1999, wood and wood products worth more than NOK 15 billion were exported from Norway. This corresponds to 4.3 per cent of total exports from Norway. In 1980, the value of exports of wood and wood products corresponded to 5.2 per cent of the country's total exports.

Roundwood removals

The total volume of commercial roundwood removals in 1999 was 8.4 million m^3. Roundwood removals have been stable at between 8 and 8.5 million m^3 for the past five years. However, the figure for 2000 may be lower as a result of the extremely mild and wet autumn in Eastern Norway. The ground remained unfrozen and soils were very wet, making transport both on and off forest roads difficult or impossible in many areas.

Preliminary figures for roundwood removals in 1999 show that they consisted of 89 per cent final felling, 9 per cent thinning and 2 per cent other types of felling (felling of windblown trees, removal of seed trees, etc). The total area of forest cleared for regeneration was 502 000 decares, and 333 000 decares of this consisted of clear-cuts. The average size of each clear-cut was 15 decares (Statistics Norway 2001d). Although these areas are called clear-cuts, some trees and bushes of no commercial use are often left on them. This vegetation used to be removed, so that such areas were truly clear-cuts. Modern forest management takes much more account of the importance of the remaining shelter for wildlife, as nest sites for hole-nesting birds and for insects and microorganisms that need dead and rotting wood. In the remaining areas that were felled, seed tree felling or shelterwood felling was used. These terms mean that fewer or more than 15 trees per decare are left standing. The purpose of these types of felling is to ensure regeneration based on locally-produced seeds.

Material recovery

Annual purchases of Norwegian waste paper and cardboard by the pulp and paper industry have risen steadily from 68 400 tonnes in 1967 to 329 300 tonnes in 2000 (Federation of Norwegian Process Industries 2001). 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 2000 is found to correspond to about 1.2 million m^3 timber.

Silviculture

In the1970s and 1980s, about 300 000 decares were planted each year. During the 1990s, the area planted decreased, and was 183 000 decares in 1999. The decrease may be explained by the weak economy of the industry, with decreasing real prices for timber and a drop in the public grants available, which reduces activity among owners and their willingness to make investments. Another possible explanation is that there has been a growing focus on the opportunities offered by natural regeneration. New forest that has grown from seed trees or surrounding forest ensures that regrowth is adapted to local climatic conditions. In combination with scarification natural regeneration may result in satisfactory regrowth on suitable soils.

Scarification involves clearing vegetation and the humus layer to leave open patches or strips of mineral soil. The area treated in this way varies from year to year. The area scarified in 1998 was the highest ever recorded (85 000 decares), but over 80 000 decares was treated in this way in 1999 as well. This promotes natural regeneration and is most effective when it is done before good seed years. During the past ten years, the use of herbicides to control weeds and broad-leaved scrub in forest has been greatly reduced. In 1990, more than 100 000 decares was sprayed with herbicides. The system of state grants for spraying with herbicides was stopped the next year, and the area sprayed dropped from 54 000 decares in 1991 to 17 000 decares in 1999. By way of comparison, 415 000 decares was cleared mechanically of weeds and other unwanted vegetation in 1999 (Statistics Norway 2000d).

Forest roads

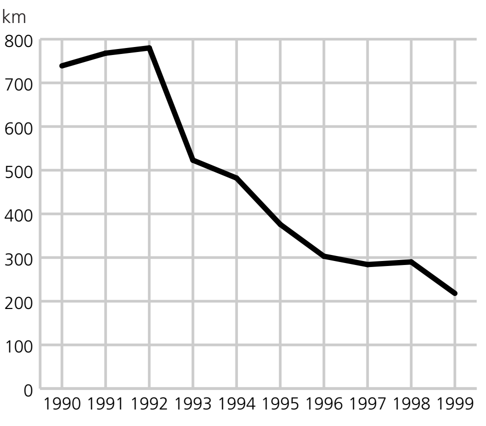
For many years, the construction of forest roads has been an important contributory cause of the reduction in the size and number of areas of wilderness-like habitat in Norway (SSB/SFT/DN 1994). Wilderness-like areas are defined as being more than 5 km from major infrastructure development (see Chapter 10 on land use). However, the rate of construction of forest roads has dropped sharply in recent years. In 1990, a total of 740 km forest roads for year-round use were completed, whereas the corresponding figure for 1999 was only 220 km (Statistics Norway 2000d, figure 4.3). In 1999, investments in forest roads for year-round use totalled NOK 119 million. In addition, NOK 45 million was invested in roads for winter use and tractor tracks. A total of NOK 164 million was invested in forest roads in 1999, and NOK 61 million of this was in the form of public grants.

See chapter 10 on land use for figures on the area of wilderness-like habitat in Norway.

4.3. Uptake of CO_2 by forest

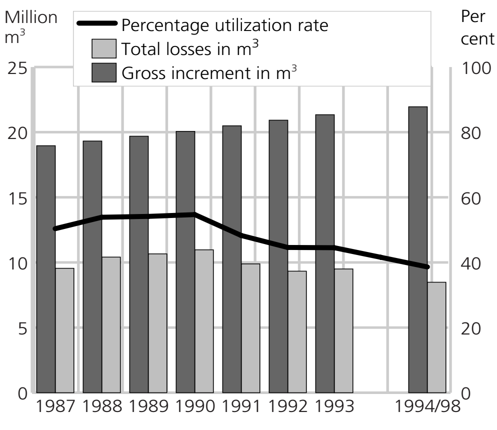
Forest inventories and calculations of volume show that the volume of the growing stock below the coniferous forest line has more than doubled since 1925 (figure 4.5).

Figure 4.3. Annual construction of new forest roads



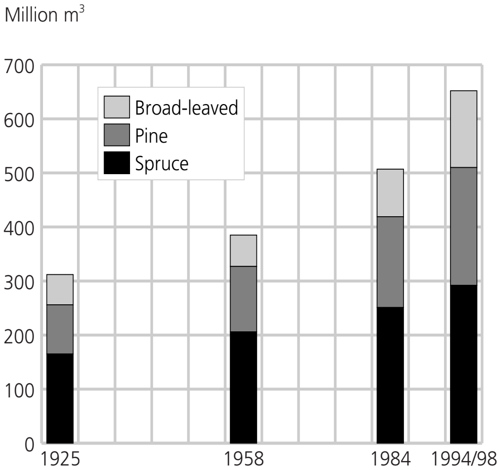
Source: Forestry statistics,Statistics Norway..

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



Source: Forestry statistics, Statistics Norway.

Figure 4.5. Volume of the growing stock without bark



Source: Statistics Norway and National Forest Inventory.

Annual figures for the volume of the growing stock, the forest balance, show the calculated figures for the growing stock at the end of the year. Data from inventories carried out by the Norwegian Institute for Land Inventory show that in 1999, the total volume of the growing stock, without bark, below the coniferous forest line was 686 million m^3.

In 1999, the net increment (annual increment minus roundwood removals and calculated natural losses) in the growing stock was 11.6 million m^3, or 1.7 per cent of the total volume (figure 4.4 and Appendix, tables C1 and C2). 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 resulted in an annual uptake of CO_2 by forest that in recent years has corresponded to about 40 per cent of Norway's anthropogenic CO_2 emissions.

4.4. Protection of forest in Norway

Norway's forests need protection even though both the total area of forest and the amount of timber forests contain are rising. Modern, rational forestry has made large areas of forest more uniform, and has reduced the area of forest that is allowed to develop without human intervention. Different habitats contain specially adapted species of insects, plants and other organisms. It is therefore important to maintain the level of variation in forests and to take special steps to maintain rare types of habitats.

Biological diversity

Norway's varied climate, quaternary geology and topography make for a wide range of vegetation and conditions of growth for forest. As mentioned earlier, productive forest covers 24 per cent of the area of Norway. Forest occurs in all Norwegian counties, and this gives a variety of vegetation ranging from temperate broad-leaved forest in the south, similar to the vegetation in Central Europe, to high arctic vegetation in the far north and in mountain areas.

An estimated 22 000 plant and animal species are associated with forest in Norway, and 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.

The Ministry of Agriculture's environmental action plan for 2001-2004 (Ministry of Agriculture 2000) emphasises the importance of sound forestry plans based on satisfactory registration of environmental data. A project on the registration of environmental data in forests (Miljøregistreringer i skog) has been started, and has so far resulted in a system for valuing habitats that can be used in forestry planning. The Ministry has decided that environmental data for forestry planning are to be registered using this system from 2001 onwards.

According to the National Forest Inventory, the percentage increase in volume was greater for broad-leaved forest than for pine and spruce forest in the 1990s. The same inventory showed that the average volume of windthrown trees and dead wood in the forest is 8.3 m^3 per hectare, or about 10 per cent of the volume of the growing stock (Hobbelstad 2000). The presence of broad-leaved trees and dead wood in the forest is important for the conservation of species of insects and other organisms that live in such habitats.

Coniferous forest protection

At the end of 1997 a total of 1 995 km^2 of forest was protected. Included in this figure is 600 km^2 of productive coniferous forest or about 0.84 per cent of the total productive coniferous area. According to current plans, a total of 1.06 per cent of all coniferous forest is to be protected (Report No. 17 (1998-1999) to the Storting). In addition, some broad-leaved and mixed forest is protected, and some forest areas are situated where they will naturally be included in new national parks. By way of comparison, 3.6 per cent of the total area of productive forest in Sweden was protected in 1996 (National Board of Forestry, Sweden 2000). In Finland too, protected forest makes up 3.6 per cent of the total area of productive forest (METLA 2000).

Forest certification schemes

Forest certification schemes are designed to ensure that operations are run in accordance with predetermined standards for sustainable forestry. Control is the responsibility of an independent third party such as Det Norske Veritas or Nemko Certification.

The period 1995-1998 saw a great deal of work being carried out in Norway to devise realistic criteria for sustainable forest management and to develop systems for documenting and controlling the state of the environment in forests. This work was done as part of the "Living Forests" project, and included representatives of forest owners, the forestry industry, the authorities, the trade unions, and environmental, outdoor recreation and consumer organizations. The project resulted in agreement on 23 standards for sustainable forest management in Norway. These can be used for certification in accordance with the ISO, EMAS and FSC systems. Because of the characteristic ownership structure in Norway, where there is a great deal of small-scale family forestry, it is possible to obtain group certification. As of January 2001, five of the nine forest-owner associations affiliated with the Norwegian Forest Owners' Federation were certified under the ISO 14001 standard. In addition, some separate forest properties have been certified under the same standard by Norwegian Forest Certification AS. At least 70 per cent of all Norwegian timber that is sold today is from forest properties that have been approved by a certification scheme.

More than 90 per cent of all certified forest in the world is in the ECE region (Europe, North America and the former Soviet Union). Little forest has been certified in the developing countries, where the problems related to forest management are most serious (UN/ECE 2000). The largest market for certified products is still in Western Europe. Supplies of certified forest products are rising faster than the demand for them, and the demand is mainly from intermediaries, not from consumers. Some German publishing houses and British supermarket chains require that all the paper they buy is produced from timber from environmentally certified forests.

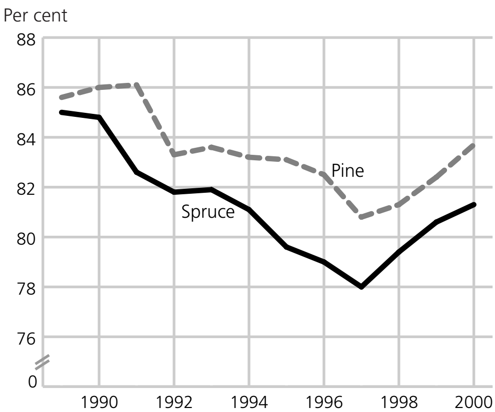
4.5. Forest damage

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 2001) show the current state of health of forests, measured as mean crown condition and crown colour for the country as a whole. Crown condition 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).

Figure 4.6. Mean crown condition for spruce and pine



Source: Norwegian Institute for Land Inventory.

The mean crown condition for spruce dropped from 85 per cent to 78 per cent in the period 1989 to 1997, but has since risen by 3.3 percentage points to 81.3 per cent in 2000 (figure 4.6). The measurements also show that the mean crown condition for pine, which was 83.7 per cent in 2000, has shown a positive trend in recent years, with a rise of 2.9 percentage points since 1997. There are regional differences in the state of health of the forest, but the material from the monitoring programme is too small to permit a detailed analysis of geographical differences. In general, there has been an improvement in the crown condition of spruce in forest areas in Eastern and Central Norway. The improvement in crown condition for pine has occurred throughout the country.

Forest damage in Europe

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 2000, 38 countries took part in the programme. A total of 5 700 test plots systematically arranged in a 16 x 16 km grid were surveyed (UN/ECE-EC 2000b). The main conclusions from the programme for 1999 were as follows:

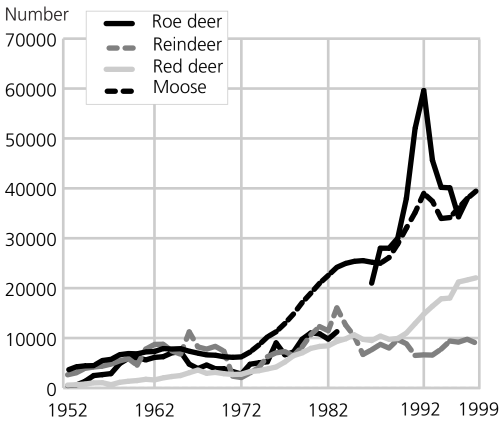
- The overall deterioration of crown condition has slowed down compared with what was found the year before. However, there are regional differences. The greatest deterioration in crown condition was in the Mediterranean region, where maritime pine (Pinus pinaster) and holm oak (Quercus ilex) are the worst affected species. In the eastern parts of Central Europe, deterioration of crown condition has slowed markedly. The improvement has been most pronounced for Scots pine. Of all the trees assessed throughout Europe, 22.6 per cent were classified as moderately or severely damaged in 1999. In 1998, the corresponding figure was 23.1 per cent.

- Detailed studies of mortality rates showed that they were in a range that may be considered as normal for managed European forests. Thus, there has been no large-scale die back during the monitoring period.

4.6. Game species and the large predators

Wildlife has always been an important element of the natural resources in uncultivated areas of Norway. Populations of predators, deer and small game species have varied over time, partly as a result of the way people have managed the various species. Hunting is an important element of game management. In Norway, every tenth male over 16 years of age is a hunter, and thus involved in management of game species.

Figure 4.7. Hunting statistics for cervids. Numbers of moose, red deer, wild reindeer and roe deer killed, 1952-2000



Source: Hunting statistics, Statistics Norway.

The Ministry of the Environment initiated a project on management plans for game and fish species, which ran from 1996 to 1999. The aim was to improve local management of game and fish species and ensure that by 2006, local management is based on close cooperation between municipalities, holders of fishing and hunting rights and user groups (Proposition No. 1 (1999-2000) to the Storting). By spring 2000, more than 650 management plans had been registered, including about 550 for moose and 50 for small game species. These plans cover about 70 per cent of the area the municipalities use as a basis when allocating hunting quotas for moose and almost all the area for wild reindeer. Most of these plans are solely biological management plans, and do not include commercial activities, recreation or financial considerations (Dervo and Østdahl 2000).

Cervids

The numbers of forest-living cervids have risen in the last 20-30 years, and they have become important commercial and recreational resources. Food supplies for moose, red deer and roe deer have improved as a result of clear-cutting and less grazing by livestock in forest areas. Mild winters and selective shooting of younger animals and male animals have also contributed to the increase. The grazing pressure exerted by large populations of cervids influences the vegetation, and this can affect the landscape and biological diversity (Norwegian Pollution Control Authority 2001b). In the autumn

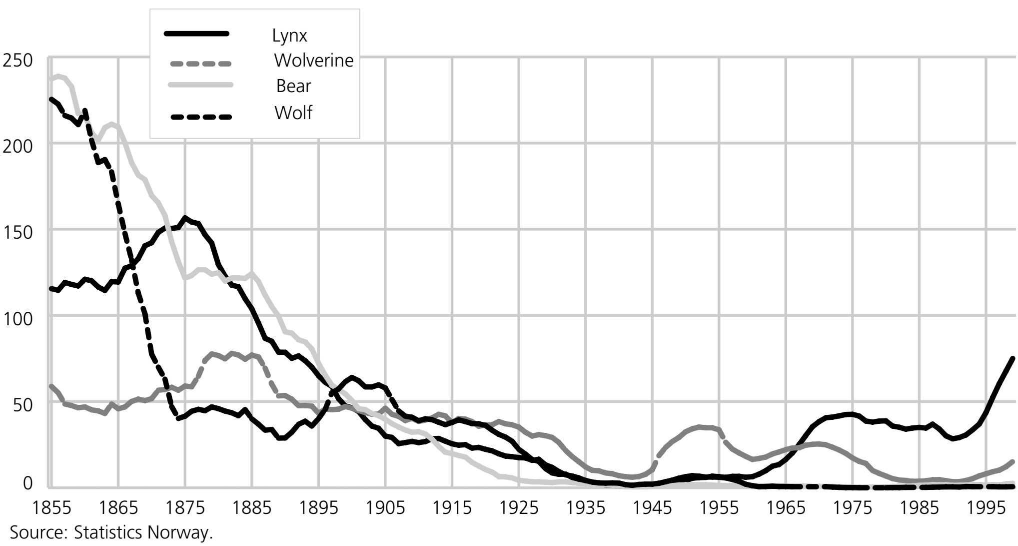
1999 hunting season, larger numbers of moose and red deer were shot in Norway than ever before (see figure 4.7). The total yield was 5 280 tonnes of moose meat and 1 285 tonnes of venison.

Norway manages the last remaining populations of the European reindeer. Earlier excessive hunting of reindeer reduced the population in the southern parts of Norway, and by around 1900 only small, scattered populations were left. Protection in 1900-1905 and around 1920 allowed some rise in numbers, but it was only after 1945 that there was a real increase in the population. One problem has been that human activities have split up the range of the reindeer, and thus disturbed the balance between summer and winter grazing areas. In some cases, it has been necessary to cull the population more heavily than normal to prevent overgrazing and food shortages. (Norwegian Pollution Control Authority 2001b). Figure 4.7 shows the numbers of moose, red deer and reindeer killed per year since 1952.

Small game

Populations of the various small game species vary naturally from year to year, partly as a result of fluctuations in food supplies. Willow grouse and ptarmigan are numerically the most important small game species, and they make up about half the total numbers of small game shot. The harvest was relatively low in the 1996-1997 hunting season, but both the total number of small game and the number of willow grouse and ptarmigans have risen each year since then. For the hunting season 2000-2001, the total reported yield of all small game species was about 954 200 (Statistics Norway 2001e). This is about 33 200 higher than the previous year. For the hunting season 1999-2000, the number of roe deer felled is calculated to be 36 900, which is somewhat lower than the year before.

Figure 4.8. Numbers of predators killed per year. Average for the preceding 10 years



Source: Statistics Norway.

The large predators

Until the middle of the 19th century, there were large populations of the brown bear, wolverine, wolf and lynx throughout much of Norway. All four species were relentlessly hunted, and as a result wolves and bears were almost exterminated by the middle of the 20th century. Wolves and bears were protected throughout Norway in 1971 and 1973 respectively. Wolverines were designated as a protected species in southern and central Norway from 1973 and in the rest of the country from 1982. Wolverine and bear populations started to rise in parts of the country from the late 1970s (Norwegian Pollution Control Authority 2001b).

Wolves were exterminated in the southern half of Norway in the mid-nineteenth century. From 1845, a new act offered bounties for predators that were considered to be vermin. Relentless hunting and periods when their prey species were in short supply contributed to the reduction of the wolf population. It has also been suggested that an epidemic may have helped to wipe out the population in the southern half of the country in around 1860 (Statistics Norway 2001c). In recent years, wolf numbers have recovered again in Scandinavia. It is uncertain whether they have spread southwards from northern Scandinavia and Russia or whether reproduction by the few resident animals that were never exterminated has raised their numbers, but it is hoped that genetic research will provide the answer to this. A preliminary status report on resident wolves in Scandinavia shows that on 15 January 2001, there were at least 10 family groups of wolves in Sweden and Norway (Aronson 2001). The Directorate for Nature Management started the culling of two wolf packs in winter 2000-2001 (Directorate for Nature Management 2000).

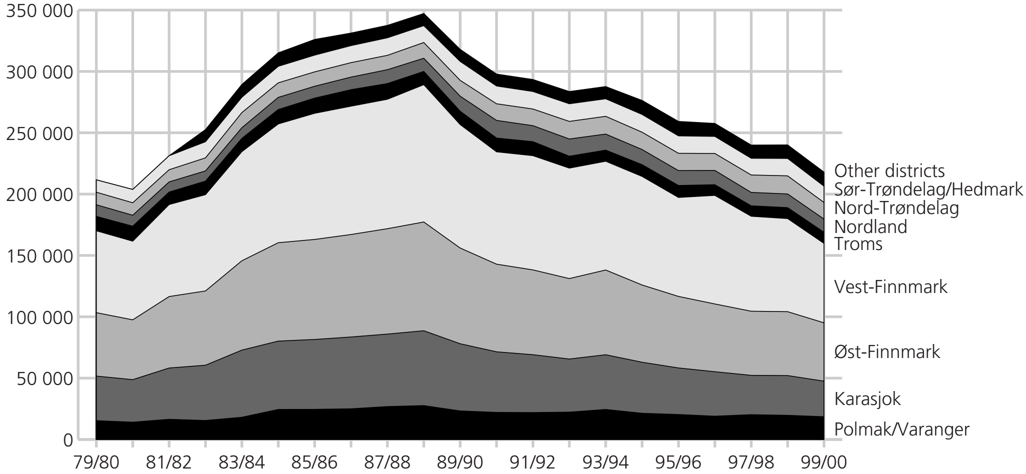
Today, licensed hunters are permitted to take wolverines in Norway, and lynx hunting is regulated by means of quotas. In the hunting season 1999-2000, 22 wolverines and 95 lynxes were killed, or 11 and 45 animals respectively fewer than the maximum permitted numbers. Nine wolverines and six lynxes were registered as dead of other causes in the same period (figure 4.8 and Appendix, table C4).

4.7. Reindeer husbandry

Geographical scope and economic importance

The area where reindeer husbandry is practised in Norway stretches from northern Hedmark and inner parts of Sør-Trøndelag all the way north to the Russian border. In addition, there are some domestic reindeer herds in other mountain areas of southern Norway (Jotunheimen/Fillefjell, Trollheimen and Rendalen). Reindeer husbandry is a small sector in national terms, with 558 active operating units and about 2 800 people involved in them. It has been calculated that labour input totalled 968 full-time equivalent persons in 1998 (Norwegian Reindeer Husbandry Administration 2000). However, reindeer husbandry requires large areas of land, and often comes into conflict with other activities, ranging from the traffic associated with roads, houses and cabins to hydropower development, agriculture and sometimes forestry. The total area that reindeer husbandry shares with other user interests is 140 000 km^2, which corresponds to about 40 per cent of the total area of Norway.

Figure 4.9. Trends in the size of the spring herd



Source: Norwegian Reindeer Husbandry Administration (2001).

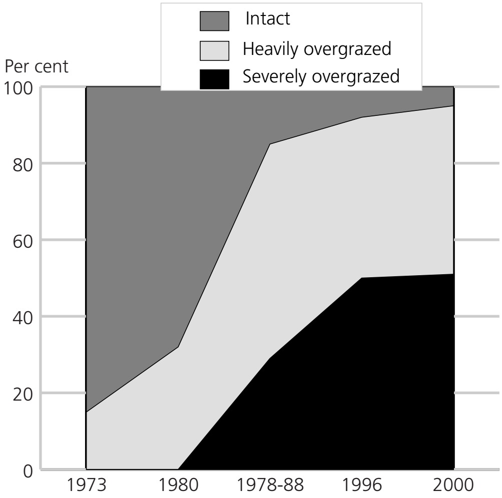
Earnings from reindeer husbandry have been declining in recent years (Norwegian Reindeer Husbandry Administration 2001). In 1999, the first-hand value of reindeer meat was about NOK 73 million, which was a rise from the year before. The total sum paid by the Norwegian state in the form of grants and compensation for losses of reindeer was somewhat higher than this. There are large regional variations in production levels and earnings between the various reindeer husbandry districts. Average income from meat and other reindeer products has in periods been lower than the costs in Nordland, Troms and Finnmark (Norwegian Reindeer Hus-bandry Administration 1998), whereas earnings have been positive in southern Norway. The large regional differences have persisted for many years.

The size and composition of reindeer herds vary continuously during the year because of slaughtering, calving and the loss of animals. The spring herd consists of the animals that have survived the winter, before calving starts. In 2000, it was calculated that the spring herd numbered about 170 000 animals (Norwegian Reindeer Husbandry Administration 2001). There has been a large reduction in the size of the herds in Finnmark since 1988-1989 (figure 4.9). This is explained by several factors, including losses of animals. There has also been great pressure on reindeer owners to reduce the size of their herds because of overgrazing.

Reindeer husbandry and the environment

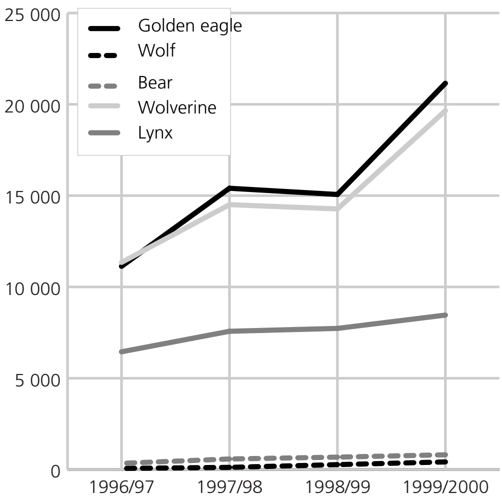
In some cases, overgrazing has had a serious environmental impact. Parts of Finnmark have been so severely overgrazed that both the environment and the future of the industry are threatened. NORUT Information Technology has calculated the state of the lichen resources in the county on the basis of satellite remote sensing measurements (Johansen

Figure 4.10. State of lichen resources in Finnmark



Source: NORUT.

Figure 4.11. Losses of reindeer from pasture according to cause



Source: Norwegian Reindeer Husbandry Administration 2001.

and Tømmervik 1993, 1995, 1998, 2000a, 2000b and 2001). In 2000, half of the grazing areas were defined as severely overgrazed, more than 40 per cent as heavily overgrazed and only 5 per cent as intact (figure 4.10). This indicates a dramatic deterioration compared with previous measurements, although the methods used are not entirely comparable.

As a result of overgrazing, the condition of the animals deteriorates, so that slaughter weights are lower and mortality is higher. For reindeer husbandry as a whole, total production (calculated as production for slaughter + the increase in the number of animals before winter) was 8.0 kg per live animal in the spring herd in 1999-2000. The figures varied from 2.1 kg in western Finnmark to 16.8 kg in southern Norway. There have been large fluctuations in the last three years alone.

It has been calculated that in the season 1999-2000, 67 900 animals were lost, which corresponds to 40 per cent of the spring herd in 1999 (figure 4.11). However, a large proportion of this loss consisted of calves that were not born when the spring herd was counted. The corresponding figure for sheep farming is 16 per cent (total losses as a percentage of the number of adult sheep), but these figures are not directly comparable since sheep are only out at pasture in summer. In the period from 1990-1991 to 1999-2000, reindeer losses have fluctuated between 38 500 and 88 800 animals per season, and have been markedly higher in the last four seasons. Calves account for the largest losses, and the number of calves lost has risen in the last few years. In 1999-2000, losses were highest in western Finnmark, and 53 per cent of all losses in Norway were recorded here. This district had 38 per cent of Norway's total spring herd.

According to the industry's own records, predators took about 50 000 animals in the 1999-2000 season, accounting for 74 per cent of all losses. Wolverines and golden eagles took roughly equal numbers (about 20 000 and 21 000 animals), lynxes took about 8 500, and bears and wolves about 1 200 animals. The authorities verified the cause of death for between 5 and 10 per cent of the carcasses. Other causes of death include starvation, disease, road accidents, avalanches, drowning, etc. The unusually high losses in 1997-1998 were a result of weather conditions that caused extensive formation of ice on grazing land in Finnmark.

The Chernobyl accident in 1986 demonstrated that reindeer husbandry is particularly vulnerable to the fall-out of radioactive substances. The most important reason for this is that reindeer feed extensively on lichens, which absorb and store radioactive substances from precipitation in much higher concentrations than plants. The region south of the Saltfjellet mountains in Nordland was particularly badly affected by fall-out from the Chernobyl accident. Since the accident, concentrations of radioactive substances have dropped gradually, and various measures have been implemented to reduce concentrations further in reindeer for slaughter. From 1986 to 1999, the amount of meat rejected as containing excessive amounts of radioactivity has dropped from 418 tonnes to 1 tonne 1999.

Further information may be obtained from: Astri Kløvstad (forest and game) and Svein Homstvedt (domestic reindeer).

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 of major importance to the economy. In 2000, fisheries products accounted for about 15 per cent of exports of traditional goods from Norway. In 1998, Norway was the next largest exporter of fish in the world. The fisheries and the fish processing and fish farming industries also provide employment and are a substantial part of the economy in outlying districts.

Stocks of several important fish species in the North Sea are now low. In the Norwegian and Barents Seas, the situation is less uniform. 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 is now at a relatively high level. There has been a decline in the Northeast Arctic cod stock in recent years, and the spawning stock is now believed to have dropped below safe biological limits.

5.1. Introduction

The Ministry of Fisheries' environmental action plan 2000–2004 (Ministry of Fisheries 1999) states that "*Norway has the rights to and is responsible for some of the world's most productive fjord, coastal and marine areas. This provides a unique basis for economic growth based on nature's own production processes, the use of marine areas for aquaculture activities and the development of coast-based industries.*" The action plan emphasizes the importance of developing a coherent management system for marine resources and the aquaculture industry that takes the whole ecosystem into consideration. This means that interactions between different species (multispecies perspective) and environmental factors are taken into account, and that the precautionary principle is systematically incorporated.

An important target for the fisheries authorities is to ensure that the marine environment is clean, and in particular to focus attention on radioactive pollution and various environmentally hazardous substances. These problems are often global or regional, requiring binding international cooperation.

Global climate change will affect the temperature of the sea and the ocean climate. Changes in the ocean climate may have serious consequences for marine ecosystems and living marine resources.

There are also other factors in the administration and distribution of fisheries resources – apart from the management of marine stocks – that must be considered by the authorities in the formulation of fisheries policy. These factors include the industry's need for raw materials, the structure of the fishing fleet and the distribution of quotas both geographically and among the various vessel classes.

5.2. Principal economic figures for the fisheries

GDP and employment

According to the Norwegian National Accounts, fishing, sealing and whaling, and fish farming contributed NOK 9.9 billion to Norway's gross domestic product (GDP) in 2000. This is 0.7 per cent of GDP.

The fishing industry accounted for 0.8 per cent of total employment. At the end of 2000, about 20 240 fishermen were registered in Norway, and for 71 per cent of these fishing was their main occupation.

Production and prices

Preliminary figures show that both production costs and sales prices in the fisheries as a whole increased from 1999 to 2000. This increase is due to a growing fish farming industry, where there was a 5 per cent increase in volume and a 13 per cent rise in prices. However, there was a slight decline in production in fishing, sealing and whaling, while sales prices dropped by almost 4 per cent (Statistics Norway 2001g).

Export

The total export value of fish and fisheries products accounted for 15 per cent of exports of traditional goods from Norway in 2000 (i.e. exports excluding crude oil, natural gas, ships and oil platforms) and 6 per cent of total exports of goods.

5.3. Trends in stocks

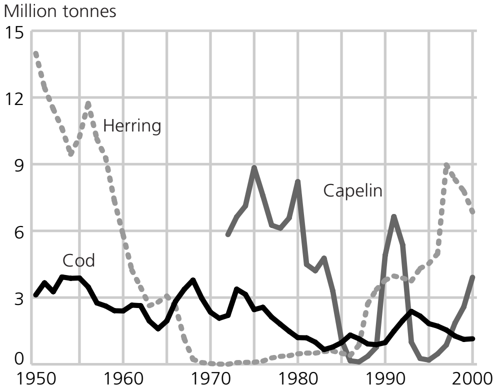
Barents Sea – Norwegian Sea

Norwegian spring-spawning herring, capelin and Northeast Arctic cod (figure 5.1) are three of the most important fish stocks in Norwegian waters.

The herring stock was severely depleted by overfishing at the end of the 1960s, but has been recovering very satisfactorily in recent years (Appendix, table D 1). The spawning stock of Norwegian spring-spawning herring was calculated to be about 9 million tonnes in 1997. The large increase in the stock in 1997 is explained by the fact that the two strong year-classes from 1991 and 1992 had by then become part of the spawning stock. There have been several weak year-classes since 1992 and an anticipated reduction of the spawning stock has been observed. Stock levels have been adjusted downwards in the latest calculations, but the herring stock is still in good condition at the moment. In 2000 the spawning stock was estimated at just under 7 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 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

Figure 5.1. Trends for stocks of Northeast 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.
Source: International Council for the Exploration of the Sea (ICES) and Institute of Marine Research.

1996 as a result of the decrease in the capelin stock, but had risen to 0.9 million tonnes in 1997 and 1998, which corresponded with the new growth in the capelin stock (Toresen et al. 1998, 1999 and 2000). The stock continues to grow and the total stock was estimated to be 3.9 million tonnes as of 1 August 2000.

The Northeast Arctic 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 and lower individual growth, in addition to a periodically high incidence of cannibalism (Toresen et al. 2000). The spawning stock of cod was calculated to be about 250 000 tonnes in 2000, a level which is considered to be below safe biological limits. Experience has shown that the lowest level of spawning stock to give good recruitment[1] is 500 000 tonnes. Growth in the capelin stock will benefit the stock of cod.

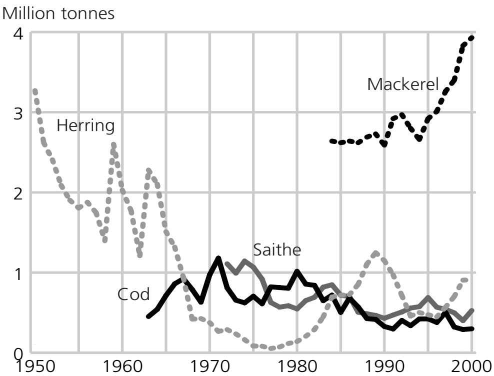
The International Council for the Exploration of the Sea (ICES) recommended that the total catch in 2001 should not exceed 263 000 tonnes. This recommendation was supported by the Institute of Marine Research. An annual quota of 395 000 tonnes for three years from 2001 was set by the Norwegian-Russian Fisheries Commission. If the stock situation should deteriorate in the course of this period, quota levels can be adjusted downwards. There is considerable uncertainty about future trends 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]. One reason for this is that recruitment to the stock was generally poor, because of large annual harvests 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 2000 is calculated to be about 900 000 tonnes (figure 5.2 and Appendix, table D 1).

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

Figure 5.2. 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.
Source: International Council for the Exploration of the Sea (ICES) and Institute of Marine Research.

Misreporting of catches of both adult and juvenile herring has produced considerable uncertainty in the catch statistics, and consequently in stock assessment for North Sea herring (Toresen et al. 2000). Stocks of demersal fish in the North Sea (cod and saithe are shown in figure 5.2) have remained low for some time.

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 (North East Atlantic mackerel). 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 total spawning stock, now estimated to be just under 4 million tonnes. The largest component of the stock is found off Ireland, while the component that spawns in southern waters is between 15 and 20 per cent. Both of these mackerel sub-stocks are considered to be in good condition. The North Sea component, however, which accounts for around 3 per cent of the total stock, has reached an all-time low. Mackerel can make lengthy migrations in a short space of time. There is therefore some exchange of individuals between all three sub-stocks, and all are harvested at feeding grounds in the North Sea, Skagerrak and the Norwegian Sea.

Table 5.1. World fisheries production. 1997 and 1998

	1997		1998	
	1 000 tonnes	Per cent	1 000 tonnes	Per cent
Total production[1]	122 443	100.0	117 162	100.0
Catches in marine fishing areas	86 087	70.3	78 296	66.8
Catches in inland waters	7 532	6.2	8 003	6.8
Farming of fish, crustaceans, etc. in seawater and brackish water	11 794	9.6	12 744	10.9
Freshwater farming of fish, crustaceans, etc.	17 030	13.9	18 119	15.5
Aquaculture production of aquatic plants[2]	7 207	.	8 568	.

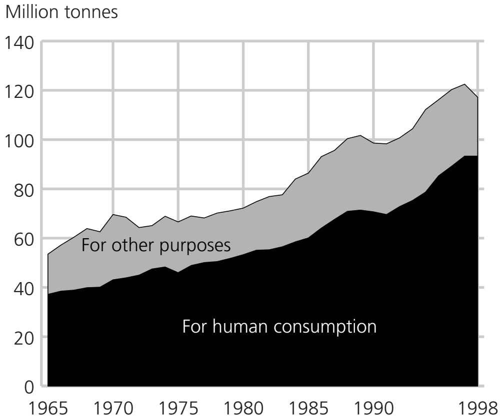
[1] Aquatic plants not included in total production. [2] Most production of aquatic plants is conducted in marine and brackish areas.
Source: FAO 2000c, FAO 2000d, FAO 2000e.

5.4. Fisheries

World catches

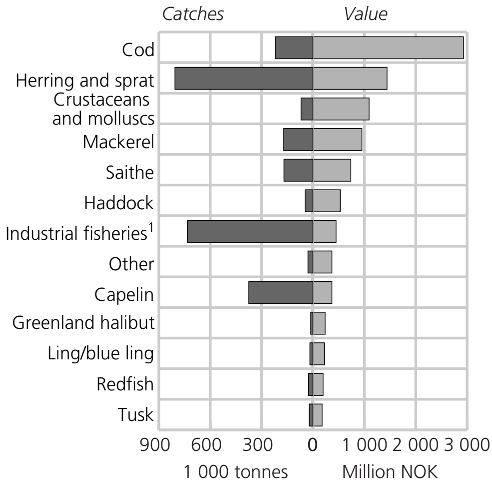
Production in the world's fisheries, including both fresh-water and marine catches and aquaculture production, has increased substantially from slightly more than 50 million tonnes in 1965 to about 122 million tonnes in 1997 and 117 million tonnes in 1998 (figure 5.3). The various categories of fisheries production are shown in table 5.1. The preliminary figure for production in 1999 is 125 million tonnes (FAO 2000b).

Figure 5.3. World fisheries production[1] by main uses



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

Figure 5.4. Norwegian catches, by groups of fish species, molluscs and crustaceans. 2000



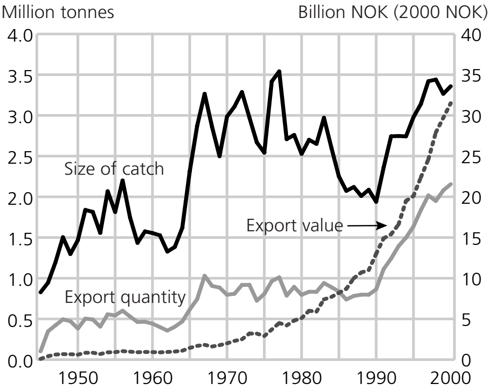
[1]Includes lesser and greater silver smelt, Norway pout, sandeel, blue whiting and horse mackerel.
Source: Directorate of Fisheries.

Marine fisheries declined by over 7 million tonnes (9 per cent) from 1997 to 1998, while inland fisheries rose by 500 000 tonnes (6 per cent). According to FAO, catches in marine areas have mainly declined as a result of the atmospheric phenomenon El Niño, which particularly affected fish stocks in the Southeast Pacific. Total landings of anchoveta and Chilean jack mackerel dropped from 11.3 million tonnes in 1997 to 3.7 million tonnes in 1998. However, these stocks made a rapid recovery in 1999 (FAO 2000a). In the Southeast Pacific, total catches declined by about 45 per cent from 1997 to 1998 (FAO 2000b, 2000d). Although there were no dramatic changes in catches in other marine areas, there was a slight rise in catches in the West Pacific and a slight decline in the Northeast Atlantic. World aquaculture production (excluding plants) increased by about 2 million tonnes (7 per cent).

Norway ranks as number 10 among the world's largest fishing nations (excluding farmed production), with a total catch of 2.85 million tonnes in 1998. At the head of the list are China (17.2 million tonnes), Japan (5.3 million tonnes), the United States (4.7 million tonnes), Russia (4.5 million tonnes), and Peru (4.3 million tonnes), (see also Appendix, tables D 7 and D 8).

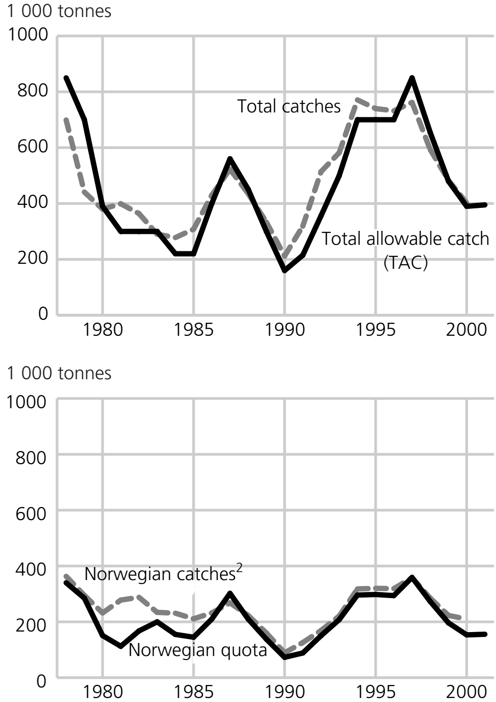
The proportion of world fish production for human consumption (i.e. not for the production of fish meal or oil) has remained relatively stable at about 70 per cent for the entire period after 1965 (see figure 5.3). In 1998, however, there was a marked decline in fish meal and oil production worldwide, raising the proportion for human consumption to 80 per cent. This was largely due to the 1998 drop in anchoveta catches mentioned above. In Norway, the proportion was 60 per cent. However, in 1966 and 1975, when there were large catches of herring

Figure 5.5. Catches, weight of products exported and export value[1,2]



[1] Fish farming included. [2] Deflated by the price index for external trade.
Source: External trade statistics, Statistics Norway and Directorate of Fisheries.

Figure 5.6. Quotas and catches of Northeast Arctic cod[1]



[1] Excluding Norwegian coastal cod. [2] Including part of Russian quota caught by Norwegian vessels.
Source: Ministry of Fisheries and Institute of Marine Research.

and capelin, which are important raw materials for the production of fish meal and oil, less than 30 per cent was used for human consumption in Norway.

Norwegian catches

The total catch in Norwegian fisheries (including crustaceans, molluscs and seaweed) in 2000 was 2.9 million tonnes, and the value of the catch was NOK 9.7 billion. The total catch was about 80 000 tonnes more than in 1999, but the value was about NOK 240 million lower. The catch of herring fell only slightly in 2000 compared with the previous year, but its value nonetheless increased by about NOK 220 million to NOK 1.4 billion. The catch of cod was about 35 000 tonnes lower than in 1999, and its value also showed a decline of about NOK 400 million to NOK 2.93 billion. Mackerel catches increased by around 10 000 tonnes, reaching a catch value of 0.95 billion. Capelin catches increased dramatically from 91 000 to 375 000 tonnes. Shrimp catches totalled 65 000 tonnes, with a catch value of about NOK 1 billion. Apart from these, there was a substantial decline in catches of horse mackerel and sprat in 2000 and a continued decline in catches of sandeel. First-hand values and catches in 2000 are shown in figure 5.4 (see also Appendix, table D 2). Figure 5.5 shows trends in catches in Norwegian fisheries, weight of products exported and the export value of fish and fish products.

5.5. Quotas for some important fish stocks

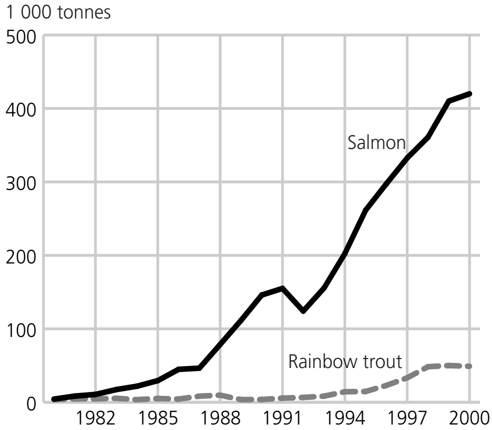
According to the FAO, 47–50 per cent of the world's marine fish stocks for which stock data is available are fully exploited, and catches of these stocks are already so large that there is very little room for

Table 5.2. Quotas for some important fish stocks in 2000 and 2001. 1 000 tonnes

Stocks	2000 TAC	2000 Norwegian quota	2001 TAC	2001 Norwegian quota
Northeast Arctic cod[1]	390	153.4	395	155.55
Northeast Arctic haddock[2]	62	33.4	85	46.3
Norwegian spring-spawning herring	1 250	712.5	851.5	484.5
Barents Sea capelin[3]	435	261	630	378
Saithe north of 62° N	125	118.5	135	125
Saithe south of 62° N	85	40	87	41
Mackerel	560	169.95	574	174.2
North Sea herring[4]	265	76.85	265	76.85
North Sea cod[5]	81	13.77	48.6	8.26
North Sea haddock[5]	73	16.79	61	14.03

[1] Excluding coastal cod. [2] Excluding coastal haddock. [3] Winter capelin catch. [4] Caught in the North Sea for human consumption. [5] Norway's quota in the agreement with the EU: quotas may subsequently be exchanged with other countries.
Source: Ministry of Fisheries.

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



Source: Fisheries statistics, Statistics Norway, Directorate of Fisheries and Kontali AS.

increase. Catches are small or moderate for 25–27 per cent of fish stocks. An estimated 15–18 per cent of stocks are overfished, and there is imminent danger of a decline in catches because of stock depletion. Furthermore, it is estimated that 9–10 per cent of the fish stocks are depleted, so that they give absolutely no yield or are in slow recovery (FAO 1999, 2000b). It is therefore of the utmost importance that catches are regulated in the best possible way.

Figure 5.6 shows quotas and catches of Northeast Arctic cod since 1978. In much of the 1980s Norwegian catches were well above the quotas. There were minor deviations in subsequent years. Table 5.2 shows quotas for some important fish stocks in 2000 and 2001.

5.6. Aquaculture

In 1998, global aquaculture production totalled 30.9 million tonnes of fish, crustaceans, molluscs, etc., about 35 per cent of the total catch in marine and inland fisheries. Freshwater fish farming accounted for 59 per cent of aquaculture production, while the figures for fish farming in salt and brackish water were 35 and 6 per cent respectively. A total of 8.6 million tonnes of aquatic plants were also produced (see also table 5.1). China is by far the largest aquaculture producer, accounting for almost 70 per cent of the total production (animals and plants) in 1998. The species farmed in the largest volume in 1998 was the Pacific oyster, followed by a number of species of carp. On a list of 29 farmed species of which over 100 000 tonnes were produced in 1998, Atlantic salmon ranked eleventh and mussel fifteenth (FAO 2000c). Global aquaculture production has more than doubled since 1989.

Production in the fish farming industry

Salmon and trout

The production of salmon in the fish farming industry has increased dramatically since the industry was established in the beginning of the 1970s. There has been a moderate increase in the volume of slaughtered salmon from 410 000 tonnes in 1999 to about 420 000 tonnes in 2000 (figure 5.7). The Norwegian production of Atlantic salmon in 1998 accounted for half of the total global production of this species (688 000 tonnes). Over 80 per cent of farmed salmon is exported. Trout production in 2000 was maintained at about the same level as in 1999, about 50 000 tonnes.

Other aquaculture
Both in terms of volume and value, salmon is the dominant species in Norwegian fish farming. There is also increasing interest in several other species. *Mussel farming* is gaining ground, and although annual production is currently 300–400 tonnes, there is considerable potential for the production of mussels in Norwegian waters, both from a biological and environmental point of view and in terms of resources. Some studies indicate that mussel production could approach 200 000 tonnes as early as 2010 (Karlsen et al. 2000). On a global basis, 500 000 tonnes of mussels were produced in 1998 (FAO 2000c).

Other bivalve species of interest to Norwegian aquaculture are *scallops* and *oysters* (European oyster *(Ostrea edulis)* and Pacific oyster *(Crassostrea gigas)*), although current production of these species is modest. On a global basis, about 3.4 million tonnes of Pacific oysters were produced in 1998 (FAO 2000c).

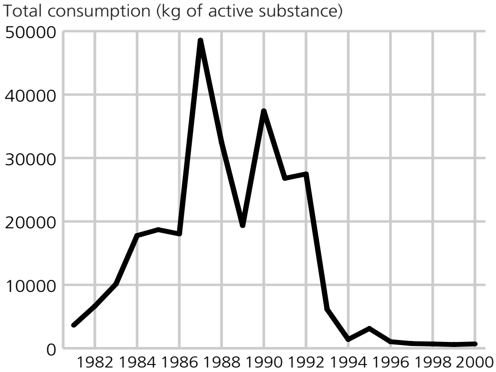
Sea urchins – a group not exploited at all in Norway so far – are also attracting interest in the aquaculture industry, although activities in Norway are still at the research and testing stage. Sea urchins may be farmed by rearing animals collected in the wild or by producing from the roe stage. Sea urchins have been in focus in Norway mostly because of increasing stocks causing depletion of seaweed in some coastal areas. The world harvest of sea urchins reached 120 000 tonnes in 1995, with Chile, the United States and Japan as the most important fishing nations. However, all the areas where sea urchins are caught suffer from overharvesting and depleted stocks (Karlsen et al. 2000).

Other species of fish, such as cod, halibut, turbot, wolf-fish and Arctic char will probably become more relevant as fish farming organisms in the years ahead. The production of these species for human consumption is nonetheless still relatively modest in volume. In 1998, 190 tonnes of fish farmed Arctic char, 200 tonnes of cod and 290 tonnes of halibut were sold (Statistics Norway 2000a).

Fish health in salmon farming
The figures for the incidence of these diseases in 2000 are preliminary figures from the National Veterinary Institute and the Norwegian Animal Health Authority. Serious diseases affecting farmed salmon include the following:

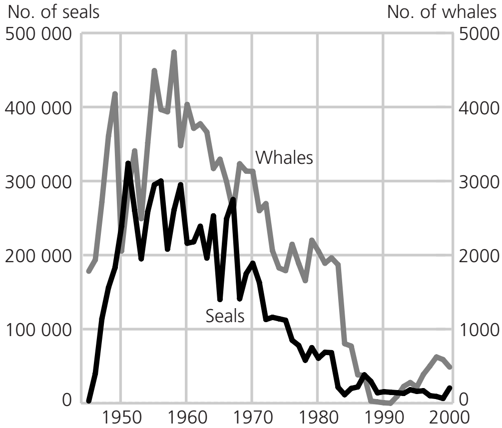
- Furunculosis, caused by the bacterium *Aeromonas salmonicida* (diagnosed at six fish farms in 2000);
- Bacterial kidney disease (BKD), caused by the bacterium *Renibacterium salmoninarum* (diagnosed at three fish farms in 2000);
- Vibriosis and cold-water vibriosis, caused by the bacteria *Vibrio anguillarum* and *Vibrio salmonicida* (diagnosed at four and two fish farms respectively in 2000);

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



Source: Norwegian Medicinal Depot.

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



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

- Infectious salmon anaemia (ISA), a virus disease (diagnosed at 17 fish farms in 2000);
- Infectious pancreatic necrosis (IPN), a virus disease (diagnosed at 131 fish farms in 2000).

There has been a considerable improvement in the salmon health situation, and the use of medicines has been dramatically reduced over the last few years. New vaccines and improved operational procedures are probably the main reasons for these improvements. The consumption of antibacterial agents was highest in 1987, when it reached 49 tonnes (figure 5.8 and Appendix, table D 3) and accounted for 58 per cent of the total consumption of antibiotics in Norway (fish, animals and human medicine). Consumption in 2000 was 685 kg. It is important to restrict and make sensible use of antibiotics so as to prevent their transfer to other organisms and the development of resistant bacteria.

The salmon louse (a parasitic crustacean which lives in salt water and drops 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. 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 species commonly used). Salmon lice can cause poor growth, injury to salmon and secondary infections followed by outbreaks of disease. The parasite can also be a threat to wild salmon and sea trout stocks (Kristiansen et al. 1999, Karlsen et al. 2000).

According to fisheries statistics (Statistics Norway 2000a), the food fish processing plants suffered a shortfall in 1998 due to disease and injuries affecting 12 million fish (salmon). The total shortfall was 25 million fish, and the other loss factors were escapees (0.6 million) and other reasons (12 million).

5.7. 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. 2000).

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 2000, the total catch was 20 549 animals (18 678 harp seals and 1 871 hooded seals). The catch in the West Ice includes both hooded seals (1 871) and harp seals (12 321), whereas in the East Ice it consists entirely of harp seals (6 357).

Until the early 1980s, the annual value of the seal catch was between NOK 10 and 40 million (current prices). In 2000, the value was about NOK 2.7 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 2000 season, only four trips were made to the sealing grounds in the West Ice and one to the East Ice.

Norwegian catches of small whales have consisted mainly of minke whales. The traditional commercial hunt was discontinued after the 1987 season, but was resumed in 1993, when 226 whales were taken. In 1999, 589 minke whales of a total quota of 753 animals were caught. The quota for 2000 was 655 animals and 487 were caught. The quota for 2001 has been set at 539 animals.

The Norwegian authorities gave permission in principle for the resumption of exports of whale products early in 2001. The export of these products has been prohibited for a number of years. Export permits will be given in the form of licences, and export will only be permitted to countries that issue import licences and that conduct DNA testing of imported products in order to track minke whale individuals caught as part of the Norwegian quota.

The value of the small whale catch in 2000 was about NOK 22 million.

The *Northeast Atlantic minke whale stock* (which includes animals on the whaling grounds in the North Sea, along the Norwegian coast, in the Barents Sea and off Svalbard) is calculated to be 112 000 animals (Toresen et al. 2000).

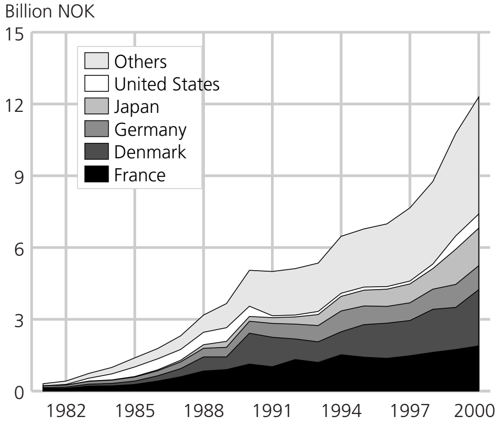
The C*entral Atlantic minke whale stock* (Central Atlantic, Iceland, Jan Mayen) is calculated to be 72 130 animals, 11 500 of which are in the Jan Mayen area (Toresen et al. 2000).

Table 5.3. Biomass of important species and animal groups in the Barents Sea and consumption by top predators. Million tonnes

Species or group	Biomass	Consumption
Zooplankton, incl. krill	30	
Capelin	0.2–10	
Herring	0–4	
Cod	1.5	4.0
Whales	0.5	1.8
Seals	0.5	3.4
Seabirds	0.01	1.4

Source: Toresen et al. (2000).

Figure 5.10. Salmon exports[1], by main purchasing countries. Current prices



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

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 annual 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). Annual consumption by harp seals totals about 3.4 million tonnes, 2.1 million tonnes of which consists of fish (Toresen et al. 2000). Table 5.3 shows the biomass figures for species and groups of animals in the Barents Sea and consumption figures for the top predators in this ecosystem.

5.8. Exports

Preliminary figures show that in 2000 exports of fish and fish products were about 2.2 million tonnes, with a value of NOK 31.5 billion (figure 5.5 and Appendix, tables D 4 and D 5). Exports to EU countries accounted for 58 per cent of the total. Salmon exports totalled NOK 12.3 billion in 2000 (figure 5.10 and Appendix, table D 6). This corresponds to 39 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 Japan continue to rise, and exports to the US have been rising again over the last couple of years.

According to the FAO, Norway was in 1998 the world's next largest exporter of fish in terms of value behind Thailand, and ahead of Denmark, China, and the United States[2]. The value of Norway's fish exports corresponded to about 7 per cent of the value of total world fish exports (Appendix, table D 7).

Further information may be obtained from: Frode Brunvoll.

[2] The FAO statistics (FAO 1999) ranking Norway as the world's leading fish exporter in 1997 were included in *Natural Resources and the Environment 2000*. These statistics were obviously incorrect. Updated statistics for 1996–1998 are given by the FAO (2000c), showing Thailand as the world's largest fish exporter for the whole of this period and Norway in second place.

6. Transport

Efficient transport is a necessity in our modern society. At the same time transport has a major impact on the environment. A substantial proportion of air pollution is generated by combustion emissions from various modes of transport. Road traffic is the most common cause of exposure to pollution and noise. Developing the transport sector can also mean disturbing the natural landscape when agricultural and recreational areas are developed. Transport arteries can also act as barriers to other forms of travel.

The volume of transport continues to increase. Between 1946 and 1999, passenger transport in Norway rose thirteen-fold, and goods transport six-fold. In 1999, 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. The road network in many towns and urban settlements was built without any thought for the noise problems that might arise. Air traffic, railways and ports also produce noise that can affect people's health and quality of life, although to a lesser extent than road traffic. The transport sector is also a major source of air pollution due to the harmful emissions produced by the combustion of fuel. Car tyres pollute by releasing plasticizing oils and by churning up harmful particulate matter from the road surface. In 1998 emissions to air from mobile sources accounted for 37.6 per cent of the total CO_2 emissions and 73.7 per cent of the total NO_x emissions.

Today's transport supply and demand is a result of developments in a number of areas: changes in the labour market, 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. Consequently, achieving results requires a holistic approach to the formulation of environmental policy. There are many different kinds of environmental problems caused by the transport sector for example, and this sector is only one of several that contribute to pollution.

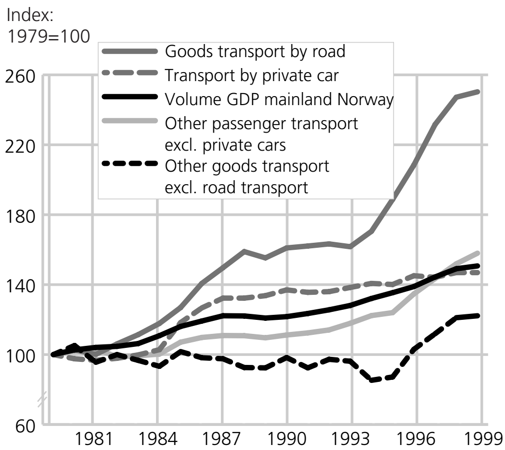
There has been a substantial increase in domestic transport over the last few decades. From 1980 up to the end of 1999, passenger transport in passenger-kilometres has increased by 52 per cent. Goods transport in tonne-kilometres has increased by 56 per cent in volume, and if oil and gas transport from the North

Sea is included, by no less than 176 per cent. In addition to transport from the North Sea to the Norwegian mainland, the growth in transport since 1980 is particularly due to a rising volume of transport by private car and goods transport by road.

Report No. 46 (1999-2000) to the Storting clearly states that a coordinated and efficient transport system must be devised within the framework of the Government's traffic safety and environmental policy objectives. An extensive set of instruments will be required to meet the environmental challenges related to transport. These instruments may include sound barriers, sound insulation of building facades, channelling road traffic, road pricing, time-differentiated toll rates and parking regulation. The Plan also states that cost efficiency and coordination will be key issues in the overall decisions on the use of instruments. Coordination between the various forms of transport must also be strengthened through the development of effective transport nodes with good connections for goods and passenger transport so as to allow for combined/intermodal transport (i.e. combinations of different methods of transport, such as road/rail/road). The aim is to transfer from road transport to transport by sea and rail. Consequently, further upgrading of the railway is planned for the years ahead.

Of the transport industries, transport by sea accounts for the largest proportion of GDP, but most of this activity takes place outside Norway's borders. If both international sea traffic and oil and gas transport from the North Sea are excluded, the transport sector accounts for about 3.9 per cent of GDP in mainland Norway in 2000 (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 9.3 per cent from 1995 to 1999. Private cars, which account for around 75 per cent of the number of passenger-kilometres, only increased by 4.9 per cent. In the same period, total goods transport (in tonne-kilometres) increased by 36 per cent. Goods transport by road, accounting for almost half of the total domestic goods transport work in 1999, increased by just over 33 per cent. GDP for mainland Norway increased by 11.3 per cent in this period. Compared with GDP, goods transport by road has therefore shown a higher rate of growth over the last few years, while passenger transport has shown relatively slower growth.

Figure 6.1. Trends in GDP for mainland Norway and in domestic goods and passenger transport work



Source: National accounts and transport and communication statistics, Statistics Norway.

6.2. The environmental perspective in the transport sector

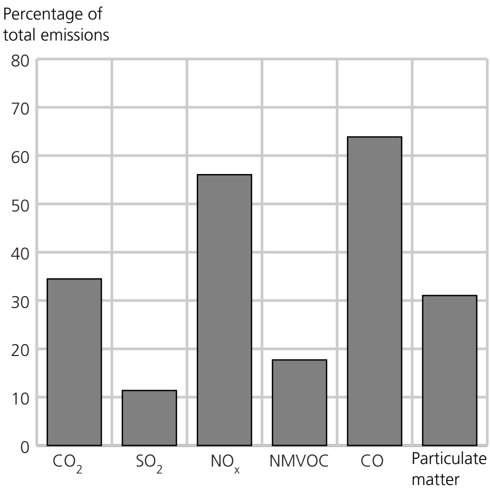
A number of serious environmental impacts are associated with transport: it causes emissions to air and excessive noise, and it occupies areas of land. A more general description of these issues can be found in Chapters 7 and 10 of this book, while this chapter will describe the environmental impacts of the transport sector in particular.

Emissions to air

Transport is a major source of greenhouse gas emissions. Emissions from transport also contribute to acidification of the natural environment and poor air quality in towns and other heavily trafficked areas.

In 1999, 34 per cent of the national CO_2 emissions came from transport (fishing vessels, mobile drilling rigs and international shipping and air traffic are not included). Road traffic accounted for 22 per cent of the total emissions, while the figures for shipping and air traffic were 6 and 3 per cent respectively. CO_2 emissions from the transport sector were 23 per cent higher than in 1990 (Kyoto reference year) and 5 per cent higher than in 1998. The increase was primarily due to an increase in volume of transport (see e.g. table 6.6, figure 6.8 and Appendix, tables E1 and E2). Emissions from transport have risen slightly more than the total emissions over the last few years (more about CO_2 emissions in section 7.2).

Figure 6.2. Percentage of total emissions to air from transport in 1999. Selected components



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

NO_x emissions from transport accounted for 56 per cent of the total emissions in 1999. Shipping (not including fishing vessels) produces 36 per cent of these emissions, while road traffic accounts for 24 per cent. Shipping also produces substantial emissions of other gases. This is described in more detail further on in this chapter.

Over the last few years, particulate matter from exhaust emissions and road dust has become the focus of attention. Emissions from transport accounted for 31 per cent of the total emissions of particulate matter in 1999. These emissions can involve a serious local health risk (more about this in section 7.8). As a result of measures such as those to combat the use of studded tyres, road dust emissions have decreased by 20 per cent from 1997 to 1999.

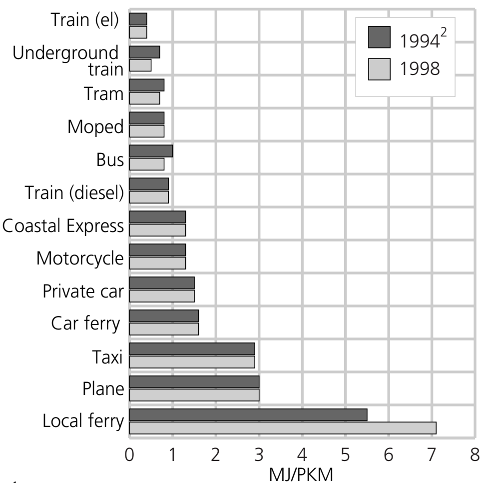
Energy use and emissions from various modes of transport

Statistics Norway has calculated which modes of transport are most energy effective and produce the lowest emissions in relation to the transported distance for passengers and goods

(Holtskog 2001). The calculations are for 1994 and 1998 so that any changes over time can be recorded. The volume of transport of persons is calculated in passenger or person-kilometres (pkm), while goods transport is calculated in tonne-kilometres. For modes of transport carrying both passengers and goods, figures are converted into person or goods equivalents[1]. Actual capacity utilization is taken into account in the calculations.

Approximately 75 per cent of all transport of persons in Norway is by private car, while transport by rail, air and bus account for the next largest percentage. Most passenger transport is by bus, followed by aircraft (Statistics Norway 1999d).

Figure 6.3. Energy use per passenger kilometre[1], by mode of transport. 1994[2] and 1998



[1] For trains, Norwegian Coastal Express, car ferries, local ferries and planes, freight is included. [2] 1993 for transport by sea.
Source: Holtskog (2001).

Calculations show that electric railways have the lowest energy use per passenger-kilometre, closely followed by the underground railway in Oslo (figure 6.3). Transport by taxi and plane involves approximately six times more energy use per pkm than electric railways, while local ferries use almost 18 times more energy per pkm. Energy use per pkm by private cars is approximately equivalent to the average figure for all modes of passenger transport.

Figure 6.3 shows that there has been marked growth in energy use per passenger-kilometre for local ferries. This is due to a reduction in goods transport on these ferries. Even though passenger transport actually increased, the converted figures for passenger transport decreased by 20 per cent. Energy use per passenger-kilometre for buses has declined, due to the fact that new buses use less fuel per kilometre and that the number of express routes has increased. The underground railway in Oslo has also had a reduction in energy use per pkm. This reduction is due to a 30 per cent growth in passenger transport. Fuel consumption for trains has also declined, mainly because electric trains have to a greater extent replaced diesel trains.

Table 6.1 shows emissions per person-kilometre of various emission components from the different modes of transport. There are no calculations for emissions from electrically powered modes of transport. CO_2 emissions per pkm largely follow the same pattern as energy use per pkm, i.e. local ferries, planes and taxis have the highest values. For the other components, emission factors vary more according to the mode of transport and

[1] A passenger with luggage is estimated to weigh on average 86.5 kg (Statistics Norway 1999d).

Table 6.1. Emissions per person- or passenger-kilometre[1]. 1994[2] and 1998. g/pkm. CO_2 in kg/pkm

	Greenhouse gases			Acidifying gases		Harmful substances		
	CO_2	CH_4	N_2O	SO_2	NO_x	NMVOC	CO	Particulate matter[3]
Private car								
1994	0.11	0.05	0.01	0.02	0.82	1.24	9.43	0.02
1998	0.11	0.04	0.02	0.01	0.53	0.83	6.21	0.02
Taxi								
1994	0.21	0.04	0.01	0.08	0.87	0.91	6.29	0.20
1998	0.21	0.03	0.02	0.04	0.70	0.64	4.44	0.15
Moped								
1994	0.06	0.11	0.00	0.01	0.05	6.93	13.19	0.00
1998	0.06	0.11	0.00	0.00	0.05	6.93	13.19	0.00
Motorcycle								
1994	0.09	0.15	0.00	0.02	0.21	3.81	21.47	0.00
1998	0.10	0.15	0.00	0.00	0.22	3.65	21.53	0.00
Bus								
1994	0.07	0.00	0.00	0.03	0.97	0.08	0.29	0.07
1998	0.06	0.00	0.00	0.02	0.77	0.05	0.19	0.05
Train (diesel)								
1994	0.07	0.00	0.03	0.03	1.00	0.09	0.24	0.08
1998	0.07	0.00	0.03	0.02	0.99	0.08	0.23	0.08
Plane								
1994	0.22	0.01	0.01	0.01	0.27	0.45	0.69	0.01
1998	0.22	0.01	0.01	0.01	0.24	0.33	0.39	0.01
Car ferry								
1993	0.12	0.01	0.00	0.08	1.82	0.10	0.11	0.02
1998	0.12	0.01	0.00	0.07	1.86	0.10	0.11	0.02
Coastal Express								
1993	0.10	0.01	0.00	0.13	2.14	0.08	0.09	0.02
1998	0.10	0.01	0.00	0.13	2.13	0.08	0.09	0.02
Local ferry								
1993	0.41	0.03	0.01	0.30	8.98	0.35	0.38	0.06
1998	0.53	0.04	0.01	0.35	11.61	0.46	0.50	0.08

[1] For trains, car ferries, the Norwegian Coastal Express, local ferries and planes, goods transport is included. [2] 1993 for transport by sea. [3] Emissions of particulate matter from combustion only. Emissions resulting from e.g. tyre wear and tear are not included.
Source: Holtskog (2001).

type of technology. Mopeds and motorcycles have the highest emissions per pkm of CH_4, NMVOC and CO, while transport by sea produces the largest emissions of NO_x and SO_2. Taxis produce the largest emissions of particulate matter per pkm. Only combustion emissions have been calculated, i.e. particulate matter generated by road wear and tear caused by studded tyres has not been included.

A comparison of the years 1994 and 1998 shows that for most modes of transport there has been a reduction in SO_2 emissions per pkm. This is due to a lower sulphur content in petrol, diesel and heavy distillates. Stricter emission restrictions and improved technology have contributed to a reduction per pkm of emissions of NO_x, NMVOC, CO and particulate matter from cars and buses. For local ferries, there has been an increase in emissions of all components because of

Figure 6.4. Energy use per tonne-kilometre[1], by mode of transport. 1994[2] and 1998

[1] Tonne-km for trains, planes, goods vans and combination cars includes transport of passengers. [2] 1993 for ships.
Source: Holtskog (2001).

increased energy use per pkm (see above).

Goods transport in Norway today is mainly by ship and lorry. In 1998, these two modes of transport accounted for 60 and 30 per cent respectively of the total goods transport in tonne-kilometres. There has been a major increase in goods transport by sea due to an increase in the transport of oil from the continental shelf to the mainland. Goods transport by lorry has also grown considerably, while transport by rail has increased slightly. Transport by air accounts for a very small percentage of the total goods transport.

Calculations show that the most energy-effective way to transport goods is by electric railway, although the figures for diesel-driven locomotives and ships are also favourable (figure 6.4). Transport by lorry uses four times as much energy per tonne-kilometre as the electric railway, while air transport requires as much as 70 times more energy.

For lorries, energy use per tonne-kilometre has declined from 1994 to 1998 (figure 6.4). This is due to the fact that there has been a slight rise in overall capacity utilization for lorries and that energy use per kilometre for the largest lorries has been reduced. There has also been an apparent reduction in energy use per tonne-kilometre for goods vans, while diesel trains have shown a slight increase. However, the level of uncertainty in relation to fuel consumption for these modes of transport is so high that it is not possible to draw any conclusions with regard to this trend.

Table 6.2 shows emissions in relation to transport work in tonne-kilometres for the various modes of transport. Overall emissions of greenhouse gases (CO_2, CH_4 and N_2O) are highest for planes, goods vans and combination cars, but these modes of transport account for only a small percentage of goods transport in Norway. Ships and lorries, i.e. the modes of transport that account for most goods transport, produce relatively high emissions of NO_x and SO_2 per tonne-kilometre.

As is the case for passenger transport, emissions of SO_2 per tonne-kilometre have decreased for most modes of transport in the period 1994 to 1998 because of the reduction in sulphur content in fuel. Improvements in combustion technology have also resulted in lower emissions of NO_x, NMVOC and CO per tonne-kilometre for planes and modes of road transport. For lorries, goods vans, combination cars and diesel trains, changes in energy use per tonne-kilometre will also, as explained above, have an impact on emissions per tonne-kilometre.

Table 6.2. Emissions per tonne-km[1]. g/tkm. CO_2 in kg/tkm. 1994[2] and 1998

	Greenhouse gases			Acidifying gases		Harmful substances		
	CO_2	CH_4	N_2O	SO_2	NO_x	NMVOC	CO	Particulate matter
Goods van and combination car								
1994	0.86	0.14	0.04	0.29	3.94	3.77	26.78	0.73
1998	0.79	0.08	0.06	0.16	2.40	1.89	13.40	0.50
Lorry								
1994	0.18	0.01	0.00	0.08	2.21	0.26	1.22	0.20
1998	0.16	0.01	0.00	0.04	1.57	0.18	0.66	0.10
Train (diesel)								
1994	0.07	0.00	0.03	0.03	1.10	0.09	0.26	0.09
1998	0.06	0.00	0.02	0.02	0.91	0.08	0.21	0.07
Plane								
1994	2.56	0.10	0.08	0.11	3.17	5.19	7.98	0.12
1998	2.54	0.10	0.08	0.12	2.84	3.81	4.56	0.12
Ship								
1993	0.07	0.01	0.00	0.16	1.60	0.05	0.06	0.02
1998	0.07	0.00	0.00	0.11	1.66	0.05	0.05	0.02

[1] For trains, planes, goods vans and combination cars, goods transport is included. [2] 1993 for transport by sea.
Source: Holtskog (2001).

In other words, trains are very energy-effective whether transporting people or goods and produce little or no emissions to air. The modes of transport most used for people (private cars) and goods (ships and lorries) are neither the most energy-effective nor the least energy-effective.

However, a comparison of the various modes of transport must be made with some caution. There are great differences between them with regard to what they transport, their optimal transport distance and speed. And because of the country's infrastructure and topography, replacing one mode of transport with another, e.g. train instead of high-speed boat, is often impossible.

It is also important to be aware that there are large variations in energy use and emissions within the various transport mode categories. This is due to differences in the size of a particular form of transport, the work it is used for and which part of the country it is used in.

The length of a journey is also very important, since energy use per kilometre is often higher on short journeys. Energy use per passenger-kilometre for an urban bus will, for example, be considerably higher than for an express bus with the same number of passengers.

Emissions to air from national sea traffic and fishing vessels

National sea traffic and fishing vessels are major sources of SO_2, NO_x and CO_2 emissions. In 1998 these sources accounted for as much as 42 per cent of the total NO_x emissions in Norway, and 10 per cent of the SO_2 and CO_2 emissions. Statistics Norway has previously conducted surveys of fuel consumption and emissions to air from Norwegian ships (Flugsrud and Rypdal 1996) and from foreign shipping in Norwegian waters (Flugsrud and Haakonsen 1998). The estimates of emissions from fishing vessels and domestic shipping have now been updated (Tornsjø 2001).

Table 6.3. Emissions to air from domestic shipping, fishing vessels, mobile drilling rigs etc. 1993 and 1998. 1 000 tonnes. CO_2 in million tonnes

	Million tonnes CO_2	1 000 tonnes CH_4	N_2O	NO_X	SO_2	NMVOC	CO	Particulate matter
Total 1993	**3.4**	**0.2**	**0.1**	**71.8**	**4.7**	**2.3**	**5.4**	**0.6**
Change 1993-1998	0.7	0.2	0.0	21.8	0.1	0.7	0.4	0.2
Total 1998	**4.1**	**0.4**	**0.1**	**93.6**	**4.8**	**3.0**	**5.8**	**0.8**
Fishing vessels	1.2	0.1	0.0	27.5	0.8	0.6	3.1	0.2
Coastal traffic	1.6	0.1	0.0	33.8	2.0	1.2	1.5	0.3
- Cargo ships[1]	0.8	0.1	0.0	19.0	1.4	0.6	0.7	0.2
- Passenger traffic[2]	0.8	0.1	0.0	14.8	0.6	0.7	0.8	0.1
Oil-related	1.1	0.1	0.0	26.7	1.5	1.1	1.1	0.3
- Supply/standby	0.6	0.0	0.0	15.2	0.3	0.4	0.3	0.2
- Buoy loaders	0.2	0.0	0.0	4.7	1.0	0.1	0.1	0.1
- Mobile rigs	0.3	0.1	0.0	6.8	0.2	0.5	0.7	0.0
- Seismic vessels	0.0	0.0	0.0	0.1	0.0	0.0	0.0	0.0
Other vessels	0.2	0.0	0.0	5.5	0.5	0.2	0.2	0.1
- Rescue vessels	0.0	0.0	0.0	0.2	0.0	0.0	0.0	0.0
- Military vessels	0.0	0.0	0.0	1.7	0.0	0.1	0.1	0.0
- Other vessels owned by the authorities[3]	0.0	0.0	0.0	0.3	0.0	0.0	0.0	0.0
- Other	0.1	0.0	0.0	3.3	0.4	0.1	0.1	0.0

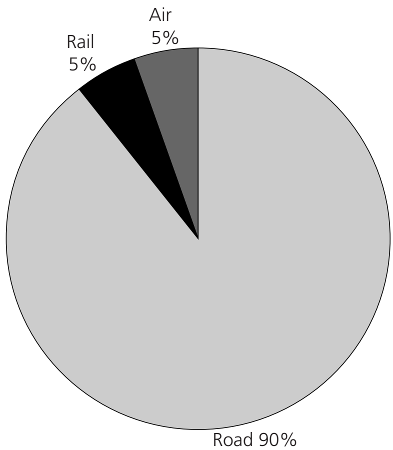
[1] Including tugs. [2] Includes ferries that are part of the national road system, other ferries, the Norwegian Coastal Express, other ferry services andsmall passenger ships etc. [3] Includes lightships, pilot vessels and harbour maintenance vessels.
Source: Figures for 1993: Flugsrud and Rypdal (1996), figures for 1998: Tornsjø (2001).

Emissions are calculated by multiplying fuel consumption for the various types of ship by emission factors. Fuel consumption for fishing vessels and national sea traffic has risen by 25 per cent from 1993 to 1998. The increase is mainly due to a rise in fuel consumption by ships involved in oil-related activities, although cargo ships have also shown a substantial increase in fuel consumption. National shipping is defined here in accordance with international environmental protocols, i.e. ships sailing between two Norwegian ports.

Table 6.3 shows the total emissions from national sea traffic, fishing vessels and mobile drilling rigs for 1993 and 1998, and 1998 emissions as produced by the various types of vessel. With the rise in fuel consumption, total emissions of most emission components have also increased. CO_2 emissions have risen by 20 per cent, while NO_x emissions have increased by 30 per cent. SO_2 emissions are approximately the same for these two years, the lower sulphur content in fuel compensating for the effect of higher fuel consumption.

In 1998 coastal traffic accounted for almost 38 per cent of the fuel consumption of national sea traffic, while fishing vessels and oil-related activities

Figure 6.5. Individuals highly annoyed by noise from road, rail and air traffic (noise annoyance index). Percentage of total. 1999



Source: Norwegian Pollution Control Authority (2000a).

accoun-ted for 29 and 26 per cent respectively. We find approximately the same percentages in CO_2 emissions (table 6.3). This is because the emission factor for CO_2, calculated on the basis of the carbon content of the oil products, shows little variation between types of fuel. The percentages of SO_2 and NO_x emissions show greater deviation from the fuel consumption figures because the emission factors vary according to the fuel and consumption technology used.

Large areas occupied by infrastructure

The development and operation of infrastructure affects the landscape, valuable natural and cultural sites and opportunities for recreation, both when the areas are simply used and when tracts of land are split up. Overall, this has resulted in losses or degradation of valuable natural and cultural sites. New transport systems, in particular new roads, have also opened up areas that were previously inaccessible, increasing traffic in these areas (Report No. 46 (1999-2000) to the Storting).

Noise

Noise is a serious environmental problem in Norway today. There are many sources of noise, but the increase in annoying noise is particularly due to the growth in the volume of road traffic. A nationwide survey was conducted in 1999 to establish how many people were annoyed by noise from road, rail and air traffic (Norwegian Pollution Control Authority 2000a). The results of the survey showed that almost half a million people were highly annoyed by traffic noise in Norway, and almost 90 per cent of these were annoyed by noise from road traffic (figure 6.5).

Table 6.4 shows how many people were *exposed* to noise of varying strength from road, rail and air traffic in 1999 (in 5 dB intervals). The table also shows the number of persons who were *annoyed* by noise from the same sources. The number of people exposed to noise can be established by measuring or calculating the noise level (in dB, decibels) in areas where people are present (Granøien 1999). However, there is no clear connection between these measured levels of noise and subjective perceptions of how annoying the noise is. A noise annoyance index has been developed so that the measured or calculated noise levels can be used to find out how many individuals are annoyed by noise. The index is based on a number of comparisons between measured noise from various sources and subjective perceptions of noise from the same sources. For example, table 6.4 shows that only just over 400 000 people are estimated to be highly annoyed by road traffic noise, while over 1 million people live in areas exposed to noise

Table 6.4. Number of individuals exposed to noise of varying strength from road, rail and air traffic (in 5 dB intervals), and number of individuals annoyed by noise from the various sources (noise annoyance index). 1999

	50-55	55-60	60-65	65-70	>70	Total exposed	Highly annoyed (noise annoyance index)
Total	**60 250**	**450 485**	**416 931**	**221 630**	**60 662**	**1 209 958**	**460 464**
Road	..	411 900	385 800	204 460	57 040	1 059 200	411 413
Rail	18 368	21 758	24 243	15 294	3 611	83 274	24 120
Air	41 882	16 827	6 888	1 876	11	67 484	24 931

Source: Granøien (1999).

levels exceeding 55 decibels (which is the World Health Organization's recommended maximum level for noise in residential areas).

Noise is at the root of a number of health problems, such as hearing impairment, stress, communication interference and sleep disturbance, and is a major problem for individuals and for the population at large. To reduce noise annoyance among the population, a target has been set by the government authorities stipulating that the number of people annoyed by noise is to be reduced by 25 per cent by the year 2010. Many different measures have already been launched to reduce annoyance caused by road traffic, but more must be introduced if the authorities are to reach their target. Measures to combat noise from road traffic have particular potential impact, but this is also where it is most difficult to achieve results because the volume of road traffic continues to increase and because many effective measures conflict with other public interests. Measures that are being considered include tighter restrictions on noise from engines and car tyres, the use of noise-reducing road surfaces, higher taxes on fuel and car use in general, increased support for public transport, noise screens and sound insulation of building facades.

Work is currently in progress to develop tools that can monitor the situation until 2010, so as to check whether measures that have been introduced are helping and whether the authorities are achieving their objective. Statistics Norway has recently drawn up a proposal for a model that can be used for this purpose. The model is intended to be operative by the end of 2001 and it will therefore be possible to follow developments in this area, for example in future issues of *Natural Resources and the Environment.*

Objectives and methods

Various measures are being implemented to reduce environmental damage from transport. Technological innovation has in most areas resulted in substantial reductions in emissions per passenger-kilometre. Nevertheless, technological improvements and a more efficient traffic regulation system will not prevent an increase in emissions of greenhouse gases because the expected growth in air traffic will cancel out this effect (Report No. 46 (1999-2000) to the Storting).

After negotiations with the EU, the European car industry has taken on a commitment to reduce CO_2 emissions from private cars, preferably by 2005, but no later than by 2010. The agreed reduction stipulates 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 (Report No. 46 (1999-2000) to the Storting).

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 street-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 may also result in lower levels of air pollution.

In Norway's Road and Road Traffic Plan 1998-2007, it was assumed that the percentage of vehicles using non-studded tyres would probably have to reach 80 per cent in the four largest urban areas by 2002 in order to meet regulations relating to limit values for particulate matter. In the winter season 1999/2000 the percentage of vehicles with non-studded tyres was about 70 per cent in Oslo, Bergen and Stavanger, and about 35 per cent in Trondheim (Report No. 46 (1999-2000) to the Storting).

6.3. Transport networks and vehicles

By 31 December 1999, the total length of public roads in Norway was 90 880 km, or 281 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 public road length per km^2 is 2 877 metres, whereas in Finnmark it is only 87 metres. National roads accounted for 29 per cent of the total, county roads for 30 per cent and municipal roads for 41 per cent. In addition to public roads, the length of private roads is estimated at about 73 000 km, of which 46 000 km are forestry roads that can be used all year round.

The total area taken up by roads in urban settlements in Norway was 315 km^2 in 1998, accounting for 15 per cent of the area of urban settlements. In comparison, buildings occupy about 7.6 per cent of the area of urban settlements (see also chapter 10).

Car density today is far higher than it was 70 years ago (table 6.5). Particularly in the decades before and after the Second World War, the number of motor vehicles rose much faster than the increase in the length of public roads. There has been little change in car density over the past few years. By the end of 1999, there was an average of just over 33 metres of public road available per motor vehicle. Car density was 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 6.6).

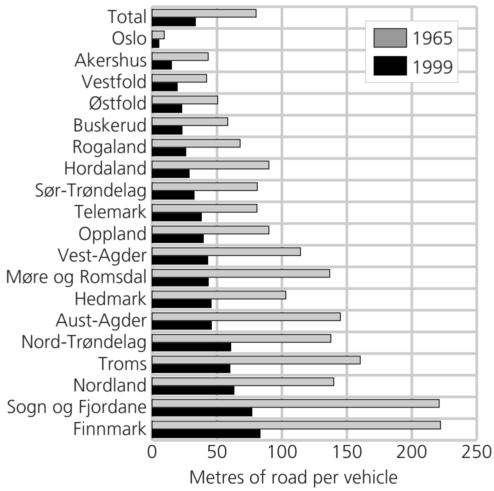
As of 31 December 2000 there were a total of 2.78 million registered motor vehicles, of which 1.85 million were private cars, an increase of 2.3 and 2.1 per cent respectively on the previous year. In the course of 1999, over 189 000 motor vehicles were registered for the first time, including 127 000 private cars.

Table 6.5. Length of public roads

	Total kilometres	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
1999	90 880	33	281

Source: Transport and Communication Statistics, Statistics Norway and the Directorate of Public Roads.

Figure 6.6. Number of metres of road per motor vehicle, by county. 1965 and 1999



Source: Directorate of Public Roads.

The number of diesel-powered private cars has shown a considerable increase over the last few years. In 1980 there were just over 22 000 diesel private cars, or 1.8 per cent of the total number of private cars. Corresponding figures as of 31 December 2000 were 136 000 and 7.4 per cent. Almost 1 in 8 of the private cars registered in 2000 were diesel-powered. In the course of 1999 over 88 000 passenger and goods vehicles were scrapped under the refund payment scheme. At the end of 1999, the average age of the stock of Norwegian private cars was 9.9 years. The average age was lowest in Oslo, 8.4 years, and highest in the county of Oppland at 11.4 years. In 1970, the average age of the stock of private cars was 6.3 years.

By the end of 1999, there were 757 road tunnels on the national road network in Norway and 147 tunnels on the county road network. The number of national road tunnels has increased by 22 per cent since 1992. The total length of tunnels on the national road network came to 638.5 km. Of the total tunnel length in Norway, 44 per cent is to be found in the counties of Hordaland and Sogn og Fjordane. The number of bridges is also rising. By the end of 2000, there were in all over 16 150 bridges on national and county roads, an increase of 1 150 since 1992. The number of ferries has, on the other hand, dropped considerably over the last few years. In the peak year of 1978, there were 174 ferry services in Norway. By the end of 1999, the number had fallen to 135. It is difficult to put a figure on how and to what extent these changes in infrastructure affect the environment. Generally speaking, more tunnels and bridges and fewer ferry links are the basis of more efficient transport. On the other hand, a development in this direction will probably generate more transport, and in particular passenger transport. The balance between the various forms of emissions to air will also change to a certain extent as a result of the changes in infrastructure. A reduction in ferry transport will result in lower sulphur emissions, to be weighed against higher CO_2 emissions from cars.

By the end of 1999 the total length of cycleways and footways along national roads in Norway was 2 800 km, an increase of about 850 km since 1990. As of 31 December 1999, Rogaland county had most footways and cycleways along national roads, with a total of 301 km. A total of 65 km of footways and cycleways were built in 1999, 20 per cent of which was in Akershus county.

The total length of the public railway network was about 4 300 km just after the end of the Second World War and 17 per cent of the line was electrified. Today the total length has dropped to 4 000 km. However, the proportion of the line that is electrified has risen to 61 per cent or 2 500 km. There are nonetheless considerable regional differences. In half of the counties of Norway, the railway is fully electrified, while in Hedmark, Nord-Trøndelag and Nordland counties the percentage of electrified line is 31, 0 and 9 per cent respectively. These three counties account for 34 per cent of the total length of railway line. Dual tracks make up 3.3 per cent of the total track length. The railway network comprises 700 tunnels and 2 700 bridges.

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 private cars were lifted 1 October 1960, and from 1960 to 1975 the proportion of total passenger transport work carried out by private cars rose from 40 to 75 per cent (figure 6.7 and Appendix, Table E1). This proportion has changed very little since 1975. For short and medium-length journeys in particular, private cars are the dominant mode of transport today. The domestic transport work accounted for by private cars in 1999 was calculated to be 46 billion passenger-kilometres. 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 7.1 per cent in 1999, equalling the percentage for transport by bus. The figure for rail transport was bypassed in 1988. Nonetheless, air transport only accounted for 9.5 per cent of the number of passenger-kilometres accounted for by cars in 1999. Since the average domestic plane journey is about 430 km, air transport work, measured by the number of passenger journeys, is moderate. In 1999 10 million passenger journeys were made by air, equivalent to just under 0.25 per cent of the total number of domestic passenger journeys in 1999. On long trips in particular, air travel is the preferred mode of transport. Of domestic passenger journeys longer than 300 km made as collective transport, 70 per cent are by air.

Railways, including suburban railways and urban tramways, accounted for over 3.3 billion passenger-kilometres in 1999 and, of this, 507 million passenger-kilometres were on suburban railways and urban tramways. The share of the total transport work carried out by railways was 5.4 per cent in 1999. In 1980, the corresponding percentage was just under 6.8 per cent, and ten years later it had dropped to only 4.5 per cent. Following a downward trend throughout the 1980s, passenger transport by rail has increased by a relatively large margin over the last few years and by as much as 24 per cent, measured in passenger-kilometres, from 1995-1999. This increase is mainly due to Gardermobanen, the Oslo Airport rail link.

Although passenger transport by sea can be extensive in some regions, the total volume is relatively limited. In 1999, 46 million passengers were carried on domestic routes, or 1.1 per cent of all transported passengers. Car ferries accounted for almost 83 per cent of the total number of passengers transported by sea. The total transport work accounted for by buses has remained almost unchanged since 1970, with about 4 billion passenger-kilometres in 1998. The percentage of the total transport work accounted for by buses declined from 14.4 to 7.0 per cent in the same period.

Norwegians travelled an average of just under 37.9 km per day each in 1999, more than a nine-fold rise since 1946 (table 6.6). The number of passenger-kilometres travelled per capita per day by boat and train has varied during this period. Norwegians travelled by train and ship almost as much in 1960 as in 1999. The other modes of transport have generally shown steady growth.

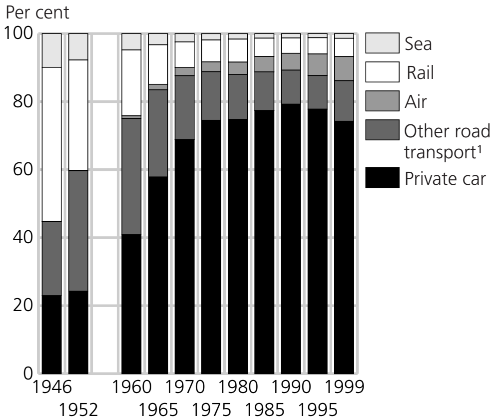
Several factors influence the volume of transport and its distribution among the various modes. For instance, there has been a clear relationship between the volume of transport and general economic activity. The general improvement in the economy of private households has particularly influenced the use of private cars. Families with children in particular give priority to car use. In 1998, just over 85 per cent of all married couples with children owned private cars, as compared with 79 per cent for married couples without children. Almost 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 can explain why families with children give priority

Table 6.6. Number of passenger-kilometres in Norway per capita per day

	Total	Private car	Other passenger transport by road	Air	Rail[1]	Boat
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	0.41
1995	35.28	27.74	3.49	2.24	1.68	0.36
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
1999	37.87	28.11	4.52	2.68	2.04	0.53

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

Figure 6.7. Domestic passenger transport work, by mode of transport



[1] Other road transport comprises motorcycles, mopeds, taxis, hire cars and buses.
Source: Transport and communication statistics, Statistics Norway and the Institute of Transport Economics.

to car ownership at the expense of other benefits.

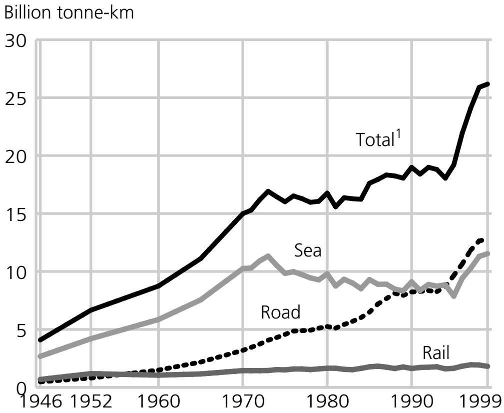
It is not only couples with children who find that the existing public transport system does not meet their daily needs. For most people, car ownership provides freedom and a wider choice of both place of residence and occupation. Cars also provide far more mobility and flexibility than public transport can offer. Our many daily activities can be carried out more quickly and easily with access to a private car. Social contacts are also easier to maintain and develop, and cars open up more opportunities for holidays and leisure activities. A study of car ownership and use 1980-1995 (Monsrud 1997) shows 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 private car. Statistics Norway's holiday survey (Statistics Norway 1999c) 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 ship/ferry. However, the percentage of holiday trips by car has declined in recent years, and was at 61 per cent in 1993. On the other hand, there was a sharp rise in holiday trips by air, from 21 to 34 per cent of the total, in the period 1993-1998. These changes in transport patterns must be viewed in the light of the rise in the number of international journeys in the same period. If the figures are limited to domestic travel only, private cars accounted for 70 per cent of holiday trips in 1998.

Calculations of the average *annual* growth in transport work show an average growth in transport by air, by private car, and by rail/bus/ship of 5.9, 2.2 and 0.5 per cent respectively for the period 1980-1999. In the National Transport Plan 2002-2011 (Report No. 46 (1999-2000) to the Storting), the average annual growth in the period 2002-2012 is estimated to be 3.5, 1.3 and 0.9 per cent (air, private car, rail/bus/ship) and 3.0, 1.1 and 0.9 per cent for 2012-2020. While the growth in both private car and air travel is expected to decline, stronger growth is expected for other modes of collective transport. Projections of traffic trends have been produced by the Institute of Transport Economics and are based on infrastructure investments in accordance with the reference strategy stated in the Report to the Storting (Chap. 12), anticipated future air, rail and bus services and updated assumptions about population trends and macro-economic developments.

6.5. Goods transport

In 1946 domestic goods transport work totalled 4.1 billion tonne-kilometres. By 1999 this figure had risen to 26.2 billion tonne-kilometres, excluding oil and gas transport from the North Sea (figure 6.8 and Appendix, table E2). Measured in absolute figures, the transport work accounted for by railways has remained relatively stable over the last twenty years, 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 (figure 6.8).

Figure 6.8. Domestic goods transport[1] work, by mode of transport



[1] Excluding oil and gas transport from the continental shelf.

Source: Transport and communication statistics, Statistics Norway and the Institute of Transport Economics.

At the end of the 1950s, goods transport by rail and by road totalled about 1 billion tonne-kilometres each. In 1999, transport by rail had increased to 1.8 billion tonne-kilometres, while transport by lorries with a payload of 1.0 tonne or more had increased to 12.8 billion tonne-kilometres.

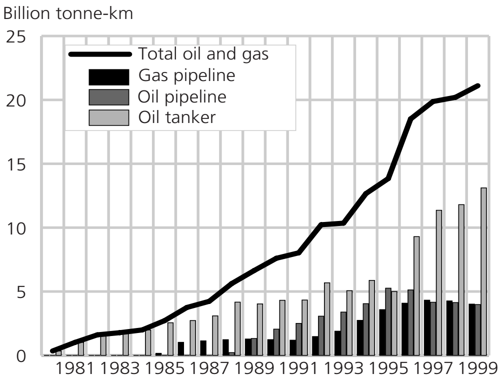
In 1960 traditional maritime transport (excluding oil transport by ship from the North Sea) accounted for 67 per cent of total domestic transport work. By 1999 this figure had dropped to 44 per cent. Although for a number of years maritime transport lost ground in domestic goods transport, this trend has levelled out over the last 3-4 years.

Goods transport by air is moderate and has not increased over the last few years. Total transport work was the same in 1999 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 1999 goods transport by road accounted for 49 per cent of total domestic transport work. In 1960 the corresponding figure was 17 per cent. In 1999 a total of 265 million tonnes of goods were transported by road. This was 80.1 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 goods 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

Figure 6.9. Oil and gas transport from Norwegian continental shelf to mainland



Source: Transport and communication statistics, Statistics Norway and the Institute of Transport Economics.

kilometre is important and the transport time less important, for example for bulk transport.

Efficient transport is dependent on infrastructure suitable for modern transport. 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 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 amount of domestic goods transported by road is four times greater than the amount transported by ship, shipping is by far the dominant mode in international goods traffic. In 1999, 70.6 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 in international trade and oil transport, 175 million tonnes were transported, of which 83.5 million tonnes was carried by Norwegian ships. Goods imported and exported by lorry (Norwegian and foreign) accounted for 3.2 per cent, or 7.9 million tonnes.

Calculations of the average *annual* growth in transport work show an average growth in road, sea, and rail transport of 4.8, 0.9 and 0.5 per cent respectively for the period 1980-1999. In the National Transport Plan 2002-2011 (Report No. 46 (1999-2000) to the Storting), the Institute of Transport Economics estimates the average annual growth in the period 2002-2012 to be 1.29 (road), 1.95 (sea) and 3.84 per cent (rail). For the period 2012-2020, the estimates are 1.06, 1.48 and 1.19 per cent respectively for road, sea and rail transport. The estimates are based on considerable restructuring and strengthening of the interaction between the different forms of transport, for instance in the form of intermodal transport. The Report to the Storting stresses this point while also proposing that action should be taken to create favourable conditions for competition in goods transport by rail.

Oil transport from the North Sea to mainland Norway, as shown in figure 6.9, has increased dramatically. Measured in tonne-kilometres, average annual growth from 1990 to 1999 was 12 per cent. In 1999 oil and gas transport totalled 21.1 billion tonne-kilometres and of this 13.1 billion, or 62 per cent of the total oil and gas transport from the North Sea, was by ship. The remaining oil and gas transport is by pipeline, and goods transport of this kind has declined slightly over the last few years. In 1995, transport by pipeline accounted for 64 per cent and in 1999 for

38 per cent of the total oil and gas transport from the North Sea.

Documentation, transport in general: Statistics Norway (2000c).

Further information may be obtained from: Jan Monsrud.

7. Air pollution and climate

Preliminary calculations show that Norway's greenhouse gas emissions dropped by 1 per cent from 1999 to 2000. This is the first time since 1995 that there has been a reduction in these emissions. However, it is doubtful whether this is the beginning of a new trend or whether the drop will continue in 2001. Between 1990 and 2000, emissions rose by more than 6 per cent. Emissions of CO_2 *decreased by just over 1 per cent in 2000 compared with the year before. This is the first time since 1991 that emissions have dropped. Overall emissions of greenhouse gases other than* CO_2 *are almost unchanged since 1999.*

There has been a small reduction in emissions of nitrogen oxides (NO_x*), while emissions of non-methane volatile organic compounds (NMVOCs) have continued to rise from 1999 to 2000. For both these pollutants, emission levels are higher than the targets Norway has undertaken to meet under international agreements on long-range air pollution.* NO_x *and sulphur dioxide are the pollutants that contribute most to acid rain in Europe, while NMVOCs are involved in the formation of ground-level ozone.*

The decrease in emissions of particulate matter and carbon monoxide (CO) appears to have continued from 1999 to 2000. These pollutants and NO_x *are very important for local air quality in towns and urban settlements. Norwegian emissions of particulates are now at about the same level as in 1990, while CO emissions have been reduced by more than 30 per cent.*

7.1. Introduction

Many substances that are emitted to air can contribute to environmental problems or be harmful to health. Emissions may have effects locally where they occur, but may also have effects across national borders. Boxes 7.1 and 7.2 summarize the adverse effects of various air pollutants.

International environmental agreements are very important as a means of reducing emissions that have regional or global effects. Various protocols under the Convention on Long-range Transboundary Air Pollution apply to a number of substances that have regional effects, for example by contributing to acidification and the formation of ground-level ozone. Climate change and depletion of the ozone layer are important global environmental problems. The Montreal Protocol has helped to bring about substantial reductions in the use of ozone-depleting substances in the industrial countries. It is hoped that the Kyoto

Protocol, which was signed in 1997, will lead to gradual reductions in global emissions of greenhouse gases.

Under the international environmental agreements, Norway has undertaken commitments to limit or reduce emissions of most of the pollutants listed in box 7.1. Air quality guidelines have been drawn up for pollutants that have local effects on health, and the local authorities are responsible for ensuring that these are respected. An emission inventory (box 7.3) makes it possible to identify the major sources of each pollutant and to follow emission trends over time. This information is important for a consideration of which measures to implement and in evaluating the effects of such measures.

This chapter starts with a presentation of Norway's greenhouse gas emissions, followed by a description of Norway's efforts to follow up the Kyoto Protocol and a discussion of emissions of greenhouse gases in other countries. Other environmental problems caused by air pollution are discussed in sections 7.4-7.8, which focus on Norwegian emissions. In section 7.9, an analysis of energy and emission indicators for industry is presented. Finally, section 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 had risen to about 370 ppm in 1999 (University of California 2000). This can disturb the heat balance and result in climate change on earth.

The most widely used indicator of possible climate change is the global mean temperature (see section 1.2). This has risen by 0.6 ± 0.2 °C during the last 100 years (IPCC 2001). In its third assessment report, the IPCC[2] concludes that it is likely that most of the warming observed in the last 50 years is a result of the rising concentrations of greenhouse gases in the atmosphere (IPCC 2001). The report also presents new projections indicating that the global mean temperature may rise by between 1.4 and 5.8 °C by the end of this century.

In Norway, the mean temperature has risen by 1.7 °C in the last 100 years (Norwegian Meteorological Institute 2001). In the research project RegClim, a climate scenario for the next 50 years has been modelled, which shows an even warmer Norway with substantially higher precipitation and slightly more frequent strong

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[1] ppm = parts per million, or 1/10 000 per cent. [2] The Intergovernmental Panel on Climate Change (IPCC) is a politically independent panel established by the WMO (World Meteorological Organization) and UNEP (United Nations Environment Programme). The IPCC presents results from climate research and other relevant information that can increase our understanding of the risks associated with anthropogenic climate change.

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, NO_x and NMVOCs (in sunlight)	Increases the risk of respiratory complaints and damages vegetation.
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.
Cadmium (Cd)	Combustion of wood and black liquor, mineral production	Liable to bioaccumulate. Delayed effects such as pulmonary emphysema, cancer, reduced fertility in men and kidney damage.
Carbon dioxide (CO_2)	Combustion of fossil fuels, changes in land use and deforestation	Enhances the greenhouse effect.
Carbon monoxide (CO)	Combustion (fuelwood, road traffic)	Increases risk of heart problems in people with cardiovascular diseases.
Chlorofluorocarbons (CFCs)	Cooling fluids	Deplete the ozone layer
Mercury (Hg)	Combustion of wood and black liquor, mineral production	Becomes concentrated in organisms and food chains. Gives kidney damage and harms nervous system. May cause cellular changes.
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 contribu- tes to formation of ground-level ozone.
Nitrogen oxides (NO_x)	Combustion (industry, road traffic)	Increase the risk of respiratory disease (particu- larly NO_2). Contribute to acidification, corrosion and formation of ground-level ozone.
Perfluorocarbons (PFCs; CF_4 and C_2F_6)	Aluminium production	Enhance the greenhouse effect.
Polycyclic aromatic hydrocarbons (PAHs)	All incomplete combustion of organic material and fossil fuels	Several are carcinogenic.
Particulate matter ($PM_{2,5}$ and PM_{10})	Road traffic and fuelwood use	Increase the risk of respiratory complaints.
Sulphur dioxide (SO_2)	Combustion, metal production	With other components, increases the risk of respiratory disease. Acidifies soil and water and causes corrosion.
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.
Source: 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. Since 1750, concentrations of the three most important greenhouse gases, CO_2, CH_4 and N_2O, have risen by 31, 151 and 17 per cent respectively (IPCC 2001). (Norway's total direct greenhouse gas emissions are shown in figure 7.3.)
Climate change	Anthropogenic emissions of greenhouse gases, SO_2 and particulate matter can alter the natural chemical composition of the atmosphere. This in turn may accelerate changes in the global climate system. It is difficult to quantify what proportion of climate fluctuations is a result of human activity. However, the evidence that most of the global warming that has been observed in the last 50 years is anthropogenic has become stronger (IPCC 2001). (Variations in global mean temperature are shown in Chapter 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. 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 7.10.)
Ground-level ozone	Ozone in the lower atmosphere is a pollution problem because it has adverse effects on health, vegetation and materials. 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 1999 there were about the same number of pollution episodes[2] as the average for the 10-year period 1989-1998. The highest hourly mean concentration in 1999 was 154 mg/m^3 (Norwegian Institute for Air Research 1999). No measuring station recorded above 160 mg/m^3, which is the Norwegian Pollution Control Authority's population warning threshold.
Acidification	Total emissions of SO_2 and NO_x are lower in Norway than in most other European countries. Sulphur and nitrogen compounds 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 µg pr. m^3.

Source: IPCC (2001) and Norwegian Pollution Control Authority/Directorate for Nature Management (1999).

winds (Norwegian Institute for Air Research 2000).

The three most important greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Anthropogenic 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 mainly by decomposition of biological waste in landfills and by livestock (agriculture). Manure and the use and production 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 (section 7.3). In addition to CO_2, CH_4 and N_2O, the Kyoto Protocol applies to sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Carbon dioxide (CO_2)

According to preliminary calculations, Norwegian emissions of carbon dioxide totalled 41.0 million tonnes in 2000. This is a decrease of about one per cent from the year before, and the first time since 1991 that emissions have dropped. However, there has been a rise of 17 per cent since 1990 (figure 7.1 and Appendix, table F1). Emissions rose by 0.6 per

Box 7.3. The Norwegian emission inventory

Norway's emission inventory is produced by Statistics Norway and the Norwegian Pollution Control Authority. The inventory includes all the most important pollutants that cause environmental problems such as climate change, acidification and the formation of ground-level ozone, and also includes PAHs and some heavy metals. However, the inventory only covers anthropogenic emissions, not natural emissions for example from oceans and forests.

Emission figures are based partly on data reported by industrial plants, based on measurements or calculations at these plants, and partly on calculations using activity data and emission factors. Activity data may include consumption of energy commodities (e.g. fuel oil consumption by manufacturing industries and households) or other data such as the number of sheep put out to pasture, the quantity of waste landfilled, the quantity of ferro-alloys manufactured, etc.

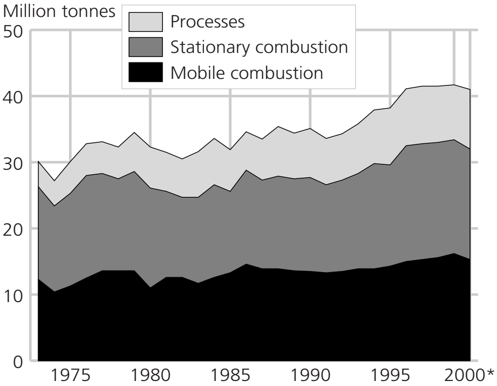
This year, national emission figures for 2000 are being published. These are preliminary figures based on last year's calculations, in addition to emission figures reported by large enterprises and the activity data available now. Experience shows that these emission figures are good estimates for most pollutants at national level. However, the allocation of emissions to sources and sectors is more uncertain for a number of pollutants, and we have therefore mainly used 1999 figures in this presentation to describe the distribution of emissions and the causes of any changes.

The 1999 figures are also considered to be preliminary figures. This is because auditing of the energy accounts, which are a very important source of data for the emission inventory, takes about eighteen months to complete. However, we would normally only expect minor adjustments between the preliminary figures for 1999, which are published now, and the final figures, which will be published next year.

Time series for the national emission figures and emissions split by source, sector, county and municipality are also available on Statistics Norway's website at: http://www.ssb.no/english/subjects/01/04/10/main.html

For documentation of the emission inventory, see Flugsrud et al. (2000).

Figure 7.1. Emissions of CO_2 by source



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

Box 7.4. 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).

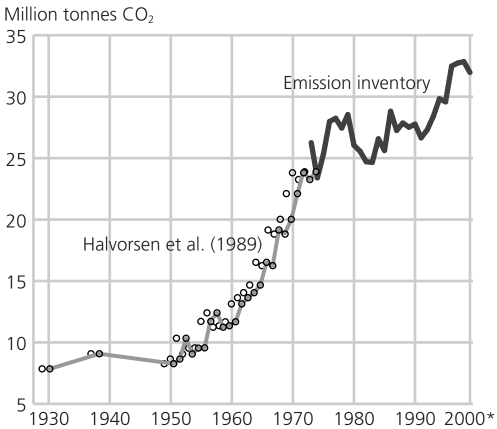
Mobile combustion includes emissions from all combustion of energy commodities in various modes of transport and mobile motorized equipment.

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.

cent from 1998 to 1999. The most important sources of CO_2 emissions in Norway are road traffic (22 per cent) and oil and gas extraction (20 per cent), in addition to combustion in manufacturing industries (14 per cent) and process emissions from metal production (13 per cent).

The decrease in emissions is explained by several factors. The heating season in 2000 was the mildest since 1992 (measured in degree-days), and consumption of fuel oil and heating kerosene was very low as a result. A number of air services were discontinued, and sales of aviation fuel therefore dropped. Even though road traffic has risen, newer vehicles are more economical, which helps to reduce fuel consumption and emissions. However, the drop in emissions has not been apparent in all sectors. CO_2 emissions from oil and gas activities in the North Sea are still rising, as are process emissions from manufacturing industries.

Figure 7.2. CO_2 emissions from combustion in Norway in the period 1929 - 2000



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

Calculations of Norwegian CO_2 emissions from stationary and mobile combustion for earlier years (figure 7.2) show that emissions nearly tripled during the 20-year period from 1950 to 1970 (Halvorsen et al. 1989). The growth in emissions in this period can be related to rising industrial activity and rising consumption of energy commodities as a result of economic growth.

Projections suggest that Norwegian CO_2 emissions will rise by about 38 per cent from 1990 to 2010 if the use of climate policy instruments continues unchanged (Ministry of the Environment 2000a). The most important reason for this substantial rise is the expected rise in the energy requirements of the petroleum sector and manufacturing industries. 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. The planned gas-fired power plants at Skogn, Kårstø and Kollsnes have been given emission permits that allow them to release 4.44 million tonnes of CO_2 per year (see box 7.5). Unless measures to reduce emissions are implemented, Norway's CO_2 emissions may thus rise by as much as 50 per cent from 1990 to 2010.

Box 7.5. Emissions of CO_2 from gas-fired power plants

The conditions in the licences issued to Naturkraft for gas-fired power plants at Kårstø in Rogaland and Kollsnes in Hordaland have been changed. This was done after a decision by the Ministry of the Environment in October 2000 to alter the licences issued by the Norwegian Pollution Control Authority for the power plants. The Ministry decided that CO_2 emissions are not to be subject to stricter conditions than those that normally apply in other EEA countries. Naturkraft is therefore licensed to emit 1.12 million tonnes CO_2 from each of the power plants, both of which will have an installed capacity of about 380 MW.

In autumn 2000, Industrikraft Midt-Norge also received a licence to construct a gas-fired power plant in Skogn in Nord-Trøndelag with an installed capacity of about 800 MW. The power plant is expected to generate annual emissions of about 2.2 million tonnes CO_2 per year, and this alone will cause Norwegian CO_2 emissions to rise by 6 per cent compared with the 1990 level.

For more information on processing of the licences, see the Norwegian Pollution Control Authority's website at www.sft.no. Chapter 11 of this publication includes an analysis of the possible consequences of the construction of Norwegian gas-fired power plants for emissions in Europe.

Methane (CH_4)

Methane accounted for 13 per cent of Norway's greenhouse gas emissions in 1999. Methane emissions changed little from 1998 to 1999, and preliminary calculations for 2000 show that they have risen by 1 per cent. This is a result of an increase in emissions from loading of oil offshore and from agriculture. Methane 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.

In the period 1990 to 1999, methane emissions rose by 8 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. However, more than one third of the rise is related to greater activity in the oil and gas extraction sector. Large amounts of methane evaporate when oil is loaded offshore.

In landfills, methane is generated by biological degradation of waste. Emissions are reduced by flaring and energy recovery of methane from landfills[3]. In 1999, 15 per cent of the methane generated was flared or used for energy recovery.

Nitrous oxide (N_2O)

Emissions of nitrous oxide rose by 3 per cent from 1990 to 1999, but preliminary figures for 2000 show a drop of almost 2 per cent. This is explained by a substantial drop in emissions from the chemical industry, which however is partly counteracted by a rise in emissions from road traffic. The largest sources of N_2O emissions in Norway are agriculture and the manufacture of commercial fertilizer. These accounted for 48 and 35 per cent respectively of domestic emissions in 1999. Emissions from the agricultural sector are largely related to the application of fertilizer and manure and to manure deposited by grazing animals.

The rise in emissions from 1990 to 1999 is related to emissions from petrol-driven vehicles fitted with catalytic converters. When NO_x is converted to N_2, a small proportion of N_2O is also formed. These emissions made up 10 per cent of the total in 1999. Emissions from agriculture and the manufacture of fertilizer have dropped in this period.

There is a large degree of uncertainty associated with the overall level of nitrous oxide emissions. This is because information on emissions from these sources is poor and in most cases, few measurement data are available. Emissions from agriculture are a result of complex processes that are not completely understood, and these may vary widely with climate and soil types.

Other greenhouse gases

From 1990 to 1999, emissions of sulphur hexafluoride (SF_6) were reduced by 65 per cent and emissions of perfluorocarbons (CF_4 and C_2F_6) by 63 per cent. These reductions are mainly a result of wide-ranging measures to reduce emissions from the process industry (magnesium and aluminium production). Measured in CO_2 equivalents, these gases accounted for 3 per cent of Norway's overall greenhouse gas emissions in 1999.

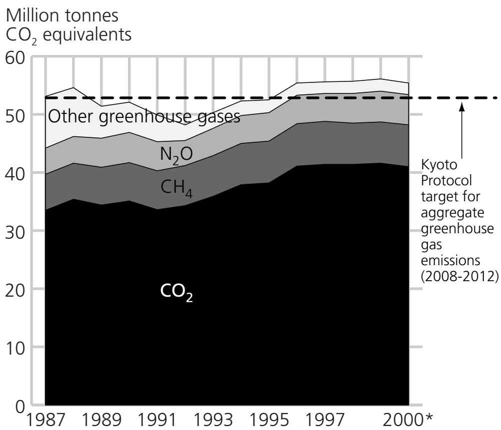
Emissions of hydrofluorocarbons (HFCs) rose from 0.130 to 92 tonnes from 1990 to 1999. These gases only constitute a very small proportion of total greenhouse gas emissions in Norway at present (0.3 per cent in 1999). However, HFC emissions are expected to rise in the years ahead, mainly because they will replace chlorofluorocarbons (CFCs) and hydrochlorofluorocarbons (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 7.6). In 2000, emissions of greenhouse gases in Norway totalled about 55.4 million tonnes CO_2 equivalents (see figure 7.3 and Appendix, table F1). This

[3] The GWP value (see box 7.6) 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.

Figure 7.3. Norwegian emissions of greenhouse gases



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

corresponds to a rise of 6 per cent since 1990. From 1999 to 2000, emissions dropped by 1 per cent. This is the first time since 1995 that there has been a reduction in emissions. However, it is doubtful whether this is the beginning of a new trend and thus whether the drop will continue in 2001.

According to the Kyoto Protocol, Norway's aggregate emissions of greenhouse gases may not rise to more than 1 per cent above the 1990 level by the period 2008-2012[4]. In 1999, total emissions were about 8 per cent higher than this. Projections show that aggregate emissions of greenhouse gases may rise by more than 13 million tonnes CO_2 equivalents in the period 1999-2010 unless new measures are implemented (Report No. 24 (2000-2001) to the Storting). This corresponds to an increase of about 24 per cent from 1990 to 2010. If gas-fired power plants are built, emissions will rise even more (see box 7.5). Without measures to reduce emissions, and if three gas-fired power plants are constructed, Norway's greenhouse gas emissions may rise to about 20 million tonnes CO_2 equivalents higher than the level specified by the Kyoto Protocol. The Protocol allows countries to meet part of their reduction commitments on the basis of measures in other countries,

Box 7.6. 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. The list below shows GWP values for greenhouse gases emitted by Norway to which the Kyoto Protocol applies. The time horizon used here is 100 years.

Substance:	GWP value:
Carbon dioxide (CO_2)	1
Methane (CH_4)	21
Nitrous oxide (N_2O)	310
Hydrofluorocarbons (HFCs)	
HFC-23	11 700
HFC-32	650
HFC-125	2 800
HFC-134a	1 300
HFC-143a	3 800
HFC-152a	140
HFC-227	2 900
Perfluorocarbons (PFCs)	
CF_4 (PFC-14)	6 500
C_2F_6 (PFC-116)	9 200
C_3F_8 (PFC-218)	7 000
Sulphur hexafluoride (SF_6)	23 900

4 According to the Kyoto Protocol, the Kyoto or flexibility mechanisms (see box 7.7) may be used in addition to national measures to reduce emissions in order to achieve the targets of the Protocol. However, the rules for the use of these mechanisms have not yet been finalized.

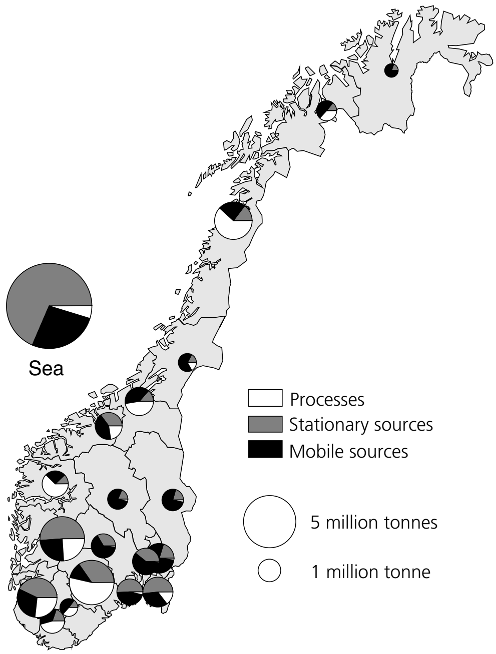
using the Kyoto mechanisms (see box 7.7). However, it is uncertain how large this proportion will be.

Measures to limit emissions
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. The use of coal and coke in process industries is also exempt from the tax. 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.

In addition to national measures, the Government also has proposals for Norway to make use of the Kyoto mechanisms in order to meet its emission targets (see section 7.3). In spring 2001, the Government presented a report to the Storting on its future climate policy. This discusses climate policy instruments generally and a domestic emissions trading system in particular (Report No. 54 (2000-2001) to the Storting).

Greenhouse gas emissions at local level
The environmental authorities wish municipalities and counties to draw up strategies for reducing greenhouse gas emissions on a voluntary basis. In 2000, a grant scheme was therefore established to promote work on climate plans and measures at regional or local level, and many municipalities and county authorities are now drawing up local climate plans.

Figure 7.4. Greenhouse gas emissions in 1998 by source and county



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

Although greenhouse gas emissions are a global environmental problem and do not have direct consequences for the locality or region where emissions occur, measures to reduce emissions may have local consequences. The introduction of greenhouse gas emission permits in energy-intensive manufacturing industries may for instance lead to the closure of enterprises that are very important to their local communities (Bye et al. 1999a). The local consequences of introducing emission permits in energy-intensive manufacturing industries are expected to vary from one part of the country to another (Bye et al. 1999b).

Emissions at county level
Figure 7.4 shows how greenhouse gas emissions were distributed by county in 1998. Carbon dioxide is the most important component in all counties, but in certain agricultural counties, methane accounts for up to 30 per cent of greenhouse gas emissions measured in CO_2 equivalents (see Appendix, table F7).

The distribution of emissions from stationary combustion and process emissions is closely related to the distribution of different types of industrial activity in Norway. As a result of emissions from the petroleum industry and shipping, almost one third of Norway's CO_2 emissions take place at sea off the Norwegian coast. Metal manufacturing results in relatively high CO_2 emissions in Hordaland, Telemark, Rogaland and Nordland. In addition, fertilizer and cement production and the petrochemical industry generate substantial CO_2 emissions in Telemark, and oil refining gives high CO_2 emissions in Hordaland.

Rogaland and Hordaland are the counties where methane emissions are highest. Emissions from livestock farming and landfills here make up about 4 per cent of the total process emissions of greenhouse gases. Process emissions of nitrous oxide from fertilizer production also contribute a substantial proportion of emissions in Telemark and Nordland.

Emissions at municipal level
Manufacturing, road traffic, agriculture and landfills are the most important sources of greenhouse gas emissions in most municipalities. In Oslo, for example, road traffic alone accounted for half of all emissions of CO_2, methane and nitrous oxide in 1998. Emissions from combustion in housing, industrial buildings and other buildings (mainly for domestic heating) accounted for 36 per cent of the total.

From 1997 to 1998, greenhouse gas emissions have risen by an average of 9 per cent in municipalities in Norway[5]. The rise has mainly been caused by higher emissions from road traffic.

7.3. Follow-up of the Kyoto Protocol and greenhouse gas emissions in other countries

In Kyoto, the industrialized countries[6] agreed to reduce their aggregate emissions of the greenhouse gases carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O), hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6) by 5.2 per cent by the period 2008-2012. The quantitative commitments in the agreement are differentiated - some countries must reduce their emissions to below the 1990 level (or the 1995 level for the last three gases), while others may allow a certain increase in emissions. Norway's emissions may rise by 1 per cent compared with the 1990 level.

Flexibility mechanisms (the Kyoto mechanisms, see box 7.7) 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

5 Unlike the national emission inventory, this does not include emissions from the continental shelf, Norwegian fishing vessels outside the 200-mile limit, emissions from air traffic and emissions from Svalbard and Jan Mayen.

6 These 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).

Box 7.7. The Kyoto mechanisms

Emissions trading
Countries that have undertaken commitments 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 is 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.

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. By mid-2001, the Protocol has been ratified by 35 countries, but these are mainly small island states. Neither Norway nor any other countries that have undertaken commitments to reduce emissions have ratified the Protocol as yet.

Since the Kyoto meeting, several Conferences of the Parties have been held in an attempt to deal with unresolved matters, for example in connection with the flexibility mechanisms. The sixth Conference of the Parties (COP6) was begun in The Hague in November 2000, but it has not yet been possible to reach agreement on supplementary rules for the Protocol. The aim is to complete COP6 in the course of 2001.

In Report No. 24 (2000-2001) to the Storting, the Government states that it is working actively with various policy instruments and measures to ensure that Norway meets its commitment under the Kyoto Protocol. The first objective is to show significant progress by 2005. The Government submitted a report to the Storting on future climate policy in June 2001 (Report No. 54 (2000-2001) to the Storting). This describes the policy instruments that are to be used, and in particular, deals with the introduction of a domestic quota-based emissions trading system. A committee that was appointed to review the introduction of such a system submitted its report early in 2000 (Ministry of the Environment 2000a). The report 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. Quotas can 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.

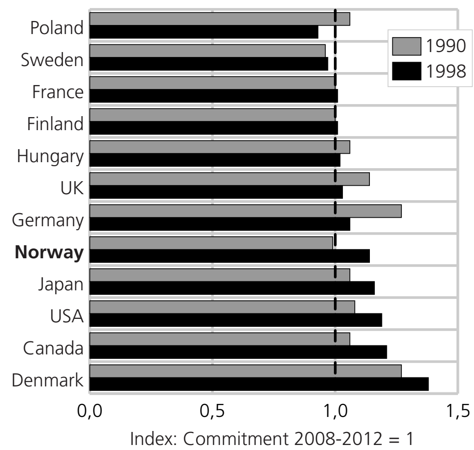
Norway is also dependent on being able to make use of the Kyoto mechanisms to fulfil its commitments. In addition to emissions trading, use of the clean development mechanism is one way of compensating for domestic emissions (see Box 7.7). Norway has entered into an agreement with China to provide NOK 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.

Greenhouse gas emissions in other countries

The national emission inventories that have been reported to the IPCC show that CO_2 emissions rose in most industrial countries between 1990 and 1998. 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 in the period 2008-2012.

Figure 7.5 shows reported emissions of the greenhouse gases CO_2, CH_4 and N_2O in 1990 and 1998 for some selected Annex I countries[7], 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, Japan, the USA, Canada and Denmark, there has been a substantial increase in aggregate emissions in the period 1990-1998.

Figure 7.5. Emissions in 1990 and 1998[1] and emission reduction commitments under the Kyoto Protocol[2] for the period 2008-2012



[1] Japan has not reported 1998 figures, so figures for 1997 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.
Source: 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 7.7) to meet its commitments.

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

In the OECD countries, there has been an overall slight rise in CO_2 emissions from energy use in the period 1980-1997 (Appendix, table F9). Emissions of CO_2 from energy use 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).

7.4. 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 deposition of acidifying substances in Norway (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, acid rain has its most serious impact 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, the 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).

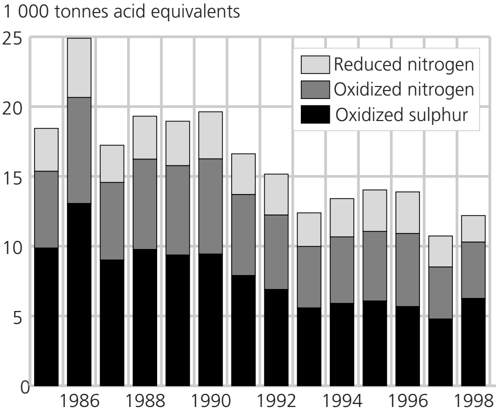
In 1979, the ECE[8] Convention on Long-range Transboundary Air Pollution (LRTAP) was adopted. The first two protocols under this convention dealt with reductions of sulphur dioxide and nitrogen oxide emissions. Later, protocols have also been developed for other long-range pollutants such as volatile organic compounds, heavy metals and persistent organic pollutants (POPs). In December 1999, a new protocol was signed in Gothenburg, 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

[8] UN Economic Commission for Europe.

Figure 7.6. Deposition of acidifying substances in Norway[1]



[1] Calculations for 1997 and 1998 were made using a different model and the figures are therefore not directly comparable with those for earlier years.
Source: Norwegian Meteorological Institute (2001).

Table 7.1. Contributions of different countries to deposition of acidifying substances in Norway. 1998

	Total (1 000 tonnes acid equivalents)	Oxidized sulphur (1 000 tonn S)	Oxidized nitrogen (1 000 tonnes N)	Reduced nitrogen (1 000 tonnes N)
Total	**12.1**	**100.1**	**56.4**	**26.6**
Norway	1.8	5.2	8.3	11.8
Other Nordic countries ...	0.9	3.1	5.1	4.3
UK	1.5	14.0	6.6	1.9
Germany ...	1.0	7.8	4.2	2.7
France	0.4	2.3	2.1	1.5
Russian Federation .	1.2	18.5	0.9	0.1
Poland	0.6	6.7	1.5	1.2
Sea[1]	0.9	6.5	6.4	-
Other countries and sources	3.9	36.0	21.3	3.1

[1] Includes emissions from shipping and petroleum activities.
Source: Norwegian Meteorological Institute (2001).

the deposition of such substances in Norway (figure 7.6). 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).

In 1998, Russia, the UK, Germany and Poland accounted for the largest amounts of sulphur deposition in Norway, but SO_2 emissions from international shipping are also a major source of sulphur deposition (table 7.1). 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 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 (Norwegian Meteorological Institute 2001), but about 10 per cent of each pollutant is deposited in Sweden.

Sulphur dioxide (SO_2)

Calculations for 1999 show that about 28 700 tonnes of SO_2 were emitted, which is a reduction of 4 per cent from the year before. Since 1980, emissions have been reduced by about 80 per cent.

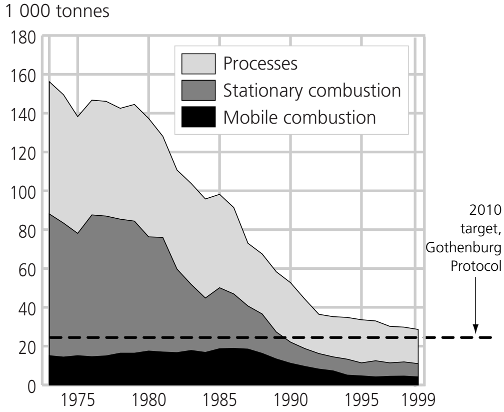
Industrial processes accounted for more than 60 per cent of Norway's SO_2 emissions in 1999, and stationary and mobile combustion for 24 and 15 per cent respectively. Thirty-two per cent of the total was generated by the manufacture of iron, steel and ferro-alloys (Appendix, table F6). Emissions from 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 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. Nor are they included in the international commitments.

In the period from 1980 to 1992, there was a particularly marked reduction in SO_2 emissions from industrial processes and stationary combustion (figure 7.7). 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.

In 1999, Norway's emissions were well under the country's commitment under the 1994 Sulphur Protocol. However, according to the Gothenburg Protocol, Norway has undertaken to ensure that its emissions do not exceed 22 000 tonnes in 2010, which corresponds to a reduction

Figure 7.7. Emissions of SO_2 by source



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

of 6 700 tonnes compared with the 1999 level.

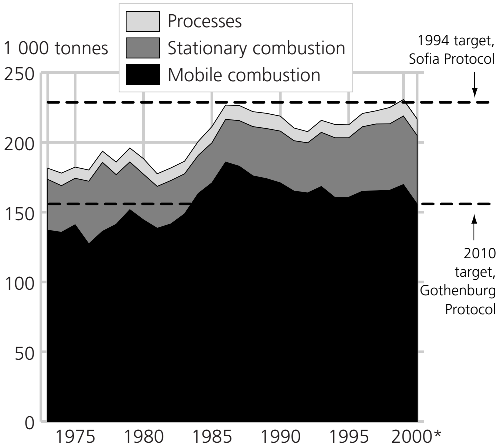
Norway has used a number of different instruments to reduce its SO_2 emissions. The most important of these are the sulphur tax, the use of discharge permits under the Pollution Control Act to regulate emissions, and restrictions on the permitted sulphur content of mineral oils (Report No. 8 (1999-2000) to the Storting). In 1999, a sulphur tax was introduced on coal, coke, emissions from oil refineries and mineral oils that were previously exempt from the tax.

From 1 January 2000, a separate tax was introduced on auto diesel containing more than 0.005 per cent by weight sulphur. From the same date, a graded system for taxation of shipping was introduced, based partly on levels of SO_2 emissions (Proposition No. 87 (1999-2000) to the Storting).

Nitrogen oxides (NO_X)

In the period 1980 – 1999, emissions of nitrogen oxides rose by more than 20 per cent (figure 7.8). Preliminary figures

Figure 7.8. Emissions of NO_x by source



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

show that NO_x emissions totalled 216 700 tonnes in 2000, which corresponds to a reduction of 6 per cent compared with the 1999 level. However, there is a long way to go before the emission ceiling set out in the Gothenburg Protocol is reached. Emissions must be reduced by a further 25 per cent before 2010. The drop in the past year is mainly a result of a reduction in emissions from road traffic and shipping. The main sources of NO_x emissions are shipping (ca. 40 per cent), road traffic (ca. 25 per cent) and oil and gas extraction (ca. 15 per cent, see Appendix, table F6).

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 57 per cent in 2000. NO_x emissions from road traffic have been reduced by 22 000 tonnes in this period, despite the fact that annual emissions from diesel vehicles have risen by almost 5 000 tonnes. Emissions from shipping and oil and gas extraction rose by 23 000 tonnes and 10 000 tonnes respectively in the period 1990 – 1999. However, there is evidence to suggest that NO_x emissions in 2000 were in fact somewhat higher than our figures show, so that the true reduction in emissions was not as much as 6 per cent. Emissions from road traffic are calculated on the basis of sales figures, not consumption, and it appears that the consumption of auto diesel and petrol in 2000 did not drop as much as sales of these products.

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. In the county with the next-highest NO_x emissions, Akershus, mobile sources account for 94 per cent of the total.

According to the 1988 Sofia Protocol, Norway undertook to stabilize its NO_x emissions below the 1987 level from 1994 onwards. This commitment was met in the period 1994 – 1998, but the emission ceiling was exceeded by 2 000 tonnes in 1999. Preliminary calculations for 2000 indicate that emissions were 12 000 tonnes below the 1987 level this year. In the Gothenburg Protocol, Norway has agreed to an emission ceiling of 156 ktonnes NO_x in 2010. This corresponds to a reduction of 61 000 tonnes from the 2000 level.

In Report No. 24 (2000-2001) to the Storting, the Government describes a number of measures that could be used to ensure that Norway fulfils its commitment under the Sofia Protocol. The measures are targeted towards shipping, fishing vessels, land-based industry and petroleum activities. The Government wishes to implement the most cost-effective measures.

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). A grading system for tonnage dues, based on environmental declarations for ships, has also been introduced (Proposition No. 87 (1999-2000) to the Storting). Emissions of nitrogen oxides from road vehicles are governed by the regulations relating to motor vehicles. In addition, the road tax for heavy-duty vehicles has since 2000 been differentiated according to their NO_x emissions. The tax rate is determined on the basis of which of the emission standards set out in the relevant EU directive the vehicles satisfy (see also section 7.10).

Ammonia (NH_3)

Preliminary calculations for 2000 indicate that ammonia emissions totalled 27 000 tonnes, which is an increase of 18 per cent from 1990. Ammonia emissions rose by 2 per cent last year. 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.

In the Gothenburg 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 a further 15 per cent. Report No. 24 (2000-2001) 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 .

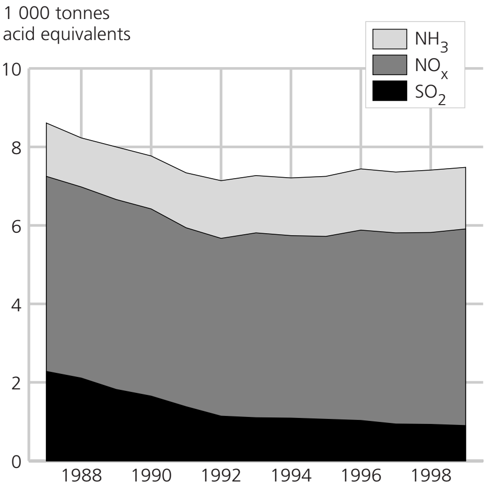
Aggregate emissions of acidifying substances

Norway's aggregate emissions of acidifying substances, expressed as acid equivalents, have been reduced by 13 per cent from 1987 to 2000 (figure 7.9). This reduction is explained by the drop in sulphur dioxide emissions in the late 1980s and early 1990s. Since 1992, emissions have risen slightly as a result of higher emissions of NO_x and NH_3. Nitrogen oxides make up more than one third of the total expressed as acid equivalents.

In 1999, mobile combustion accounted for more than half of the overall emissions of acidifying substances, and shipping (30 per cent) and road traffic (18 per cent) were the largest sources. Two other major sources of emissions are agriculture and oil and gas extraction, which accounted for 20 per cent and 10 per cent respectively of the total.

However, when emissions of various acidifying substances are weighted and pooled to find the total figure, it is important to remember that the dispersal potential varies from one substance to another. A larger proportion of sulphur

Figure 7.9. Emissions of acidifying substances in Norway



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

dioxide and nitrogen dioxide than of ammonia is deposited in other countries or in the sea. On the other hand, Norway receives large amounts of SO_2 and NO_x emitted by other countries.

Because the damage caused by the various acidifying substances depends on several factors, including their acidifying and dispersal potential and the sensitivity of the area where they are deposited, the Gothenburg Protocol specifies separate emission targets for each substance.

Acidifying emissions in other countries

In the Gothenburg 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 7.2 shows trends in emission levels and the targets set for 2010 for these three countries and for Sweden, Denmark and Norway. 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 58 per cent for NO_x.

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

Table 7.2. Emissions and emission targets for SO_2 and NO_x. 1 000 tonnes

Country	SO_2			NO_x		
	Emissions		Target	Emissions		Target
	1990	1998	2010	1990	1998	2010
UK	3 736	1 615	625	2 788	1 753	1 181
Germany	5 321	1 292	550	2 709	1 780	1 081
Russian Federation[1]	4 460	2 208	..	3 600	2 488	..
Sweden	119	49	67	338	257	148
Denmark	183	77	55	279	231	127
Norway	53	30	22	219	224	156

[1] The figures apply to the European part, within the EMEP area.

Source: Norwegian Meteorological Institute (2001) and UN/ECE(1999).

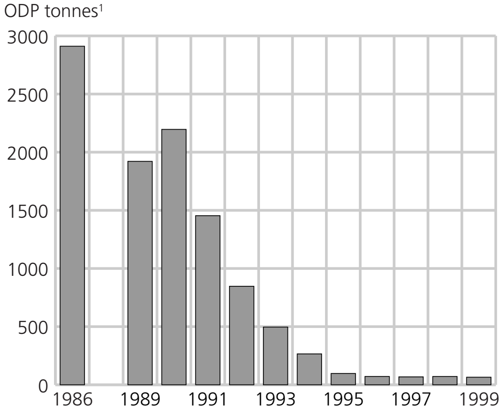
addition, growth of plants and plankton may be reduced.

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, they 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 7.10). 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 (Norwegian Institute for Air Research 1996a, Braathen 1999). An analysis for the period 1979-1998, based on measurements at ground level in Oslo, shows a reduction of 0.39 per cent per year in the thickness of the ozone layer (Norwegian Institute for Air Research 1999).

Figure 7.10. 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.

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 southern 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.

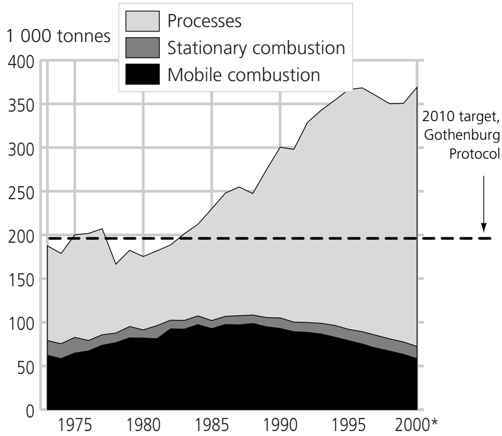
The Gothenburg Protocol applies to long-range air pollutants that are responsible for three different environmental problems – acidification, eutrophication and the formation of ground-level ozone. These include NO_x and NMVOCs[9] (non-methane volatile organic compounds). Nitrogen oxides also cause acidification 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 are still rising, and have increased by more than 5 per cent in the past year. Preliminary calculations for 2000 indicate total emissions of 369 000 tonnes. 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 the past year is mainly from loading of crude oil offshore.

Emissions of NMVOCs rose steeply from the late 1970s to 1996 (figure 7.11). This was 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. NMVOC emissions from mobile combustion have dropped steadily since 1988 as a result of improvements in energy efficiency and lower emissions per unit of fuel for road vehicles. In the last few years, there has also been a reduction in process emissions, mainly because of the installation of a recovery facility for oil vapour at one of the onshore oil terminals.

Figure 7.11. Emissions of NMVOCs by source



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

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 27 per cent in this period. In the 1999 Gothenburg Protocol, Norway has also undertaken to meet an emission ceiling of 195 ktonnes NMVOCs in 2010. This means that emissions must be reduced by 47 per cent compared with the 2000 level.

The Norwegian Pollution Control Authority has now, pursuant to the Pollution Control Act, required oil companies to reduce VOC emissions from loading and storage of crude oil on the continental shelf (Report No. 24 (2000-2001) to the Storting). Even though the industry has been given until 2005 to meet the emission targets fully, quantitative requirements for emission reductions have been set for 2001 and 2003 as well.

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

7.7. Persistent organic pollutants (POPs) and heavy metals

Emissions of persistent organic pollutants and heavy metals to water, air and soil are considered to be a serious pollution problem. Persistent organic pollutants break down very slowly in the environment, and heavy metals do not break down at all. Both groups of pollutants may therefore accumulate in food chains. They may also be transported over long distances, and pollution of this type is therefore considered to be a regional environmental problem. Persistent organic pollutants and heavy metals are now included in two protocols under the Convention on Long-range Transboundary Air Pollution (LRTAP Convention). So far, these only include specific commitments for lead (Pb), cadmium (Cd) and mercury (Hg) of the heavy metals, and for polycyclic aromatic hydrocarbons (PAHs), dioxins/furans and hexachlorobenzene. Emissions of these substances are not to exceed the level in a given reference year (1990 for Norway). This is less ambitious than Norway's national target, which states that emissions of these substances are to be substantially reduced by 2010 at the latest, using 1995 as the base year (Report No. 58 (1996-1997) to the Storting).

There have been major changes in emission levels for most heavy metals and persistent organic pollutants in recent years (Finstad et al. 2001). Emissions of lead from petrol have been greatly reduced, as have industrial emissions of a number of hazardous chemicals. However, the figures for emissions of heavy metals and POPs are very uncertain. This is partly because relatively few measurements have been made of emissions from diffuse sources (non-industrial sources), but also because the content of such substances in products is variable. There may also be emissions from unknown sources. The quality of data on industrial emissions (measured and reported to the Norwegian Pollution Control Authority by the enterprises themselves) has been substantially improved in recent years. More enterprises are providing reports, and many of them are reporting higher levels of emissions than previously. However, there is considerable uncertainty as to what the levels of emissions were in 1990, which is the reference year for both LRTAP protocols.

PAHs

PAHs (polycyclic aromatic hydrocarbons) include many different compounds with a variety of toxic properties. In general, their acute toxicity is low, but they may be carcinogenic and cause cellular changes. They are fat-soluble, and if inhaled may be absorbed in the lungs. The most serious effects of inhaled PAHs arise when they become attached to particles in the air that are then inhaled. Current knowledge suggests that the risk of cancer is higher when PAHs are inhaled than when they are ingested. PAHs may also react with halogens and gases containing nitrogen and sulphur to form more harmful products.

PAH is a generic term for a group of substances that consist of two or more carbon rings, at least one of which is a benzene ring. PAHs are always formed during incomplete combustion of organic material, for example in heating systems, motor vehicle exhaust and during forest fires. PAHs with a low boiling point are emitted as gases, but in most cases they become attached to particulates in smoke, dust and soot.

The term "PAHs" may include many different compounds, and there are several different standards defining which PAHs are to be measured. The Norwegian aluminium industry is required to measure concentrations of 16 PAHs, according to a Norwegian standard (NS9815). In addition, there is a standard for measuring emissions from fuelwood use (NS3058-3). The term "total PAH" as used here means roughly the same as the compounds included in NS9815. The LRTAP protocol is based on only four indicator compounds. Table 7.3 shows which PAHs are included in the various standards.

PAH emissions have remained relatively stable in the period 1990 – 1999 (figure 7.12 and Appendix, table F12). In 1999, emissions of total PAH were 149 tonnes. This is 6 per cent less than in 1990, and 4 per cent lower than in 1995, which is the base year for the national target of a substantial reduction in emissions. Emissions of the four substances included in the LRTAP protocol have been reduced by 8 per cent since 1990.

In 1999, 93 per cent of PAH emissions were generated by stationary combustion and processes (Appendix, table F13). Fuelwood use accounted for 37 per cent of total PAH emissions in Norway. Emissions from fuelwood use have increased by 10 per cent since 1990, but are expected to drop in the future as the proportion of modern wood-burning stoves rises.

Ten per cent of emissions from stationary combustion were generated by a variety

Table 7.3. PAHs included in two different Norwegian standards (NS), US-EPA, LRTAP (PAH-4) and Borneff (PAH-6)

Name	NS9815[1] (aluminium industry)	NS3058-3[1] (fuelwood use)	U.S.EPA[2] PAH-16	LRTAP	Borneff
Benzo(a)pyrene	x	x	x	x	x
Benzo(b)fluoranthene	x	x	x	x	x
Benzo(k)fluoranthene	x	x	x	x	x
Indeno(1,2,3-cd)pyrene	x	x	x	x	x
Fluoranthene	x	x	x		x
Benzo(ghi)perylene	x	x	x		x
Phenanthrene	x	x	x		
Anthracene	x	x	x		
Pyrene	x	x	x		
Benzo(a)fluorene	x				
Benzo(b)fluorene	x				
Benzo(a)anthracene	x	x	x		
Chrysene/triphenylene	x	x [1]	x		
Benzo(e)pyrene	x	x			
Dibenzo(ah)anthracene	x	x	x		
Dibenzo(ae)pyrene	x				
Dibenzo(ah)pyrene	x				
Dibenzo(ai)pyrene	x				
Acenaphthene		x	x		
Acenaphthylene			x		
Fluorene		x	x		
Naphthalene			x		

[1] NS3058-3 includes chrysene only. NS9815 also includes chrysene/triphenylene.[2] US-EPA: US Environmental Protection Agency.
Source: Finstad et al. (2001).

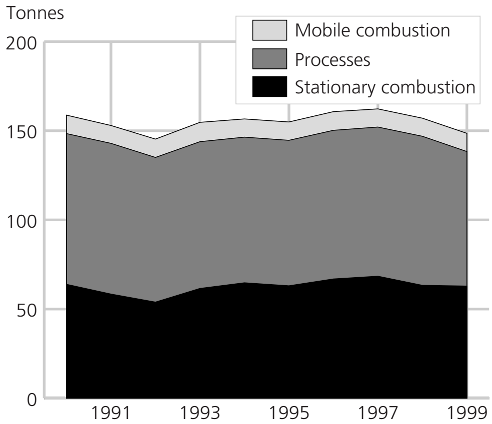
of small sources. Most of this was from burning of stubble, but these figures are very uncertain. However, there has been a reduction in the area of stubble burnt during the 1990s, with a resulting drop in emissions. Aluminium production accounts for 35 per cent of total emissions. This is 9.5 per cent less than in 1990, despite an increase in production. The drop is explained by changes in production methods. The use of materials treated with creosote generated 18 tonnes of PAH emissions, or 12 per cent of total PAH emissions in Norway. However, the data for emissions from this source are very uncertain.

Emissions from mobile combustion have been fairly constant since 1990, and made up 7 per cent of the total in 1999. However, emissions have dropped relative to the volume of traffic because of stricter standards for the content of particulate matter and VOCs (volatile organic compounds) in exhaust. Today, diesel is the main source of PAH emissions from mobile combustion, whereas emissions from petrol-driven vehicles were equally important in 1990.

Lead

Lead is transported in the atmosphere bound to particulate matter. It is readily absorbed into the body, and accumulates in the skeleton, where it has a half-life of 20 years. Lead damages the nervous system. Children are more vulnerable than adults, the concentration at which brain damage becomes apparent in children is only one-fifth of that which causes damage in adults. It has been shown that children who have been exposed to lead may show behavioural disturbances and have reading and concentration problems. It has also been shown that lead is harmful to the kidneys, but it is uncertain whether it is carcinogenic.

Figure 7.12. Emissions of total PAH to air, by source. 1990 to 1999

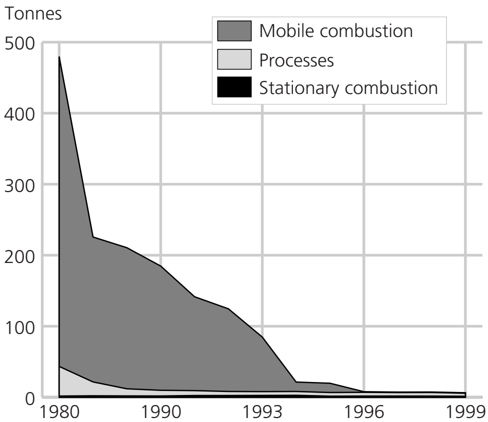


Source: Statistics Norway and Norwegian Pollution Control Authority.

In 1999, lead emissions to air totalled 6.3 tonnes. This is a drop of 97 per cent since 1990 (figure 7.13 and Appendix, table F12). The main reason is that there has been no leaded petrol on the Norwegian market since 1997. Since 1995, emissions have been reduced by 68 per cent.

Emissions from the process industry are the most important source of lead emissions to air in Norway today (Appendix, table F13). In 1999, these accounted for two-thirds of the total, and the largest source was the manufacture of iron, steel and ferro-alloys. Using the improved data reported on industrial emissions, it has been calculated that in 1998, emissions were more than twice as high as previously assumed in the figures published by Statistics Norway. Nevertheless, industrial emissions have been reduced by 40 per cent since 1990, mainly because of the closure of industrial enterprises that had high emissions. In 1999, 22 per cent of

Figure 7.13. Emissions of lead to air by source. 1990 to 1999



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

total emissions were generated by stationary combustion, mainly incineration of wood waste, black liquor, heavy fuel oil and waste oil. Mobile combustion accounted for only 11 per cent of the total, as compared with 95 per cent in 1990. Today, leaded aviation fuel used in domestic air transport is the largest source of lead emissions from mobile combustion.

Mercury

Mercury is transported in the atmosphere as vapour, but is converted to organic mercury in contact with organic material and anaerobic bacteria. Organic mercury is extremely toxic, and is the most important form of mercury in connection with health damage resulting from exposure to environmental pollution. The most serious effects in adults are damage to the nervous system, and in the fetus, widespread damage if the mother has been exposed to mercury. Organic mercury has also been shown to cause cellular changes. Organic mercury bioaccumulates both in organisms and along food chains. Inorganic and elemental mercury can accumulate in the kidneys and cause damage there.

In 1999, emissions of mercury to air totalled 1.2 tonnes. This is 32 per cent lower than in 1990, but 3.5 per cent higher than in 1995 (figure 7.14 and Appendix, table F12). The drop since 1990 is mainly explained by a 45 per cent reduction in mercury emissions from the manufacture of iron, steel and ferro-alloys. In 1999, this industry accounted for 28 per cent of total mercury emissions.

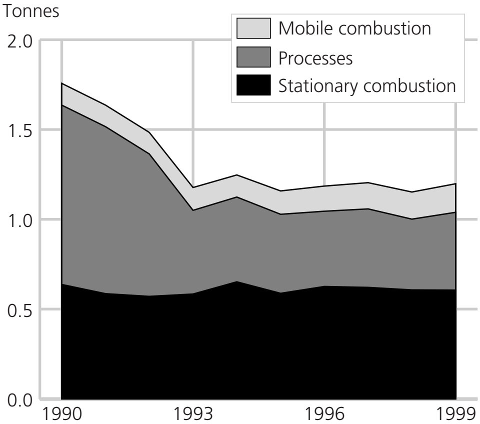
The largest percentage decrease has been in mercury emissions from the use of products containing mercury, such as thermometers and amalgam fillings (Appendix, table F13). The reduction here was 85 per cent.

In 1999, half of all mercury emissions were generated by stationary combustion, mainly the combustion of wood and black liquor. However, these figures are relatively uncertain. Emissions from mobile combustion have risen by 31 per cent from 1990, and accounted for 13 per cent of the total in 1999. The rise is explained by higher consumption of diesel by road vehicles and shipping.

Cadmium

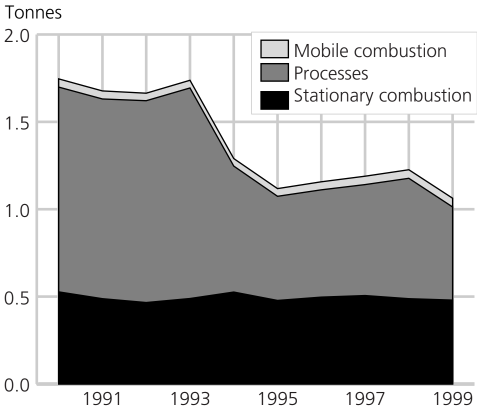
Cadmium is readily absorbed by plants, and accumulates in fish and mammals. The most important route of exposure for cadmium is via the lungs, while relatively little is absorbed via the intestines. Cadmium accumulates in soft tissues, especially the kidneys, and has a biological half-life of more than 30 years. Delayed effects of cadmium include reduced fertility in men, pulmonary emphysema and cancer.

Figure 7.14. Emissions of mercury to air by source. 1990 to 1999



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

Figure 7.15. Emissions of cadmium to air by source. 1990 to 1999



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

In 1999, emissions of cadmium to air totalled 1.1 tonnes, which is a reduction of 39 per cent since 1990 and 5 per cent since 1995 (figure 7.15 and Appendix, table F12). The large cut in emissions since 1990 is explained by a 58 per cent drop in emissions from metal manufacturing in the same period, mainly a reduction in emissions during zinc production. Nevertheless, more than half of all emissions were still generated by process activities in 1999, mainly the manufacture of iron, steel and ferro-alloys (Appendix, table F13). The emissions of cadmium from the process industry in 1998 reported here are about twice as high as previously published figures. This is a result of improvements in the reporting of emission data by the enterprises themselves. In 1999, 45 per cent of emissions were generated by stationary combustion, mainly the combustion of wood and black liquor. However, these figures are uncertain.

7.8. Local air quality and emissions to air in towns and urban settlements

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

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. Road traffic (exhaust, wear and tear of asphalt) and fuelwood use 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 1999b). 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 may be a cause of death. Rosendahl (2000) 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 (1999b) 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 2000).

The relationship between emissions to air and air quality is not always straightforward. Emissions via chimneys from domestic heating may not have the same effect on air quality where people are exposed to pollution as emissions from car exhaust or the 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.

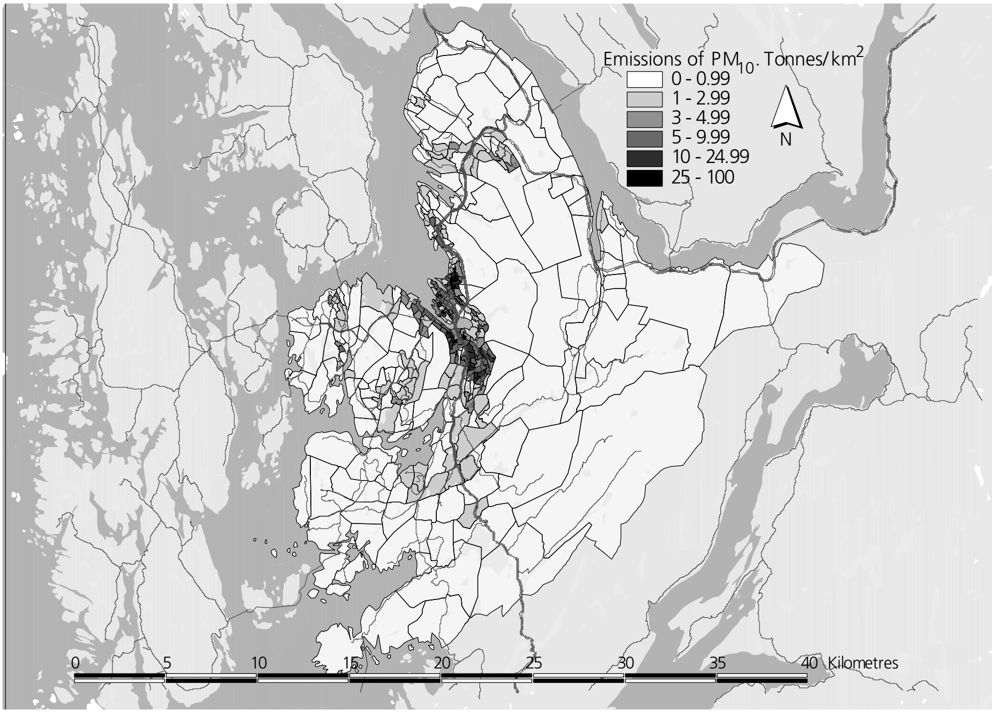
The concentrations of benzene, carbon monoxide (CO) and ozone (O_3) are also important for air quality. Benzene is carcinogenic, and emissions originate from incomplete combustion of petrol, the use of fuelwood and other combustion. Measurements in Oslo and Drammen suggest that benzene levels are relatively 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.

Particulate matter

Total emissions of particulate matter in Norway reached a peak of 25 000 tonnes in 1997. In 1999, emissions were just over 23 000 tonnes, about the same as in 1990. Preliminary figures for 2000 indicate that emissions have been reduced by a further 3.5 per cent from 1999.

In Norway, heating in private households accounted for 61 per cent of emissions in 1999. Most of this was generated by fuelwood use. Emissions in exhaust from road traffic (mainly from diesel vehicles)

Figure 7.16. Emissions of particulate matter in Bergen[1]. Basic units. 1996. Tonnes/km²



[1] Road traffic is not included in the figures.
Source: Haakonsen (2000).

accounted for 14 per cent and dust from wear and tear of asphalt for 7 per cent. Although national emission figures can tell us something about pollution levels and trends, it is primarily local emissions that are important. Table F8 in the Appendix shows emissions of particulate matter to air by municipality. For a number of municipalities, emissions for certain years have been further split between basic units (see box 7.9). Figure 7.16 shows as an example the geographical distribution of emissions of particulate matter in Bergen in 1996 by basic unit (Haakonsen 2000).

The maximum concentrations of particulate matter recommended in Norwegian air quality guidelines are 24-hour means of 35 mg/m³ for particles measuring less than 10 μm in diameter (PM_{10}) and 20 mg/m³ for particles measuring less than 2.5 μm in diameter ($PM_{2.5}$). Norway's national target is that the 24-hour mean concentration of particulate matter (PM_{10}) shall not exceed 50 μg/m³ on more than 25 days per year by 2005 and 7 days per year by 2010 (Report No. 24 (2000-2001) to the Storting).

It is estimated that to meet the requirements of the current Regulations relating to limit values for local air pollution and noise, 80 per cent of the cars in Oslo, Bergen, Trondheim and Stavanger must use non-studded tyres in winter. Even though the proportion of cars using non-studded tyres has risen, calculations by the Directorate of Public Roads show that the proportion using studded tyres will still exceed 20 per cent in several of these towns in 2002 (Report No. 8 (1999-2000) to the Storting).

From winter 1999-2000, the municipalities have had the authority to impose a charge on vehicles using studded tyres. In Oslo, a charge for the use of studded tyres was introduced last year, combined with a refund scheme if studded tyres are replaced by new non-studded winter tyres. The proportion of the volume of transport carried out using studded tyres in Oslo has been reduced from ca. 80 per cent in 1995-1996 to 30 per cent in winter 1999-2000 (Report No. 24 (2000-2001) to the Storting). In winter 1999-2000, the corresponding figures for Bergen and Trondheim were just under 40 per cent and just over 60 per cent respectively. Trondheim and Bergen will probably introduce charges for the use of studded tyres from winter 2001-2002. The Government will revise the Regulations relating to limit values for local air pollution and noise, partly in order to implement new EU legislation (Report No. 24 (2000-2001) to the Storting). In connection with this, the possibility of giving the municipalities more responsibility and authority for ensuring compliance with the regulations will be considered.

Other means of improving local air quality in addition to charging for the use of studded tyres include road pricing schemes, regulation of parking, improvements in public transport and measures to make cycling more attractive. The Government will therefore make arrangements to facilitate the use of road pricing schemes where the local authorities wish to introduce them, and has proposed that the revenues from such schemes should be earmarked for local transport purposes (Report No. 24 (2000-2001) to the Storting). The Government also wishes to modify the legislation to allow municipalities to use regulation of parking as an effective policy instrument.

Possible measures to reduce emissions from domestic fuelwood use 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 about 800 old wood-burning stoves were replaced with new, cleaner types (Kjønnerud 2000). Bergen ran a similar scheme in winter 1999-2000, which has resulted in the replacement of 500 stoves (Grindheim 2000).

NO_x

Norway's total NO_x emissions have dropped by 6 per cent (14 000 tonnes) from 1999 to 2000. In the period 1990 – 2000, the decrease was only 1 per cent (section 7.4). The distribution of NO_x emissions by municipality (Appendix, table F8) shows that in general, emissions are highest in municipalities where there are manufacturing industries, or where population density is high and/or there are national highways.

Norway's national target is that by 2010, the hourly mean concentration of nitrogen dioxide (NO_2) shall not exceed 150 $\mu g/m^3$ for more than 8 hours per year (Report No. 24 (2000-2001) to the Storting). At present, this limit is exceeded in several of Norway's larger towns.

Calculations show that it will be difficult to achieve the national target without introducing new measures (Report No. 24 (2000-2001) to the Storting). Measures that can be implemented to reduce particulate emissions from combustion (see above), will also reduce NO_x emissions.

CO

In 1999, carbon monoxide emissions totalled 565 000 tonnes in Norway. This is a drop of more than 30 per cent from the 1990 level. Road traffic, mainly petrol-driven engines, accounted for 55 per cent of total CO emissions. Heating of housing, particularly with fuelwood, accounted for 25 per cent of the total. Manufacturing accounted for 9 per cent, and the rest was generated by the use of motorized equipment, small boats and shipping.

Box 7.8. Emissions to air by county and municipality

Tables F7 and F8 in the Appendix show emissions of a number of pollutants by county and 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 (Daasvatn et al. 1994).

The reduction since 1990 is mainly explained by a drop in emissions from mobile sources as a result of improvements in combustion technology and lower petrol consumption. Preliminary calculations for 2000 give emissions of 532 000 tonnes, which is a further reduction of 6 per cent from the year before.

Box 7.9. Calculation of air pollution per basic unit

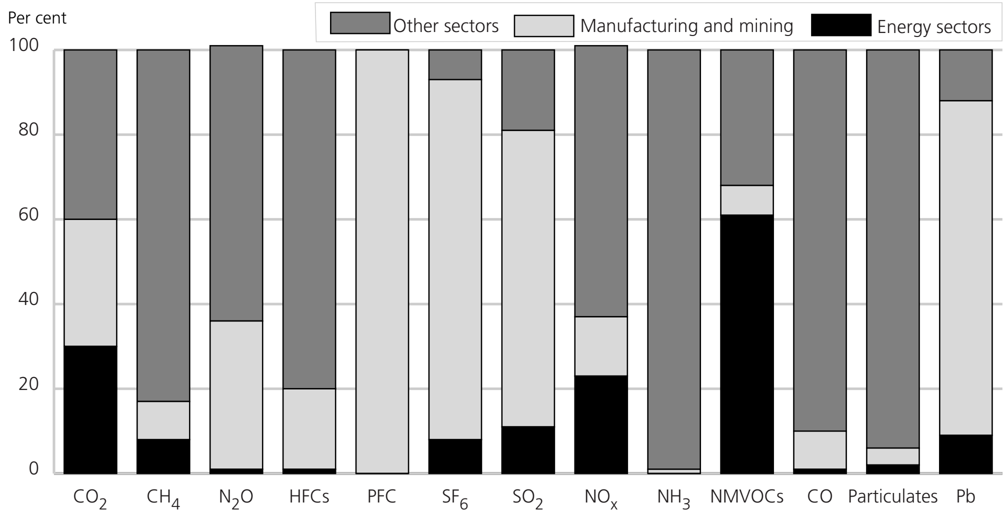
Statistics Norway has calculated emissions to air per basic unit in 12 Norwegian municipalities (Flugsrud et al. 1996, Haakonsen 2000 and Haakonsen et al. 1998a, 1998b) for the Norwegian Pollution Control Authority. Basic units are the smallest geographical unit Statistics Norway uses for statistical 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 cooperation with NORGIT. The Oslo City Department of Environmental Health and Food Control uses AirQUIS for daily monitoring of air quality and in impact assessment to evaluate measures to combat pollution.

Fuelwood use and road traffic are equally important as sources of particulate emissions in urban areas. However, the figures for fuelwood consumption per municipality, their geographical distribution within municipalities and emission factors (g particulates/kg wood) are very uncertain. The emission factors for particulates depend for example on heating patterns and combustion technology. Statistics Norway is currently trying to improve the quality of these emission figures.

Figure 7.17. Emissions of various pollutants to air split between the energy sectors, manufacturing and other sectors. 1998



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

7.9. Trends in emissions from important sources

Earlier sections of this chapter present emission levels and trends in emissions of greenhouse gases and air pollutants. In general, transport, oil and gas extraction and various types of industrial production are the most important sources of emissions (Appendix, table F6 and figure 7.17). However, the overall emission level is not the only fact of interest with regard to trends in emission levels. In manufacturing industries, for example, emission levels in relation to production and value added are relevant indicators for trends in emissions, while emissions relative to transport work[10] are particularly significant in the transport sector. Chapter 6 presents an analysis of energy use and emissions relative to transport work for various modes of transport (Holtskog 2001). Her, we present an analysis of energy use and emissions to air relative to production in certain industrial sectors.

Indicators for industrial energy use and emissions to air

Norway's industries provide employment and contribute to economic growth, but their emissions to air of greenhouse gases and other pollutants also give rise to environmental problems. As part of Statistics Norway's project on industrial energy use (Martinsen 2000), we have looked at various indicators related to industrial energy use and emissions to air.

In NOREEA (Norwegian Environmental and Economic Accounts), energy use and

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[10] Transport work is measured in tonne-kilometres for goods transport and passenger-kilometres for passenger transport.

[11] Value added is the additional value created or income generated by the process of production in a sector, and defined as the value of output less the value of intermediate consumption (Statistics Norway 1999a).

emissions to air are linked to data from the national accounts for each industry (Hass and Sørensen 1997, Statistics Norway 1998b). By considering for example emissions in relation to value added[11], we obtain an indicator of how much air pollution is associated with value added in various industries. However, this indicator will vary with the sales value of the goods produced and other economic factors.

An alternative is to calculate emissions in relation to production expressed in physical units. This gives an indicator that is independent of economic parameters and that can supplement an indicator based on value added. We have looked at emissions and energy use in relation to production in the following industries: cement, ferro-alloys, aluminium, crude oil and natural gas, petroleum products, pulp, and paper and board. These industries are considered to be particularly important as regards both value added and emissions to air. To obtain an indication of trends in specific energy use (energy use per unit produced) and specific emissions (emissions per unit produced), indicators have been calculated for the years 1990 and 1998.

Table 7.4 shows the direction of trends in energy use and emissions per unit produced when the years 1990 and 1998 are compared. Only those pollutants that are important in most industrial sectors have been included. The data on which the calculations are based are uncertain for some of the types of production we have considered, so that the changes indicated by the table must be treated with some caution.

Table 7.4. Changes[1] in energy use and emissions relative to production from 1990 to 1998, expressed in physical units

	Specific energy use	Specific emissions to air			
		CO_2	SO_2	NO_x	NMVOC
Oil and gas	–	–	–	–	–
Petroleum products	o	o	–	–	–
Pulp[2]	o	+	–	+	+
Paper and board	(+)	(+)	(+)	(+)	(+)
Cement	(+)	(+)	o	–	+
Aluminium	o	–	–	+	–
Ferro-alloys[3]	o	(o)	–	–	+

[1] +: increase, -: decrease, o: little or no change. Brackets indicate that the underlying data or calculation methods make the result particularly uncertain. [2] Includes only enterprises where there was production in both years. [3] Includes process emissions only.
Source: Kvingedal (2001).

Our material suggests that both energy use and emissions per quantity of energy extracted[12] during the extraction of crude oil and natural gas were lower in 1998 than in 1990. For the production of refined petroleum products, emissions of most pollutants per unit of energy produced[13] were also lower, but specific energy use and specific emissions of CO_2 were unchanged.

For the manufacture of paper and board, the calculated values for both specific energy use and specific emissions have risen. However, a large proportion of the increase can be explained by the fact that certain enterprises have changed their production systems to integrated manu-

[12] Production is defined as the sum of the quantities of crude oil, natural gas and condensate extracted, expressed in energy units. There has been little change in the ratio between production of crude oil and natural gas measured in energy units from 1990 to 1998, so that we assume that the results cannot be ascribed to changes in production patterns.

[13] Production is given by the sum of the quantities of petrol coke, petrol, kerosene, middle distillates, heavy fuel oil and liquefied petroleum gas, expressed in energy units.

facture of pulp and paper. This makes these indicators less relevant.

Before 1992, hazardous waste was not included in the energy accounts. The 1990 figures for energy use and combustion emissions in cement manufacturing may therefore be underestimates. The changes in energy use and CO_2 emissions shown in table 7.4 are therefore uncertain.

In general, there has been a reduction in specific emissions of SO_2 for most of the types of production we have considered, whereas specific energy use and specific emissions related to combustion of energy goods have generally remained unchanged or shown only small changes.

In order to develop relevant indicators of emissions in relation to production expressed in physical units, the range of products involved must be homogenous and suitable for pooling. Alternatively, all significant energy use and emissions must be related to a specific type of product. Even though we considered the types of production presented here to be suitable for this kind of calculation, changes in product ranges will affect the results. In this analysis, this factor is particularly important in the case of ferro-alloy manufacturing. The drop in specific NO_x emissions shown in table 7.4 is a result of changes in production patterns.

In three sectors (extraction of oil and gas, refining of petroleum products and manufacture of pulp), there was little change in the proportions of different products from 1990 to 1998. The changes shown in table 7.4 cannot therefore be explained by changes in production patterns alone. For the production of primary aluminium and cement, the calculations were made on the basis of one main product, and all significant energy use and emissions were related to this product, so that in this case the problem does not arise. As regards the manufacture of paper and board, we cannot exclude the possibility that changes in the product range are of some importance, but a greater problem here is the fact that the production process has been changed in certain enterprises. A more detailed analysis should be carried out for both industries (ferro-alloys and paper and board) in order to make the indicators more relevant.

One purpose of this analysis was to test the suitability of Statistics Norway's data for calculating indicators of this type. Reorganization of the production statistics and changes in the energy accounts complicated the calculations and have made some of the estimates more uncertain. However, calculating complete time series instead of figures for two years will reveal changes related to reorganization of the statistics and make it possible to take them into account in evaluating trends.

The results shown in table 7.4 can be compared with NOREEA-based indicators for the industrial sectors to which each type of production belongs. For some industries, the direction of trends in energy use and emissions to air in relation to value added are the same in both systems, but this is not true in all cases. The discrepancies can mainly be related to variations in value added for an industrial sector or to differences in classification, where an industrial sector as defined in the national accounts includes other types of production as well. The results are presented and discussed in more detail in Kvingedal (2001).

Project financed by: Norwegian Water Resources and Energy Directorate.

Project documentation: Kvingedal (2001).

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

Below, we describe measures that have been introduced by the public authorities 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, 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 lay down limit values for maximum permitted concentrations in air of SO_2, NO_2, particulate matter (PM_{10}) and lead. If these values are exceeded near housing, day care centres, or health or educational institutions, measures shall be taken to reduce them. In 1999, the EU adopted stricter limit values for SO_2, NO_x, PM_{10} and lead. These are considerably stricter than the concentrations currently laid down in the Norwegian regulations. These regulations will therefore be revised to bring them into line with the new EU legislation in the course of 2001.The EU's new limit values apply to all outdoor areas where the public may be affected. The limit values are expressed as 24-hour or annual mean concentrations, and air pollution is required to be under these levels by 2005 or 2010, depending on the pollutant involved.

In 2000, the EU Commission adopted a similar directive concerning limit values for CO and benzene. This directive will also be implemented in Norwegian legislation by revision of the Regulations relating to limit values for local air pollution and noise.

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. The municipalities can also regulate local emissions indirectly by using the Planning and Building Act, for example by introducing restrictions on parking.

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. In practice, this applied to emissions of PFCs (CF_4 and C_2F_6).

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. 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.

The Norwegian Pollution Control Authority has recommended the introduction of an import tax on the greenhouse gases hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF_6). The three gases are regulated by the Kyoto Protocol, and the Norwegian emission inventory shows that consumption is growing rapidly. Analyses made by the Norwegian Pollution Control Authority show that a tax of around NOK 250 per tonne CO_2 equivalent will stimulate measures to reduce emissions of HFCs, PFCs and SF_6 by more than 40 per cent.

To reduce emissions of particulate matter, the municipalities have been given the authority to impose a charge on vehicles using studded tyres. Currently, only Oslo has done this, but Trondheim and Bergen have decided to introduce a charge from winter 2001-2002. See also section 7.8.

The sulphur tax applies to mineral oil, coal, coke and emissions from oil refineries (Proposition No. 1 (1999-2000) to the Storting). For 2001, the tax rate for mineral oil is NOK 17 per kg SO_2 released. Mineral oil with a sulphur content of less than 0.05 per cent by weight was previously exempt from the tax. However, from 1 January 2000, a tax of NOK 0.25 per litre was introduced for autodiesel containing more than 0.005 per cent sulphur. 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). A lower sulphur content will of course also result in lower SO_2 emissions. Last year, the oil companies started to supply autodiesel with a sulphur content of less than 0.005 per cent (Birkeland 2000).

Another measure related to road traffic is differentiation of the weight-based road tax for heavy-duty vehicles according to their environmental impact. This was first introduced in 2000 (Proposition no. 1 (1999-2000) to the Storting), and 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 tax is also being levied in 2001 (Proposition no. 1 (2000-2001) to the Storting).

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. 24 (2000-2001) to the Storting.

Other measures

The Ministry of Transport and Communications has given the Norwegian Public Roads Administration and the municipalities the authority to introduce acute measures to limit air pollution on days when it is expected to be high. For the winter season 1999-2000, the Public Roads Administration decided that the speed limit on the main roads in Oslo was to be reduced to 60 km/h on days when at least 20 000 people were expected to be exposed to a concentration of particulate matter exceeding 100 $\mu g/m^3$ (Norwegian Public Roads Administration 1999). Higher concentrations than 100 $\mu g/m^3$ were measured on five days, but the speed restrictions were only implemented on one day (Oslo City 2000). On three of the days, the forecast did not suggest that the limit values would be exceeded.

Domestic fuelwood use is also an important source of emissions of particulate matter in many areas. Oslo has run a scheme involving partial refunds to encourage delivery of old, polluting wood-fired stoves in central parts of the town, and Bergen ran a similar scheme in winter 1999-2000.

Further information may be obtained from: Gisle Haakonsen, Ketil Flugsrud, Kristin Rypdal 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. While the quantity of waste incinerated has risen, improved technology for emission control has reduced most environmentally harmful emissions from waste incineration in recent years. Strict standards for the establishment of new landfills have improved control of discharges of polluted seepage. However, methane emissions from landfilling of waste have risen.

The quantity of household waste has risen in recent years, and was equivalent to 328 kg per person in 2000. Generation of waste by manufacturing industries has also increased, and this fraction now accounts for more than half of all waste in Norway. Nevertheless, the quantities of waste delivered for final treatment are decreasing steadily. During the 1990s, the quantity of waste incinerated rose. However, stricter emission standards and the use of cleaner combustion technology led to reductions of the most important environmentally hazardous emissions. 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 1999, methane emissions from landfills accounted for just over 7 per cent of Norway's total greenhouse gas emissions (table 8.1 and Appendix, table F 6). These emissions can be reduced, for example by increasing the amount of biologically degradable waste that is recycled. Alternatively, methane can be extracted from the landfills where it is generated and flared or burnt. The importance of increasing recycling for the amount of methane emitted by landfills can be illustrated by the following example. In 1999, 250 000 tonnes more waste paper was used for material recovery than in 1992. If this waste had been landfilled, today's model indicates that total methane emissions would have been 45 000 tonnes higher. This corres-ponds to about one quarter of current methane emissions from landfills, or about the same amount as the estimated potential for methane extraction from Norwegian landfills using currently available technology (Report No. 8 (1999-2000) to the Storting, Report No. 24 (2000-2001) to the Storting). Calculations indicate that in 1998, about 200 000 tonnes of methane was generated in Norwegian landfills, and about 10 per cent was flared or burnt for energy recovery (see Chapter 7). Biologically degradable waste that is landfilled has a half-life of about 10 years (Norconsult 1999). This means that even after a landfill has been closed, methane emissions may continue to be a problem for some decades.

Incineration of waste reduces the quantity of waste landfilled and produces heat energy that can be used, but results in emissions of harmful gases and substances such as mercury, lead, cadmium and dioxins. Calculations show that in 1999, emissions from waste incineration and landfill gas totalled about 0.6 tonnes of lead, 53 kg of mercury and 41 kg of cadmium (table 8.1 and Appendix, table F 6). Some dioxins are also generated by waste incineration, in 1999 about 5 g[1]. By way of comparison, the known dioxin emissions from industry were three times as high, and emissions from fuelwood use are estimated to be at least four times as high as this (Lien 2000, Norwegian Pollution Control Authority 2001a). Dioxins are formed during the combustion of wood, paper, etc. mixed with materials such as PVC that contain chlorine. Thus, sorting of waste at source can help to reduce emissions further. Stricter emission standards are expected to reduce dioxin emissions by about 80 per cent compared with the current levels (Kleffelgård 2001). Emissions of other substances from waste incineration make up only a very small proportion of national emissions to air. Locally, NO_x emissions can be important. In Oslo, almost 9 per cent of NO_x emissions were generated by waste incineration in 1998 (Statistics Norway 2001f).

Table 8.1. Emissions from waste treatment. Percentages of total emissions in Norway in 1999 and percentage change from 1990 to 1999

	Percentage of total Norwegian emissions	Percentage change from 1990
Incineration plants		
Quantity of waste incinerated		+ 26
Sulphur dioxide	0,7	- 40
Nitrogen dioxide	0,5	+ 6
Carbon dioxide	0,3	+ 29
Particulate matter	0,3	+ 79
Lead	9,9	- 65
Cadmium	3,9	- 57
Mercury	4,4	- 46
Total PAH[1]	0,3	- 61
NMVOCs	0,1	+ 29
Landfills		
Methane (greenhouse gas)	7,3[2]	+4
Seepage: heavy metals[3]	1	..
Seepage: nitrogen[3]	2	..
Seepage: phosphorus[3]	1	..

[1] According to NS9815 with the exception of emissions from fuelwood use, where NS3058-3 has been used. [2] Calculated as a percentage of total greenhouse gas emissions. [3] Figures from 1996.
Source: Statistics Norway, Norwegian Pollution Control Authority and Ministry of the Environment.

Incineration of a given quantity of waste contributes less to the greenhouse effect than landfilling the same quantity of waste, even though combustion generates CO_2 emissions. The reason is that landfilled waste generates methane, which is a much more potent greenhouse gas than CO_2.[2]

[1] About half of this is generated by illegal waste incineration (Lien 2000).
[2] Based on the assumption that up to 25 per cent of the methane from landfills can be extracted and that oxidation through the cover layer of the landfill reduces methane emissions by 10 per cent.

Polluted seepage from landfills can have toxic effects and cause eutrophication. Requirements for the containment, measurement and control of seepage have been tightened up in recent years. In 1998, 32 per cent of all municipal landfills treated seepage. The landfills that did this handled 56 per cent of all municipal waste that was landfilled in 1998, as compared with 48 per cent in 1995 (Statistics Norway 2001a). However, it is difficult to determine exactly how great the improvement is, since most pollution from landfills is released in periods when discharge volumes are very high, exceeding the capacity of treatment plants.

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 management can also result in local problems related to unpleasant smells, littering and vermin, and occupy areas of land. This can restrict the way areas near waste treatment and disposal plants can be used, and their quality.

Many types of waste contain materials and energy that can be recovered and used. Energy recovery from waste can replace the combustion of fossil fuels, and material recovery can for example replace energy-intensive production based on limited supplies of virgin raw materials. If waste is dealt with in other ways than by landfilling, there is also less need to open new landfills. Landfilling is primarily an alternative for waste fractions which cannot as yet be recycled in a way that provides social benefits, and which do not result in polluting emissions when landfilled.

Main objectives of waste policy

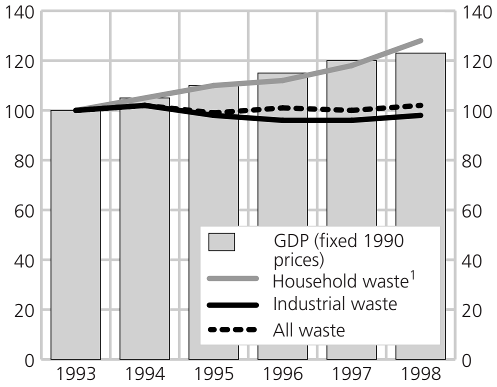
According to the environmental authorities, waste must be managed in such a way as to minimize injury and nuisance for people and the natural environment. At the same time, the resources required by waste and its management must be minimized. Three national targets have been set for waste and recycling. These are shown in box 8.1.

Key figures are calculated for each of the national targets. For the first target, the key figure is the total quantity of waste generated per year in relation to economic growth measured as GDP. As figure 8.1 shows, total quantities of waste have risen very little since 1993, while GDP has continued to rise. This shows a trend that is in accordance with the national target.

The key figure for national target 2 is the proportion of the total quantity of waste generated that is delivered for final treatment (box 8.2). This proportion was calculated to be 43 per cent in 1998, which is a little lower than in 1996[3]. The

[3] The figures for 1996 have been revised since last year. According to the new calculations, 47 per cent of all waste was delivered for final treatment in 1996.

Figure 8.1. Trends in the quantity of waste generated and GDP. 1993 = 100



[1] Excluding scrapped cars and other means of transport.
Source: Statistics Norway.

total quantities of waste generated in Norway have been relatively stable in recent years. Nevertheless, there has been a reduction in the quantity of waste delivered for final treatment.

The third key figure consists of two parts. The first part is the quantity of hazardous waste disposed of in unknown ways, i.e. hazardous waste that we cannot be sure is treated at approved facilities. The figures for this category are very uncertain. The second part is the quantity of hazardous waste exported for final treatment. In 1999, slightly more was exported than in 1994 (about 6 per cent of the total), but in the intervening years, the quantity exported was considerably lower (NORSAS 1996, 2000).

Policy instruments for waste management

There have been rapid developments in the field of waste management in the last few years. A variety of policy instruments have been established, targeted at both municipalities and business and industry. They include acts and regulations, taxes, grant schemes, agreements with industry and information campaigns, as well as combinations of these. The Government believes there is a considerable potential for obtaining further effects from the instruments already in place, and any new instruments that are introduced should therefore mainly supplement those already in effect (Report No. 8 (1999-2000) to the Storting, Report No. 24 (2000-2001) to the Storting).

Table 8.2. Quantities (given in 1 000 tonnes) of waste generated in Norway and proportion delivered for final treatment (in brackets, given as percentage), by material

Year	Total[1]		Wet - organic	Paper and board	Wood	Plastic	Glass	Metal	Tex-[2] tiles[2]	Hazar- dous waste	Other mate- rial
1986	..	..	..	1 027	..	247	..	..	..	..	..
1990	..	..	909	1 051	1 266	280	..	..	106	..	..
1993	5 927	(54.1)	1 156	1 065	1 185	324	117	459	108	621	1 513
1994	6 030	(50.3)	1 197	1 048	1 169	337	123	658	109	640	1 389
1995	5 797	(49.9)	1 243	1 027	1 158	353	136	507	111	628	1 262
1996	5 891	(47.0)	1 260	1 007	1 144	364	142	717	111	608	1 146
1997	5 826	(45.5)	1 268	1 092	1 153	368	134	533	110	596	1 168
1998	5 983	(42.9)	1 295	1 096	1 197	375	131	591	111	709	1 187
1999	..	..	1 039	..	..	..	..	..	..	619	..

[1] Excluding hazardous waste. In addition, a large amount of waste consisting of stone, gravel and soil is generated. [2] Revised august 2001.
Source: Statistics Norway and Norsas.

Box 8.2. Waste and waste statistics – terminology and classification

According to the Pollution Control Act, waste is defined as discarded objects of personal property or substances.[4]

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. The Norwegian General Standardizing Body has now drawn up a new standard for waste classification. The objective is to encourage uniform use of categories when registering and reporting waste quantities.

In the Pollution Control Act, waste is divided into three categories: consumer waste, production waste and special waste (including hazardous waste). The Government is now considering whether to propose a change in this classification. This would mean dividing waste into the three categories household waste, industrial waste and hazardous waste, which is in accordance with the classification system used by Statistics Norway in its waste statistics. 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, electrical and 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. Includes all waste that is not classified as consumer waste or hazardous waste.

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. In its waste statistics, Statistics Norway further subdivides industrial waste according to the branch of industry from which it originates. The degree of aggregation in the classification varies. Includes all waste that is not defined as household waste or hazardous waste.

Municipal waste
All waste treated or administered in the municipal system, in practice the same as consumer waste. Municipal waste includes almost all household waste and a large proportion of industrial 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.

Recycling
Includes both material recovery and incineration combined with energy use.

Final treatment
Means either landfilling or incineration without energy recovery.

[4] Waste water and waste gases are not defined as waste.

8.2. What does waste consist of?

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.

Statistics Norway is working on waste accounts for various materials. The objective is to provide a better overview of waste quantities and streams in Norway. The waste accounts and the methods used are described in box 8.3. Table 8.2 shows some of the main results of the waste accounts that have been completed so far.

Wet organic waste

Wet organic waste means readily degradable organic waste, including food waste. There are serious environmental problems associated with landfilling of wet organic waste. At global level, the most important of these is the formation of methane as the waste rots. Regionally, inputs of nutrients and environmentally hazardous chemicals with seepage from landfills can contribute to eutrophication and pollution of rivers and lakes. In addition, there are problems associated with vermin and unpleasant smells near

Box 8.3. Waste accounts for Norway

The waste accounts are being developed on the basis of traditional principles for natural resource accounting, as a material balance between annual waste generation and the quantities treated or disposed of 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:

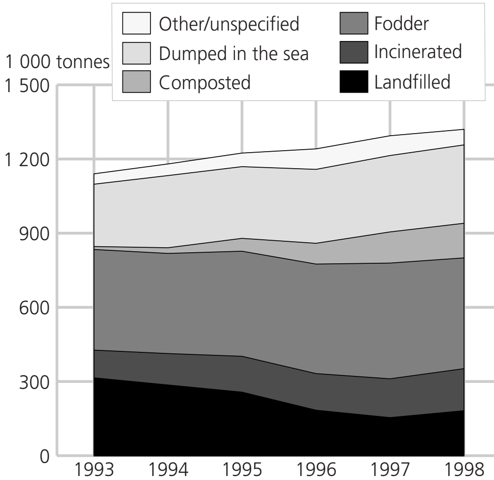
- material type
- product type
- origin
- form of treatment/disposal.

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. So far, accounts have been developed and published for *paper and cardboard, textiles, glass, wet organic waste*, *metals*, *plastic* and *wood*.

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. The two methods use different points in the waste stream as their starting points. The supply of goods methods estimates the quantities of waste that are generated, while the waste statistics method shows the quantities delivered for various types of treatment. There may be a small real difference between these quantities.

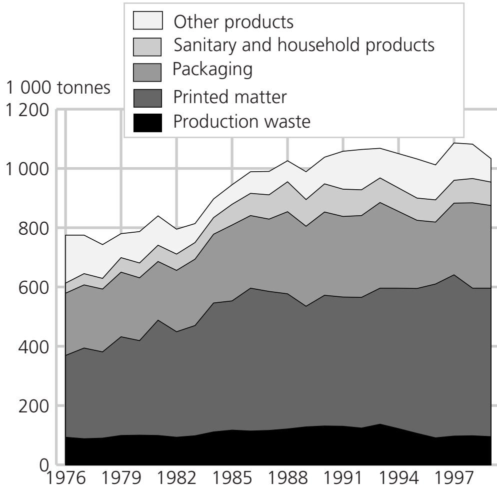
The calculation methods will be further developed in the years ahead, and time series and already published figures will be revised.

Figure 8.2. Wet organic waste by method of treatment/disposal



Source: Statistics Norway.

Figure 8.3. Waste paper by product categories



Source: Statistics Norway.

landfills. Strict restrictions on landfilling of wet organic waste are intended to ensure that a high proportion is recycled. The quantity of wet organic waste generated has risen steadily in recent years. In 1998, the total quantity was 1.3 million tonnes, which is 12 per cent more than in 1993 (Appendix, table G 1). However, the quantity landfilled has dropped considerably (see figure 8.2 and section 8.4).

Paper and cardboard

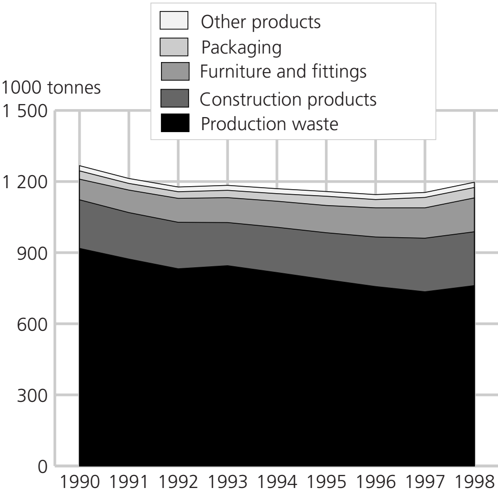
Waste paper and cardboard is readily degradable, in the same way as wet organic waste, and landfilling of this type of waste therefore also generates methane. In addition, paper and cardboard has a relatively high heat value (10 - 20 MJ/kg, Hustad (2001)) and can be incinerated and used to replace other energy sources. Printing ink contains heavy metals that can pollute seepage from landfills and result in emissions to air if waste is incinerated. If paper and cardboard is incinerated together with materials such as PVCs that contain chlorine, dioxins are generated. Incineration at the right temperature and improvements in flue gas treatment at incineration plants can reduce dioxin emissions, as does sorting of waste paper and cardboard at source.

During the 1980s, the quantity of waste paper generated in Norway rose fairly rapidly. By 1990, the quantity of waste paper generated was 34 per cent higher than in 1980. The rise stopped during the 1990s. In the last few years, total quantities of waste paper and cardboard have varied but not shown any definite trend. The largest product group is printed matter, which totalled 500 000 tonnes in 1999, up from 440 000 tonnes in 1990 (see figure 8.3 and Appendix, table G 2).

Wood

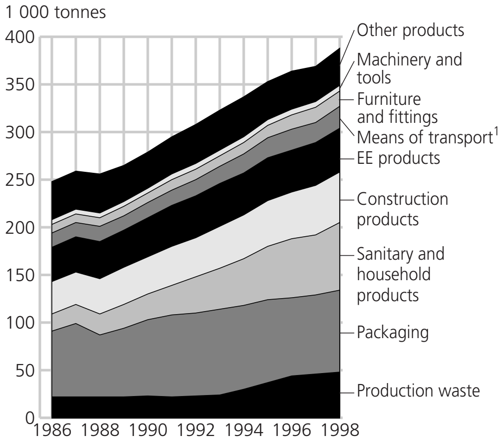
The environmental problems associated with wood waste are much the same as for waste paper and cardboard. Waste consisting of wood only generates only low emissions of heavy metals, but inci-

Figure 8.4. Wood waste by product categories



Source: Statistics Norway.

Figure 8.5. Plastic waste by product categories



[1] Excluding ships.
Source: Statistics Norway.

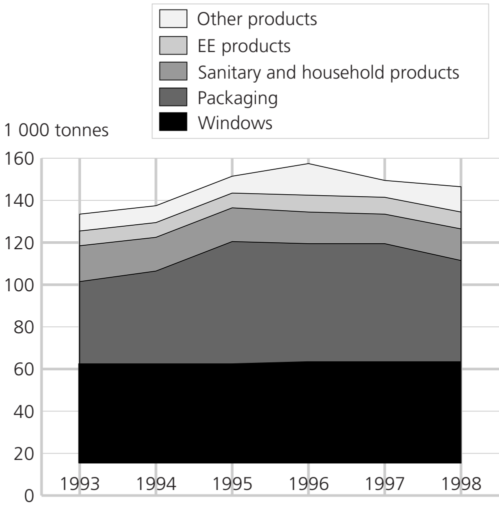
neration of wood that is impregnated, painted or otherwise treated can result in substantial emissions of copper, chromium, arsenic or other hazardous chemicals. The heat value of wood is somewhat higher than for a mixed paper fraction of waste, and wood waste is therefore suitable for energy recovery, provided that the incineration process results in low emissions.

There was an overall drop in the quantity of wood waste in the period 1990 to 1998. However, since 1996 the quantity has risen, and in 1998 about 1.2 million tonnes of wood waste was generated in Norway. The quantity of wood waste generated in Norway has not been higher since 1991 (see figure 8.4 and Appendix, table G 3).

Plastic

Many different types of plastic are produced for various purposes. Some, such as food packaging, give very "clean" waste. However, other types contain various additives used to give the plastic the required properties. Examples of additives include heavy metals (e.g. lead, cadmium and organotin compounds), phthalates and brominated flame retardants. If plastics are landfilled, these substances may be discharged with seepage. If plastic is incinerated, there is a risk of pollution with heavy metals. PVC also contains large amounts of chlorine, and incineration can generate emissions of dioxins. Most of the chlorine is released as HCl vapour, which is acidic and corrosive in the same way as SO_2. Norwegian plastic manufacturers have shown a growing awareness of these problems, and as a result, the content of certain additives has been reduced (Kolstad 2001). For example, cadmium has been eliminated from new plastic products. Most types of plastic break down very slowly in the environment. Plastic waste that is dumped will therefore cause long-term littering problems.

Figure 8.6. Glass waste by product categories



Source: Statistics Norway.

Plastic waste is a very energy-rich fuel (40 - 50 MJ/kg, with the exception of PVC, which gives about 25 MJ/kg) and therefore suitable for energy recovery provided that flue gases are satisfactorily treated (Hustad et al. 2001).

There has been a steady rise in the quantity of plastic waste throughout the 1990s, and in 1998 a total of 375 000 tonnes of plastic waste was generated in Norway. Between 1986 and 1998, the quantity of plastic waste generated in Norway rose by 52 per cent. Plastic waste includes a number of product categories, the most important of which are packaging and sanitary and household products (see figure 8.5 and Appendix, table G 4).

Glass

Normally, there are only minor environmental problems associated with glass waste, largely littering. However, the production of glass is energy-intensive, and the authorities therefore consider material recovery of glass to be preferable, both because this results in lower energy use and because it limits the environmental impact of the extraction of raw materials.

In 1998, 131 000 tonnes of glass waste was generated in Norway. This is 7.3 per cent less than in the peak year, which was 1996, but 12 per cent more than in 1993. Windows and packaging were the most important product categories (see figure 8.6 and Appendix, table G 5).

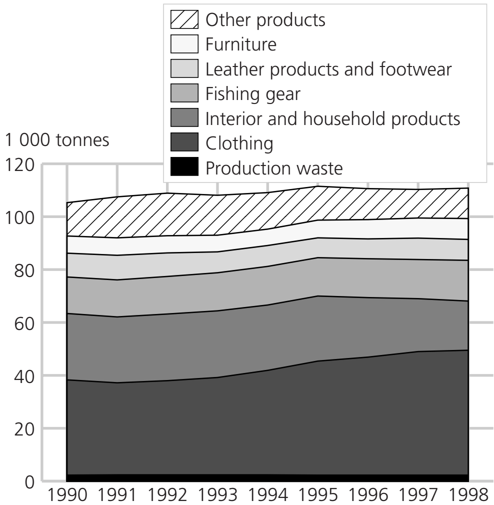
Metals

Metal waste[5], like glass waste, does not directly give rise to serious environmental problems, but metal manufacturing is also a very energy-intensive process. In addition, extraction of metals may cause severe acidification locally and result in emissions of heavy metals to air and water. Material recovery and reuse can therefore help to reduce the overall environmental impact. However, mixed metal waste such as discarded cars, household appliances and other EE waste[6] contains various hazardous chemicals that can result in serious pollution if the waste is treated inappropriately. Schemes for the collection and treatment of such waste have now been established.

In 1998, almost 600 000 tonnes of metal waste was registered in Norway[7]. This figure is very uncertain, and the true quantity is probably somewhat higher. The quantity of metal waste generated has risen slightly since 1992, but there are large variations from year to year and it is therefore difficult to determine

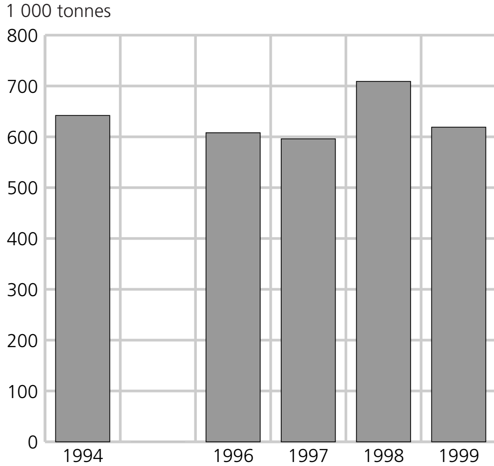
[5] With the exception of hazardous waste.
[6] Electrical and electronic waste.
[7] Calculated using the waste statistics method (8.3).

Figure 8.7. Textile waste by product type



Source: Statistics Norway.

Figure 8.8. Quantities of hazardous waste generated in Norway



Source: Norsas.

whether the rise is the result of a sustained trend. Metal waste originates from a wide variety of products. Pipes, means of transport, ships and other large structures, machinery and tools, and electrical and electronic products are all categories that account for large quantities of metal waste. The variations from one year to another are largely explained by the rise in the number of cars scrapped when the refund payment was temporarily raised in 1996 and variations in the numbers of ships to be broken up (Appendix, table G 6).

Textiles

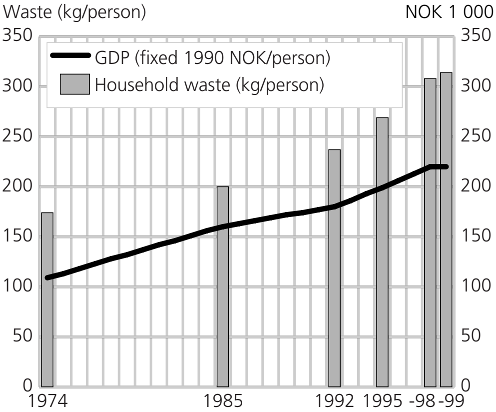
Textiles include natural and synthetic fibres, various mixtures of these and products manufactured from such fibres. This means that textile waste is a very variable waste fraction, and the environmental problems associated with it are correspondingly variable. Some synthetic fibres contain environmentally harmful additives that may be released to water if waste is landfilled or emitted to air if it is incinerated. Certain textiles, for example curtains, contain brominated flame retardants as additives. Chemical additives are also commonly used to improve the performance quality of textiles. These are often lost in the wash, and can thus pollute rivers and lakes. Natural fibres that are landfilled generate methane as they are broken down, but since the quantities of textile waste are relatively small, this is not a very important problem.

The quantity of textile waste generated has been stable at around 110 000 tonnes since 1990, which is barely 2 per cent of the total quantity of waste in Norway (figure 8.7 and Appendix, table G 7).

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. In 1999, a total of 588 900 tonnes of hazardous waste was registered in Norway (NORSAS 2000). A large proportion of this consists of

Figure 8.9. Per capita generation of household waste and rise in GDP



Source: Statistics Norway.

diluted acid, oil-contaminated waste and slag from metal manufacturing containing heavy metals. In addition, a certain amount of hazardous waste is for various reasons not reported to the Norwegian Pollution Control Authority or to Norsas. Calculations suggest that in 1994, about 30 000 tonnes of hazardous waste was dealt with outside official channels (NORSAS 1996). No more recent calculations are available.

The total quantities of hazardous waste generated in Norway in recent years have shown some variation but not followed a clear trend (figure 8.8 and Appendix, table G 8).

Statistics Norway is currently working on more comprehensive accounts for hazardous waste, in which this fraction is split both by substance categories (EWC codes) and by the branch of industry where it is generated. In these accounts, special emphasis is being put on making more reliable estimates of the quantities of special waste not being dealt with through official channels, cf. national target 3 (box 8.1). Another important objective is to make the hazardous waste statistics more complete and easier to understand than they are at present.

8.3. Where is waste generated?

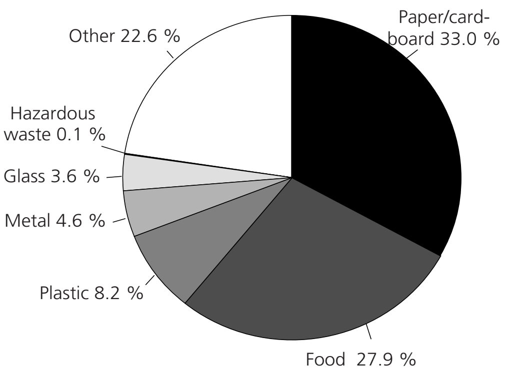
The sectors that produce most waste are manufacturing industries, the construction industry and private households. The composition of waste varies greatly from one sector to another. In the manufacturing industries, the largest fractions are slag and wood waste. This is also the sector that generates most hazardous waste. Concrete makes up the largest fraction of the waste generated by the construction industry, whereas households mainly generate waste paper and cardboard and food waste.

Household waste

Calculations show that in 2000, each person in Norway generated an average of 324 kg household waste, and the total quantity of household waste was 1.45 million tonnes. 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 (Appendix, table G 9). 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.

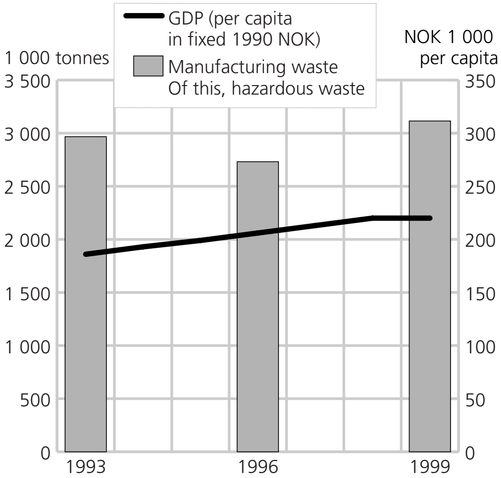
On the basis of projections of waste quantities made by Statistics Norway (Bruvoll and Ibenholt 1999), it has been expected that the growth in quantities of household waste up to the year 2010 would be lower than the growth in private consumption. However, more recent statistics show that the quantity of household waste is rising faster than both GDP

Figure 8.10. Composition of household waste



Source: Heie 1998.

Figure 8.11. Manufacturing waste and GDP



Source: Statistics Norway.

(figure 8.9) and household consumption. See also figure 8.1.

People from the southern third of the country generate more household waste than those who live further north. In 1998, per capita generation of household waste by the population of the ten southerly counties was 328 kg, while the average figure for the nine northerly counties in the same year was 265 kg. This corresponds to a difference of 24 per cent. There is a tendency for people in towns and nearby areas to generate more household waste than people in more remote areas. In 1998, average per capita generation of household waste was 340 kg in the ten municipalities with the highest populations and 261 kg in the ten with the lowest populations (Statistics Norway 2001a).

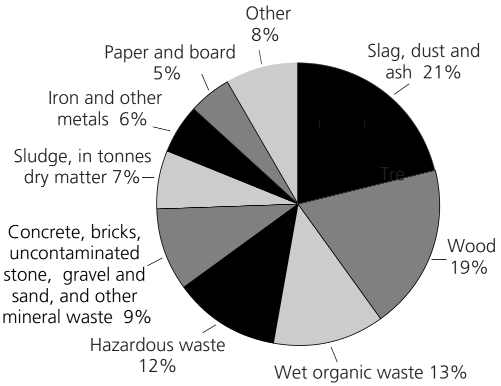
Manufacturing waste

The manufacturing industries generate more waste than any other sector. Manufacturing is responsible for more than half of all waste generated in Norway[8]. Waste quantities have risen since the last two sample surveys in 1996 and 1993, and were 14 per cent higher in 1999 than in 1996 (Appendix, table G 11). The waste quantities generated by manufacturing do not appear to follow the same trend as GDP (figure 8.11).

Since 1996, the quantity of slag, dust and ash has almost doubled, while the quantity of wood waste has dropped (figure 8.12 and Appendix, table G 12). Slag, dust and ash is now the largest waste category and wood waste the next largest. More than 80 per cent of all slag, dust and ash in manufacturing waste originate from the manufacture of metals and metal products and over 90 per cent of all wood waste from the manufacture of wood and wood products and pulp and paper manufacture. Wet organic waste consists almost entirely of food, slaughterhouse waste and fish waste from the manufacture of food products and beverages. The quantity of hazardous waste generated by manufacturing has

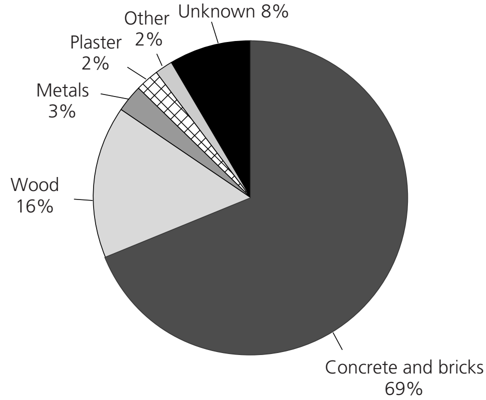
8 Stone, gravel and soil excluded.

Figure 8.12. Manufacturing waste by material types. 1999



Source: Statistics Norway.

Figure 8.13. Waste generated by building, rehabilitation and demolition in 1998



Source: Statistics Norway.

risen throughout the period. In 1999, this accounted for about two thirds of all hazardous waste in Norway. Much of the hazardous waste is generated by the chemical industry and manufacturing of metals and metal products.

Construction waste

Construction waste accounts for a large proportion of total waste quantities in Norway. Calculations show that in 1998, the total quantity of waste from building, rehabilitation and demolition was 1.5 million tonnes (figure 8.13 and Appendix, table G 14. A great deal of this (1.1 million tonnes) consisted of concrete and bricks, and three-quarters of this fraction was generated by demolition. Wood was the next largest fraction, and 240 000 tonnes of wood waste was generated in 1998. In addition, more than 7 700 tonnes of hazardous waste was generated in 1998, and 6 400 tonnes of this was asbestos.

Table 8.3. Production and consumer waste from manufacturing industries, by branch of industry. 1 000 tonnes

Branch of industry	1996	1999
Manufacturing, total	**2 731**	**3 115**
Metals and metal products	555	827
Food products, beverages and tobacco	573	619
Pulp, paper and paper products; publishing and printing	495	525
Wood and wood products	626	453
Mineral products	104	269
Chemicals and chemical products	87	143
Other manufacturing	291	279

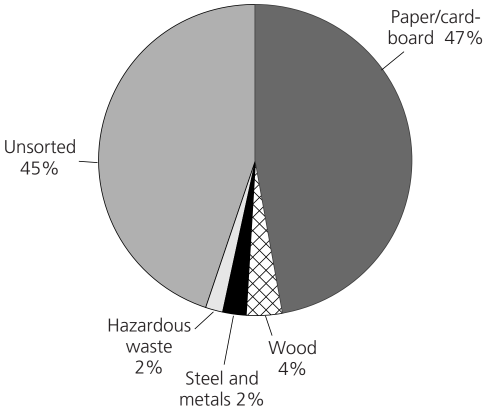
Source: Statistics Norway.

Oslo, Akershus, Rogaland and Hordaland were the counties where most construction waste was generated. There is a more detailed discussion of waste from building, rehabilitation and demolition in *Natural Resources and the Environment 2000*.

Waste from service industries

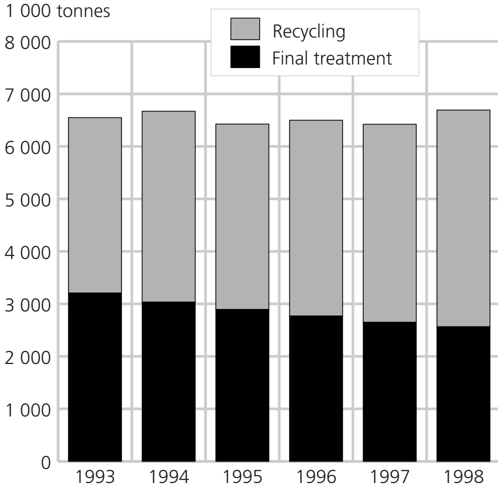
Statistics Norway is developing waste statistics for the service industries. Calculations show that 630 000 tonnes of waste was generated by wholesale and retail trade in 1999. This corresponds to almost 10 per cent of all waste generated in Norway. Almost 300 000 tonnes of this

Figure 8.14. Waste[1] from wholesale and retail trade. 1999



[1] The underlying data are not sufficiently representative, and the quantity of wet organic waste, plastic and glass is probably larger than shown in the figure. A proportion of these fractions may also be included in the unsorted fraction.
Source: Statistics Norway.

Figure 8.15. Waste delivered for final treatment[1] and recycling[2] in Norway



[1] Final treatment means landfilling or incineration without energy recovery. [2] Recycling means both material recovery and energy recovery.
Source: Statistics Norway.

was waste paper and cardboard (figure 8.14). This is more than the previous estimate for the total from all service industries. In addition, the unsorted fraction will contain some paper and cardboard. Wholesale and retail trade also generated 11 000 tonnes of hazardous waste. Half of this was from car repair workshops and almost a quarter from petrol stations and car dealers.

In all, grocery retailing generated 200 000 tonnes of waste in 1999, or more than 30 per cent of all waste from wholesale and retail trade. More than 20 per cent of this was food waste (Appendix, table G 15).

Other industries

There are no complete waste statistics for the primary industries in Norway, nor for electricity and water supplies. Statistics Norway carried out a sample survey of mining and quarrying in 1994, which indicated that this sector generated 3.5 million tonnes of waste, including 3 million tonnes of stone, etc. However, the results of the survey were relatively uncertain. Thus, there is some way to go before the waste statistics are complete for all branches of industry.

8.4. How do we treat and dispose of waste?

Once waste has been generated, some form of treatment or disposal is necessary. This may be reuse, 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. Final treatment is a collective term for landfilling and incineration without energy recovery. These forms of treatment make little use of the resources in waste. One of Norway's national targets is to reduce the proportion of waste delivered for final treatment (box 8.1).

The quantity of Norwegian waste delivered for final treatment is dropping, even though the total quantity of waste is stable. In 1998, 2.6 million tonnes of waste was delivered for final treatment[9], as compared with 3.2 million tonnes in 1993, which corresponds to a drop of 20 per cent. The proportion of all waste delivered for final treatment was 43 per cent in 1998. The quantity used for material recovery was 300 000 tonnes higher than in 1996, while the quantity incinerated with energy recovery was more or less unchanged.

How are different material types treated as waste?

The waste treatment methods used vary widely from one material type to another (figure 8.16). A relatively small proportion of *wet organic waste* is landfilled, and the Government's goal is to reduce this to a minimum because landfilling results in methane generation and poses a risk of eutrophication of lakes and rivers. In 1998, 242 000 tonnes of wet organic waste was landfilled, almost 40 per cent less than in 1993 (see also figure 8.2). More and more wet organic waste has been composted or incinerated in recent years. Advanced technology has made it possible to produce good compost relatively quickly and without unpleasant smells in special composting plants. Material recovery of wet organic waste generally means fodder production. However, in some cases such fodder has a high content of moulds and yeasts and contains meat and bones from the species it is fed to, and this has caused animal health problems. The Norwegian Agricultural Inspection Service therefore prohibited the use of wet organic household waste in animal fodder in 1996. Since then, the quantity used for material recovery has not risen. Because of its high moisture content, wet organic waste has no or only a low direct heat value, but decomposition in special plants is an efficient way of generating methane that can be burnt for energy purposes. About a quarter of all wet organic waste is fish waste that is dumped at sea. The environmental authorities do not consider this to be a problem, since the waste becomes part of the natural food chain and does not cause eutrophication.

A large proportion of *plastic, textile* and *glass waste* is landfilled. All of these are material types that can be recycled. Plastic waste in particular is combustible and can be used for energy recovery, and the same applies to textile waste. Some waste textiles are exported for reuse[10], but this is only a relatively small proportion of the total. Certain types of plastic can also be used for material recovery, but only if the different types of plastic are not mixed. As a result, only small amounts of plastic are used for material recovery at present. As regards glass, packaging from households and industry is generally the only type of material used for material recovery. However, new areas of use for glass waste that is sorted at source have been developed in recent years, making recycling of waste glass a more interesting proposition. Examples of new uses are glass concrete, the production of a shock-absorbing mass and foam glass as an insulating material in buildings. The data available for the management of plastic, textile and glass waste go back to 1995 (plastic) and 1993 (textiles and glass). There have been no significant changes in

[9] Hazardous waste is not included here.
[10] Classified as material recovery here.

the way any of these fractions are treated during this period.

In the case of *waste paper and cardboard* and *wood waste*, far more is recycled than is landfilled. Good collection and recycling schemes have been established for paper and cardboard, and ensure a high degree of recycling. Most of the waste paper collected is used as a raw material in the production of new paper (material recovery). Paper has been recycled in this way for many years, but the quantity recycled has only exceeded the quantity landfilled since 1998. Much of the wood waste is incinerated with energy recovery, but a relatively large amount is also used for material recovery.

Metal waste is the material type for which the proportion of material recovery is highest. It is primarily the metal manufacturing industry itself that recycles metal waste. Metal waste that is not used for material recovery is mainly landfilled.

Because of its toxicity and the high risk of pollution, *hazardous waste* is governed by special legislation (the Regulations concerning hazardous waste and the appendices to the regulations). These 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). All companies that are not licensed to treat hazardous waste themselves or to export it directly are required to deliver and declare hazardous waste through this system.

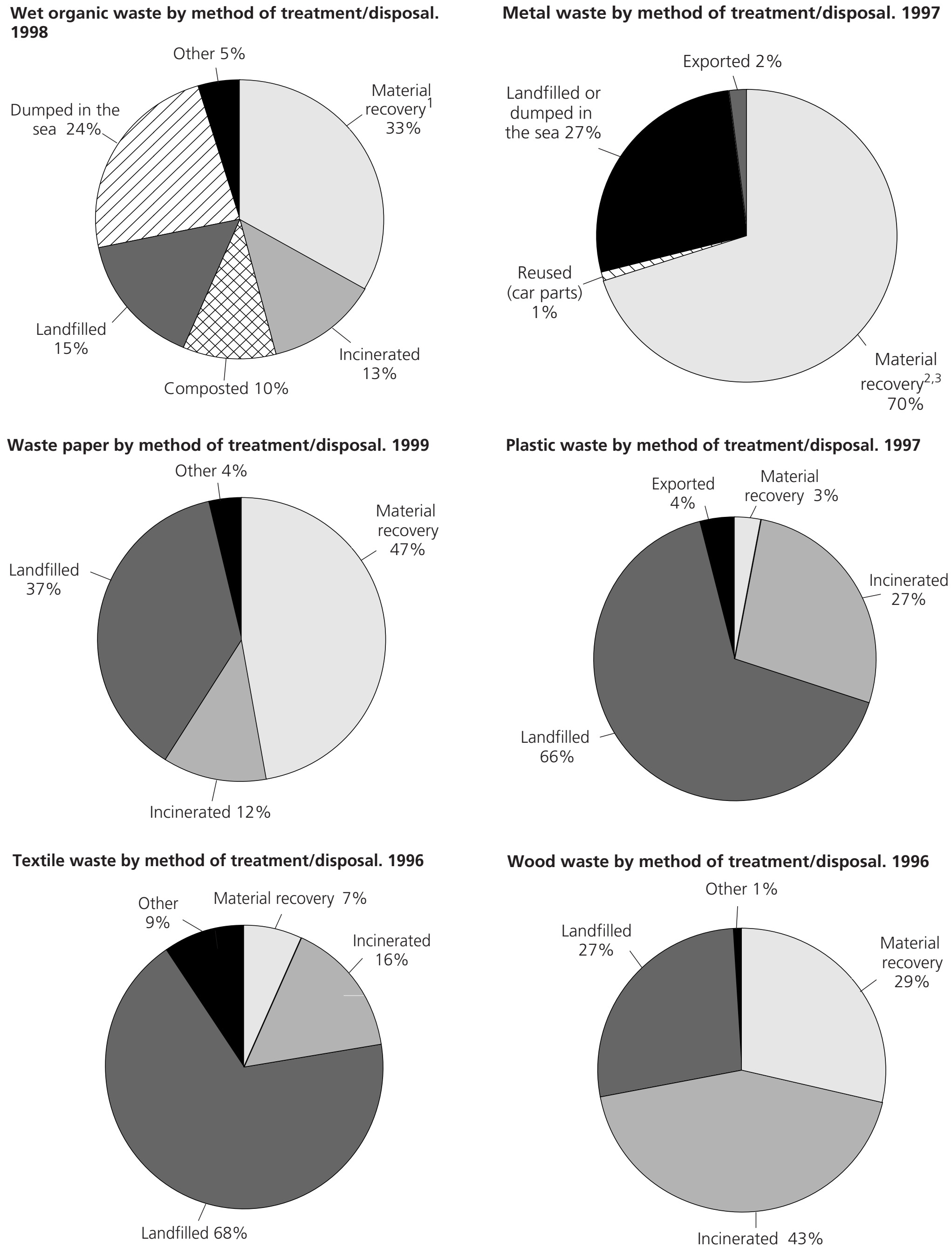
From 1994 to 1999, the trend has been for more hazardous waste to be treated by approved external treatment facilities, and less by enterprises themselves on-site (Appendix, table G 8). In 1999, about 440 000 tonnes of hazardous waste was delivered to approved external treatment facilities (figure 8.17). Around half of this consisted of acid and acid sludge, almost all of it from a single enterprise. About a quarter of the total consisted of waste oil and oil-contaminated waste. The quantities of the category slag, dust, ash, catalysts and blasting agents have risen after new types of waste were included as hazardous waste in 1997. In 1999, this category made up more than 5 per cent of the hazardous waste delivered to external facilities (NORSAS 2000). Hazardous waste treated on-site consists mainly of waste from the metal industry that is contaminated with heavy metals and waste oil (Norwegian Pollution Control Authority 2001a).

Calculations indicate that in 1994, the method of disposal was unknown for about 30 000 tonnes of hazardous waste (NORSAS 1996). No attempt was made to evaluate how much of this was disposed of illegally. It is difficult to judge what the position is today, both because the estimate of 30 000 tonnes is relatively uncertain and because the situation may have changed considerably in the meantime.

How is household waste dealt with?

More and more household waste is being sorted at source, mainly for material

Figure 8.16. Waste by method of treatment/disposal



[1] Used as fodder. [2] Scrap metal exported for material recovery is registered as material recovery. [3] Discrepancies in the underlying data mean that the proportion may be lower than the figure indicates.
Source: Statistics Norway.

Figure 8.16. Waste by method of treatment/ disposal
(cont.)

Glass waste by method of treatment/disposal. 1998

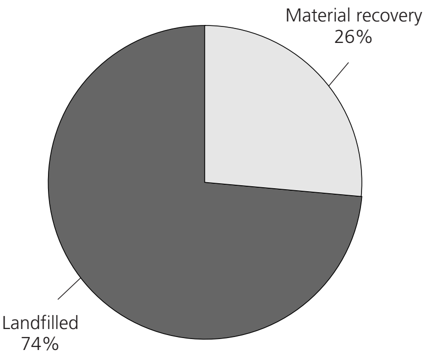
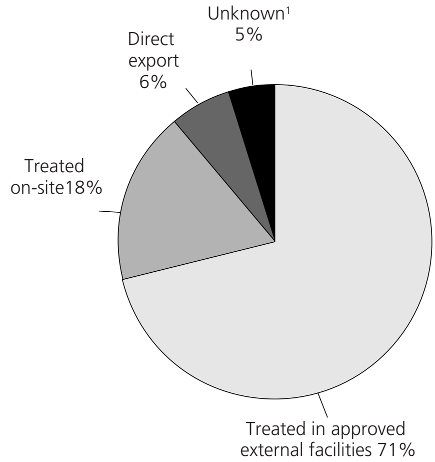


Figure 8.17. Treatment of hazardous waste. 1999



[1] Figure from 1994.
Source: Norsas (1996 and 2000).

recovery. In 1992, each Norwegian sorted on average 20 kg of household waste, but this had risen to 130 kg in 2000. The proportion sorted is highest for paper and cardboard and for glass (figure 8.18 and Appendix, table G 10). This is probably because there are good collection and return schemes for these waste fractions. Even though the quantity of household waste is rising, less and less of it is being delivered for final treatment. In 1998, 15 per cent less household waste was delivered for final treatment than in 1996. However, about half was still delivered for final treatment, which means there is some way to go before the national target of 25 per cent is reached.

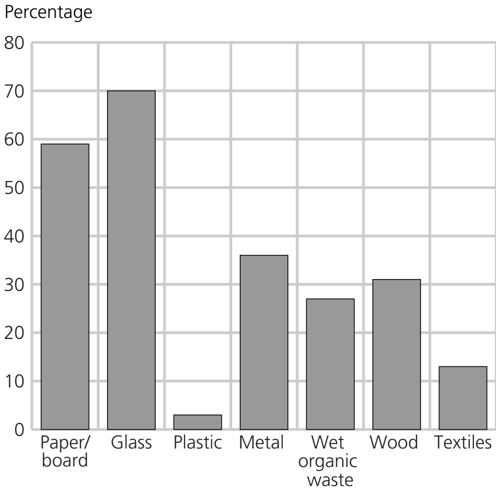
8.5. Sorting at source: time and energy use

The time and energy households spend on sorting waste was investigated as part of Statistics Norway's Omnibus survey 4/99 (Bruvoll et al. 2000). These surveys are based on interviews with a representative sample of the Norwegian population aged between 17 and 79. In this survey, 93 per cent of those interviewed stated that they sort at least some waste at source. Table 8.4 shows the percentages of the sample who stated that they sort all, most, some or none of the different waste fractions.

The effort put into recycling varies from one type of waste to another, and this to some extent reflects the scope and quality of the collection systems. Most people state that they sort either all or none of each waste fraction, which suggests that families usually have rules for what to do with household waste. Sorting at source is most widespread for paper and cardboard and for glass, and least widespread for metal and plastic.

The respondents stated the time used per week to clean, fold and take out sorted waste at home, and to take waste to central collection points (table 8.5). The figures did not include waste types for which there are tax and return schemes. The time reported corresponds to an average of 30 minutes per week for people who sort waste at source. On average, each person who does this reports that

Figure 8.18. Sorting of household waste: Percentages for various material types in 1999



Source: Statistics Norway/Norwegian Pollution Control Authority 2001-1, Heie 1998, Søre Sunnmøre reinhaldsverk 1991.

they spend 9 minutes a week cleaning waste. Of those who clean sorted waste, 59 per cent use hot or warm water for this only, 26 per cent use cold water, and 15 per cent use the same water as for dishwashing.

Table 8.6 gives estimates of the average time, energy and water consumption per household, calculated as the average per tonne waste delivered for material recovery by Norwegian households. The figures for water and energy consumption are based on figures for the time spent given by the respondents and on estimates of water and energy consumption per minute for washing waste from a laboratory test run by the Swedish Consumer Agency.

Table 8.4. Percentage of all interviewees who state that they sort all, most, some or none of the different waste fractions[1]

	All	Most	Some	None
Paper and cardboard	69	15	4	12
Glass not incl. in tax and return scheme ...	60	14	7	19
Beverage cartons	43	14	11	31
Food waste/compost	40	6	4	50
Metal not incl. in tax and return scheme ...	35	9	11	45
Plastic not incl. in tax and return scheme ...	20	8	7	64

[1] Number of respondents: 1 162.
Source: Omnibus 4/99, Statistics Norway.

Seven of ten people would like to have their waste sorted by others if this was possible. Many of them would also be willing to pay for this service. The average willingness to pay for all those who sort waste at source was NOK 176 per household per year. If the sample is representative, this corresponds to about NOK 800 per tonne waste delivered for material recovery.

8.6. Municipal waste management fees

According to the Pollution Control Act, the municipalities are required to make arrangements for the collection and treatment of consumer waste, and to charge fees that subscribers must pay to cover the costs of waste management. Statistics Norway makes annual surveys of a sample of the municipalities in Norway in which they are asked to quote standard fees for waste management, chimney-sweeping, water supplies and waste water treatment. Waste management fees vary widely from one municipality to another. In 2000, the fee varied from NOK 941 to NOK 2 840[11] per household. The average fee was NOK 1 750.

[11] Including VAT.

Table 8.5. Time spent sorting waste at source. Minutes per person per week. Average

How many minutes extra per week do you spend, on average, on	Average for people who sort waste
Cleaning sorted waste	9
Folding, sorting and taking out sorted waste at home	14
Taking sorted waste to central collection points	7
Do not include waste covered by tax and return schemes.	
Total	30

[1] Number of respondents: 1 084.
Source: Omnibus 4/99, Statistics Norway.

Table 8.6. Resources used by households in sorting waste at source. Estimates. Averages for all households and per tonne sorted waste

Resource use	Average per household per year	Average per of waste
Total time used	41 hours	186 hours
Energy used to wash waste	48 kWh	218 kWh
Water consumption	1,6 m^3	7,3 m^3

Important assumptions:
- on average 1.7 persons per household sort waste,
- same relationship between time used and water consumption as found by the Swedish Consumer Agency.
Source: Omnibus 4/99, Bruvoll , Halvorsen and Nyborg (2000).

The fees have risen steeply in recent years, and rose by an average of 7 per cent from 1999 to 2000. The rise is explained partly by reorganization of municipal waste management systems and partly by the introduction of stricter standards for waste collection and treatment.

Grading of waste management fees has become more and more common in recent years. This system means that people who generate little waste or sort their waste pay a lower fee. This is in accordance with the polluter-pays-principle. In 1998, more than 200 municipalities stated that their subscribers could choose between different waste management services for which different fees were charged. The corresponding figure for 1997 was 60 municipalities. However, it should be noted that the figures give no information on the extent to which subscribers made use of these options, merely that such systems existed.

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9. Water resources and water pollution

Norwegians tend to look on water as something that can be taken for granted. Few of us has experienced any major problem due to water shortages or polluted drinking water. However, increasing consumption and exploitation of water resources have resulted in greater difficulties in maintaining the quality of drinking water and more serious pollution problems. In addition, our water sources and marine areas are being exposed to long-range pollution from human activity in other countries. Substantial investments in, for example, waste water treatment plants and other mitigating measures are necessary to control the increasing pressure on water resources. To enable us to manage our rich water resources in a sustainable manner in the future, we may have to accept that water cannot be taken for granted in Norway either.

9.1. Introduction

Water resources are used in almost all forms of economic activity, and this makes them 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 by discharges of waste water and environmentally hazardous substances. Although the overall situation in Norway is good as regards both quantity and quality, there can nevertheless be substantial problems at the local level.

Drinking water is of vital importance to life and health and to society as a whole. 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 50 persons or 20 households or holiday homes, or supplying water to food manufacturers, health institutions, etc. to be approved by the authorities. At present a large number of water works still do not meet the requirements of the drinking water regulations and many do not have the water disinfection facilities required by the regulations (Norwegian Food Control Authority 2000).

Almost 90 per cent of the population in Norway receive their water supplies from surface sources. These water sources are vulnerable to acid rain, which has been regarded as one of the greatest environmental problems in Norway for several decades. However, a substantial reduction in sulphur and nitrogen discharges in Europe has reduced the acidification of Norwegian inland waters since 1980. Nonetheless, there is still a long way to go before the natural ecosystems in the most vulnerable areas have recovered, and new international agreements have already been concluded to reduce discharges of harmful substances even further.

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 the eutrophication of rivers, lakes and coastal areas. Eutrophication causes excessive growth of algae and oxygen depletion. Agriculture and aquaculture are also important sources of large nutrient inputs to inland waters and coastal areas.

In recent years, both Norway and other countries that drain to the Skagerrak and the North Sea basin (from the border with Sweden to Lindesnes at the southernmost tip of Norway) 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 and the OSPAR convention, thereby undertaking to halve inputs of phosphorus and nitrogen compared with the 1985 level.

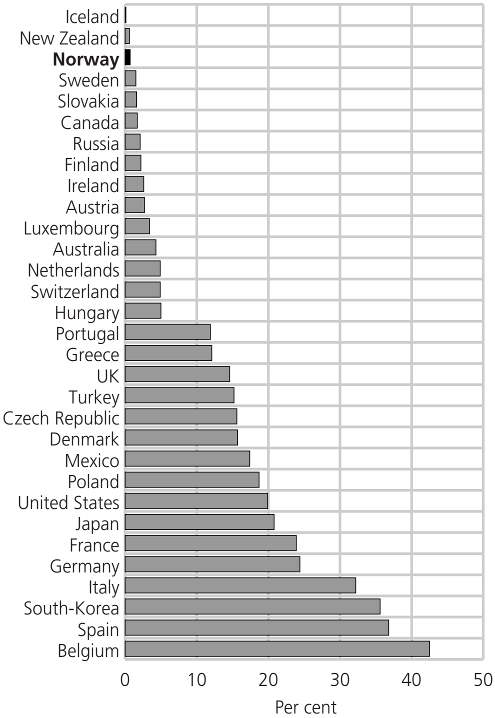
During the past 20 years, Norway has achieved a satisfactory level of treatment efficiency for phosphorus, mainly by building waste water treatment plants providing chemical or chemical/biological treatment. Nitrogen removal measures have been given priority over the last few years in areas where discharges from Norway have a major impact on eutrophication (as defined in the EU waste water directive and the nitrate directive), i.e. areas from the border with Sweden to Strømtangen lighthouse near Fredrikstad (Hvaler/Singlefjorden in Eastern Norway) and in the Inner Oslofjord. Discharges of nitrogen and phosphorus from Norway are relatively modest in comparison with discharges from the other countries bordering the North Sea and the Baltic Sea. To achieve the objective of reducing pollution in these marine areas, cooperation across national borders is as important in this context as it is in many others.

9.2. Water supplies and water consumption

The Norwegian Water Resources and Energy Directorate has calculated that renewable water resources in Norway total just under 400 billion m^3 in a normal year, in other words we use well below 1 per cent of the available water resources. However, there are considerable differences between the various parts of the country in the degree of utilization. The only European country that utilizes a smaller percentage of its total water resources than Norway is Iceland (figure 9.1).

The largest consumers of fresh water in Norway are industry, agriculture and households. On the basis of factors used in Swedish surveys, water consumption in the Norwegian industrial sector is calculated at 1.28 billion m^3 per year. In the agricultural sector, large amounts of water are needed primarily for livestock production and irrigation of crops. Because of the climate, the need for irrigation is low in Norway compared with some other European countries, and preliminary figures from Statistics Norway indicate that overall water consumption in the agricultural sector is around 265 million m^3. However, these figures show a high level of uncertainty. Industry and agriculture largely meet their water needs from

Figure 9.1. Percentage of total water resources utilized by selected countries



Source: OECD (1999).

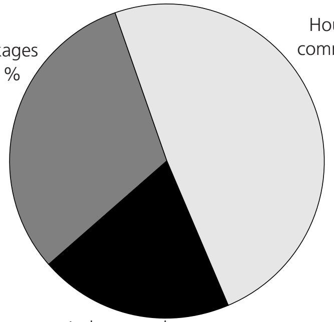
their own sources, and no official statistics giving a detailed picture of this consumption are currently available.

The National Institute of Public Health collects data each year, on behalf of the central authorities, from water works that supply at least 100 permanent residents or 20 households or holiday homes (from 2000 the register includes all water works supplying at least 50 permanent residents or 20 households or holiday homes). An overall assessment of the quality of the water supplied was also carried out in 1994 and 1998. A satisfactory water supply is defined on the basis of assessments of the water works' infrastructure, the pollution situation in the catchment areas of the water sources, and whether the treatment plants can guarantee good water quality. 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 (Appendix, table H 1).

As of 31 December 1999, 1 807 water works were registered as supplying permanent residents. Another 61 water works were registered as only supplying water to holiday homes. Of the 1 807 water works, 1 065 were municipal, 18 were intermunicipal, 721 were privately owned and 3 were state-owned. These water works supplied about 3.95 million persons, or 89 per cent of the Norwegian population. The remainder of the population are supplied by smaller water works, or take water from their own wells, or from rivers and lakes. In addition to these water works, there are a large number (4000-5000) of water supply systems that supply water to individual enterprises, such as abattoirs, hotels, camp sites, schools, etc., but there is little information available about them.

In 1996, the total water production at Norwegian water works was estimated to be 768 million m^3. Norwegian water works mainly use surface water for water supplies. In 1999, 67 per cent of the water works used surface water as the source of water, while 33 per cent used groundwater as their source of water (National Institute of Public Health 2001). Nevertheless, groundwater only constitutes 12-13 per cent of total water production (National Institute of Public Health 1998).

Figure 9.2. Water production (drinking water) in Norwegian water works, by user. 1999



Source: National Institute of Public Health.

Figure 9.2 shows how water production from water works is used. It is important to note that many industrial enterprises use their own water supply in addition to the supply they receive from water works. This means that the food industry, and other industries where enterprises are supplied with water from their own facilities, uses considerably more water than the amount shown in the figure. Private households and commercial enterprises (except industry) are the largest consumers, using 376 million m^3 (38 per cent), or about 261 litres per connected person per day. It is also important to note that more than a third of the water from water works is lost due to leakages from pipelines and joints. It must be stressed that there is some uncertainty associated with these figures, and that the figures for leakages in particular may be higher.

The drinking water regulations require all water to be disinfected or treated to prevent infection. The treatment of drinking water involves adding chemicals, primarily chlorine, and UV radiation. Although there is some discussion about the health effects of chlorine, it is considered a more serious problem that about 450 water works using surface water still do not comply with the disinfection requirements. The widespread belief that the quality of water in Norway is impeccable has resulted in many water works giving priority to low water charges rather than major investments in water treatment equipment. Most of the water works without disinfection facilities are located in the counties of Hordaland, Møre og Romsdal, Sør-Trøndelag, Nordland and Troms. Of these, the water works in Hordaland supply the largest number of people.

In some cases, the quality of the groundwater is so good and so stable that exemptions may be made from the requirement regarding disinfection. Most of the groundwater works are relatively small in size and the number of persons supplied with groundwater is thus much smaller than those supplied with surface water. A large proportion of the water works in the counties of Hedmark, Oppland and Buskerud use groundwater as a source of water.

Although it only represents a small proportion of total consumption, groundwater is often a better alternative than surface water. Factors in favour of greater use of groundwater 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 European countries, groundwater accounts for a large proportion of total water production, largely because of the lack of clean surface water.

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 in this field. 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 for water intake, hygiene, water treatment and water quality. These water works supplied 22 per cent of the population connected to water works. Small water works generally show the poorest results. 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 supplied 34 per cent of the population connected to water works. Table 9.1 shows the percentage of water works with test results that satisfy the limit values in 1999 for the seven most important parameters in the drinking water regulations.

Water consumption

It is assumed that the consumption of water is 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 and the costs related to the supply of water, the price of water may also become one of the factors affecting consumption (see paragraph on new regulations for municipal water and waste water treatment fees).

Table 9.1. Percentage of samples from water works that satisfied the limit values for the 7 most important parameters in the drinking water regulations. 1999

Parameter	Percentage of samples that satisfy the limit values
Odour	75
Taste	79
Colour	72
Turbidity	86
Acidity	50
Intestinal bacteria	65
Thermo-tolerant intestinal bacteria	69

Source: National Institute of Public Health.

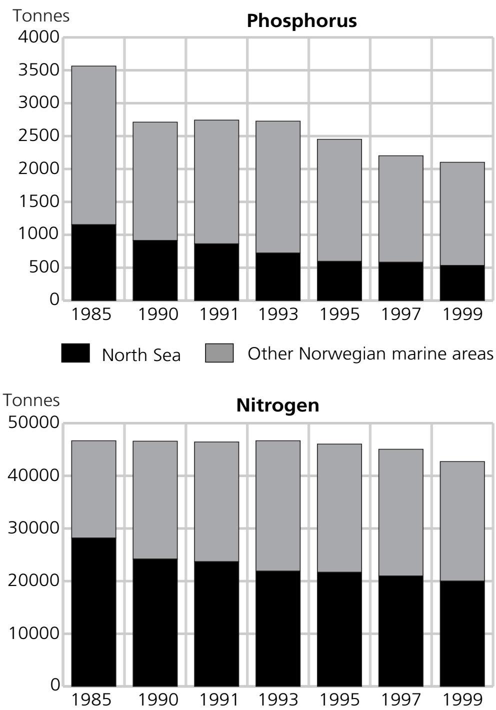
9.3. Inputs of nutrients to Norwegian marine areas

Most of the water used or affected by industry, agriculture, households and other activities in Norway eventually runs into the sea. The volume of water is substantial in the course of a year, and the pollutants contained in it can create major problems in the most vulnerable marine areas off the coast. Beside environmental toxins, phosphorus and nitrogen in particular have caused problems, such as excessive algal growth along parts of the coast.

Total inputs of phosphorus and nitrogen to marine areas off the coast of 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 and the OSPAR convention, see box 9.1) are being achieved. These calculations use discharge figures for waste water, agriculture, aquaculture and industry, and take into account retention (natural "treatment" in the ecosystems) in fjords and river systems.

In 1999, total Norwegian anthropogenic inputs of nutrients to the Norwegian coast from agriculture, industry, aquaculture and waste water were calculated at 6 326 tonnes of phosphorus and 62 927 tonnes of nitrogen (Appendix, table H2,

Figure 9.3. Anthropogenic inputs of phosphorus and nitrogen to the North Sea and other Norwegian marine areas (excluding inputs from aquaculture). 1985, 1990-1999. Tonnes

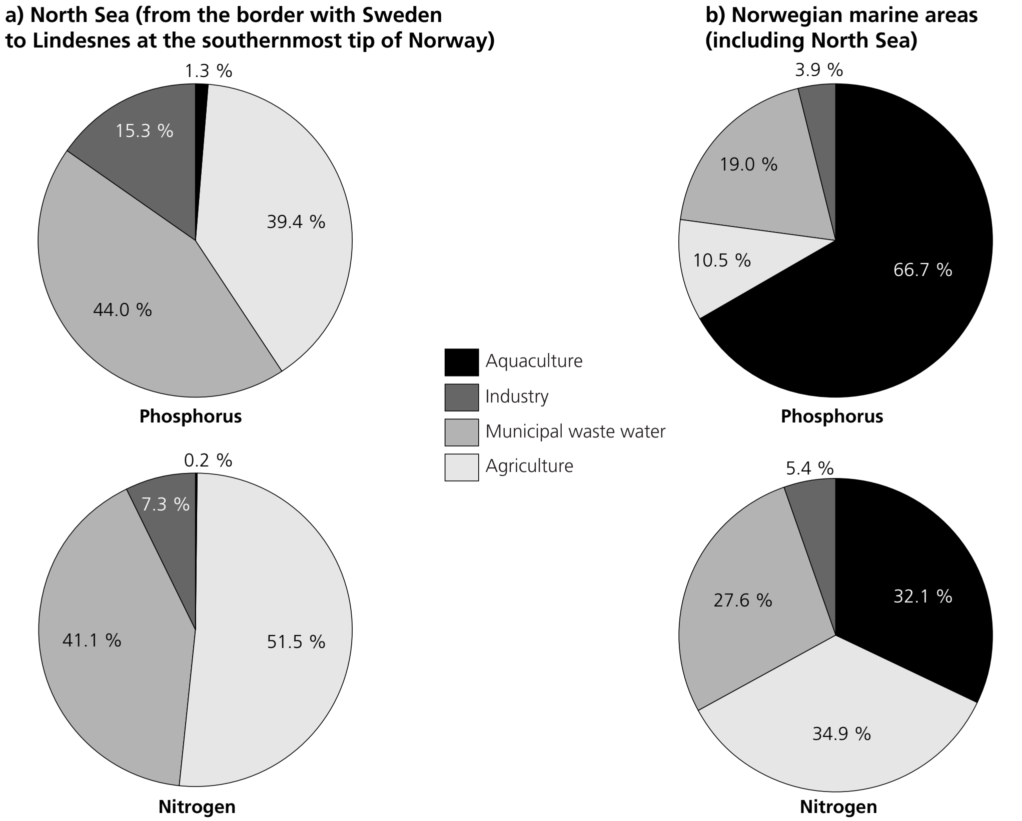


Source: Norwegian Institute for Water Research (2001).

Norwegian Institute for Water Research, 2001). Aquaculture accounted for about 66 per cent of the discharges of phosphorus and 33 per cent of the discharges of nitrogen. Since 1985 anthropogenic inputs of nitrogen and phosphorus to Norwegian coastal areas have been reduced by 8 and 41 per cent respectively (aquaculture excluded). The drastic reduction in inputs of phosphorus is mainly due to more efficient treatment of waste water from industry and private households. The authorities differentiate their requirements with regard to waste water treatment because the conditions in recipients in the various areas along the coast vary widely. This has resulted in the investment of substantial resources in the treatment of sewage and industrial discharges in areas draining to the North Sea and Skagerrak (from the border with Sweden to Lindesnes) and measures to reduce runoff from agriculture in the same area (Chapter 3).

Figure 9.3 shows calculated inputs of phosphorus (figure 9.3a) and nitrogen (figure 9.3b) to the North Sea (from the border with Sweden to Lindesnes) and other Norwegian marine areas in the period 1985 to 1999 (Appendix, table H 3). Retention in river systems has been taken into account. Anthropogenic inputs of nitrogen and phosphorus to Norwegian coastal areas were reduced by 53 and 29 per cent respectively in this period. Figure 9.4 shows that municipal waste water is the largest source of inputs of both phosphorous and nitrogen to the North Sea, while aquaculture accounts for 67 per cent of the total inputs of phosphorous to all Norwegian marine areas. In the counties draining to the North Sea, large sums have been invested in water treatment facilities (Appendix, table H 9), and as a result discharges of phosphorus and nitrogen from the municipal waste water sector alone have been reduced by 67 and 17 per cent respectively from 1985 to 1999. Discharges from agriculture have been reduced by 26 and 19 per cent respectively in the same period. Municipal waste water and agriculture are still the largest sources of inputs of phosphorus and nitrogen to the North Sea (figure 9.4a).

Figure 9.4. Sources of total inputs of phosphorus and nitrogen to the North Sea and Norwegian marine areas. 1999. Per cent



Source: Norwegian Institute for Water Research (2001).

9.4. Acidification and eutrophication in Norwegian inland waters

Open water bodies, such as lakes and rivers, are exposed to both airborne pollution and runoff. Acidification has been one of the most serious environmental problems in Norway for a long time and is mainly caused by fossil fuel combustion outside Norway's borders. Water bodies in the southern half of Norway and eastern parts of Finnmark county are particularly vulnerable to this kind of pollution. Eutrophication is a local problem in a number of lakes, and is caused by inputs of nutrients from agriculture, industry and waste water systems. Eutrophication is most widespread in the major agricultural districts in Eastern Norway, Jæren in the west and around the Trondheimsfjord.

Both acidification and eutrophication reduce the utility value of affected inland waters. The quality of drinking water is impaired, and acidic water causes more corrosion and wear and tear on pipelines and sanitation systems. In addition, both

Box 9.1. Definitions

Waste water treatment plants 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 that 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 treat.

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

Separate waste water treatment plants are designed to receive waste water equivalent in amount or composition to that from up to seven residential households or holiday homes (generally private plants in areas with scattered settlements).

The North Sea Agreements/ OSPAR convention
The North Sea Agreements/ OSPAR convention refer to the joint declarations made by the countries round the North Sea to reduce inputs of nutrients to the North Sea. One of the targets was to halve the total inputs of nitrogen and phosphorus during the period 1985 to 1995. Norway had not reached these targets by the end of 1995, and the national time limit was extended to 2005.

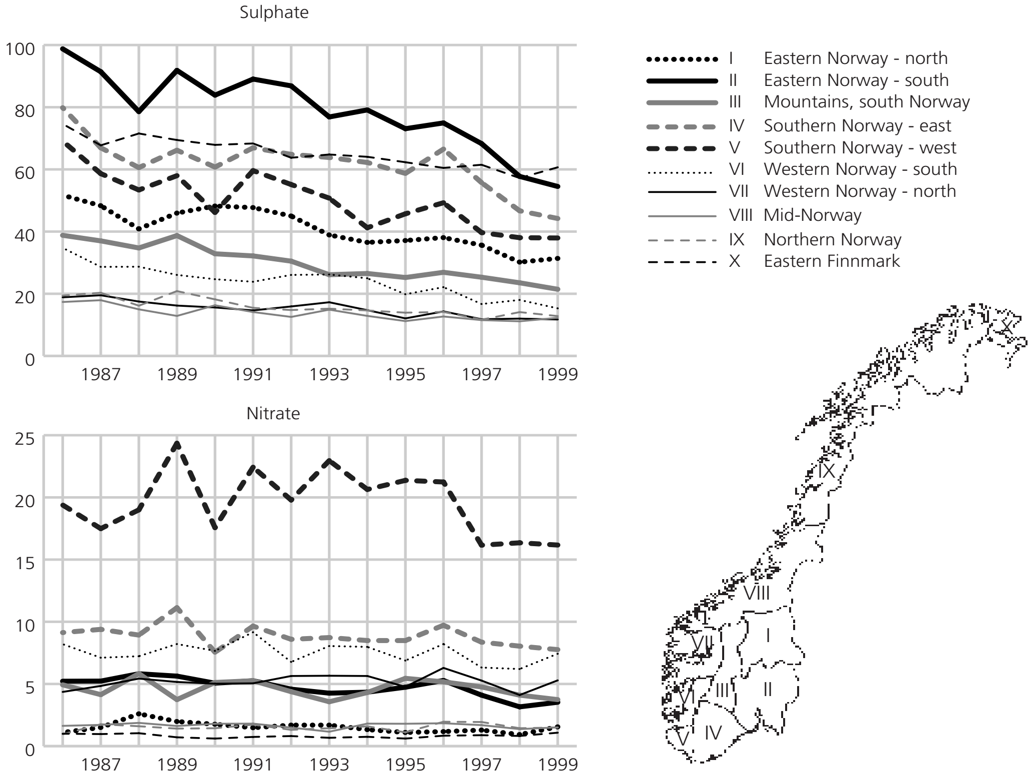
The North Sea counties or North Sea region
In principle, the North Sea Agreements apply to the areas south of 62°N. In Norway, the targets for reducing inputs of nutrients apply to the counties from the border with Sweden to Lindesnes. Thus, the North Sea counties or North Sea region means the following counties: Østfold, Akershus, Oslo, Hedmark, Oppland, Buskerud, Vestfold, Telemark, Aust-Agder and Vest-Agder. Virtually all land in these counties drains into the Skagerrak or the North Sea.

Eutrophication is a gradual process in which inputs of organic matter containing plant nutrients alter biological production conditions in water bodies. Water that is rich in nutrients and very productive biologically is called eutrophic, while water that is poor in nutrients and unproductive is termed oligotrophic. Excessive inputs of nutrients, often anthropogenic, can lead to problems such as algal blooms and oxygen depletion. In fresh water, eutrophication is usually caused primarily by phosphorus (P) inputs, although nitrogen and other substances may also play a role.

The sensitive area for phosphorus
The area that drains to the coast from the border with Sweden to Lindesnes is particularly sensitive to phosphorus inputs. As well as the North Sea counties, south-eastern parts of Trøndelag are particularly phosphorus-sensitive.

The sensitive area for nitrogen
The inner Oslofjord, the area Hvaler-Singlefjorden (around the estuary of the river Glomma) and the catchment areas of the rivers Glomma and Halden are regarded as particularly sensitive to nitrogen inputs. In these areas, the authorities have issued instructions for nitrogen removal at six waste water treatment plants.

Figure 9.5. Nitrate and sulphate content[1] of lakes in selected regions of the country. 1986-1999



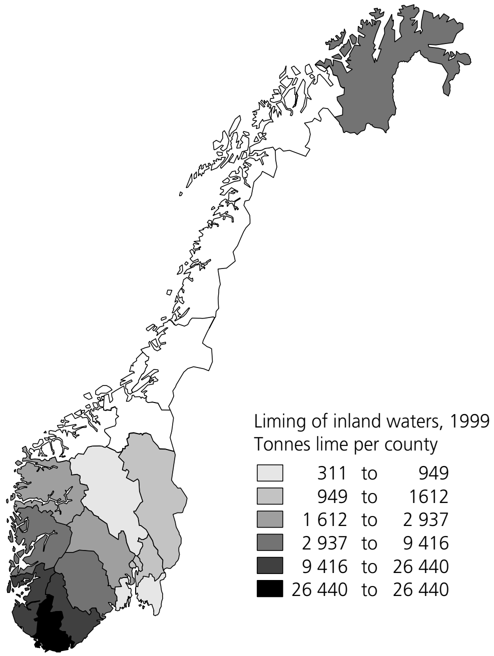
[1] Measured in microequivalents carbonate/bicarbonate per litre water (mequiv/litre).
Source: Norwegian Institute for Water Research/Norwegian Pollution Control Authority (2000).

acidification and eutrophication cause ecological changes in inland waters. Typically, vegetation grows vigorously, dominated by a relatively small number of pollution-tolerant species (though in large numbers of individuals). In seriously affected waters, oxygen deficiency may reach a dangerously low level, with the potential development of toxic blue-green algae. Acidification reduces the numbers of fish and other animals in general in inland waters. A survey of fish stocks in the southern half of Norway shows that 19 per cent of the stocks have been wiped out, and the salmon has disappeared from all the major salmon rivers in Southern Norway (Norwegian Pollution Control Authority/Ministry of the Environment, 2000).

Acidification

Southern Norway and eastern parts of Finnmark county are the areas of Norway that receive the highest concentrations of sulphur dioxide and nitrogen oxides from central and eastern Europe and the Russian industrial areas on the Kola peninsula respectively. About 85 per cent of sulphur and nitrogen deposition in Norway is the result of emissions in other countries.

Figure 9.6. Amounts of lime added to inland waters in counties affected by acidification. 1999. Tonnes



* Liming in Finnmark county is mainly carried out in the areas bordering on Russia (Sør-Varanger, Unjárga, Vadsø, Vardø and Båtsfjord municipalities).
Source: Directorate for Nature Management (1998, 1999).

Sulphur emissions in Europe have been more than halved since 1980, and this has brought about a substantial decrease in the sulphate content of river systems in Southern Norway, and consequently an improvement in the situation cause by acidification. The situation in eastern Finnmark, however, shows little sign of improving, and an increase in sulphate concentrations was recorded in this area in 1999.

Figure 9.5 shows trends in the sulphate (figure 9.5a) and nitrate (figure 9.5b) content of lakes in 10 different regions of the country between 1986 and 1999. The results are based on annual monitoring of about 100 lakes. The figure shows that there has been a substantial reduction in sulphate content in lakes all over the country, ranging from 19 per cent in eastern Finnmark to 48 per cent in the southern part of Western Norway. Although there have also been clear changes in nitrate levels in several regions, they vary so much from year to year that it is difficult to distinguish a clear trend for this nutrient.

Despite the reduction in acidification, it may take a long time before the natural ecosystems in the fjords and river systems are restored. Measures to further reduce acidification will therefore be necessary in the future. Liming has been used for many years to reduce the damage to salmon stocks and other fauna in acidified river systems. Over the last few years, public funds for liming programmes have risen to NOK 100 million a year, and the Norwegian Institute for Water Research recommends that this level should be maintained or increased in the years ahead, despite the fact that the sulphate content of water bodies is decreasing. Figure 9.6 shows the amount of lime used to counteract acidification in the various counties in Norway in 1999. In the last few years, over 60 000 tonnes of lime have been added to water bodies in Norway, most of which was used in the counties of Aust-Agder, Vest-Agder and Rogaland. The amount of lime used in Vest-Agder more than doubled between 1995 and 1999, while in Telemark the amount has been more than halved in the same period. This is partly because the sulphate content in lakes and rivers in Telemark and the mountains of the southern half of Norway has been reduced to a level closer to the critical load. Even though the sulphate content in Vest-Agder has been reduced more than in

Telemark, Vest-Agder still has the highest concentrations of sulphate in the country.

In the long term, the implementation of international agreements on reducing emissions to air will be of more fundamental importance (see also Chapter 7.4). The latest of these is the Gothenburg Protocol, signed in 1999, which applies to emissions of ammonia and volatile organic compounds (VOCs) in addition to sulphur dioxide and nitrogen oxides. Under this agreement, twenty-nine countries, including Norway, have undertaken to make substantial reductions in emissions in the years leading up to 2010. It is expected that this agreement will reduce the area damaged by acid rain in Norway by up to 90 per cent by 2010. The agreement will cost Norway somewhere between NOK 350 and 550 million, but the gains in the form of reduced damage to health, less material damage, higher crop yields, etc. are estimated at between NOK 1 and 3 billion (Norwegian Pollution Control Authority/ Ministry of the Environment, 2000), even without including the gains from restored fish stocks and ecosystems.

Eutrophication

Inputs of phosphorus from agricultural activity and, to a lesser extent, untreated waste water from households are the main causes of eutrophication of fresh water sources in Norway. In comparison with the rest of Europe, eutrophication in this country cannot generally be considered a major problem. Nevertheless, it can be a considerable problem at the local level, particularly in the areas around the Oslofjord and in the lowlands of Eastern Norway, in the areas around Stavanger, in the Jæren district of Western Norway and along the Trondheimsfjord. It is also a widespread problem in areas where there is intensive milk production along the coast of Nordland county. In the 1970s, lake Mjøsa and several other large lakes in Eastern Norway were threatened by eutrophication, and substantial funds were invested in waste water treatment.

Over 90 per cent of all the lakes in Norway are considered good recipients and do not trigger measures above minimum requirements to limit input of phosphorus. Only about 2.5 per cent of all the country's lakes are considered sensitive or overloaded and would trigger measures above minimum requirements. This nevertheless applies to around 800 lakes and surveys show that eutrophication results in a number of user conflicts with regard to drinking water, swimming, fishing and natural assets.

Table 9.2 shows a subjective assessment of changes in degree of eutrophication in 27 lakes in the period 1995-1999. The lakes have been selected on the basis of the following criteria: 1. They are among the most eutrophic lakes in the country, 2. Eutrophication is largely the result of human activity, and 3. All the lakes were monitored over at least 3-4 years. An improvement in water quality was recorded in 14 of these lakes, while only four showed deteriorating quality. In the remaining 9 lakes, no clear trend was recorded. The reasons for the improvement varied between the different lakes. A reduction in the quantity of phosphorus applied, spreading manure at a more suitable time of year, less autumn ploughing and a transition from the cultivation of vegetables to cereals has resulted in an improvement in the eutrophication situation in the Nærevatnet, Liavatn and Langmovatn lakes. Treating waste water from households and improving the sewerage system has had a major positive

Table 9.2. Changes in degree of eutrophication in selected lakes. 1995-1999

Lake	County	Change
Revovatnet	Vestfold	Definite improvement
Gjersjøen	Akershus	Improvement
Nærevatnet	Akershus	Improvement
Årungen	Akershus	Improvement
Farstadvatnet ...	Nordland	Improvement
Langmovatn	Nordland	Improvement
Frøylandsvatnet	Rogaland	Improvement
Liavatn	Sør-Trøndelag	Improvement
Hillestadvatnet .	Vestfold	Improvement
Hellesjøvann	Akershus	Slight improvement
Stovivatnet	Akershus	Slight improvement
Stokkelandsvatnet	Rogaland	Slight improvement
Gjølsjøen	Østfold	Slight improvement
Rokkevatnet	Østfold	Slight improvement
Hersjøen	Akershus	No trend
Gjesåssjøen	Hedmark	No trend
Lyngstadvatn ...	Møre og Romsdal	No trend
Limavatnet	Rogaland	No trend
Frøylandsvatn ..	Rogaland	No trend
Laugen	Sør-Trøndelag	No trend
Akersvatn	Vestfold	No trend
Isesjø	Østfold	No trend
Hostadvatnet ...	Møre og Romsdal	Slight deterioration
Østensjøvatnet .	Oslo	Slight deterioration
Lilandsvatnet ...	Nordland	Deterioration
Mæna	Oppland	Deterioration

Source: Based on Norwegian Institute for Water Research (NIVA) (1999) and NIVA/Norwegian Centre for Soil and Environmental Research (2000).
Definite improvement means that the phosphorus concentration has been more than halved in the period, and that there has been clear improvement in one or more of the other parameters: nitrogen concentration, light penetration and/or chlorophyll concentration. *Improvement* means clear improvement in one or more parameters and no detectable deterioration in any of the parameters. *Slight improvement* means more parameters show noticeable improvement than noticeable deterioration. *No trend* refers to no change in any direction. *Slight deterioration* means more parameters show noticeable deterioration than noticeable improvement. *Deterioration* means clear deterioration in one or more parameters and no detectable improvement in any of the parameters.

impact on the situation in lakes such as Gjersjøen. In general, the most effective ways of counteracting eutrophication are changes in agricultural methods and waste water treatment.

9.5. Waste water treatment

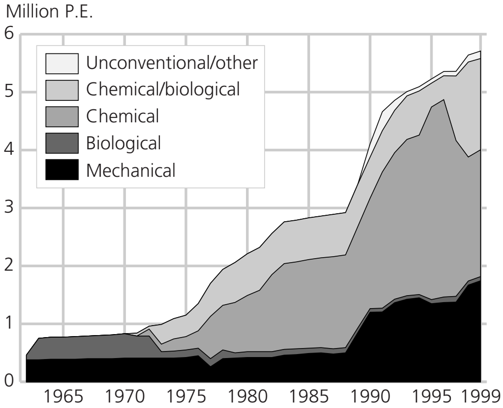
Waste water treatment plants and treatment capacity

In order to avoid the pollution problems mentioned in the previous sub-chapters, there are a variety of waste water treatment plants that remove various pollutants from waste water before it is discharged into the environment. Most waste water treatment plants in Norway have been built within the last 25 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 that 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 areas considerably.

Figure 9.7 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 (Appendix, table H 4).

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

Figure 9.7. Hydraulic capacity, by treatment method. 1962-1999



Source: Waste water treatment statistics from Statistics Norway.

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.

In 1999, 2 871 municipal and private waste water treatment plants with a treatment capacity of at least 50 population equivalents (PE) were registered in Norway. Their total treatment capacity was 5.71 million PE. In addition, 544 sewerage systems with direct discharges of untreated sewage were registered, and these had a total capacity of 0.54 million PE. In Eastern and Southern Norway, a large proportion of municipal waste water is treated in high-grade (chemical and/or biological) treatment plants (figure 9.8). These plants account for 92 per cent of total treatment capacity in this area. Along the coast from Rogaland county and northwards, mechanical treatment and untreated discharges are more common, and high-grade treatment plants account for only just over 24 per cent of total hydraulic capacity (Appendix, tables H 4 and H 5).

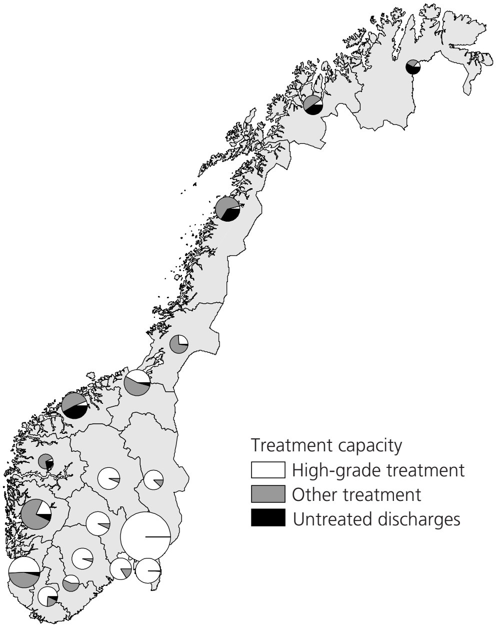
Discharges from municipal sewerage systems

Just 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. The rest of the population are mainly connected to separate sewerage systems located in areas of scattered settlement. The statistics for separate sewerage systems only includes permanent settlements, and there is little data available about the extent of discharges from holiday homes (cabins).

Figure 9.9 shows that the municipal sewers discharged a total of 835 tonnes of phosphorus in 1999, while 345 tonnes were discharged from the separate sewerage systems. Average treatment efficiency for the two types of systems was 69 and 34 per cent respectively, in other words a total of 2 030 tonnes of phosphorus was retained in the treatment plants. This ends up as a component of sewage sludge, and is subsequently used in, for example, integrated plant nutrient management.

In the North Sea counties, treatment efficiency was calculated to be 92 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. Despite the fact that 55 per cent of Norway's population live in the North Sea counties, only 120 tonnes of phosphorus, or 14 per cent of the country's total discharges from municipal sewerage systems, come from this area.

Figure 9.8. Hydraulic capacity of municipal sewerage systems, by treatment method[1,2]. 1999

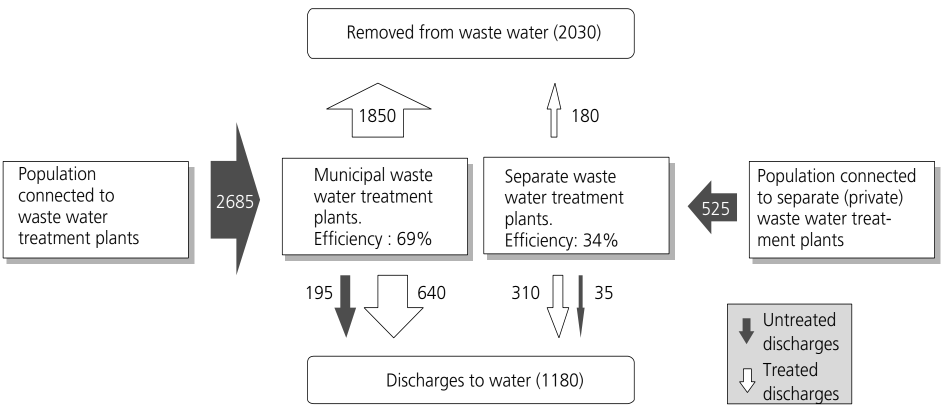


[1] High-grade plants are plants with chemical and/or biological treatment. [2] See Appendix table H 5 for actual figures.
Source: Waste water treatment statistics from Statistics Norway.

As conditions in the recipients are generally better along the coast from Rogaland county 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 717 tonnes of phosphorus was discharged from these plants in 1999. The average treatment efficiency in this area was calculated to be 28 per cent.

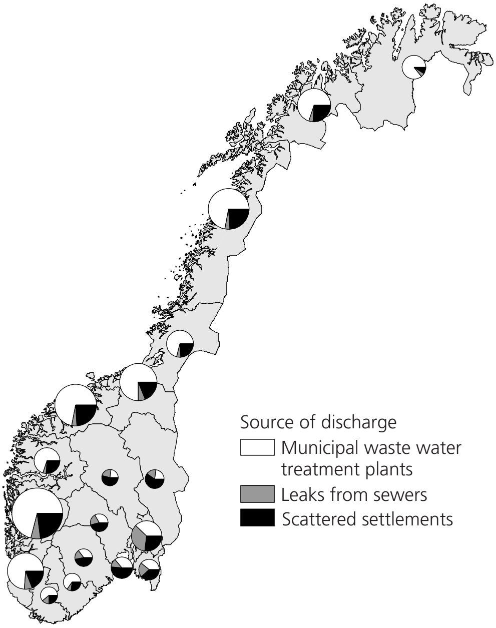
Many areas have municipal sewerage systems that discharge untreated waste water. In 1999, 544 of these sewerage systems were registered, mainly in the counties of Sogn og Fjordane, Møre og Romsdal, Nordland, Troms and Finnmark. It is calculated that these sewerage systems discharged just under 200 tonnes of phosphorus in 1999, or as much as 23.5 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.

Figure 9.9. Material flow diagram for phosphorus in waste water[1]. 1999. Tonnes



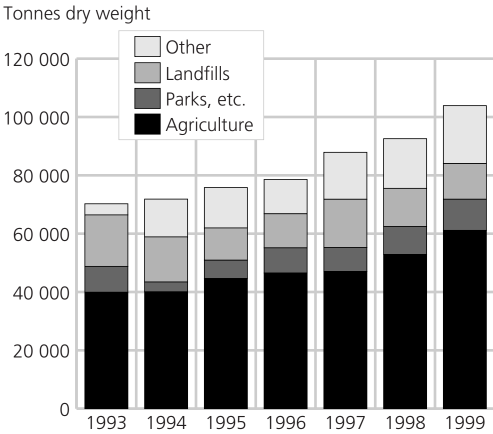
[1] Leaks from sewers not included.
Source: Waste water treatment statistics from Statistics Norway.

Figure 9.10. Discharges of phosphorus from municipal and private sewerage systems by county[1]. 1999



[1] For actual figures, see Appendix, table H 6.
Source: Waste water treatment statistics from Statistics Norway.

Figure 9.11. Quantities of sewage sludge used for different purposes. 1999



Source: Waste water treatment statistics from Statistics Norway.

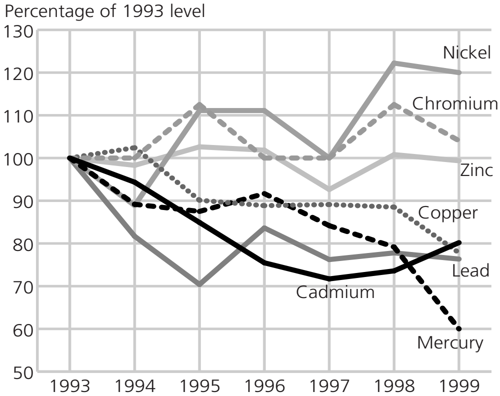
It should be noted that leaks from sewers and overflow in periods of heavy rainfall can make up a substantial proportion of total discharges. It is difficult to give an exact figure for such losses, but on average it is assumed that about 5 per cent of the waste water is lost from leaking pipes and joints. This will vary widely from one municipality to another depending on the type of sewer system and its age.

Use of sewage sludge

Sludge is a residual product of the waste water treatment process, and contains both organic matter and plant nutrients that can be used as fertilizer or in integrated plant nutrient management. In 1999, a total of 103 900 tonnes of sludge, expressed as dry weight, was used for various purposes (figure 9.11), an increase of 12 per cent on the previous year. Of this, 59 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 (12 per cent) and for other purposes (19 per cent).

The composition of sewage sludge, 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. On the basis of 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 sludge utilized in 1999 contained about 110 kg of cadmium and 90 kg of mercury (table 9.3), but there is a great deal of uncertainty attached to some of these calculations. Even though the average figures are fairly low in relation to the authorities' requirements regarding the use of

Figure 9.12. Trend in content of heavy metals in sewage sludge, calculated on the basis of annual median values. 1993-1999. Index: 1993=100 per cent



Source: Waste water treatment statistics from Statistics Norway.

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. Because of the danger of bioaccumulation of environmentally hazardous substances in organisms and food chains, sludge that exceeds the limit values cannot be used on agricultural areas or parks and other green spaces.

Figure 9.12 shows trends in median values in relation to the 1993 level. The figure indicates that the content of cadmium, copper and mercury was reduced, while the content of nickel rose from 1993 to 1999.

9.6. Investments in waste water treatment and sewers

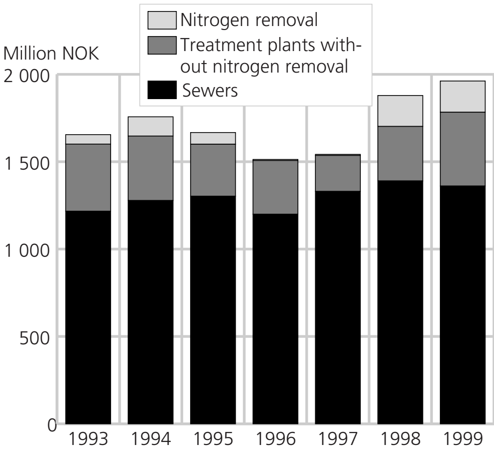
In 1999 the waste water sector cost the municipalities a total of NOK 4.04 billion. About half of these costs are related to municipal investments in this sector. The remainder are costs related to operation and maintenance. Annual costs have risen in all the counties from 1998 to 1999. Although annual costs per subscriber within the municipalities varied

Table 9.3. Content of heavy metals and nutrients in sewage sludge. 1999

	Average for all treatment plants		Highest registered value (mg per kg)	Limit value: Agricultural areas (mg per kg)	Limit value: Green spaces (mg per kg)	Total quantity in sewage sludge used (tonnes) [1]
Heavy metals						
Cadmium (Cd)	0.96	mg per kg	12.7	2	5	0.11
Chromium Cr)	29.79	mg per kg	436	100	150	3. 05
Copper (Cu)	248.22	mg per kg	1 497	650	1 000	24.76
Mercury (Hg)	0.95	mg per kg	24	3	5	0.09
Nickel (Ni)	13.76	mg per kg	407	50	80	1.56
Lead (Pb)	24.18	mg per kg	150	80	200	2.94
Zinc (Zn)	361.29	mg per kg	2 907	800	1 500	35.07
Other substances						
Organic matter	62.53	% of DW				64 970
Kjeldahl-N	2.82	% of DW				2 930
Ammonium-N	0.31	% of DW				320
Total phosphorus (P) .	1.62	% of DW				1 680
Potassium (K)	0.17	% of DW				180
Calcium (Ca)	3.30	% of DW				3 430

[1] DW (dry weight) means dried sludge or what remains after the water has been removed (mainly organic matter and nutrients).
Source: Waste water treatment statistics from Statistics Norway.

Figure 9.13. Investments in municipal waste water treatment sector, by category. The whole country. 1993-1999. 1999 NOK



Source: Waste water treatment statistics from Statistics Norway.

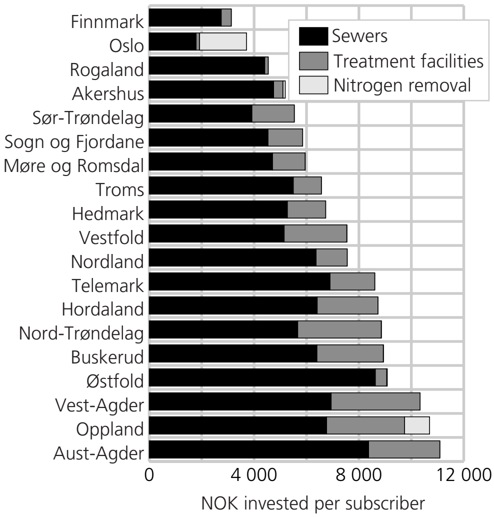
between NOK 64 and 20 990, half of the municipalities had annual costs of between NOK 1 001 and 3 000 per subscriber.

The municipalities make substantial investments in waste water treatment in order to minimize pollution from waste water. However, by far the largest proportion of the investments made in the municipal waste water sector consists of the investments in the sewer system transporting the waste water to the treatment plants. Investments in new sewers and renovation of existing systems accounted for 69 per cent of the total investments made in 1999 (figure 9.13). Investments in nitrogen removal processes in treatment plants accounted for 9 per cent in 1998 and 1999, as against only 0.4 per cent in 1997. Investments in treatment plants without nitrogen removal processes accounted for 22 per cent. In other words, municipal investments are to a great extent focused on those aspects of the waste water sector that are not directly connected to waste water treatment (Appendix, table H 9).
Total gross investments, which include sewers and waste water treatment, increased by 9 per cent from NOK 1.81[1] billion in 1998 to NOK 1.96 billion in 1999 (current NOK). In real terms, this is an increase of 4.4 per cent. Investment levels in 1998 and 1999 have been the highest since 1993 when comprehensive statistics of the waste water sector were started. The steep growth in investments is partly because the construction of nitrogen removal facilities in Oslo was resumed after a prolonged delay.

Investments in the various counties vary widely. There are a variety of reasons for this. To meet Norway's commitments under the North Sea Agreements (see definition in box 9.1), stricter requirements for reductions in discharges were included in the licences granted to the municipal treatment plants in the North Sea counties than those in other counties. In the period 1993-1999, NOK 1 541 million was invested in treatment plants (including nitrogen removal) in the North Sea counties, while the corresponding figure for the rest of the country was NOK 908 million. Settlement patterns also play a role because investments in municipal treatment facilities are not as large in areas of scattered settlement. In these areas, separate treatment plants are more common. Figure 9.14 shows how investments per subscriber vary from county to county. The investments in the waste water sector for the years 1993-1999 have been added together and divided by the number of subscribers in each county, showing that most North

[1] The investment figure for 1998 has been corrected in relation to Statistics Norway (2000) because of an error discovered in earlier reports.

Figure 9.14. Investments per subscriber in the municipal waste water treatment sector, by method of treatment in the various counties. Total investments per subscriber. 1993-1999. Current NOK



Source: Waste water treatment statistics from Statistics Norway.

Sea counties have invested more per subscriber than the other counties. Investments per subscriber in the counties of Akershus and Oslo are relatively low. This is partly due to economies of scale (densely populated counties) and the fact that substantial investments were made before the statistics were started.

9.7. New regulations concerning municipal water and waste water treatment fees

Changes in the regulations concerning municipal water and waste water treatment fees allow users to pay to a greater extent according to their consumption and discharges. The new regulations may thereby result in less water being used and less pollution.

The Pollution Control Act and the regulations concerning municipal water and waste water fees give the municipalities the legal authority to charge consumers so as to finance the removal and satisfactory treatment of polluted waste water, and build and maintain water works that will maintain adequate supplies of good quality water. The regulations allow the municipalities to recoup all their costs[2] with respect to water and the waste water sector by charging fees. However, the municipalities are not entitled to charge more in fees than the sector costs them. If this sector shows a surplus in a municipality in any particular years, the surplus is to be transferred to the following year and is not to be used for other purposes in the municipality (Ministry of the Environment 2000b).

Differences between municipalities in levels of fees charged (Appendix, table H 11) are a result partly of the different choices made with respect to investments and costs, partly of various central government measures, and partly the fact that natural conditions and population patterns vary from place to place.

In the regulations, the Ministry recommends that the service should be fully financed by the users. Even though the polluter-pays-principle (Pollution Control Act, section 2, paragraph 5) supports this, the municipalities are in practice free to choose whether to charge lower fees from users. There is a distinction between the water and waste water sector and the waste sector here. With regard to the waste sector, the Storting (Norwegian parliament) has explicitly instructed the municipalities to determine fees so that

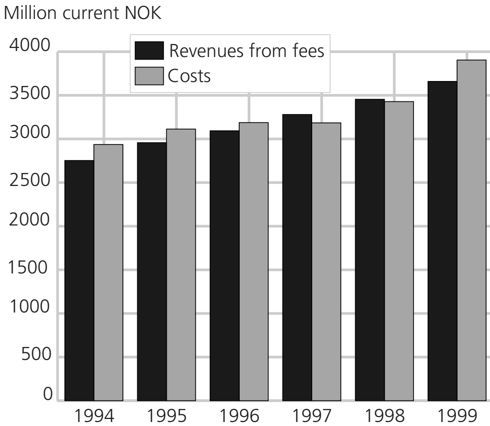
[2] Calculations of municipal costs are based on the principle of full costing.

all the costs are fully covered (Pollution Control Act, section 34).

Waste water sector – the polluter pays most of the costs

Statistics for municipal revenues from fees and costs in the waste water sector show that the costs are largely covered by revenues from fees (Appendix, table H 10). From a national perspective, the claim that the polluter pays is therefore largely valid. However, this is not necessarily the same as saying that the individual user pays more the more the user pollutes. Figure 9.15 show the relationship between costs and revenues from fees in the municipal waste water sector nationwide.

Figure 9.15. Revenues from fees and costs in the municipal waste water sector. The whole country. 1994-1999. Million current NOK



Source: Statistics Norway.

In 1999, the municipalities' total revenues met 94 per cent of their total costs, the lowest income-to-cost ratio since 1994, when this figure was also 94 per cent. Changes in interest rates in particular cause municipal capital costs to vary considerably from year to year, while fees do not change at the same rate. The municipalities often prefer to transfer a surplus or a deficit to the following year.

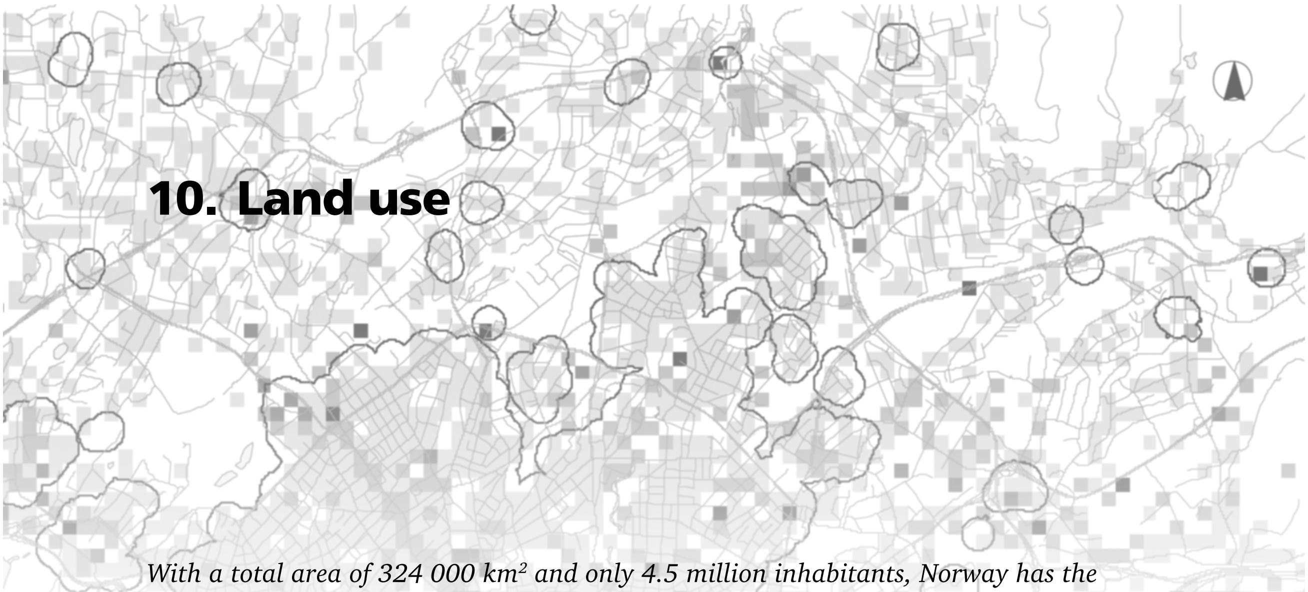
Even though the national figures show that the polluter pays most of the costs related to the waste water sector, there are considerable differences between the various municipalities with regard to the implementation of the polluter-pays-principle. In 1999 the average income-to-cost ratio (municipal average) was 81 per cent. But since revenues and costs are higher in municipalities with a high income-to-cost ratio, the weighted average is higher than the municipal average. However, the trend since 1994 indicates that fewer and fewer municipalities have a low income-to-cost ratio for this sector. In 1994, 40 per cent of the municipalities had an income-to-cost ratio below 60 per cent, but this percentage had dropped to 27 per cent in 1999.

Will the new regulations result in lower consumption and discharges?

As of 2001, the municipalities can use a dual fee scheme, consisting of one fixed and one variable element. This allows for a fee scheme that more closely reflects the municipalities' fixed and variable costs in relation to the consumer. Furthermore, the individual consumer may (like the municipality) require water consumption to be measured. Whether this will influence subscribers' consumption of water and discharge of waste water remains to be seen. No data is currently available to enable an analysis of whether subscribers who pay according to what they actually use reduce their consumption.

Documentation: Kjetil Mork et al.

Further information may be obtained from: Svein Erik Stave (physical data) and Tone Smith (economic data).



10. Land use

With a total area of 324 000 km² and only 4.5 million inhabitants, Norway has the second lowest population density in Europe after Iceland. Because of Norway's climate, geology and geography, a large proportion of the country has not been developed for settlement. Agricultural land accounts for only 3 per cent of the area of the Norwegian mainland, and only 0.6 per cent of the mainland is regarded as urban settlement area. Settlements are to a large extent to be found in the most productive agricultural and forest regions, with the population concentrated in and around the largest urban settlements. Three out of four people in Norway today live in urban settlements and, as a result, the biologically most productive areas are under considerable pressure from development. Land use has increased in intensity in sparsely settled areas too, as a result of extensive public and private road construction, the construction of power lines, building of holiday cabins, and so on.

How the land is used is of great importance in terms of economics and the environment in both central and outlying districts, and it is important to people's health, the local environment and quality of life, and to sustainability and biological diversity. Work is being conducted nationally and internationally to develop targets and indicators as planning and management tools to monitor land use developments in general and in and around urban settlements in particular.

10.1. Introduction

An increasing percentage of the population live in urban settlements in central parts of the country, and this trend creates pressure on the most productive areas, making it increasingly important to manage and monitor developments in land use in these areas. With the population increasingly concentrated primarily along the coast and in the most productive agricultural areas, resource and environmental problems often result. These can include the conversion of the most valuable agricultural areas for other purposes, pressure on recreational areas in and around urban settlements, conflicts about whether to demolish or restore old buildings, and more concentrated air pollution. On the other hand, population concentrations provide opportunities for environmental gains such as reduced energy use for transport and residential areas, and more efficient water, sewage and waste disposal schemes.

Demands for efficient transport, hydropower development, transmission lines, and modern agricultural and forestry operations have an impact on land use and change the landscape even in sparsely populated areas. More specialized farming and the trend towards fewer and larger farms results in less variation in the agricultural landscape as ditches and ecotones are filled in or removed. See also Chapter 3. On the other hand, when summer and mountain farms are abandoned and uncultivated pasture is no longer used in the traditional way, long-established cultural landscapes in the mountains and heaths along the coast are reclaimed by forest and the original vegetation returns.

Despite the fact that the number of people living in areas of scattered settlement is declining, land use has also become more intensive here. The area of uncultivated land that has not been affected by road construction or other major infrastructure development is becoming smaller.

In Europe, many of the land use issues are related to the use of agricultural land and are dealt with through the Common Agricultural Policy. However, over the last few years there has been an increasing focus on urban areas and the important role of regions surrounding the large towns, where there is competition to establish new companies, attract expertise, attract tourists and establish national and international institutions. Consequently, there is an international need for statistics that make it possible to compare trends in the urban regions with regard to actual economic development, social conditions and the environment in the broadest sense of the word.

10.2. Land and land use in Norway

Geography

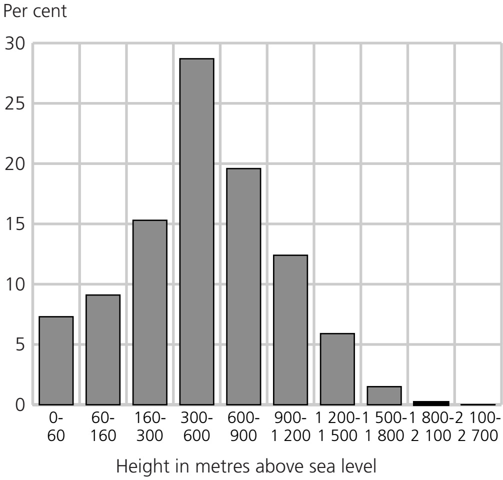
The mainland of Norway is 1 752 km long and stretches from Lindesnes in the south (57° 58' N to Kinnarodden in the north (71° 7' N). The most westerly and most easterly points are Vardetangen near Bergen (4° 56' E and Kibergneset near Vardø (31° 3' E) respectively. The total mainland area, including islands in saltwater areas, covers 323 758 km^2. Of this, 17 505 km^2 or 5.4 per cent is made up of freshwater areas. Islands in saltwater areas account for 22 275 km^2, or 6.9 per cent of the mainland. The mainland is bounded to the south, west and north by a 2 650 km long coastline, not including fjords and bays. The national boundary towards the east is 2 542 km long in all, sharing 1 619 km with Sweden, 727 km with Finland and 196 km with Russia.

The geographical location of the country and its elongated form with variations in climate, quaternary geology and topography mean that the conditions for land use cover a wide range. In terms of altitude, 31.7 per cent of the land area lies 0-299 metres above sea level, and this is where most people live and where agricultural production is most intensive. As much as 20.1 per cent of the land area lies at least 900 metres above sea level and productivity (in terms of vegetation) is therefore low (figure 10.1).

Land use/cover

At the turn of this century, there were a total of 3.4 million buildings, 4 021 km of rail track and 90 741 km of public roads, as well as about 73 000 forestry roads and other roads. The total land area occupied by the railway network is 200 km, or 0.06 per cent of the mainland

Figure 10.1. Distribution of mainland Norway by height above sea level



Source: Norwegian Mapping Authority, 2000 and Statistical yearbook, Statistics Norway.

(Norwegian State Railways 1992). Calculated in this way, built area accounts for a total of about 1.2 per cent of the mainland (see box 10.1). Urban settlements account for a major proportion of built area and, as of 1 January 1999, took up a total of 2 084 km^2, or 0.64 per cent of the total mainland area.

The Agricultural Census of 1999 shows that agricultural area in use accounts for a total of 10 382 km^2, or 3.2 per cent of the mainland. Most of this area is concentrated in the lowlands of Eastern Norway, Jæren in the west and the areas around the Trondheimsfjord. The length of the growing season, the climate and economic conditions set restrictions on what kind of plant production agricultural land is used for, and only 3 345 km^2, or about 1/3 of the total agricultural area, was used for the production of cereals and oil seeds in 1999.

About 75 000 km^2 of the land area, or 23.2 per cent of the mainland, is covered by productive forest (Norwegian Institute For Land Inventory 1999). The remaining land area comprises other cultivated land, scrub and heaths along the coast, mountain forest and marginal forest, and sparsely vegetated mountains and mountain plateaux. Of this, 49 km^2 is under permanent ice and snow (figure 10.2).

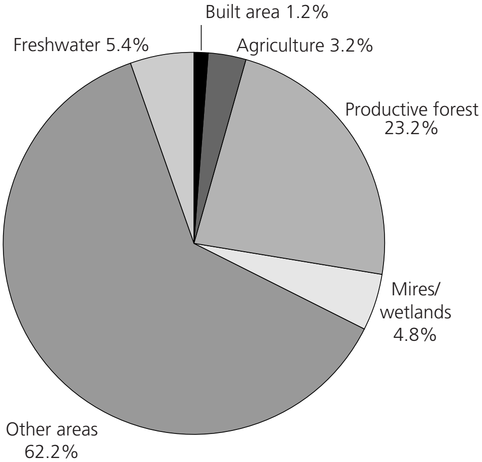
Protection and area development

As of 31 December 1999, a total of 24 556 km^2 or 7.6 per cent of the land area was protected under the Nature Conservation Act. Protected areas comprised 18 national parks, 1 441 nature reserves, 97 protected landscapes and 76 other forms of protected area.

Over the last few years, special attention has been focused on the protection of coniferous forests, and by the end of 1997 a total of 1 995 km^2 of forest or 1.68 per cent of all forest area had been protected. This included 449 km^2 of productive coniferous forest, or about 0.84 per cent of the total area of productive coniferous forest. According to current plans for the protection of coniferous forests, a total of 1.06 per cent of coniferous forests will be designated for protection. Added to this are broadleaved and mixed forest and forest areas that will be part of new national parks because of their location (Report No. 17 (1998-1999) to the Storting).

Despite the fact that large areas have been designated for protection, it is even more important to ensure biological diversity and sustainability in other areas. This raises a variety of issues such as, for example, the use of small green spaces in

Figure 10.2. Relative area occupied by main categories of land cover



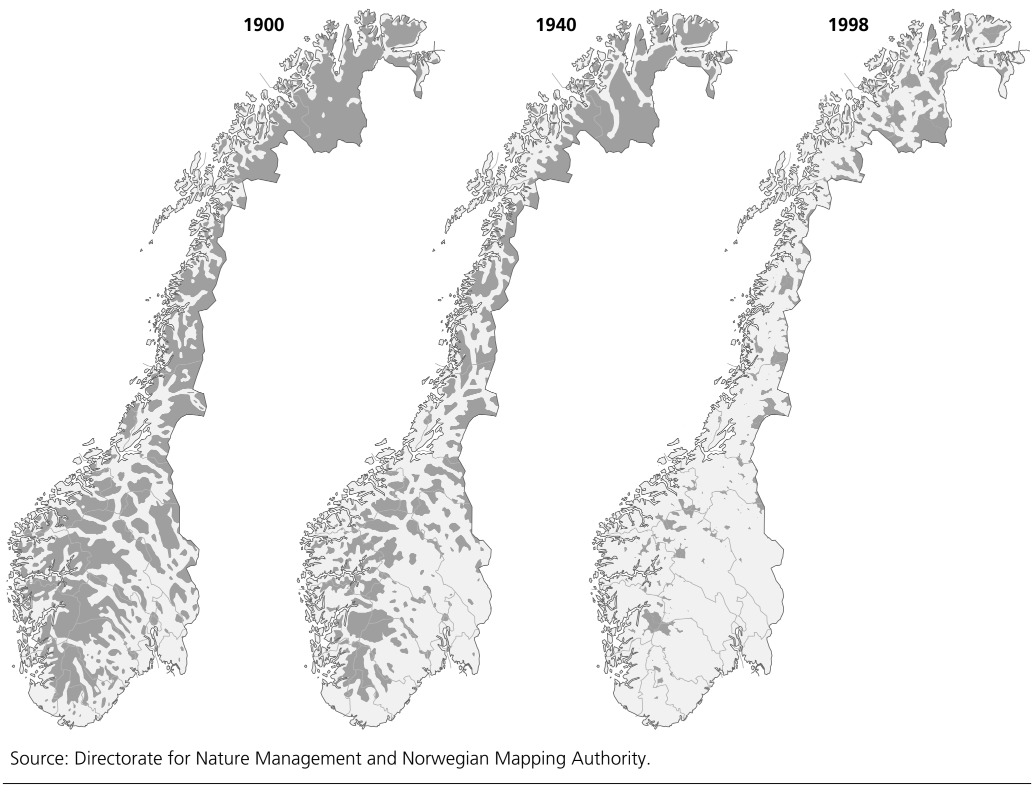
Source: Norwegian Mapping Authority 2000 and Land use statistics, Statistics Norway.

urban settlements or the large tracts of forest in Eastern Norway and Trøndelag.

Safeguarding areas of recreational value is an express national target. Several specific key figures have been drawn up as operational tools to monitor developments in relation to the national targets set out in Report No. 24 (2000-2001) to the Storting.

Access to the 100-metre belt along the coast is one such key figure. The mainland coastline is 83 281 km long, including islands, fjords and bays. This is equivalent to twice the circumference of the earth at the equator. Most of the

Figure 10.3. Wilderness-like areas more than 5 km from major infrastructure development. 1900, 1940 and 1998



Source: Directorate for Nature Management and Norwegian Mapping Authority.

urban settlements and built areas, including holiday cabins, are concentrated along the coast. As much as 22.4 per cent of the total length of the coastline is less than 100 metres from a building. From Halden in the south-east to Hordaland in the west, a stretch of the coast specifically mentioned in the context of key figures, as much as 37.7 per cent of the coastline is less than 100 metres from a building. This indicates that public access to the 100-metre belt of the coastal zone is considerably restricted on this stretch of the coast.

Change in the extent of wilderness-like areas is much used as a general indicator of increasingly intensive use of uncultivated land (figure 10.3). Wilderness-like areas, defined as areas more than 5 km from major infrastructure development, have been dramatically reduced from about 48 per cent of the land area in the year 1900 to about 12 per cent today. In south Norway there is only about 5 per cent wilderness-like area left (Report No. 8 (1999-2000) to the Storting).

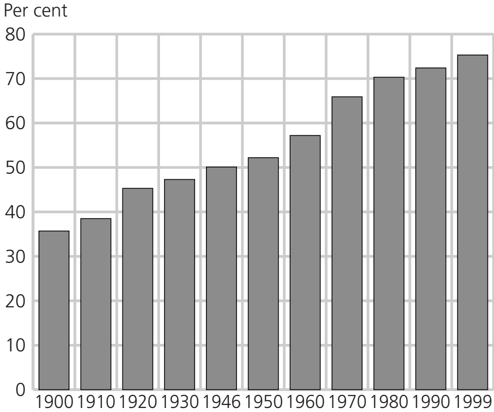
It has so far been difficult to obtain national statistics showing current status and trends with regard to land used for built areas in urban settlements, the proportion of areas for outdoor recreation near dwellings and the structure of green spaces in urban settlements and in the immediate vicinity of urban settlements.

10.3. Total area and population in urban settlements

History

Around the year 1900, 35 per cent of the population of Norway lived in densely populated areas. Changes in methods of operation in the primary industries and the evolution and concentration of the manufacturing industries and service sectors have resulted in major changes in settlement patterns over the last 100 years. Today about 77 per cent of Norway's population live in urban settlements (figure 10.4).

Figure 10.4. Percentage of population resident in urban settlements/densely populated areas



Source: Population and education statistics, Statistics Norway.

Number of urban settlements, area and residents in urban settlements today

An urban settlement has been defined by Statistics Norway in simple terms as an area which has at least 200 residents and where the distance between buildings does not normally exceed 50 metres. Urban settlement boundaries are thus dynamic, changing in pace with building patterns and changes in the population. In addition to the increasing expansion of the major urban settlements, general population growth has resulted in some areas of scattered settlement developing into urban settlements. In areas where the industrial structure is weak, a declining population has meant that some urban settlements are no longer classified as such.

Urban settlements have been localized and delimited as of 1 January 1999, and calculations show that 76.7 per cent of the population was at that time resident in a total of 911 urban settlements. The total area occupied by urban settlements was 2 084 km², or 0.64 per cent of the total mainland area. Although urban settlements vary greatly in size, whether measured as area or in number of residents, the great majority of them are small. As many as 359 urban settlements have less than 500 residents (table 10.1).

The percentage of the population living in urban settlements is greatest in the counties of Oslo and Akershus, with 99.3 and 86.6 per cent respectively of the total county population. The percentage is smallest in the counties of Sogn og Fjordane, Oppland, Nord-Trøndelag and Hedmark, where about half of the total population live in urban settlements (Appendix, table I 1).

Even though a large percentage of the population live in densely populated areas, there are only a small number of large urban settlements in Norway. Only 19 urban settlements have over 20 000 residents, and of these only Oslo, Bergen, Stavanger/Sandnes and Trondheim have more than 100 000. In the four largest urban settlements, the population has increased by between 28 and 63 per cent from 1960 to 1999 (figure 10.5), and as of 1 January 1999, 28.1 per cent of Norway's total population was living in these four urban settlements.

The overall area of the 19 urban settlements with at least 20 000 residents in 1999 has increased by 7.6 per cent in the course of nine years, from 811 km² as of 1 January 1990 to 873 km² in 1999 (Appendix, table I 2).

Table 10.1. Urban settlements, residents and area. All urban settlements. 1 January 1999*

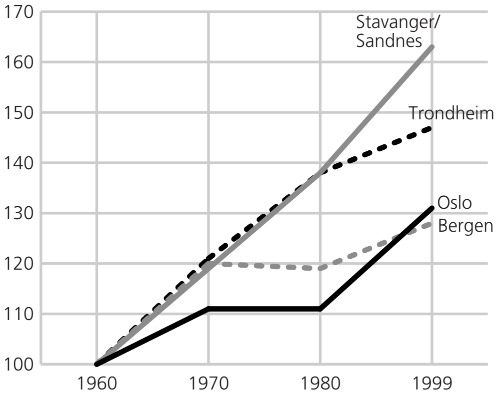
Size category Number of people	Number of urban settlements	Residents	Total area in km²	Residents per km²
All urban settlements	**911**	**3 304 352**	**2 084.3**	**1 585**
200 - 499	359	120 848	166.0	728
500 - 999	219	150 806	180.4	836
1 000 - 1 999	143	205 059	203.7	1 007
2 000 - 19 999	171	897 656	663.5	1 353
20 000 - 99 999	15	681 168	400.2	1 702
100 000 -	4	1 248 815	470.6	2 654

Source: Land use statistics, Statistics Norway.

10.4. National targets and indicators for sustainable urban settlement development

Sustainable urban settlement development is one of the main themes in Report No. 29 (1996-1997) to the Storting on regional planning and land use policy. The objective of planning is to focus on strengthening activity and settlement in urban settlement centres, reducing the need for transport, making more efficient use of the land and ensuring green spaces are protected for recreational purposes and to maintain biological diversity. Efforts to develop a national environmental and land use policy have been followed up in Report No. 8 (1999-2000) and Report No. 24 (2000-2001) to the Storting, which set national targets for the conservation of biological diversity, outdoor recreation and the preservation of our cultural heritage. National land use statistics and indicators are needed in order to monitor whether measures that have been implemented are having the desired effect and whether the environmental policy objectives mentioned above have been reached.

Figure 10.5. Relative increase in number of residents in the four largest urban settlements. 1960-1999 (1960=100)



Source: Statistical yearbook, Statistics Norway.

The sustainable urban development programme (Ministry of the Environment 1995) resulted in the formulation of a number of general targets. Their objective was to reduce land use for development and transport purposes while safeguarding natural surroundings and local outdoor areas to maintain biological diversity and opportunities for recreation, and to improve access to inland water bodies and the sea.

In connection with these goals, a number of indicators were proposed (Norwegian Pollution Control Authority 2000), including:

Under the strategic objective for outdoor recreation stated in Report No. 24 (2000-2001) to the Storting, national target 4 reads as follows: "Near housing, schools and day care centres, there shall be adequate opportunities for safe access and play and other activities in a varied and continuous green structure and ready access to surrounding areas of countryside." On the basis of this target, two key figures to measure performance over time have been calculated:

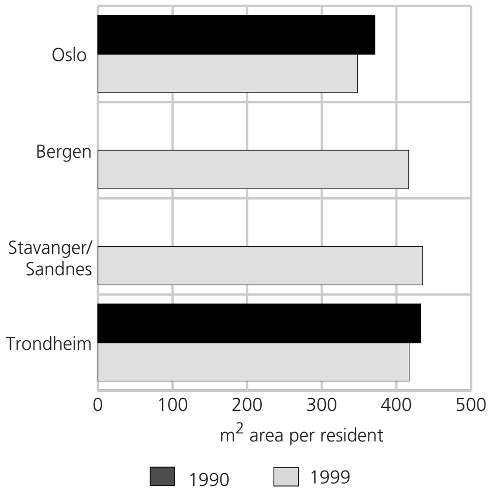
1. Percentage of dwellings, schools and daycare centres with safe access to play and recreational areas (at least 0.5 hectares) within a distance of 200 metres.

2. Percentage of dwellings, schools and daycare centres with access to nearby outdoor recreation areas (larger than 20 hectares) within a distance of 500 metres.

Alongside international recommendations, these national key figures indicate the direction work on environmentally sound and sustainable urban settlement development should take. Several of the indicators are already supported or can be supported by national statistics on the basis of data that is already available (see box above), while for other indicators a

	Indicators	Figures available?
1	Urban settlement area in m^2 pr resident	Yes
2	Traffic area in urban settlement in m^2 pr resident	Yes
3	Base area for residential housing in urban settlements pr resident	Yes
4	Dwelling base area in m^2 pr resident	Not yet
5	Green structure as a proportion of urban settlements in m^2 per resident and as percentage of urban settlement area	Not yet
6	Undercapacity of available play and recreation areas near dwellings in urban settlement	Not yet
7	Undercapacity of available outdoor recreation area near dwellings in urban settlement	Not yet
8	Average distance from centre to newly-built residential housing	Yes
9	Percentage of population living in centre	Yes
10	Percentage of population within walking distance of various service functions	Yes

Figure 10.6. Area of urban settlement per resident in m². Urban settlements with more than 100 000 residents. 1990 and 1999*



Source: Land use statistics, Statistics Norway.

great deal of work remains to be done to harmonize, collect and process background data. For the indicators to be useful tools for management and performance monitoring, time series must be used for each indicator so that the direction and speed of changes can be illustrated.

Area of urban settlement in square metres per resident

The key figure shows the extent to which previously unbuilt areas have been used for buildings and other installations. Low figures (high density) should in principle be positive with regard to conserving area resources. However, the need for nearby recreational areas points in the opposite direction since high density can indicate that there are few "green lungs" within the urban settlement boundary (Norwegian Pollution Control Authority 2000b).

For the period 1990 to 1999, the area of the four largest urban settlements has increased[1] by 6.4 per cent from 442 km² to 470 km². For Oslo urban settlement, comparable area and population figures show that the average population density has increased from 2 697 residents per km² in 1990 to 2 874 residents per km² in 1999, i.e. that population density has risen by 6.6 per cent in 9 years. Corresponding figures for Trondheim urban settlement are 2 314 residents per km² and 2 396 residents per km² respectively.

The current status for the 19 largest urban settlements as of 1 January 1999 shows that Oslo has by far the lowest figure for urban settlement area per resident with 348 m², followed by Bergen and Trondheim with 417 m² urban settlement area per resident. There is great variation in population density both between urban settlements and within the individual urban settlement. In Oslo urban settlement, population density was easily greatest in Oslo municipality, which had an average of 3 800 residents per km². In the remaining parts of Oslo urban settlement, average population density varied from 2 600 persons per km² in Rælingen municipality to just over 1 500 per km² in Røyken municipality (figure 10.10).

Of all the 19 urban settlements examined, Arendal has the largest area, 799 m², per resident, followed by Tønsberg and Fredrikstad/Sarpsborg with 683 m²

[1] Because of changes in method and incomplete background data it is currently difficult to give retrospective figures with any great degree of confidence for trends in the relationship between area and number of residents for most urban settlements.

and 675 m² respectively per resident (Appendix, table I 3). Differences between urban settlements measured in area per resident must be seen in the context of their historical development, functional content, geographical location and the topography of the surrounding landscape.

Traffic area per resident in m²

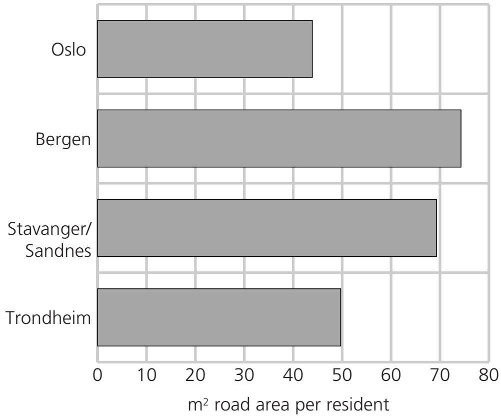
The key figure shows the extent to which traffic areas dominate land use in the urban settlement. The figure also gives partial information on the extent of irreversible use of areas in the urban settlement (Norwegian Pollution Control Authority 2000b).

Traffic area in urban settlements has been delimited and calculated as road area only, on the basis of a simplified set of standard road widths according to type of road and information on road lengths and types. The data sources make it difficult to establish retrospective figures. A comparison of traffic area, defined as area of road per resident in the 19 largest urban settlements, shows a variation from 43.9 m² road area per resident in Oslo to 113.1 m² road area per resident in Arendal (see Appendix Table I 3). It is interesting to note that Arendal, which has the largest urban settlement area per resident, also uses most area for roads. Of the four largest urban settlements, Oslo and Trondheim have by far the smallest road area per resident. Bergen and Stavanger had 74.3 m² and 64.3 m² road area per resident respectively in 1999 (figure 10.7).

Base area for residential buildings in urban settlements in m² per resident

The indicator describes how much area is actually used for residential buildings. Measured over time, the indicator can show whether there is a trend towards

Figure 10.7. Road area in urban settlement per resident in m². Urban settlements with more than 100 000 residents. 1999*

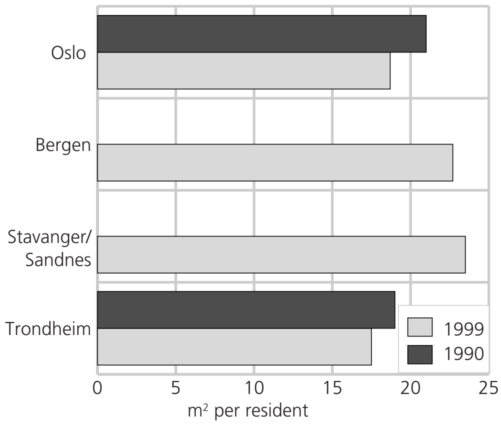


Source: Land use statistics, Statistics Norway.

housing developments that occupy smaller areas (Norwegian Pollution Control Authority 2000b).

The base area of residential buildings per resident is calculated from statistics in the GAB register, the official Norwegian register for property, addresses and buildings, and the National Population Register. Preliminary 1999 figures for the 19 largest urban settlements show a variation in total base area of residential buildings from 17.5 m² per resident in Trondheim to 29.2 m² per resident in Hamar (Appendix, table I 3). For the four largest urban settlements this area varies from 17.5 m2 to 23.5 m² per resident (figure 10.8). Area data in the GAB register are incomplete, particularly for older buildings, and rather than giving undue emphasis to variations between urban settlements, the focus should be on an average level for size categories of urban settlements and on monitoring relative changes in this level over time. Preliminary figures for trends in Trondheim and

Figure 10.8. Base area for residential buildings in urban settlements in m² per resident. Urban settlements of more than 100 000 residents. 1990 and 1999*



Source: Land use statistics, Statistics Norway.

Oslo show that from 1990 to 1999 the area taken up by the base area of residential buildings per resident has declined by 10.9 per cent and 7.9 per cent respectively. It will be possible to establish whether this constitutes real changes and trends or is due to methodological error when a time series of some length has been established.

Proportion of population resident in urban settlement centre

The key figure is based on the assumption that the function of the centre as meeting-place, for trade as well as culture, is strengthened by the fact that more people live there (Norwegian Pollution Control Authority 2000b).

The centre (see section 10.6) has been delimited for all urban settlements as of 1999, and the proportion of the population resident in the centre has been calculated for this year. For the 19 largest urban settlements, the proportion of the urban settlement population resident in the centre (the main centre or centres) in 1999 varied between 2.4 per cent in Porsgrunn/Skien and 16.6 per cent in Oslo. It should be added that with the current definition of centre, delimitation results in very large centres in the largest towns and a correspondingly large proportion of the population.

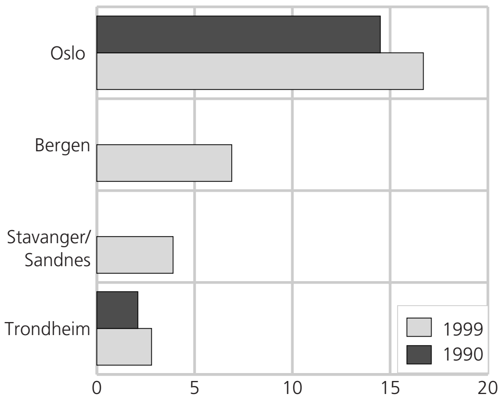
For Oslo and Trondheim, figures have also been calculated for the population of the centres in 1990 (as delimited in 1999). There has been a sharp rise in the number of registered residents in the centre of both these urban settlements in the period 1990 to 1999 (Appendix, table I 3, figure 10.9 and details in section 10.6).

Proportion of population within walking distance of various service functions

The key figure gives a description of the proportion of space, services and facilities available at each stage of life. The figure is particularly important to the elderly, children and families with small children in the local community (Norwegian Pollution Control Authority 2000b).

Pending data more suitable for businesses and enterprises, national figures for this indicator have not been produced so far. However, a methodological study and a pilot survey was carried out for Fredrikstad urban settlement as of 1996 (Statistics Norway 1998a) based on local data sources. The survey shows that, for instance, 82 per cent of all children in the 6-12 year age group live less than 1 000 metres walking distance from a junior school, and that 91 per cent of the population who are over 66 years old live within walking distance of a general store.

Figure 10.9. Proportion of urban settlement population resident in centre. Urban settlements of more than 100 000 residents. 1990 and 1999*



Source: Land use statistics, Statistics Norway.

Access to a post office, general store and stops for public transport were also studied in relation to age groups in the resident population.

Average distance from centre to new housing

The purpose of this key figure is to be able to compare figures from the various periods to see whether there is a trend towards increasing or decreasing dependence on cars and energy use (Norwegian Pollution Control Authority 2000b).

A pilot survey of Fredrikstad urban settlement (Statistics Norway 1998a) shows that the average distance from the centre to new housing developments had increased from 4 577 m in the years 1993/94 to 4 938 m in the years 1995/96. National figures for housing are currently unavailable, and efforts to develop an indicator and associated definitions should be continued.

10.5. Land use in the largest urban settlements

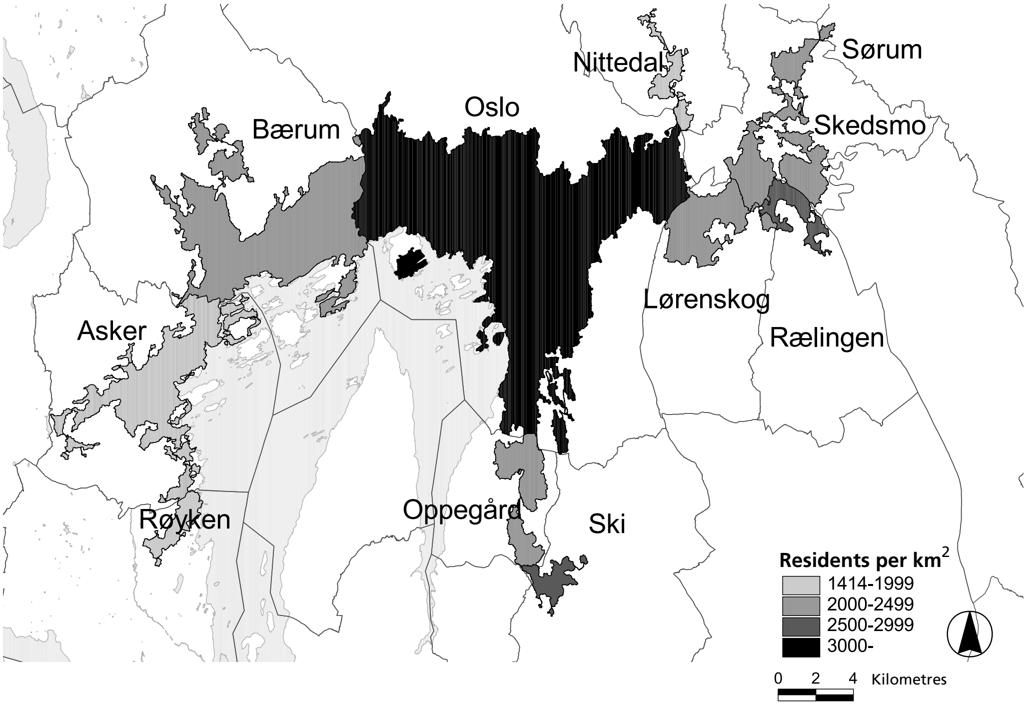
Preliminary figures show that the total area that has been built on or is near buildings (sites of buildings, see Box 10.1) and that is used for housing and holiday cabins takes up between 28 and 46 per cent of the total land area in the 19 urban settlements in the study that had at least 20 000 residents. Transport area, calculated as the sum of the area occupied by roads, railways and terminal buildings, accounts for between 14 and 19 per cent of the total area.

Areas used for commercial purposes and for public administration accounted for between 3 and 10 per cent, while areas used for industry and storage occupied between 1 and 8 per cent of the area. It is also interesting to note that between 15 and 49 per cent of urban settlement areas is not occupied by roads or railways, nor are they in the immediate vicinity of buildings (Appendix, table I 4 and figure 10.11).

Because of the data sources on which these statistics are based, it is not possible to specify what the land in "open" areas has been used for. However, it is reasonable to assume that these consist of agricultural or forest areas, large, open storage spaces and construction sites, docks, vacant industrial sites, car parks, open areas near traffic arteries, and parks, playing fields and lakes within the boundaries of the urban settlement.

The urban settlements can be ranked according to "physical openness" on the basis of the proportion of undeveloped/ open areas. Of the largest urban settlements, Sandefjord has the highest score with just under 49 per cent open area. Bergen and Stavanger/Sandnes are at the

Figure 10.10. Oslo urban settlement. Average population density by municipality as of 1 January 1999



Source: Land use statistics, Statistics Norway. Basic map from the Norwegian Mapping Authority.

other end of the scale with well under 20 per cent open area.

10.6. Land use in urban settlement centres

In January 1999, a national policy decision, applicable for up to 5 years, was adopted to call a temporary halt to the establishment of shopping centres outside central parts of towns and urban settlements (Ministry of the Environment 1999a). One important reason for this decision was the desire to actively strengthen the development of urban settlement centres and to counteract the tendency towards a pattern of increased transport by private car to large shopping centres outside urban areas.

As a result of this national policy decision, there was a need for a clearer definition of the concept of the centre to ensure that the decision could be uniformly practised by central and local authorities. A pilot project was launched by Statistics Norway and Oslo and Akershus counties to operationalize the concept of the urban centre for statistical use. A total of 124 centre zones were delimited automatically in the counties of Oslo and Akershus on the basis of register data and geographical information systems (GIS) (Statistics Norway 1999e). A preliminary delimitation of the centre has subsequently been carried out, based on criteria from the pilot project, for all the urban settlements in Norway as of 1 January 1999.

Box 10.1. The concept of the site, land use calculations, data sources and uncertainty

The site of a building is the base area of the building and its immediate area of influence. The area of the site, and its use, is calculated on the basis of buildings and property figures in the GAB register, the official Norwegian register for property, addresses and buildings, and information on commercial activity in the form of a business code from the Register of Business Enterprises.

Open area is what remains when the area of sites, roads, railways and fresh water areas is deducted from the total area of the urban settlement.

The results of the 1999 Statistics Norway land use survey show that the various categories of land use correspond well in size with previous surveys in Norway and Sweden, which were based on counts made from aerial photographs and maps (Statistics Norway 1982, Statistics Sweden 1997). This particularly applies to the categories of residential area and transport and open areas. The uncertainty in land use statistics is primarily due to the varying quality of buildings and property information in the GAB register.

On the basis of criteria of density and commercial diversity, the largest urban settlements are allocated several centre zones in the form of one main centre and several smaller sub-centres. In urban settlements such as Stavanger/Sandnes and Sarpsborg/Fredrikstad, where the boundary extends beyond the municipal border, there are typically two more or less equally important main centres where the municipal administration and other services are located.

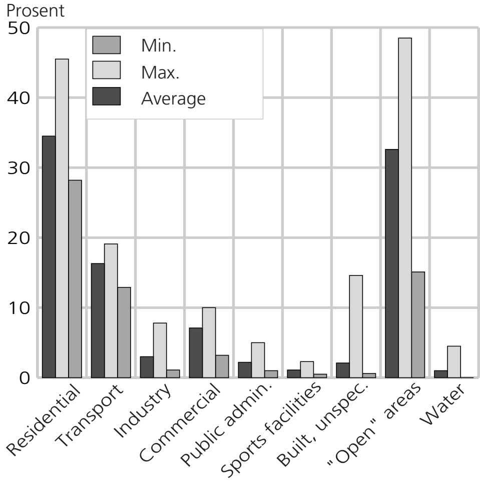
Box 10.2. Operationalization of the concept of the centre zone

A *centre core* was delimited in the pilot project based on criteria of physical concentration and diversity of activity:
- retail trade must take place
- there must be either a public administrati on centre, a health and social centre or other social/personal services
- at least three main industries must be represented
- the maximum distance between the buildings where these undertakings are located must not exceed 50 metres

A 100-metre zone was added around the centre core to comprise the *centre zone.*

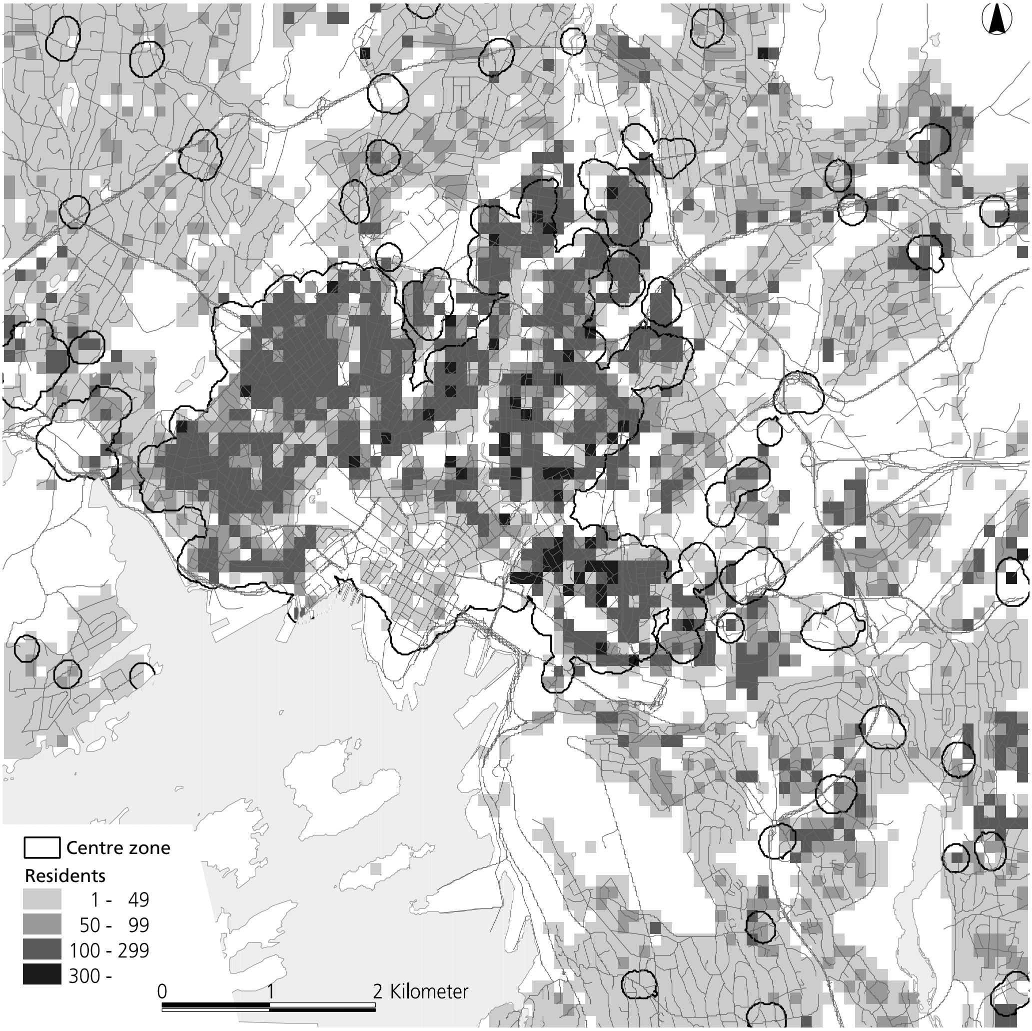
The centre structure in Oslo is a special case both because Oslo is the capital city and because geographically the urban settlement extends into 11 municipalities and 3 counties. There is therefore a large capital centre in the Inner Oslo area and several smaller urban district centres spread throughout Oslo municipality. The

Figure 10.11. Land use in urban settlements. Urban settlements with more than 20 000 residents. 1999*



Source: Land use statistics, Statistics Norway.

Figure 10.12. Population density in Oslo centre. Residents 1 January 1999. (100x100 metre squares)



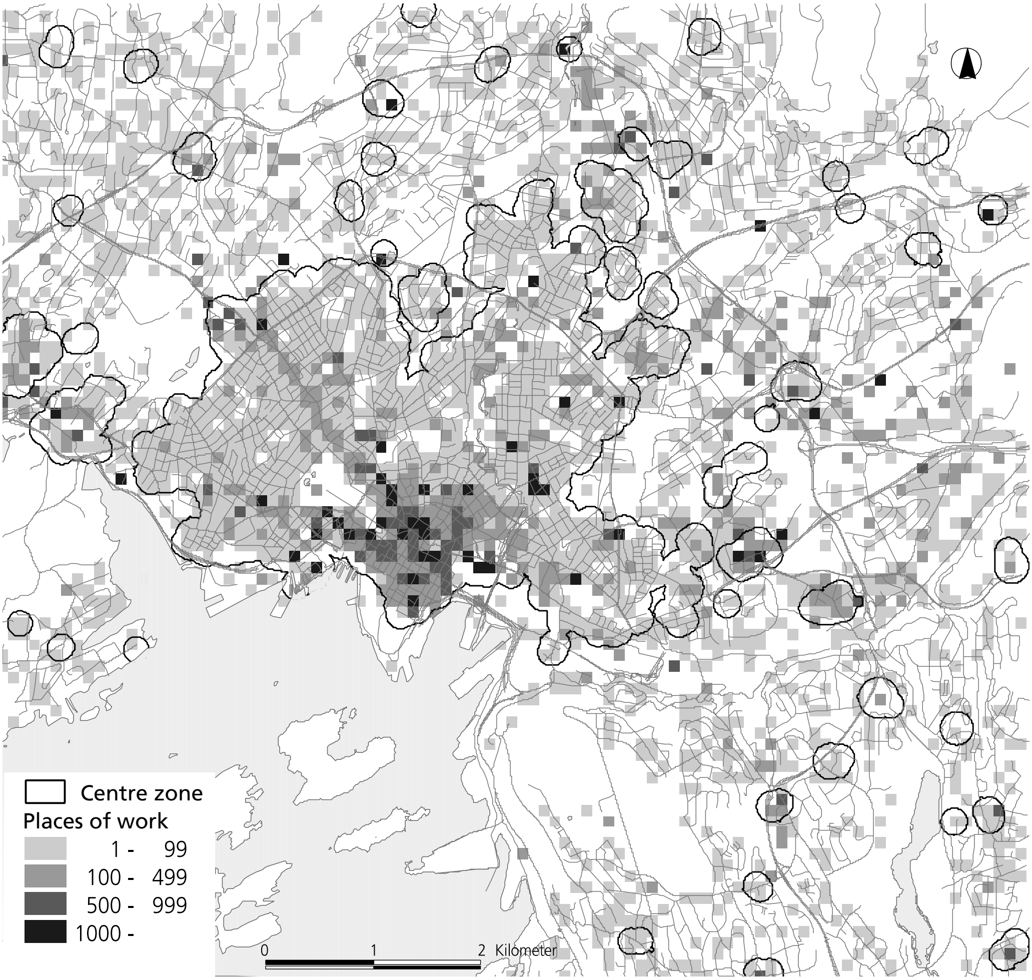
Source: Land use statistics, Statistics Norway. Basic map from the Norwegian Mapping Authority.

surrounding municipalities have their own municipal centres and smaller service centres. The main Oslo centre takes up 4.8 per cent of the total urban settlement area within Oslo municipality, but only 1.3 per cent of the area of Oslo urban settlement as a whole.

Land use in areas in the centre is intensive, with a substantial percentage of all the jobs in the urban settlement and of all retail trade turnover to be found here.

Average population density in the centre, as delimited here, is also considerably higher than the average for the urban settlement as a whole. Population density in particularly high in Oslo and Bergen.

Figure 10.13. Concentration of jobs in Oslo centre. Number of jobs 1 January 1999. (100x100 metre squares)



Source: Land use statistics, Statistics Norway. Basic map from the Norwegian Mapping Authority.

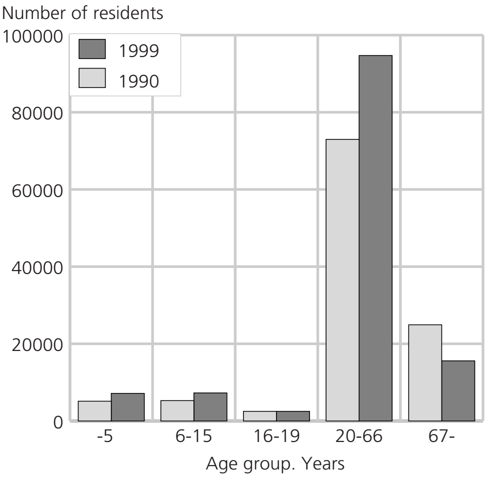
The population resident in the Oslo centre zone in 1999 accounts for 16.6 per cent of the total number of residents in the urban settlement as a whole and 25.5 per cent of those resident within the boundaries of Oslo municipality. Population density in Oslo centre is therefore much higher than in the other urban settlements in the survey, where the population density for the centre was found to lie between 3 and 7 per cent of the total population of the urban settlement (table 10.2). In the Oslo centre zone, the highest resident population density is found in the districts of Grønland/Kampen, Dælenenga and Grünerløkka, and a correspondingly lower density in the core of the centre zone – the Kvadraturen district (figure 10.12).

Table 10.2. Residents, jobs and trade in the centre zone. Selection of large urban settlements. 1999*

Urban settlement	Area in centre km²	No. of residents in centre	No. of residents in centre per km²	Proportion of urban settlement in centre: Area	Residents	Jobs	Retail trade turnover
				Per cent			
Oslo	12.65	127 238	10 053	1.3	16.6	36	34
Bergen	2.17	14 036	6 465	2.6	6.9	31	37
Stavanger/ Sandnes[1]	1.87	5 517	2950	3.0	3.9	20	35
Trondheim	1.12	39 44	3 531	1.9	2.8	25	32
Fredrikstad/ Sarpsborg[2]	1.32	37 67	2 853	2.1	4.1	25	35
Kristiansand	0.90	3 557	3 952	3.1	5.9	42	56
Tromsø	0.68	1 579	2 336	3.3	3.3	37	42

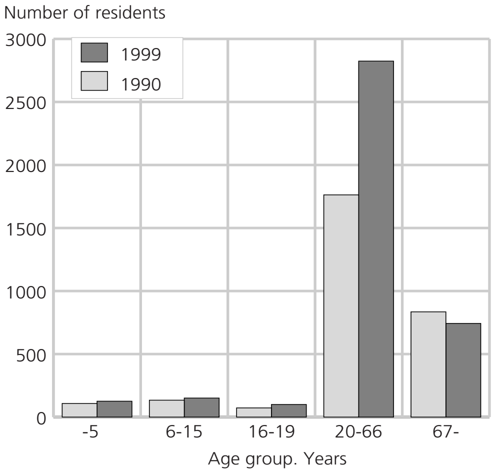
[1] Main centres in Stavanger and Sandnes municipalities. [2] Main centres in Fredrikstad and Sarpsborg municipalities.
Source: Land use statistics, Statistics Norway.

Figure 10.14. Residents in Oslo centre. 1990 and 1999



Source: Land use statistics, Statistics Norway.

Figure 10.15. Residents in Trondheim centre. 1990 and 1999



Source: Land use statistics, Statistics Norway.

How the centre areas are used varies throughout a 24-hour period, depending on the activities of the population and the geographical location of important functions. A simple illustration of this is the concentrations of jobs in Oslo as seen in microperspective. Job density is highest in the area from Akersgaten to Oslo Central Station. Job concentrations surrounding Drammensveien, Bogstadveien and westwards in the direction of Helsfyr are also easily visible on the map in figure 10.13.

In the period from 1990 to 1999, the population in the centre of Oslo has increased from 110 818 to 127 238, or by 14.8 per cent. In the same period, the population of the municipality as a whole increased by 9.7 per cent. The numbers of children (0-15 years) and adults (20-66 years) rose by 39 and 30 per cent respectively, while the number of residents 67 years old or more declined in the same period by 38 per cent (figure 10.14).

A corresponding study of the main centre in Trondheim shows substantial population growth in the period 1990 to 1999, by 35.4 per cent. There was a 7.2 per cent population increase in the municipality as a whole in the same period. In Trondheim centre, there has been an increase in all age groups except the 67 years and above age group (figure 10.15). The centre zone of the main centre in Trondheim, as delimited in this study, comprises Midtbyen and Kalvskinnet, including the station area and the buildings closest to the river on the west side of the Nidelva river, i.e. parts of Bakklandet and Møllenhaug.

A large number of students registered at their home addresses in various parts of Norway who are receiving further education in Oslo and Trondheim, in addition to a backlog in notifications of change of home address, make the actual population density and any changes difficult to assess. The statistics nonetheless indicate that in the period 1990 to 1999 there has been a vitalization of the defined centre zones as a whole and an increase in population density in these zones both in Oslo and Trondheim.

The comparison was made between the population within the centres of Oslo and Trondheim as these areas were delimited as of 1999.

Further information may be obtained from: Per Schøning and Erik Engelien.

11. Other analyses and research projects

11.1. Effects of freer trade on the economy and pollution levels – a general equilibrium analysis for Norway

Norwegian trade policy has been liberalized through the implementation of the EEA Agreement, an EFTA agreement on fisheries policy from 1994, and the 1995 WTO Agreement. The main motivation for liberalization has been that it is to the economic advantage of all the parties to the agreements. However, the environmental effects are less clear. This analysis looks at the economic and environmental effects of the trade agreements and how they influence each other.

The trade agreements include stricter restrictions on trade barriers and subsidies that shelter Norwegian companies from competition from imported goods. Export and import conditions for Norway are also altered as the agreements are implemented in other countries that are parties to them. This analysis looks at possible economic adaptations to such trade reforms and the consequences this may have for waste generation and emissions to air of 12 gases (including the greenhouse gases regulated by the Kyoto Protocol) in Norway. Using an applied equilibrium model of the Norwegian economy, MSG-6, the isolated effects of trade liberalization have been quantified by comparing a scenario in which the trade agreements are implemented with a reference scenario without the agreements. The model is suitable for this type of analysis since it gives a relatively detailed description of how trade and industrial policy influences production, factor inputs and consumption of 60 groups of goods and services, and how such activities, according to observed data, generate emissions and waste. The level of technological development and the environmental policy framework are kept unchanged during the analysis.

Table 11.1 shows that the overall effect of the trade reforms is a rise in emissions, and that this is largely generated by households. Their real income rises by 0.8 per cent in the long term, mainly because the agreements result in the elimination of costly trade barriers and thus in cheaper imports. This growth in income contributes to higher emissions. Composition effects in households generally reinforce the problem. An important distorting effect is that the growth in real income results in a one per cent rise in the consumption of goods and services, in other words relatively more than would be expected from the growth in real income, whereas there is a relatively smaller rise in the use of leisure time, which does not cause pollution. The component of consumption that rises most is the use of fossil fuels, since

Table 11.1. Estimated long-term changes in emissions to air and waste generation as a result of trade liberalization. Calculated percentage change compared with a reference scenario without trade liberalization

	Changes in emissions from households as a result of			Changes in emissions from businesses as a result of			Overall changes in emissions
	Change in real income	Change in composition	Overall effect	Change in GDP	Change in composition	Overall effect	
Kyoto gases	0.8	0.1	0.9	-0.1	0.4	0.3	0.4
Sulphur dioxide	0.8	0.7	1.5	-0.1	2.1	2.0	2.0
Nitrogen oxides	0.8	0.0	0.8	-0.1	0.0	-0.1	0.0
Ammonia	0.8	-0.1	0.7	-0.1	-2.6	-2.8	-2.7
NMVOCs	0.8	0.0	0.9	-0.1	-0.4	-0.6	0.0
Carbon monoxide	0.8	0.2	1.0	-0.1	0.9	0.8	0.9
Particulate matter	0.8	0.9	1.7	-0.1	-0.4	-0.5	1.0
Waste generation	0.8	-0.2	0.6	-0.1	-0.5	-0.6	0.0

Source: Fæhn and Holmøy (2001).

electricity prices rise substantially (see below). This explains the large composition effects on emissions of sulphur dioxide, particulate matter, carbon monoxide and some of the Kyoto gases (mainly carbon dioxide) from households.

On the production side, the changes in emissions do not show such clear trends. As a result of the decrease in the labour supply, GDP falls by 0.1 per cent in the long term, leading to a slight drop in total emissions. However, the industrial structure changes, with rising production of metals, industrial chemicals and pulp and paper. These industries generate large emissions of pollutants, especially sulphur dioxide, and also combustion gases. In addition, they are energy-intensive, and their expansion presses electricity prices up by 7-9 per cent. This results in greater use of fossil energy in all sectors, and thus in higher emissions of sulphur dioxide, carbon monoxide and the Kyoto gases. The growth of these export sectors is related to the fact that it will take some years before Norway enjoys higher revenues as a result of freer trade. As soon as it is clear that these revenues are on the way, consumers will be able to benefit by taking up loans abroad. To service such loans, Norwegian exports must be increased in the longer term. Overall decreases in emissions are only seen for ammonia and some of the Kyoto gases, such as nitrous oxide and methane. An important reason for this is the contraction of the agricultural sector as a result of greater competition from imports.

Project financed by: Ministry of the Environment, Ministry of Foreign Affairs.

Project documentation: Fæhn and Holmøy (2001).

11.2. Social norms for environmental behaviour

The simplest textbook models of economy describe consumers almost as impulsive egoists, who are only motivated by economic considerations and do not take into account the social context of which they are a part. This can be a useful simplification in many cases, but by no means always. In more recent economic literature, authors have therefore tried to develop better descriptions of motivation based on social norms, and of the interplay between this and more traditional forms of economic motivation.

Statistics Norway has recently been running a research project on economic modelling of social and moral norms. The project has focused partly on the development of theory, but we have also used the theory to illustrate some areas where it is of interest to look at interactions between social norms and economic motivation, i.e. voluntary efforts to sort waste at source, participation in the Norwegian system of *dugnad* (which means voluntary work done collectively, for example by residents in a neighbourhood or members of an organization), and the behaviour of smokers.

Moral motivation can be described by assuming that people want to be able to think of themselves as morally responsible individuals (Brekke et al. 2000). An image of ourselves as morally responsible is formed by comparing our actual behaviour with how we feel we should have behaved in ideal terms. To maintain a good self-image, people may be prepared to incur costs with no apparent benefit, for example by giving time or money to a nature conservation organization, carrying their own rubbish home after hiking in the mountains, or taking part in collective voluntary activities. However, there are limits to how much people are willing to do: if the costs become too high, many people will prefer to accept a somewhat poorer self-image.

If this is the way people actually think, economic incentives or direct regulation by the authorities may have different effects from those predicted by traditional economic models. This is because such measures may alter people's views on their ideal behaviour, and thus also

Table 11.2. Effects on participation in collective voluntary activities (*dugnad*) of a fee for non-participants. Percentage of people who are members of organizations that use the *dugnad* system. Number of respondents = 802

"Imagine that you have to pay an extra fee of NOK 100 if you do not take part in the *dugnad*. This is enough/not enough to pay professionals to do the job. Would you take part more often, less often, or would it have no effect?"

	Fee enough to pay professionals to do the job	Fee not enough to pay professionals to do the job
Would take part more often	10	19
Would take part less often	15	3
No effect	75	77
Don't know	1	1

Source: Brekke et al. (2000).

alter their actual behaviour. The data we have collected from interviews show for example that if a fee of NOK 100 was introduced for those who did not participate in collective voluntary activities, 15 per cent would take part less often, provided that the fee was sufficient to pay others to do the job (table 11.2). A fee of this kind can be seen as an opportunity to buy one's way out of the moral duty to take part, and thus defeat its own end. Hardly anyone answered that they would take part less often if the fee was not sufficient to allow professionals to be hired to do the work. In a questionnaire-based survey (Bruvoll et al. 2000, also described in Chapter 8), people were asked about their reasons for sorting of waste at source, and many of the answers suggest that moral motivation plays a part.

Social norms are related to the need to be accepted by others, and are maintained by the threat of social sanctions against

Table 11.3. Smoking by guests in 1999 and 10-15 years earlier. Percentages of non-smokers

"If you have guests who are smokers, what do you experience most often? Assume that no children are present." "What do you think your answer would have been 10-15 years ago?" (Only for people over 30 years of age.)

	1999	10-15 years earlier
No. of respondents	795	563
Guests smoke indoors	10	74
Guests ask first, and only smoke indoors if I say they may	45	16
Guests do not smoke indoors	44	10
Don't know	0	1

Source: Nyborg and Rege (2000).

those who do not conform. This means that we tend to follow the crowd, and may lead to positive or negative trends. One example that can be used to illustrate this is the change in norms for indoor smoking in private homes (Nyborg and Rege 2000). Recently collected data suggest that the social norms for smokers' behaviour in Norway have changed dramatically. Only 10-15 years ago, smokers commonly exposed other people to passive smoking in private homes (table 11.3). This has now become much more the exception than the rule, even though the legislation (the Act relating to Prevention of the Harmful Effects of Tobacco) does not apply to private homes. People who do expose others to passive smoking expect stronger negative reactions than they did previously.

The following line of argument may provide an explanation for this. When the Act was amended and made stricter in 1988, non-smokers were given much greater protection against passive smoking for much of the day. Many places of work became smoke-free, for example. Non-smokers thus became less used to passive smoking, and may have become less tolerant towards a smoky atmosphere, even in situations that are not regulated by the Act. Smokers are aware of this and become less comfortable about smoking indoors. Some of them therefore go outside more often to smoke. The non-smokers thus become even less used to a smoky atmosphere, and their tolerance to passive smoking is further reduced. In the end, only those smokers who care very little about the reactions of non-smokers continue to smoke indoors.

This is not the only possible explanation of what has happened. It is nevertheless interesting, because it suggests that the legislation may have started a process that changes social norms and thus alters smokers' behaviour even in places where it does not apply. Thus, government policies may affect both social and moral norms in ways that would not be predicted by traditional economic models.

Project financed by: Research Council of Norway through the SAMRAM programme.

Project documentation: Nyborg and Rege (2000), Bruvoll, Halvorsen and Nyborg (2000), Brekke, Kverndokk and Nyborg (2000).

11.3. Indicators for hazardous chemicals

People are exposed to many different chemicals that may be hazardous to health. Chemicals can also cause environmental damage. A good indicator of this type of environmental pressure should ideally provide information on total exposure and changes in exposure over time. No such indicator is available at present, because we lack sufficient knowledge of exposure to different types of chemicals, what kind of damage they cause and how their effects should be weighted together.

On the initiative of the Nordic Chemicals Group, which is a permanent working group under the Nordic Council of Ministers, Statistics Norway carried out a project on indicators for hazardous chemicals in 2000. The main purpose of the project was to draw up a status report on the development and use of such indicators in the Nordic countries and internationally. The indicators were also evaluated against various criteria defined for example by the OECD, such as relevance, measurability, analytical soundness, transparency, etc.

The main focus was on *pressure indicators*, i.e. indicators that can tell us something about exposure to chemicals when *products* are being used and emissions generated by their use. Since emissions from the "traditional" sources of pollution, i.e. manufacturing industries, have been substantially reduced, we wished to obtain more information about this more diffuse source of emissions and about general exposure during the use of products.

Various different kinds of indicators can be constructed. The simplest ones are based on the quantity of a substance in a particular organism (for example mercury in cod) or groups of substances such as pesticides (as tonnes of the active substance). In more complex indicators, different substances are weighted together using toxicity coefficients and other factors that are based on environmental or health effects or both.

It is not always easy to distinguish between pressure indicators and state indicators. The concentration of heavy metals in fish may for example be interpreted as a state indicator if it is considered to be a description of one aspect of the state of the environment, but it may also be interpreted as a pressure indicator, since fish are eaten and the heavy metal content may affect human health. In the same way, the cadmium concentration in moss may be regarded either as an indicator of the state of the environment or as an indicator of pressure from long-range pollution.

The project included a broad review of the indicators for hazardous chemicals that various countries and organizations have developed or are in the process of developing, from the simplest types to relatively complex indicators. These were evaluated in relation to the main focus of the project as described above and whether they dealt mainly with health or environmental aspects, and also in relation to more general criteria for indicators, such as those described by the OECD. As regards the more advanced indicators focusing on the *state of the environment*, the most interesting projects were considered to be a Norwegian initiative and Eurostat's work. Of the projects focusing on *health* aspects, two run by Eurostat and the US Environmental Protection Agency (EPA) were considered to be of particular interest.

Many factors have to be taken into consideration in developing indicators for hazardous chemicals, including how to set priorities, what weighting methodology to use and data availability. The report included the following main recommendations for further development of indicators:

- The user groups to be addressed should be carefully considered.
- Before a major development project is started, the results and robustness of promising indicator projects (including data availability) should be tested. When doing this, it is important to distinguish between differences arising from the models themselves and those that arise from other assumptions, e.g. weighting factors.
- Good documentation of methodology, weighting factors, etc., should be obtained.
- Routines should be established to make it easy to incorporate changes and new information (new substances, altered weighting factors, etc.).
- A *set* of indicators should be developed (for main groups of substances, media, health and environment).
- The development of more complex indicators can be considered once such a set has been developed.
- At Nordic level, the development of indicators should be closely linked to other international work to ensure comparability and make use of earlier experience.
- A breakdown of indicators by sector should be considered since this increases their information value and makes it easier to link them to projection models.
- The indicators should be linked to reference values and targets.

The report also recommends the following priorities for the development of indicators:

- Common lists of priority substances should be established at Nordic level.
- Consumption data should be obtained for the priority substances.
- As far as possible, consumption should be used to represent emissions. Emission coefficients can be developed as necessary in cases where there are almost certainly substantial differences between consumption and emissions.
- Emissions/consumption should be used to represent exposure at this stage. Exposure factors can be developed at a later stage.
- Weighting factors should preferably be based on a semi-quantitative method (i.e. an approximate scoring system that is as far as possible developed on the basis of measurement data). This will make the system less dependent on the exact values of properties of the priority substances, such as toxicity and bioaccumulation potential, but the method will nevertheless be well-documented and reproducible.
- Data in national product registers should be used, but harmonized at Nordic level.

Project financed by: Nordic Chemicals Group under the Nordic Council of Ministers.

Project documentation: Brunvoll, Rypdal and Tornsjø (2000).

11.4. Gas-based power in Norway and CO_2 emissions in Europe

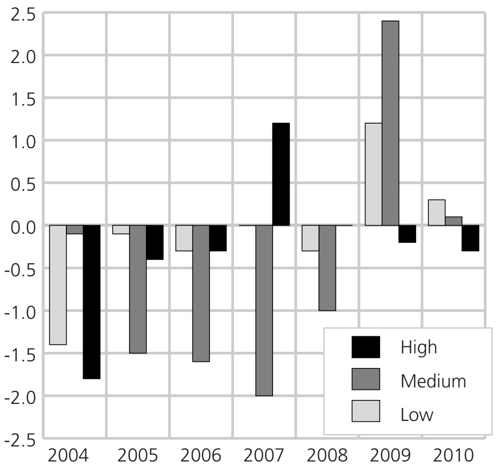
The impact on European and global CO_2 emissions of the development of

Norwegian gas-based power has recently been the subject of controversy and debate in Norway. In connection with the Ministry of Petroleum and Energy's consideration of proposed gas-based power generation projects in Norway, Statistics Norway has analysed the impacts on European energy markets of developing gas-based power generation in Norway, including any changes in CO_2 emissions (Aune et al. 2000a).

Statistics Norway used the Nordic electricity market model, Normod-T, and MSG-6, a long-term equilibrium model for the Norwegian economy. MSG-6 is used to calculate the demand for electricity in Norway. Electricity demand growth in the other Nordic countries is assumed to be equal to demand growth in Norway, adjusted for any differences between Norway and the other Nordic countries as regards changes in the price of electricity. Other important factors, such as the price of electricity, electricity generation and international electricity trading, are calculated using the Normod-T model. Aune et al. (2000a) describe how the models are run in an iterative procedure to find a consistent path for electricity prices and electricity demand. The European electricity market outside the Nordic area is not explicitly modelled in Normod-T. Instead, electricity trade between the Nordic countries and the rest of Europe is calculated by selecting a set of price conditions for these countries. The quantity of electricity traded with the rest of Europe and the countries traded with is determined by the transmission capacity of the connection between the Nordic countries and Europe and which region has the highest price. Trade flows in the direction of the region where the price of electricity is highest.

The models are used to calculate how trends in the electricity market and in emissions will change from now until 2010 if 5.6 TWh gas-based power is generated in Norway from 2004 onwards. The calculations have been made on the basis of three electricity price alternatives outside the Nordic area: low, medium and high prices (NOK 0.11, 0.15 and 0.19 per kWh average electricity price in the course of the year). Whether the development of gas-based power generation will result in an increase or reduction in emissions depends on a number of factors: initially, emissions will increase by about two million tonnes CO_2, emitted by the gas-fired power plants themselves. An increase in the demand for electricity will result in somewhat lower electricity prices, which will in turn lead to higher consumption. As a result of the lower electricity prices, some other Nordic electricity producers will reduce their production. The net impact on the Nordic market will depend on how much gas-based power is channelled into higher Nordic consumption and how much is used to reduce other forms of Nordic power generation, consequently lowering CO_2 emissions. In addition, emissions in the rest of Europe will be reduced as exports from Europe to the Nordic area decline and/or imports from the Nordic area to Europe increase. Our calculations of the impact of emissions outside the Nordic area as a result of changes in electricity trade are based on the assumption that increased exports/ reduced imports lead to a reduction in coal power generation in non-Nordic countries. We assume that coal-based power generation will remain a marginal technology in non-Nordic countries for a number of years to come.

Figure 11.1. Changes in emissions in million tonnes CO_2 as a result of gas-based power generation in Norway on the basis of three electricity price alternatives in the European electricity market up to 2010



Source: Statistics Norway.

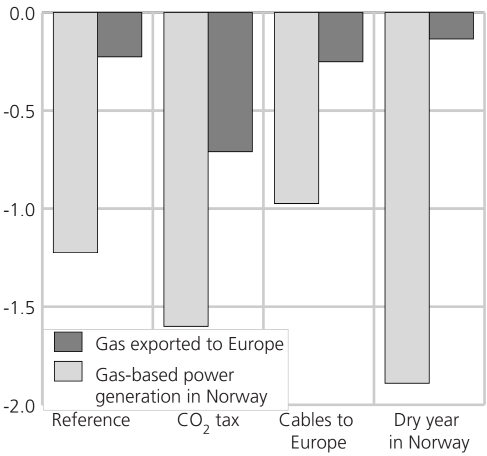
Figure 11.1 shows the trend in overall European CO_2 emissions up to 2010 if Norwegian gas-based power generation is introduced. In the first few years of gas-based power generation, emissions are lower, rising again, sometimes sharply, towards the end of the period. The aggregate result for the whole period shows a drop in emissions for all the alternatives, although the total impact is small in both the high and low-price alternative (1.8 and -0.6 million tonnes). For the medium-price alternative, the overall result is a reduction in CO_2 emissions by 3.6 million tonnes. All in all, the results show that it is difficult to draw any definite conclusion on the impact of emissions from gas-based power generation.

Under the SAMRAM programme run by the Research Council of Norway, a joint project to make a European gas and electricity market model has been conducted by Statistics Norway and the Ragnar Frisch Centre for Economic Research. The model describes a deregulated European energy market in the short term, given free competition on all the energy markets. It is assumed that present generation capacity and trade opportunities for gas and electricity can be exploited to the full. This model has also been used to analyse the impact on European CO_2 emissions of developing gas-based power in Norway or increasing gas exports (Aune et al. 2000b). The analysis has been conducted using one reference scenario and scenarios including a tax on CO_2 emissions, transmission of electricity via cables between Norway and Europe, and a dry year in Norway. The analyses made in the Statistics Norway and Frisch Centre joint project are comparable since the analyses involved the impact on emissions of increasing the supply of natural gas to the European energy market by the same amount in both cases.

Figure 11.2 shows the effects of using a larger quantity of Norwegian gas in the European energy market. We can see that emissions are reduced in all the scenarios, and most of all when the gas is used for power generation in Norway. Norwegian gas-based power has the greatest impact on emissions when there is a dry year in Norway. In a dry year, electricity prices are higher, making it more profitable to generate electricity in plants where lower fuel efficiency produces higher CO_2 emissions. Gas-based power will be used to replace power generation in these plants in a dry year, and as a result emission reductions will be greatest in this case.

Emissions are also reduced when gas is transported to Europe, although to a

Figure 11.2. Change in emissions in million tonnes CO_2 when gas is generated in Norway or exported



Source: Statistics Norway.

much smaller extent than when gas is used to generate gas-based power in Norway. This is partly due to an increase in gas consumption by end-users in business and industry and households, who do not reduce their consumption of other energy carriers such as coal and oil to any great extent. Viewed in isolation, this means that emissions increase. However, since a substantial amount of the gas is used to increase gas-based power generation, while electricity generation in coal- and oil-fired power plants is reduced, this means that emissions from European electricity generation are lower. All in all, CO_2 emissions are slightly lower, falling most in the scenario including a CO_2 tax because gas replaces coal and oil in power generation to a greater extent in this scenario than in the others.

Project financed by: Ministry of Petroleum and Energy SAMRAM.

Project documentation: Aune, Bye and Johnsen (2000b), Aune, Bye and Johnsen (2000a).

11.5. Distributional impact of higher electricity tax

As stated in the 1999 National Budget, section 4.4.1, where the main features of government policy on taxes on energy use are discussed, electricity consumption has exceeded production in years with normal precipitation and inflow since 1993. And the Budget stresses that "In order to strengthen the power balance, measures must be introduced to limit the demand for electricity and promote an increase in capacity for electricity generation from renewable energy resources". One of the measures proposed is to increase the taxes on electricity. On the basis of the majority view in the recommendation from the energy committee (cf. Official Norwegian Report (NOU) 1998:11), the introduction of a progressive electricity tax consisting of several components had been considered. A higher electricity tax will mean higher costs for households. The energy committee was therefore concerned about the distributional impact of this measure. In the subsequent white paper on energy policy (Report No. 29 (1998-1999) to the Storting) and in the National Budget for 2000, the progressive alternatives were dropped in favour of a proportional system on the grounds that a progressive system would cost too much to administrate. The intention had been to minimize any adverse distributional effects of a proportional increase in electricity tax by allowing income tax relief and increasing the basic state pension and housing benefit. However, the progressive alternatives took on new relevance when, as a result of the budget negotiations in connection with the central government budget for 2000, the Government decided to examine the effects of a two-tier electricity price system.

In the project "Flexible energy use in households", financed by the Research Council of Norway, we looked at the impact of a higher electricity tax on the distribution of consumption opportunities available to households and thereby on public welfare. We looked at four progressive and one proportional tax alternative. In alternatives 1 and 2, the electricity tax increases by NOK 0.0575 per kWh for all consumption exceeding the limit of 10 000 kWh per household in alternative 1 and 5 000 kWh per household member in alternative 2. In alternatives 3 and 4 the electricity tax doubles to NOK 0.115 per kWh for all consumption above the limit of 25 000 kWh per household in alternative 3 and 11 000 kWh per household member in alternative 4. Alternative 5 looks at an increase in the *proportional tax* of NOK 0.025 per kWh, which is equivalent to the Government's proposed increase in the National Budget for 2000. The analysis is based on selected households from Statistics Norway's consumer survey.

The results of these analyses indicate that proportional and progressive tax increases both have an impact not only on the welfare of households with high incomes but also on the welfare of households with middle and low incomes since several of these households have a relatively high level of electricity consumption. Although our data show a positive connection between household income and electricity consumption, households vary considerably. Furthermore, we find that the opportunities to evade the rise in electricity tax increase with household income, partly because high-income households have on average more alternative heating sources, such as wood- and oil-based heating, than households with lower incomes.

Looking at the differences between the various tax alternatives, we find that the progressive tax alternatives have a more favourable distributional impact than the proportional alternative. However, which of the four progressive alternatives has the best distributional impact depends on whether households are permitted to change their consumption as a result of the tax increase. If households are not permitted to change their consumption, the most progressive tax alternatives give the best distributional effect. However, when households are allowed to change their consumption, the tax alternatives rank differently. If households are allowed to change their consumption, the distributional effects of all the tax alternatives are small and none of the alternatives is clearly better than any other. We also find that the choice of equivalence scale, i.e. whether we measure the difference in consumption opportunities per household or per household member, does not affect the results to any significant extent.

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

11.6. Methods for calculating household electricity consumption according to end use

Electricity accounts for a large proportion of stationary energy use in households and can be used for many different purposes. For some of these purposes, electricity can be replaced by other energy carriers (e.g. space heating), while for others substitution is not possible (e.g. electrical household appliances). Growth in the consumption of electricity for various end uses will vary, and the effects of political measures will therefore vary according to the way the electricity is used. Changes in relative energy prices will affect household investments in heating equipment and, consequently, flexibility in energy demand in the long term if households are free to adjust their consumption. In order to calculate the effects of various policy measures, it is important to make a study of the composition of electricity consumption for various end uses.

Carrying out detailed measurements in all households is expensive and is difficult to achieve in practice. One alternative is to estimate household electricity consumption for various end uses within an econometric model based on data for a sample of households. Statistics Norway has done this on the basis of data from the 1990 energy survey. We identified differences in electricity consumption between households with certain types of appliance and households that do not have these appliances. The estimated electricity consumption per appliance was multiplied by the percentage of households that had this appliance in order to calculate average electricity consumption for the appliance in the household sector (composition of electricity consumption). The estimated parameters comprise both effects of a technical nature and effects on household behaviour. The composition of electricity consumption has been calculated previously based on the same 1990 survey using the engineering model. The engineering model was developed as a basis for technical advice on energy use in residential and commercial buildings. This model requires numerical estimates of hours of usage, the proportion of households using various types of appliance, average product power, etc. The purpose of our study was to compare the engineering model with our econometric model and assess the need for new analyses on the basis of a review of the literature.

We concluded that there are weaknesses in both the engineering and the econometric models. However, an econometric analysis is the best method for calculating the composition of electricity consumption for various end purposes if the data is supplemented by directly metered data on electricity consumption for very common appliances (refrigerators, freezers, electric cookers and washing machines). To take this into account, some households are treated as though they do not have these appliances. This means that the metered electricity consumption by these appliances is deducted from the household's total electricity consumption in order to bring out the difference in consumption between households that have these appliances and those that do not (Bartels and Fiebig 1990).

Having worked on this project, additional issues have come to light related to the composition of electricity consumption for various end purposes in Norwegian households in Statistics Norway's consumer survey for 2001. We plan to select some of the households included in the survey and install metering equipment for appliances that are very common. This will give us a very good basis for econometric calculations of household electricity consumption.

Project financed by: Ministry of Petroleum and Energy.

Project documentation: Larsen and Nesbakken (2000).

11.7. Direct and indirect household emissions of greenhouse gases in Norway

NOREEA (NORwegian Economic and Environmental Accounts) is a project designed to develop integrated accounts for economic and environmental data in Norway. So far, an integrated system has been developed for the national accounts and emissions to air, a valuation of four selected natural resources – oil, natural gas, forest and fish – has been carried out, and the extent of green taxes has been estimated (Statistics Norway 1998b, 1999b, 2000b, Hass et al. 2001).

Here, we present a pilot project in which we have tried to calculate indirect emissions of greenhouse gases from end users in Norway. In this context, *indirect emissions* is used to mean the proportion of emissions from Norwegian industry that can be linked to the end user of goods or services. The calculations are based on integration of the national accounts with figures for emissions to air (the emission inventory), as discussed in more detail in *Natural Resources and the Environment 1998*. The emission inventory shows who is directly responsible for emissions, i.e. where they are generated. The direct emissions are linked with the national accounts, and it is thus possible to calculate all emissions (in Norway) associated with goods or services before they reach the end user. Commodity flows and the emissions in Norway associated with them can be followed between sectors and to end users using an input-output analysis. The method only makes it possible to calculate emissions in Norway; emissions in other countries linked to imported goods and services are not included in these calculations.

Figures have been calculated for the household sector for the years 1993 and 1997. Both *direct and indirect emissions* from households are shown. Direct emissions are generated by an activity, for example driving a vehicle or fuelwood use. These figures are calculated in Norway's emission inventory. In this article, we use the term "total household emissions" to mean both direct and indirect emissions from the household sector.

So far, little work has been done on calculating the uncertainty of the method. All figures are therefore preliminary. A better understanding of weaknesses in the underlying data is also needed, and further work on these methodological issues will be carried out in 2001.

Indirect household emissions

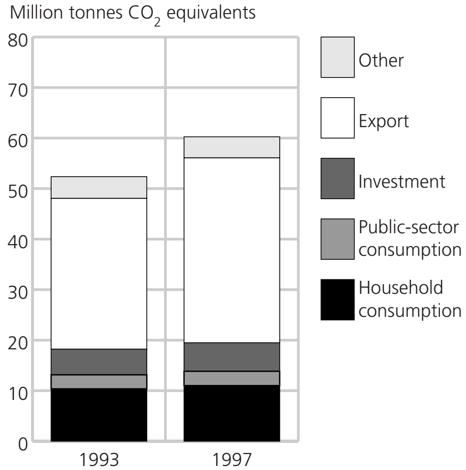
Indirect household emissions means the proportion of emissions from industry that can be related to goods that in the

Box 11.1. CO_2 equivalents

Emissions of greenhouse gases are weighted together using factors that are intended to reflect the potential for environmental damage from emissions of a substance compared with emissions of the corresponding amount of carbon dioxide (CO_2). Only the naturally-occurring greenhouse gases carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O) are included in the calculations on which this article is based. Hydrofluorocarbons (HFCs), perfluorocarbons (CF_4, C_2F_6) and sulphur hexafluoride (SF_6) are not included. These gases only account for a small proportion of emissions, so that their omission has little effect on the overall figures. However, the importance of HFCs is expected to increase in the next few years.

[1] The emission figures include international maritime transport.

Figure 11.3. Total emissions from Norwegian industry split by deliveries to end users, 1993 and 1997. Million tonnes CO_2 equivalents



Source: National accounts and environmental accounts, Statistics Norway.

final instance form part of household consumption.

In 1993, Norwegian industry emitted just over 52.4[1] million tonnes CO_2 equivalents. Of this, 10.4 million tonnes, or 19.8 per cent, was related to the production of goods and services that were consumed by Norwegian households. In 1997, emissions from Norwegian industry had risen to 60.2 million tonnes CO_2 equivalents. At the same time, indirect household emissions rose to 11.0 million tonnes, or 18.3 per cent of industrial emissions (figure 11.3).

Which goods and services contribute most to emissions?

We have also tried to calculate which types of end use (i.e. which goods and services) indirect emissions from households can be linked to. Table 11.4 shows all emissions in Norway linked to production and transport of goods and services before they reach households. The table shows that consumption of foodstuffs, beverages and tobacco is the most important source of Norwegian households' indirect emissions in Norway. The next categories in importance, well behind this, are transport services and housing, electricity and fuel. These three categories accounted for more than 80 per cent of indirect emissions from households in 1997.

Table 11.4. Indirect emissions from households, calculated as emissions linked to deliveries from industries to end users (private consumption). 1993 and 1997. 1 000 tonnes CO_2 equivalents

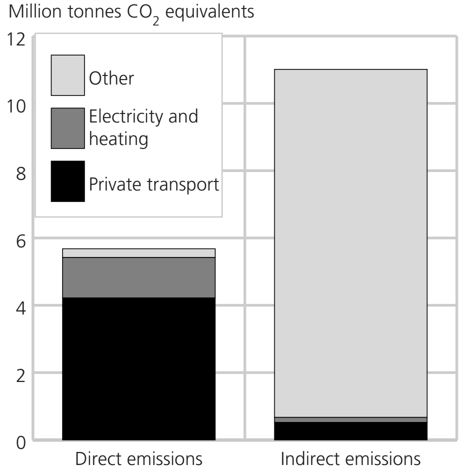
	1993	1997	Percentage change
Private consumption, total	**10 372**	**11 006**	**6.1**
Foodstuffs, beverages and tobacco	4 249	4 341	2.2
Clothing and footwear	26	20	- 23.1
Housing, electricity and fuel	2 204	2 275	3.2
Furniture and household goods	236	243	3.0
Health care (private expenditure)	112	96	- 14.3
Transport services	2 193	2 356	7.4
Leisure activities and entertainment	473	592	25.2
Education	19	21	10.6
Hotel and restaurant services	536	628	17.2
Other goods and services	323	434	31.6

Source: National accounts and environmental accounts, Statistics Norway.

Total household emissions

If we add the emissions generated by household activities, i.e. direct emissions from households, to the indirect emissions calculated above, we find overall figures for the proportion of Norwegian emissions that can be related to private

Figure 11.4. Direct, indirect and total household emissions of greenhouse gases in Norway, by source. 1997. Million tonnes CO_2 equivalents



Source: National accounts and environmental accounts, Statistics Norway.

end use in Norway. As figure 11.4 shows, indirect emissions from households are about twice as high as direct emissions.

Project financed by: Statistics Norway.

Further information may be obtained from: Kristine Erlandsen and Tone Smith.

References

Aronson, Å. (2001): *Preliminær statusrapport för stationär vargförekomst i Skandinavien vintern 2000/2001 t.o.m. 15 januari,* (Preliminary status report on stationary wolves in Scandinavia, winter 2000-2001 up to 15 January) Sverige. http://www2.dirnat.no/bin, Grimsö Wildlife Research Station.

Aslaksen, I., K. A. Brekke, T.A. Johnsen and A. Aaheim (1990): "Petroleum Resources and the Management of National Wealth" in *Recent Modelling Approaches in Applied Energy Economics*. Bjerkholt, O., Olsen, Ø. and Vislie, J., Chapman and Hall Ltd**:** pp. 103-23.

Aune, F. R., T. Bye and T.A. Johnsen (2000a): Gas Power Generation in Norway: Good or bad for the climate? Discussion Papers 286, Statistics Norway.

Aune, F.R., R. Golombek, K.E. Rosendahl and S.A.C. Kittelsen (2000b): *Norge i et liberalisert europeisk energimarked*. (Norway in a liberalized European energy market) Report 3/2000, Ragnar Frisch Centre for Economic Research.

Bartels, R. and D.G. Fiebig (1990): Integrating Direct Metering and Conditional Demand Analysis for Estimating End-Use Loads. *Energy Journal*, 11(4), 79-97.

Birkeland, E. (2000): Pers. comm. 28.01.2000, Norwegian Petroleum Institute.

BP (2000): *Statistical Review of World Energy 2000*, BP.

Braathen, G. O. (1999): Pers. comm., 21.01.1999. Kjeller: Norwegian Institute for Air Research.

Brekke, K. A., S. Kverndokk and K. Nyborg (2000): An Economic Model of Moral Motivation. Discussion Papers 290, Statistics Norway.

Brunvoll, F., K. Rypdal and B. Tornsjø (2000): *Indicators of hazardous chemicals – review and recommendations for further work*. TemaNord: 2000:574, Nordic Council of Ministers.

Bruvoll, A. and K. Ibenholt (1999): *Framskrivning av avfallsmengder og miljøbelastninger knyttet til sluttbehandling av avfall* (Projections of waste quantities and environmental pressures related to final treatment of waste). Reports 99/32, Statistics Norway.

Bruvoll, A. and T. Bye (1998): Utslipp av metan og kvotepriser på klimagasser (Methane emissions and quota prices for greenhouse gases). *Economic Survey* 7/98, Statistics Norway.

Bruvoll, A., B. Halvorsen and K. Nyborg (2000b): Husholdningenes kildesortering (Sorting of waste by households). *Samfunnsspeilet*, 4/2000, pp. 10-20, Statistics Norway.

Bruvoll, A., K. Flugsrud and H. Medin (2000a): Vekst og miljø - i pose og sekk? (Growth and the environment – can we have both?) *Samfunnsspeilet* - 4/2000, pp. 2-9, Statistics Norway.

Budget Committee for Agriculture (1997): *Resultatkontroll for gjennomføring av landbrukspolitikken* (Monitoring the implementation of agricultural policy), Norwegian Agricultural Economics Research Institute.

Budget Committee for Agriculture (2000): *Volum- og prisindekser for jordbruket. Regnskapsåra 1959-1999* (Volume and price indices for agriculture. Accounting years 1959-1999), Norwegian Agricultural Economics Research Institute.

Bye, A. S., K. Mork, T. Sandmo and B. Tornsjø (2000a): *Resultatkontroll jordbruk 2000. Jordbruk og miljø, med vekt på gjennomføring av tiltak mot forurensninger* (Result monitoring in agriculture, 2000. Agriculture and environment. Implementation of measures against pollution). Reports 2000/20, Statistics Norway.

Bye, T., Ø. Døhl and D. E. Sommervoll (2000b): Lavere bensinavgifter - god miljøpolitikk? (Lower petrol taxes – is this good environmental policy?) *Sosialøkonomen* 2000, 8, 13-15.

Bye, T., Ø. Døhl and J. Larsson (1999a): *Klimagasskvoter i kraftintensive næringer. Konsekvenser for utslipp av klimagasser, produksjon og sysselsetting* (Greenhouse gas emission permits in energy-intensive manufacturing industries. Consequences for greenhouse gas emissions, production and employment). Reports 99/24, Statistics Norway.

Bye, T., Ø. Døhl and J. Larsson (1999b): *Klimagasskvoter i kraftintensive næringer. Konsekvenser for utslipp av klimagasser, produksjon og sysselsetting. Regionale konsekvenser* (Greenhouse gas emission permits in energy-intensive manufacturing industries. Consequences for greenhouse gas emissions, production and employment. Regional consequences). Notater 99/80, Statistics Norway.

Cutter (1998): *Global Environmental Change*. Report, X, 3, Dunster, Canada: Cutter Information Corp.

Daasvatn, L., K. Flugsrud, O. K. Hunnes and K. Rypdal (1994): Beregning av regionaliserte utslipp til luft. Beskrivelse av modell og metoder for estimering (Calculation of emissions to air on a regional basis). Notater 94/16, Statistics Norway.

Debio (1999): *Økologisk produksjon*. Registreringer 1999 (Production in ecological agriculture in 1999).

Debio (2001): Registreringer 2000 (Records for 2000). Debio reports, No.1, February 2001, Bjørkelangen.

Dervo, B. K. and T. Østdahl (2000): *Lokal forvaltning av utnyttbare vilt- og fiskeressurser - status for 1998 og 1999* (Management of game and fish resources at local level. Status report for 1998 and 1999).

NINA Oppdragsmelding 657, Norwegian Institute for Nature Research.

Directorate for Nature Management (1997): *Overvåkning av biologisk mangfold i åtte naturtyper* (Biological diversity monitoring in eight different ecosystems). DN Commissioned Report no. 1997-7.

Directorate for Nature Management (1998): *Kalking av surt vann, Årsrapport 1998* (Liming of acid lakes. Annual report 1998).

Directorate for Nature Management (1999): *Kalking av surt vann, Årsrapport 1999* (Liming of acid lakes. Annual report 1999).

Directorate for Nature Management (2000): *To ulveflokker kan bli felt* (Two wolf packs may be culled). Press release 20.10.2000. http://www.dirnat.no/presse/.

EEA (1999): *Air Emissions; Annual topic update 1998*. Topic Report No. 12/1999, Copenhagen: European Environmental Agency.

Eriksen, K. S., T. E. Markussen and K. Pütz (1999): *Marginale kostnader ved transportvirksomhet* (Marginal costs of transport activities). Report 464/1999, Institute of Transport Economics.

Eurostat (2001): *Agricultural Statistics*. Quarterly Bulletin, no. 4, 2000.

Fæhn, T. and E. Holmøy (2001): Trade Liberalisation and Effects on Pollutive Emissions and Waste - A General Equilibrium Assessment for Norway. Discussion Papers 298, Statistics Norway.

FAO (1999): *Yearbook. Fishery statistics. Commodities. 1997*. Vol. 85. FAO Fisheries Series No. 53, FAO Statistics Series No. 149, Food and Agriculture Organization of the United Nations.

FAO (2000a): *The state of food and agriculture 2000*. FAO Fisheries Series No. 32, Food and Agriculture Organization of the United Nations.

FAO (2000b): *The state of world fisheries and Aquaculture 2000*. (http://www.fao.org/documents), Food and Agriculture Organization of the United Nations.

FAO (2000c): *Yearbook. Fishery statistics. Aquaculture production. 1998*. Vol. 86/2. FAO Fisheries Series No. 56, FAO Statistics Series No. 154, Food and Agriculture Organization of the United Nations.

FAO (2000d): *Yearbook. Fishery statistics. Capture production. 1998*. Vol. 86/1. FAO Fisheries Series No. 54, FAO Statistics Series No. 152, Food and Agriculture Organization of the United Nations.

FAO (2000e): *Yearbook. Fishery statistics. Commidities. 1998*. Vol. 87. FAO Fisheries Series No. 55, FAO Statistics Series No. 153, Food and Agriculture Organization of the United Nations.

Federation of Norwegian Process Industries (2001): Pers. comm., Truls Bruu, based on the Federation's paper recycling statistics and Statistics Norway's statistics on imports of waste paper.

Finstad, A., G. Haakonsen, E. Kvingedal and K. Rypdal (2001): *Utslipp til luft av noen miljøgifter i Norge* (Emissions of some hazardous chemicals to air in Norway). Reports 2001/17, Statistics Norway.

Flugsrud, K. and G. Haakonsen (1998): *Utslipp til luft fra utenlandske skip i norske farvann* (Emissions from foreign shipping in Norwegian waters). Reports 98/22, Statistics Norway.

Flugsrud, K. and K. Rypdal (1996b): *Utslipp til luft fra innenriks sjøfart, fiske og annen sjøtrafikk mellom norske havner* (Emissions to air from domestic shipping, fisheries and other maritime traffic between Norwegian ports). Reports 96/17, Statistics Norway.

Flugsrud, K., E. Gerald, S. Holtskog, H. Høie, G. Haakonsen, K. Rypdal, B. Tornsjø and F. Weidemann (2000): *The Norwegian emission inventory*. Reports 2000/1, Statistics Norway and Norwegian Pollution Control Authority.

Flugsrud, K., O. K. Hunnes and E. Lasson (1996a): Metode for beregning av energivarebruk og utslipp på grunnkretser. Beregninger for 1992 og 1993 for kommunene Oslo, Drammen, Bergen og Trondheim (Method of calculating consumption of energy commodities and emissions to basic units. Calculations for 1992 and 1993 for Oslo, Drammen, Bergen and Trondheim municipalities). Notater 95/56, Statistics Norway.

Granøien, I.L.N. (1999): *Nasjonale mål for støy. Kartlegging av antall personer berørt av flystøy* (National targets for noise. Survey of number of people affected by aircraft noise). Report SFT40 A99037, SINTEF.

Grindheim, T. (2000): Pers. comm., Bergen Fire Brigade, Fire Prevention Division.

Grønlund, A. and H. Høie (2001): Indikatorer for bruk og vern av jordressursene (Indicators for use and protection of agricultural land resources). *Kart og Plan*, in prep.

Haakonsen, G. (2000): *Utslipp til luft i Oslo, Bergen, Drammen og Lillehammer 1991-1997. Fordeling på utslippskilder og bydeler* (Emissions to air in Oslo, Bergen, Drammen and Lillehammer 1991-1997 by sources and urban districts). Reports 2000/23, Statistics Norway.

Haakonsen, G., K. Rypdal and B. Tornsjø (1998b): Utslippsfaktorer for lokale utslipp - PAH, partikler og NMVOC (Emission factors for local emissions - PAHs, particulate matter and NMVOCs). Notater 98/29, Statistics Norway.

Haakonsen, G., S. Holtskog and B. Tornsjø (1998a): Energibruk og utslipp til luft i Oslo, Drammen, Bergen og Trondheim (Energy use and emissions to air in Oslo, Drammen, Bergen and Trondheim 1995). Notater 98/52, Statistics Norway.

Halvorsen, B. and R. Nesbakken (2000a): *Effects on household income distribution of increased electricity taxation*. 23rd Annual International Conference of the IAEE, Sydney, Australia.

Halvorsen, B. and R. Nesbakken (2000b): Fordelingseffekter av økt elektrisitetsavgift for husholdninger (Distributional effects of raising the electricity tax for households). Notater 2000/16, Statistics Norway.

Halvorsen, B. and R. Nesbakken (2001): Distributional effects of household electricity taxation. *Journal of Public Economics*, in prep.

Halvorsen, B., S. Kverndokk and A. Torvanger (1989): *Global, regional and* *national carbon dioxide emissions 1949-86*. SAF Project no. 310: Energy and society, Centre for Applied Research, Department of Economics, University of Oslo.

Hass, J. and K. Ø. Sørensen (1997): NOREEA - Norsk regnskap for økonomi og miljø (NOREEA – Norwegian accounts for economy and the environment). *Economic Survey* 9/97, Statistics Norway.

Hass, J., K. Erlandsen, H. Sjølie and K. Sørensen (2001): NOREEA - Miljø-regnskap for Norge (NOREEA – Environmental accounts for Norway). To be published in the series Notater, Statistics Norway.

Heie, A. (1998): *Sorteringsanalyser - Kommunalt avfall* (Analyses of sorting of municipal waste). Report 97/248, Interconsult.

Hobbelstad, K. (2000): Utviklingstrekk i det norske skogbruk. Foredrag holdt under Norsk Skogforums møte "Mot en ny grønn løgn?", Oslo 28. nov. 2000 (Trends in Norwegian forestry. Lecture held at Norsk Skogforum's meeting in Oslo, 28 November 2000).

Holtskog, S. (2001): *Direkte energibruk og utslipp til luft fra transport i Norge* (Direct energy use and emissions to air from transport in Norway). Reports 2001/16, Statistics Norway.

Hustad, J.E., L. Sørum and M. Fossum (2001): Foredrag - Hva skjer i varmen? Avfallskonferansen for innlandet 2001 (What goes on at high temperatures? Lecture at a conference on waste management).

Indahl, B., D.E. Sommervoll and J. Aasness (2001): Virkninger på forbruksmønster, levestandard og klimagassutslipp av endringer i konsumentpriser (Effects of changes in consumer prices on consumption patterns, living standards and greenhouse gas emissions). Notater 2001/20, Statistics Norway.

IPCC (1996): *Climate Change 1995 - The Science of Climate Change: Summary for Policymakers and Technical Summary of the Working Group I Report,* Intergovernmental Panel on Climate Change, Cambridge University Press.

IPCC (2001): *Third Assessment Report. Summary for Policymakers*. http://www.meto.gov.uk/sec5/CR_div/ipcc/wg1/WGIII-SPM.pdf, Intergovernmental Panel on Climate Change.

Iversen, S.A. (ed.) (2001): Havets ressurser 2001 (Overview of resources 2001). *Fisken og havet,* Special issue 1-2001, Institute of Marine Research.

Johansen, B. and H. Tømmervik (1993): *Finnmarksvidda vegetasjonskartlegging – vegetasjonstyper, lavbeiter og endringer i lavdekket innen reinbeitedistrikt 30 og 31, Finnmarksvidda* (Vegetation survey of the Finnmarksvidda – vegetation types, lichen resources and changes in lichen cover in districts 30 and 31, Finnmarksvidda). Report, IT/2020/1-93, NORUT IT.

Johansen, B. and S.R. Karlsen (1998): *Endringer i lavdekket på Finnmarksvidda 1987-1996 basert på Landsat 5/TM data* (Changes in lichen cover on the Finnmarksvidda 1987-1996 based on Landsat 5/TM data). Report, IT/475/1-98, NORUT IT.

Johansen, B., M.E. Johansen and S. R. Karlsen (1995): *Vegetasjons- og beitekartlegging i Finnmark og Nord-Troms* (Survey of vegetation and grazing resources in Finnmark and northern Troms). Report, IT/2026/1-95, NORUT.

Johansen, B.E. (2001): Pers. comm. on grazing resources in Finnmark, NORUT.

Johansen, B.E. and S.R. Karlsen (2000a): *Finnmarksvidda - kartlegging og overvåking av reinbeiter – status 1998* (Survey and monitoring of reindeer grazing areas on the Finnmarksvidda: status report 1998). Report, IT546/1-2000, NORUT IT.

Johansen, B.E. and S.R. Karlsen (2000b): *Øst-Finnmark - kartlegging og overvåking av reinbeiter – status 1999* (Survey and monitoring of reindeer grazing areas in Eastern Finnmark: status report 1999). Report, IT583/1-2000, NORUT IT.

Johnsen, T.A., F.R. Aune and A. Vik (2000): *The Norwegian electricity market: Is there enough generation capacity today and will there be sufficient capacity in coming years?* Reports 2000/26, Statistics Norway.

Karlsen, Ø. et al. (2000): Havbruksrapport 2000 (Aquaculture report 2000). *FiskenHav*, Special issue 3: 2000, Institute of Marine Research.

Kjønnerud, S.I. (2000): Pers. comm., Energy Efficiency Centre, Oslo.

Kleffelgård, T. (2001): Pers. comm., Norwegian Pollution Control Authority.

Kolstad, A.G. (2001): Pers. comm., Norwegian Pollution Control Authority.

Kristiansen, T. et al. (1999): Havbruksrapport 1999 (Aquaculture report 1999). *FiskenHav*, Special issue 3: 1999, Institute of Marine Research.

Kvingedal, E. (2001): *Indikatorer for energibruk og utslipp til luft i industri- og energisektorene* (Indicators for energy use and emissions to air in the manufacturing and energy sectors). Reports 2001/15, Statistics Norway.

Larsen, B.M. (2000): *Investments and Option Values in a Deregulated Electricity Sector*. Conference Proceedings, 23rd Annual International Conference of the IAEE, Sydney, Australia, http://www.aaee.unsw.edu.au/1stcall/papers/Larsen.PDF .

Larsen, B.M. and R. Nesbakken (1995): *Norske CO_2-utslipp 1987-1993. En studie av CO_2-avgiftens effekt* (Norwegian CO_2 emissions 1987-1993. A study of the effects of the CO_2 tax). Reports 95/14, Statistics Norway.

Larsen, B.M. and R. Nesbakken (2000): *Household electricity consumption for different end uses*. 23rd Annual International Conference of the IAEE, Sydney, Australia, http://www.aaee.unsw.edu.au/1stcall/papers/Nesbakken.PDF

Lien, K.M. (2000): Dioksiner - hvor farlige er de og hvor kommer de fra? (Dioxins – how dangerous are they and where do they come from?) *Kretsløpet*, 8/2000.

Martinsen, T. (2000): Prosjekt over industriens energibruk (Project on industrial energy use). Notater 2000/14, Statistics Norway.

METLA (2000): *Skogstatistisk årsbok* (Statistical Yearbook of Forestry). Helsinki: Finnish Forest Research Institute.

Ministry of Agriculture (2000): *Landbruksdepartementets miljøhandlingsplan 2001-2004* (Environmental action plan for the Ministry of Agriculture).

Ministry of Finance (1996): *Grønne skatter - en politikk for bedre miljø og høy sysselsetting* (Green taxes – a policy for a better environment and high employment levels). NOU 1996: 9.

Ministry of Fisheries (1999): *Fiskeridepartementets miljøhandlingsplan 2000-2004* (Environmental action plan for the Ministry of Fisheries 2000-2004). Action plans, L-0503.

Ministry of Health and Social Affairs (1995): *Forskrift om vannforsyning og drikkevann m.m – Drikkevannsforskriften* (Regulations relating to water supplies and drinking water, etc.). I-9 /95.

Ministry of Petroleum and Energy (1999): *Miljøhandlingsplan for olje- og energisektoren 1999* (Environmental action plan for the petroleum and energy sector 1999).

Ministry of the Environment (1995): *Nasjonalt program for utvikling av fem miljøbyer* (National programme for sustainable development in five towns). T-1115.

Ministry of the Environment (1999a): *Rikspolitiske bestemmelser etter § 17-1 annet ledd i Plan- og bygningsloven om midlertidig etableringsstopp for kjøpesentre utenfor sentrale deler av byer og tettsteder* (National policy decision pursuant to § 17-1, second paragraph, of the Planning and Building Act, relating to a temporary prohibition on the establishment of shopping centres). Council of State item 1/99.

Ministry of the Environment (1999b): *Tiltak og virkemidler for å nå ulike nivå for luftkvalitet* (Measures and instruments for achieving various air quality standards). http://www.odin.dep.no/md/norsk/publ/rapporter/index-b-n-a.html.

Ministry of the Environment (2000a): *Et kvotesystem for klimagasser* (A quota system for greenhouse gases). NOU 2000:1.

Ministry of the Environment (2000b): *Forskrift om kommunale vann- og avløpsgebyrer* (Regulations relating to municipal water and waste water fees). T-1344.

Monsrud, J. (1997): *Eie og bruk av personbil: Noen utviklingstrekk 1980-1995* (Ownership and use of cars. Some trends 1980-1995). Reports 97/10, Statistics Norway.

Mork, K., T. Smith and J. Hass (2000): *Ressursinnsats, utslipp og rensing i den kommunale avløpssektoren 1999* (Inputs of resources, discharges and waste water treatment in the municipal waste water sector 1999). Reports 2000/27, Statistics Norway.

National Board of Forestry (2000): *Skogstatistisk årsbok 2000* (Yearbook of forestry statistics 2000). Sveriges officiella statistik, Skogsstyrelsen.

National Institute of Public Health (1998): *Landsrapport vannverksregisteret, Status for vannforsyning 1994* (National report, register of water works. Status report on water supplies 1994). Report 97.

National Institute of Public Health (2000): Pers. comm., Carl Fredrik Nordheim and Liliane Myrstad.

National Institute of Public Health (2001): Pers. comm., Bjørg Einan and Liliane Myrstad.

Norconsult (1999): *Utvikling av beregningsmodell for netto utslipp av metangass fra norske deponier, historiske og framtidige utslippsmengder* (Development of a model for calculating net emissions of methane from Norwegian landfills, historical and future emission quantities). Revision 2, 3168800.

Nordel's secretariat (various years): *c/o Statnett SF*.

NORSAS (1996): *Spesialavfallsmengder i Norge* (Quantities of hazardous waste in Norway). Report No. 96:02, Norwegian Resource Centre for Waste Management and Recycling.

NORSAS (2000): *Avfall 2000* (Waste 2000). Report, Norwegian Resource Centre for Waste Management and Recycling.

Norwegian Agricultural Inspection Service (2001): *Omsetningsstatistikk for bruk av plantevernmidler. Kommentarer til statistikken* (Sales statistics for use of pesticides). www.landbrukstilsynet.no/dokument.cfm?m_id=87&d_id=0, accessed 20.03.2001.

Norwegian Food Control Authority (2000): Morten Nicholls, pers. comm.

Norwegian Institute for Air Research (1996): *Årsrapport 1996* (Annual report 1996).

Norwegian Institute for Air Research (1996b): *Målinger av luftforurensninger i by/tettstedsprogrammet*. Oktober 1994 - mars 1995. Statlig program for forurensningsovervåkning (Measurements of air pollutants in towns and urban settlements, October 1994-March 1995. National programme for pollution monitoring), Report no. 648, TA 1323, Kjeller.

Norwegian Institute for Air Research (1996c): Quantification of Health Effects Related to SO_2, NO_2, O_3 and Particulate Matter Exposure, Report from the Nordic Expert Meeting Oslo, 15-17 October, 1995, OR 63, Norwegian Institute for Air Research and World Health Organization.

Norwegian Institute for Air Research (1999): *Overvåking av ozonlaget og naturlig ultrafiolett stråling* (Monitoring of the ozone layer and natural ultraviolet radiation). Report OR 63/99.

Norwegian Institute for Air Research (2000): *Forskningsprosjektet RegClim presenterer et scenario for Norges klima om 50 år som er varmere, våtere og med mer vind* (Research project RegClim presents a warmer, wetter and windier scenario for the Norwegian climate in 50 years' time). Press release 11.05.2000. http://www.nilu.no/regclim/presse/Pressemeldingsiste1005.htm.

Norwegian Institute for Land Inventory (1999): *SKOG 2000. Statistikk over skogforhold og -ressurser i Norge* (Forests 2000. Statistics on forests and forest resources in Norway). NIJOS report 7/1999.

Norwegian Institute for Land Inventory (2001): *Landsrepresentativ overvåkning av skogens vitalitet i Norge 1989-2000*

(Nationwide representative monitoring of forest vitality, 1989-2000). Report 1/01.

Norwegian Institute for Water Research (1999): *Landsomfattende trofiundersøkelse av norske innsjøer. Oppsummering og erfaringer fra første fase 1988-1998*.

(Nationwide investigation of the trophic state of Norwegian lakes. Summary and results of the first phase, 1988-1998). Report TA-1681/1999.

Norwegian Institute for Water Research (2000): *Tålegrenser og overskridelse av tålegrenser for overflatevann, skogsjord og vegetasjon i Norge* (Critical loads and areas where they are exceeded for surface water, forest soil and vegetation in Norway). Report LNR 4179-2000.

Norwegian Institute for Water Research (2001): *Tilførsler av næringssalter til Norges kystområder, beregnet med tilførselsmodellen TEOTIL* (Inputs of nutrients to coastal waters in Norway, calculated using the input model TEOTIL).

Norwegian Institute for Water Research/ Centre for Soil and Environmental Research (2000): *JOVA - Overvåkning av jordbrukspåvirkede innsjøer 1999. Tiltaksgjennomføring, vannkvalitetstilstand og utvikling* (JOVA – Monitoring programme for lakes influenced by agriculture, 1999. Measures implemented, water quality and trends). Report 4315 - 2000.

Norwegian Institute for Water Research/ Norwegian Institute for Air Research (1995): *Materialstrømsanalyse av PAH, 1995* (Material flow analysis of PAHs, 1995). NIVA/NILU report O-92108, Oslo and Kjeller.

Norwegian Institute for Water Research/ Norwegian Pollution Control Authority (2000): *Overvåkning av langtransporterte forurensninger 1999. Sammendragsrapport* (Monitoring programme for long-range transport of polluted air and precipitation. Summary). Report TA-1729/ 2000.

Norwegian Meteorological Institute (2001): *Tables of anthropogenic emissions in the ECE region*. http:// projects.dnmi.no/~emep. February 2001.

Norwegian Petroleum Institute (2000): http://www.np.no/.

Norwegian Pollution Control Authority (1992): *Virkninger av luftforurensninger på helse og miljø. Anbefalte luftkvalitetskriterier* (Effects of air pollution on health and the environment. Recommended maximum concentrations for air quality guidelines). Report no. 16, TA 848, Oslo.

Norwegian Pollution Control Authority (1993): *Miljøgifter i Norge* (Environmentally hazardous substances in Norway). Report no. 22, TA 985, Oslo.

Norwegian Pollution Control Authority (2000a): *Mulige tiltak for å redusere støy. Framskrivninger og oppsummering på tvers av kilder* (Possible noise abatement measures. Projections and summary for all sources). Report TA-1714/2000.

Norwegian Pollution Control Authority (2000b): *Å beskrive miljøtilstand og bærekraftig utvikling i byer og tettsteder. Indikatorer og metode* (Describing the state of the environment and sustainable development in towns and urban settlements. Indicators and method). 1726/2000.

Norwegian Pollution Control Authority (2001a): *Inkosys-databasen* (The Inkosys database).

Norwegian Pollution Control Authority (2001b): *Miljøstatus i Norge*. http://www.mistin.dep.no. (State of the Environment Norway http://www.environment.no/).

Norwegian Pollution Control Authority/ Directorate for Nature Management (1999): *Overvåkning av langtransportert luft og nedbør. Årsrapport - Effekter 1998* (Monitoring programme for long-range transport of polluted air and precipitation. Annual report – effects in 1998). Report 781/99.

Norwegian Pollution Control Authority/ Ministry of the Environment (2000): *Et gløtt av sol bak sure skyer*. Report TA-1735/2000, Statens forurensningstilsyn.

Norwegian Public Roads Administration (1999): *Tiltak for å bedre luftkvaliteten i Oslo og Akershus vinteren 1999/2000* (Measures to improve air quality in Oslo and Akershus in winter 1999-2000). Bedre byluft No. 8, Directorate of Public Roads.

Norwegian Reindeer Husbandry Administration (1998): *Norwegian Reindeer Husbandry. The herding year 1997/98*. Brochure 18 p.

Norwegian Reindeer Husbandry Administration (2000): *Ressursregnskap for reindriftsnæringen* (Resource accounts for reindeer husbandry).

Norwegian Reindeer Husbandry Administration (2001): Pers. comm., unpublished material on resource accounts for reindeer husbandry 2001.

Norwegian State Railways (1992): *NSB Almanakk 1992*.

Nyborg, K. and M. Rege (2000): The Evolution of Considerate Smoking Behavior. Discussion Papers 279, Statistics Norway.

OECD (1994): *Environmental indicators. OECD core set*, Organisation for Economic Co-operation and Development.

OECD (1998): *Towards sustainable development. Environmental indicators*, Organisation for Economic Co-operation and Development.

OECD (1999): *OECD Environmental Data. Compendium 1999*, Organisation for Economic Co-operation and Development.

Oil & Gas Journal (2000): *Vol 98*. No. 51.

Oil & Gas Journal (2001): *Vol 99*. No. 7.

Oslo City (2000): *Luftforurensningen i Oslo 2000* (Air pollution in Oslo 2000). To be published in the series reports, Helsevernetaten.

Proposition No. 1 (1999-2000) to the Storting: *For budsjetterminen 2000* (For the budget period 2000), Ministry of the Environment.

Proposition No. 1 (1999-2000) to the Storting: *Skatte-, avgifts- og tollvedtak, For budsjetterminen 2000* (Decisions on taxes and customs for the budget period 2000), Ministry of Finance.

Proposition No. 1 (2000-2001) to the Storting: *Skatte-, avgifts- og tollvedtak, For budsjetterminen 2001* (Decisions on taxes and customs for the budget period

2001), Ministry of Finance, Finans- og tolldepartementet.

Proposition No. 87 (1999-2000) to the Storting: *Om samtykke til ratifikasjon av ein protokoll av 30. november 1999 til konvensjonen om langtransportert grensekryssande luftureining 13. november 1979, som gjeld reduksjon av forsuring, overgjødsling og bakkenært ozon* (Approval of the Ratification of the Protocol of 30 November 1999 to the Convention of 13 November 1979 on Long-range Transboundary Air Pollution to abate Acidification, Eutrophication and Ground-level Ozone), Ministry of the Environment.

Report No. 17 (1998-1999) to the Storting: *Verdiskapning og miljø - muligheter i skogsektoren (Skogmeldingen)* (Wealth creation and the environment - opportunities in the forestry sector), Ministry of Agriculture.

Report No. 19 (1999-2000) to the Storting: *Om norsk landbruk og matproduksjon* (Norwegian agriculture and food production), Ministry of Agriculture.

Report No. 24 (2000-2001) to the Storting: *Regjeringens miljøvernpolitikk og rikets miljøtilstand* (The Government's environmental policy and the state of the environment in Norway), Ministry of the Environment.

Report No. 29 (1996-97) to the Storting: (Regional planning and land use policy), *Regional planlegging og arealpolitikk*, Ministry of the Environment.

Report No. 29 (1997-98) to the Storting: *Norges oppfølging av Kyotoprotokollen* (Norwegian implementation of the Kyoto Protocol), Ministry of the Environment.

Report No. 46 (1999-2000) to the Storting: *Nasjonal transportplan 2002-2011* (National Transport Plan 2002-2011), Ministry of Transport and Communications.

Report No. 54 (2000-2001) to the Storting: *Norsk klimapolitikk* (Norwegian climate policy), Ministry of the Environment.

Report No. 58 (1996-1997) to the Storting: *Miljøvernpolitikk for en bærekraftig utvikling. Dugnad for framtida* (An environmental policy for sustainable development), Ministry of the Environment.

Report No. 8 (1999-2000): *Regjeringens miljøvernpolitikk og rikets miljøtilstand* (The Government's environmental policy and the state of the environment in Norway), Ministry of the Environment.

Rosendahl, K. E. (2000): *Helseeffekter og kostnader av luftforurensning i Norge* (Health effects and costs of air pollution in Norway). SFT report 1718/2000, Norwegian Pollution Control Authority.

Solheim, T. (1997): *Miljøindikatorer for norske byer - bærekraftig transport* (Environmental indicators for Norwegian towns: sustainable transport). TØI-report 1074/1997, Institute of Transport Economics.

SSB/SFT/DN (1994): *Naturmiljøet i tall 1994* (The natural environment in figures 1994). Oslo: Scandinavian University Press.

Statistics Norway (1982): *Arealbruksstatistikk for tettsteder* (Land-use statistics for urban settlements), NOS B 333.

Statistics Norway (1998a): Etterprøvbare miljømål for byer og tettsteder (Verifiable environmental goals for urban settlements). Notater, 1998/42.

Statistics Norway (1998b): *Natural Resources and the Environment 1998*. Statistical Analyses 26.

Statistics Norway (1999a): National Accounts 1991-1998: Production, Use and Employment. NOS 543.

Statistics Norway (1999b): *Natural Resources and the Environment 1999*. Statistical Analyses 30.

Statistics Norway (1999c): Nordmenns ferievaner 1998 (Norwegians' holiday habits 1998). *Weekly Bulletin*, 33/99.

Statistics Norway (1999d): *Samferdselsstatistikk 1998* (Transport and Communication Statistics 1998). NOS C 557.

Statistics Norway (1999e): Sentrumsstatistikk for Oslo og Akershus. Et pilotprosjekt (Statistics for urban settlement centres in Oslo and Akershus. A pilot project), Notater, 1999/76.

Statistics Norway (2000a): *Fiskeoppdrett 1998* (Fish farming 1998). NOS C 609.

Statistics Norway (2000b): *Natural Resources and the Environment 2000*. Statistical Analyses 37.

Statistics Norway (2000c): *Samferdselsstatistikk 1999* (Transport and Communications Statistics 1999). NOS C 628.

Statistics Norway (2000d): *Skogstatistikk 1999* (Forestry Statistics 1999). NOS C 648.

Statistics Norway (2001a): *Avfallsstatistikk - Kommunalt avfall 1998* (Waste statistics – Municipal Waste 1998). NOS C 625.

Statistics Norway (2001b): *Energistatistikk* (Energy statistics). www.ssb.no/emner/01/03/10/.

Statistics Norway (2001c): "Halene var afstudsede". Rovdyrstatistikk 1846-2000 (Statistics on the four large predators 1046-2000). *Samfunnsspeilet*, 1/2000, 80-93.

Statistics Norway (2001d): *Resultater fra Landbruksundersøkelsen 2000* (Results of the agricultural survey 2000). http://www.ssb.no/emner/10/04/20/skogbruk/

Statistics Norway (2001e): *Småvilt- og rådyrjakt 1999/2000* (Hunting of small game and roe deer 1999-2000). http://www.ssb.no/srjakt/.

Statistics Norway (2001f): *Utslippsregnskapet for luft* (Inventory of emissions to air). http://www.ssb.no/emner/01/04/10/agassr/

Statistics Norway (2001g): Økonomisk utsyn over året 2000 (Economic Survey 2000). *Economic Survey* 2001, 1.

Statistics Sweden (1997): *Markanvänding i tätorter 1995 og förandringer 1990-1995* (Land use in urban settlements 1995 and changes in the period 1990-1995), Statistiska centralbyrån.

Stoltenberg, J. (2001): *Statsministerens nyttårstale 2000/2001* (The Prime Minister's Speech on New Year's Eve 2000).

Swedish Consumer Agency (1997): *Källsortering i fyra kommuner. Vad har producentansvaret betytt för hushållen?* (Waste sorting at source in four municipalities. What has producer responsibility meant for households?) Report 1997:16, Konsumentverket.

Toresen, R. et al. (1998): Havets ressurser 1998 (Overview of resources 1998). *FiskenHav*, Special issue 1: 1998, Institute of Marine Research.

Toresen, R. et al. (1999): Havets ressurser 1999 (Overview of resources 1999). *FiskenHav*, Special issue 1: 1999, Institute of Marine Research.

Toresen, R. et al. (2000): Havets ressurser 2000 (Overview of resources 2000). *FiskenHav*, Special issue 1: 2000, Institute of Marine Research.

Tornsjø, B. (2001): *Utslipp til luft fra innenriks sjøfart, fiske og annen sjøtrafikk mellom norske havner* (Emissions to air from domestic shipping, fishing vessels and other sea traffic between Norwegian ports). Reports 2001/6, Statistics Norway.

UN/ECE (1999): *New air pollution protocol to save lives and the environment*. Press release 24 November 1999. http// www.unece.org/press/99env11e.htm, United Nations/Economic Commission for Europe.

UN/ECE (2000a): *Forest Condition in Europe. 1999 Executive Report, Federal Research Centre for Forestry and Forest Products*, United Nations/Economic Commission for Europe and the European Commission.

UN/ECE (2000b): *Forest Condition in Europe. 2000 Executive Report. Federal Research Centre for Forestry and Forest Products*, United Nations/Economic Commission for Europe and the European Commission.

UN/ECE (2000c): *Timber Committee Market Statement on Forest Products Markets in 2000 and 2001: Sustainable Forest Products Markets Necessary for Sustainable Forest Management - and vice versa*. Press release 2 November 2000. http://www.unece.org/trade/timber/mis/forecasts.htm, United Nations/ Economic Commission for Europe.

UN/ECE/FAO (1995): *Forest Resource Assessment 1990*. Rome: Global synthesis, United Nations/ Economic Commission for Europe / Food and Agriculture Organization of the United Nations.

UNFCCC (2000): *http:// 194.95.3.33.Feb.2000*. United Nations Framework Convention on Climate Change.

University of California (2000): *http:// cdiac.esd.ornl.gov/ftp/maunaloa-co2/ maunaloa.co2*. Accessed 16.08. 2000, Scripps Institution of Oceanography, University of California.

Energy

Appendix A

Table A.1 Reserve accounts for crude oil. Fields already developed or where development has been approved. Million Sm^3 o.e.

	1993	1994	1995	1996	1997	1998	1999	2000
Reserves as of 1 Jan.	1 496	1 473	1 477	1 654	1 795	1 858	1 810	1 692
New fields	5	34	131	315	84	-	36	190
Re-evaluations	107	124	212	11	166	131	24	77
Extraction	-136	-154	-166	-186	-187	-179	-179	-189
Reserves as of 31 Dec.	1 473	1 477	1 654	1 795	1 858	1 810	1 692	1 770
R/P-ratio	11	10	10	10	10	10	9	9

Kilde: Norwegian Petroleum Directorate and Statistics Norway

Table A.2 Reserve accounts for natural gas. Fields already developed or where development has been approved. Million Sm^3 o.e.

	1993	1994	1995	1996	1997	1998	1999	2000
Reserves as of 1 Jan	1 381	1 356	1 346	1 352	1 479	1 173	1 172	1 247
New fields	1	2	32	195	12	-	45	61
Re-evaluations	2	18	5	-27	-271	47	82	5
Extraction	-28	-30	-31	-41	-47	-48	-52	-54
Reserves as of 31 Dec.	1 356	1 346	1 352	1 479	1 173	1 172	1 247	1 259
R/P-ratio	49	45	43	36	25	24	24	23

Source: Norwegian Petroleum Directorate and Statistics Norway.

Table A.3 Norway´s hydropower potential and developed and undeveloped hydropower[1]. GWh

Year	Hydropower potential[2]	Developed as of 31 Dec.	Undeveloped						
			Under construction[3]	Licence granted	Applied for licence	Licence denied[4]	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
2000	186 970	118 041	73	347	2 536	1 351	3 456	36 543	24 623

[1]Mean annual production capability. [2]Plans for undeveloped hydropower are evaluated regularly, and this is why hydropower potential changes from year to year. [3]Includes the category 'Licence granted' for all years before 1993. [4]Included in 'Licence granted' and 'Applied for licence' before 2000.
Source: Norwegian Water Resources and Energy Directorate.

Table A.4 Extraction, conversion and use[1] of energy commodities. 1999*

	Coal and coke	Wood, wood waste, black liquor, waste	Crude oil	Natural gas	Petroleum products[2]	Electricity	District heating	Total	Average annual change 1976-1999	Average annual change 1998-1999
	PJ								Per cent	
Extraction of energy commodities	11	-	6 026	2 057	[3]316	439	-	8 848		
Energy use in extraction sectors	-	-	-	[4]-146	-18	-7	-	-171		
Imports and Norwegian purchases abroad	54	0	89	-	260	23	-	427		
Exports and foreign purchases in Norway	-10	0	-5 436	-1 883	-650	-30	-	-8 009		
Stocks (+decrease, -increase)	1	-	1	-	-2	0	-	0		
Primary supplies	57	0	679	28	-93	425	-	1 096		
Oil refineries	7	-	-607	-	579	-2	-	-23		
Other energy sectors or supplies	-1	56	-	0	17	2	7	82		
Registered losses, statistical errors	-5	-	-73	-1	-31	-36	-2	-148		
Registered use outside energy sectors	58	57	-	27	472	389	6	1 007	0,9	-2,7
Domestic use	58	57	-	27	325	389	6	861	1,5	-0,2
Agriculture and fisheries	0	0	-	-	28	8	0	36	0,8	1,3
Energy-intensive manufacturing	44	-	-	26	52	118	0	241	1,7	-1,1
Other manufacturing and mining	13	33	-	0	30	54	1	130	0,0	-5,3
Other industries	-	0	-	0	144	88	4	236	2,4	5,8
Private households	0	24	-	-	72	121	1	218	1,6	-2,3
International maritime transport	-	-	-	-	145	-	-	145	-1,7	-16,1

[1]Includes energy commodities used as raw materials. [2]Includes liquified 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 A.5 Use of energy commodities outside the energy sectors and international maritime transport

Energy commodity	1976	1980	1985	1990	1995	1996	1997	1998	1999*	2000*	Average annual change 1976-1999	Average annual change 1999-2000
	PJ										Per cent	
Total	**610**	**678**	**742**	**748**	**796**	**818**	**831**	**863**	**861**	**841**	**1,5**	**-2,3**
Electricity	241	269	329	349	374	371	374	394	389	399	2,1	2,6
Firm power	232	265	312	324	348	357	352	367	365	:	2,0	.
Spot power	9	4	17	24	26	14	22	27	25	:	4,4	.
Oil, total	299	294	259	243	253	275	267	271	276	240	-0,4	-12,8
Oil other than transport	159	137	77	57	51	66	55	56	53	37	-4,6	-31,4
Petrol	9	3	0	0	0	0	0	0	0	0	-24,8	0,0
Kerosene	17	16	9	7	7	8	8	7	7	5	-3,9	-22,9
Middle distillates	66	62	43	36	30	39	31	32	32	23	-3,1	-28,6
Heavy fuel oil	66	56	25	14	14	18	16	17	15	9	-6,4	-41,5
Oil for transport	141	157	183	187	202	209	213	216	222	204	2,0	-8,4
Petrol, aviation fuel, jet fuel	74	82	92	100	102	101	100	100	103	92	1,5	-10,5
Middle distillates	64	71	83	84	99	108	112	115	119	111	2,8	-6,7
Heavy fuel oil	3	5	7	4	1	1	1	1	1	1	-8,0	20,8
Gas[1]	1	41	52	52	52	54	70	77	76	80	18,7	5,5
District heating	-	-	2	3	4	5	5	5	6	6	.	0,4
Solid fuel	67	74	100	101	113	113	116	115	114	116	2,3	1,7
Coal and coke	47	48	57	50	58	58	58	60	58	60	0,9	3,4
Wood, wood waste, black liquor, waste	21	26	42	51	55	55	58	55	57	57	4,5	0,0

[1]Includes liquefied petroleum gas. From 1990 also fuel gas and landfill gas, and from 1994 natural gas.
Source: Statistics Norway.

Table A.6 Net use[1] of energy in the energy sectors. PJ

	1976	1980	1985	1990	1995	1996	1997	1998	1999*	2000*
Total	**34**	**65**	**75**	**122**	**185**	**198**	**206**	**196**	**198**	**212**
Of this:										
Electricity	4	6	8	7	10	7	11	8	9	11
Natural gas	12	30	45	79	140	151	154	147	146	160

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

Table A.7 Use of energy commodities ouside the energy sectors and international maritime transport, by sector[1]. 1998. PJ

	Coal and coke	Wood, wood waste, black liquor, waste	Crude oil	Natural gas	Petroleum products[2]	Electricity	District heating	Total
Total	**59,8**	**55,5**	**-**	**24,3**	**324,3**	**394,0**	**5,1**	**862,9**
Manufacturing and mining	**59,6**	**31,5**	**-**	**24,2**	**89,8**	**175,1**	**0,8**	**381,1**
Oil drilling	-	-	-	-	4,2	-	-	4,2
Manufacture of pulp and paper	0,2	25,1	-	-	7,0	22,8	0,0	55,1
Manufacture of basic chemicals	12,2	0,1	-	23,1	50,9	24,1	0,3	110,8
Manufacture of minerals[3]	10,6	0,0	-	-	8,0	5,0	0,0	23,7
Manufacture of iron, steel and ferro-alloys	27,6	-	-	0,1	0,6	27,7	0,0	56,1
Manufacture of other metals	4,9	0,0	-	0,6	3,5	68,4	0,0	77,5
Manufacture of metal goods, boats, ships and oil platforms	4,1	0,4	-	0,0	4,0	9,7	0,1	18,3
Manufacture of wood, plastic, rubber and chemical goods, printing	-	5,7	-	-	2,5	6,4	0,1	14,7
Manufacture of consumer goods	-	0,0	-	0,4	9,1	11,0	0,3	20,8
Other industries, total	**0,1**	**24,0**	**-**	**0,0**	**234,6**	**218,8**	**4,2**	**481,8**
Construction	-	0,1	-	0,0	9,2	2,0	-	11,4
Agriculture and forestry	-	0,1	-	-	6,5	6,5	0,0	13,1
Fishing, whaling and sealing	-	-	-	-	21,8	0,5	-	22,3
Land transport[4]	-	-	-	-	43,2	2,3	-	45,5
Sea transport, domestic	-	-	-	-	21,4	0,0	-	21,4
Air transport[4]	-	-	-	-	23,5	0,1	-	23,6
Other private services	-	-	-	0,0	28,3	50,9	1,6	80,8
Public sector, municipal	-	-	-	0,0	3,1	21,7	1,0	25,8
Public sector, state	-	-	-	-	5,5	8,6	0,5	14,6
Private households	0,1	23,8	-	-	72,2	126,2	1,1	223,4

[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 A.8 Electricity balance

	1975	1980	1985	1990	1995	1997	1998	1999*	2000*	Average annual change 1990-2000*	Average annual change 1999-2000*
	TWh									Per cent	
Production	77,5	84,1	103,3	121,8	123,0	111,4	116,8	122,7	143,0	1,6	16,6
+ Imports	0,1	2,0	4,1	0,3	2,3	8,7	8,0	6,5	1,5	17,3	-77,2
- Exports	5,7	2,5	4,6	16,2	9,0	4,9	4,4	8,3	20,5	2,4	148,0
= Gross domestic consumption	71,9	83,6	102,7	105,9	116,3	115,2	120,4	120,9	123,9	1,6	2,5
- Consumption in pumped storage power plants	0,1	0,5	0,8	0,3	1,4	1,7	0,8	0,6	0,9	11,4	40,6
- Consumption in power plants, losses and statistical differences	7,1	8,0	10,0	7,9	10,0	8,7	9,1	9,4	10,3	2,7	9,1
= Net domestic consumption	64,7	75,1	91,9	97,7	105,0	104,9	110,4	110,8	112,8	1,4	1,8
- Spot power.	3,2	1,2	4,8	6,7	7,5	6,2	7,5	4,5	5,6	-1,9	24,1
= Net firm power consumption	61,4	73,9	87,1	91,0	97,5	98,7	103,0	106,3	107,2	1,7	0,8
- Energy-intensive manufacturing	26,2	27,9	30,0	29,6	28,4	28,7	30,2	31,1	33,4	1,2	7,3
= General consumption . .	35,2	46,0	57,1	61,5	69,1	70,0	72,8	75,2	73,8	1,8	-1,9
General consumption corrected for temperature	36,3	45,1	54,6	65,4	69,6	71,6	73,6	77,5	77,9	1,8	0,6

Source: Statistics Norway and Norwegian Water Resources and Energy Administration.

Table A.9 Average prices[1] for electricity[2] and some selected oil products. Energy supplied

	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999*	2000*
Heating products[3]	Price in øre/kWh[5]											
Electricity	43,5	45,7	46,5	46,6	47,8	46,8	49,7	52,4	55,0	51,0	50,0	51,9
Heating kerosene	28,3	33,9	40,1	37,4	37,8	37,1	37,7	41,6	43,8	42,6	47,6	59,5
Fuel oil no.1/light fuel oils[4]	21,6	26,6	31,9	28,3	28,0	28,2	29,6	34,0	37,0	34,3	39,9	51,5
Fuel oil no.2	20,7	25,7	30,8	27,2	26,9	27,1	[4]..	..	..	..	..	..
Transport products	Price in øre/litre[5]											
Petrol, leaded, high oct. . .	578,5	642,8	741,0	795,0	836,2	851,0	893,0	.	.	.	.	.
Petrol, unl. 98 octane	.	622,1	705,0	747,0	787,1	791,0	838,0	880,0	909,0	904,0	948,0	1 087,0
Petrol, unl. 95 octane	540,5	594,4	677,0	717,0	757,4	761,0	807,0	849,0	888,0	873,0	919,0	1 052,0
Auto diesel	233,0	285,9	341,0	326,0	403,0	649,0	701,0	757,0	779,0	781,0	827,0	991,0

[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]Fuel oil 1 and fuel oil 2 are so similar that they have been combined in the category light fuel oils after 1994. [5] 100 øre = 1 NOK.

Source: Statistics Norway, Norwegian Competition Authority, Norwegian Water Resources and Energy Directorate and Norwegian Petroleum Institute.

Table A.10 Total primary energy supply. World total and selected countries

	1971	1985	1990	1996	1997	1998	Per unit GDP (1998)	Per unit GDP (1998)	Per capita (1998)
	Million toe						toe/1000 1990-USD	toe/1000 1990-USD PPP[1]	toe per capita
World total	**5 468,5**	**7 717,0**	**8 623,5**	**9 423,9**	**9 532,0**	**9 490,1**	**0,36**	**0,28**	**1,62**
OECD	**3 371,7**	**4 117,7**	**4 495,7**	**5 029,4**	**5 095,1**	**5 097,0**	**0,25**	**0,26**	**4,63**
Norway	13,9	20,3	21,5	23,1	24,4	25,4	0,16	0,24	5,75
Denmark	19,2	19,9	18,3	22,9	21,1	20,8	0,13	0,18	3,92
Finland	18,4	26,5	28,8	32,0	33,1	33,5	0,22	0,36	6,49
Iceland	1,0	1,8	2,1	2,3	2,3	2,6	0,35	0,47	9,59
Sweden	36,5	47,6	47,8	52,3	51,4	52,5	0,21	0,32	5,93
Belgium	39,9	44,7	48,4	56,4	57,1	58,4	0,26	0,30	5,72
France	154,5	200,2	227,6	254,3	247,6	255,7	0,19	0,22	4,34
Greece	9,2	18,6	22,1	24,8	25,7	27,0	0,28	0,23	2,57
Italy	114,1	135,5	153,3	161,0	163,3	167,9	0,14	0,16	2,95
Netherlands	51,3	61,6	66,6	76,0	74,9	74,4	0,21	0,24	4,74
Poland	86,5	123,6	100,1	107,5	103,5	96,4	1,23	0,37	2,49
Portugal	6,5	11,4	16,4	19,2	20,2	21,9	0,26	0,17	2,19
Spain	43,1	71,8	90,6	101,4	107,6	112,8	0,19	0,20	2,86
United Kingdom	211,1	203,8	213,1	233,1	227,4	232,9	0,21	0,22	3,93
Switzerland	17,1	23,0	25,0	25,6	26,2	26,6	0,11	0,17	3,74
Czech Republic	45,7	49,5	47,4	42,3	42,5	41,0	1,55	0,44	3,99
Turkey	19,5	38,9	52,5	67,7	71,3	72,5	0,35	0,16	1,12
Germany	307,9	361,3	355,7	351,3	347,3	344,5	0,18	0,23	4,20
Hungary	19,2	30,5	28,5	26,0	25,4	25,3	0,71	0,35	2,50
Austria	19,1	23,2	25,7	28,2	28,7	28,8	0,15	0,19	3,57
Canada	142,7	193,4	209,1	237,2	239,5	234,3	0,35	0,38	7,73
Mexico	45,6	111,4	124,2	136,8	141,6	147,8	0,44	0,20	1,55
USA	1 593,2	1 781,7	1 925,6	2 140,1	2 180,9	2 181,8	0,31	0,31	8,11
Japan	269,6	367,0	438,8	511,0	517,7	510,1	0,15	0,20	4,03
South Korea	16,5	53,4	91,4	163,8	176,5	163,4	0,42	0,30	3,52
Australia	52,2	73,9	87,2	101,1	104,7	105,0	0,27	0,29	5,60
Non-OECD	**2 096,8**	**3 599,2**	**4 127,8**	**4 394,5**	**4 436,8**	**4 393,2**	**0,82**	**0,31**	**0,92**
Romania	42,1	64,8	61,1	49,0	43,8	39,6	1,28	0,61	1,76
Russia	..	..	..	610,9	596,7	581,8	1,74	0,87	3,96
Egypt	7,8	25,5	31,9	37,8	39,1	41,8	0,70	0,21	0,68
Ethiopia	9,0	12,7	15,2	16,4	16,6	17,4	1,95	0,65	0,28
Nigeria	36,2	61,9	70,9	82,5	85,3	86,5	2,44	0,69	0,72
South Africa	45,3	86,7	91,2	103,6	107,1	111,0	0,88	0,57	2,68
Argentina	33,7	41,4	45,0	57,0	60,0	62,4	0,27	0,21	1,73
Brazil	69,5	121,7	132,1	161,2	169,7	175,0	0,30	0,19	1,05
Guatemala	2,8	3,8	4,4	5,4	5,6	6,3	0,59	0,18	0,58
Venezuela	18,9	38,8	42,0	54,4	51,4	56,5	0,94	0,33	2,43
Bangladesh	7,7	12,8	16,0	19,1	19,9	20,0	0,46	0,10	0,16
India	183,8	294,4	360,5	453,1	465,3	475,8	0,95	0,32	0,49
Indonesia	36,3	73,3	98,9	124,3	123,3	123,1	0,75	0,19	0,60
China[2]	390,2	705,6	856,3	1 097,0	1 096,5	1 031,4	1,28	0,25	0,83
Thailand	14,1	26,6	43,6	71,2	73,5	69,0	0,57	0,19	1,13

[1]PPP (purchasing power parity): GDP adjusted for local purchasing power. [2]Hong Kong not included.
Source: OECD/IEA (2000a, b).

Table A.11 Norway´s net exports of energy commodities. Selected countries and regions. 2000*. Million NOK

	Coal, coke and briquettes	Mineral oil and products	Gas, natural and manufactured	Electricity
Nordic countries	2	28 205	199	1 874
EFTA	2	508	46	-
EU	-425	216 274	33 345	1 874
Developing countries	-190	2 969	285	-
Denmark	21	6 266	41	433
Finland	14	5 540	36	-8
Sweden	-36	15 530	122	1 450
Belgium	-70	7 521	4 210	-
France	-3	28 928	11 952	-
Ireland	0	6 071	6	-
Italy	0	3 633	145	-
Netherlands	-150	45 637	2 927	-
Spain	-9	411	2 183	-
UK	-244	84 828	13	-
Germany	51	10 881	11 703	-
Canada	-	28 390	-	-
USA	-29	25 656	10	-

Source: Statistics Norway.

Agriculture

Appendix B

Table B.1 Agricultural area in use. km²

Year	Agricultural area in use, total	Cereals and oil seeds	Other agricultural areas	Cultivated meadow	Other pastures
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	10 382	3 345	651	4 875	1 511

Source: Agricultural statistics from Statistics Norway.

Table B.2 Sales of commercial fertilizer expressed as content of nitrogen and phosphorus

Year	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	106 017	13 092	10,2	1,3
1999/2000	107 410	13 325	..	..

Source: Agricultural statistics from Statistics Norway and Norwegian Agricultural Inspection Service.

Table B.3 Sales of pesticides. Environmental taxes on pesticides

Year	Sales of pesticides/Tonnes active substances					Taxes as per cent of purchase price		Taxes		
	Total	Fungicides	Insecticides	Herbicides	Other substances including additives	Environ-mental tax	Control fee	Total	Environ-mental tax	Control fee
	Tonnes					Per cent		Million NOK		
1985	1 529,3	138,4	38,7	1 236,2	116,1	-	-	-	-	-
1988	1 193,6	107,8	37,9	919,2	128,7	2,0	5,5	..	1,5	..
1989	1 033,8	119,5	27,3	856,9	30,1	8,0	6,0	30,3	17,3	..
1990	1 183,5	153,0	19,0	965,1	46,4	11,0	6,0	28,5	20,2	8,3
1991	760,0	133,1	18,5	563,7	44,7	13,0	6,0	26,7	18,8	7,9
1992	781,1	148,6	26,9	561,3	44,3	13,0	6,0	31,6	22,5	9,1
1993	764,6	179,7	16,9	510,1	57,9	13,0	6,0	32,0	21,9	10,1
1994	861,5	156,7	20,5	626,0	58,3	13,0	6,0	30,7	21,0	9,7
1995	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	41,3	26,1	15,2
1999	796,3	219,0	24,7	448,7	103,9	..	..	52,6	35,4	17,2
2000[1]	380,2	53,1	10,7	283,4	33,0	..	..	68,7	52,9	15,8

[1]From 1999 it is no longer a fixed rate (percentage of purchase price) but differentiated rates according to the health and environmental risk of the substances.
Source: Norwegian Agricultural Inspection Service and Norwegian Agricultural Economics Research Institute.

Table B.4 Number of holdings and areas managed ecologically. Number of livestock on holdings managed ecologically and grants paid

Year	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	4,0	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]	53,5	37,1	1 707	149 510	37 824	2 998	18 393
2000	58,6	35,1	1 823	180 841	24 387	3 531	20 776

[1]Includes all holdings approved for grants and/or to sell products labelled as ecologorganically produced. [2]The rise was so large because funds were transferred from 1998.
Source: Debio and Ministry of Agriculture.

Forest and uncultivated land

Appendix C

Table C.1 Forest balance 1999. 1000 m³ without bark

	Total	Spruce	Pine	Broad-leaved treees
Growing stock as of 01.01.	674 033	299 972	225 856	148 206
Total losses.	11 441	7 575	2 142	1 725
Of which total roundwood cut	9 249	6 485	1 672	1 093
Sales, excl. fuelwood	7 706	6 045	1 561	100
Fuelwood, sales and private	1 340	281	70	989
Own use	202	158	40	4
Other losses	2 192	1 090	470	632
Logging waste	599	389	100	109
Natural losses	1 594	701	370	523
Total increments	23 076	11 684	6 163	5 229
Volume as of 31.12	685 668	304 081	229 877	151 710

Source: Statistics Norway and Norwegian Institute for Land Inventory.

Table C.2 Growing stock under bark and annual increment. 1 000 m³

	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
1995/99[1]	653 356	293 687	217 437	142 232	22 125	11 407	5 839	4 879
Region, 1995/99								
Østfold, Akershus/Oslo, Hedmark	184 268	94 955	69 076	20 237	6 808	3 798	2 152	858
Oppland, Buskerud, Vestfold	144 852	84 023	39 136	21 693	4 694	2 893	955	846
Telemark, Aust-Agder, Vest-Agder	114 260	37 238	51 326	25 696	3 540	1 402	1 289	849
Rogaland, Hordaland, Sogn og Fjordane, Møre og Romsdal	81 837	18 319	34 172	29 346	3 135	1 297	896	942
Sør-Trøndelag, Nord-Trøndelag	81 832	48 389	18 372	15 071	2 450	1 515	405	530
Nordland, Troms	46 307	10 763	5 355	30 189	1 498	502	142	854
Finnmark[2]	2 969	1	2 231	736	78	0	62	13

[1]Volume and average annual increment for all types of land use classes for 1995-1999 in counties inventoried. [2]Figures from 94/98.
Source: Norwegian Institute for Land Inventory. (Figures from inventories supplemented by calculations by Statistics Norway for Finnmark, where no inventory has been carried out.)

Table C.3 Registered non-harvest mortality of cervids

Hunting year	Total				Killed by motor car or train				Felled as pests, felled illegally or killed by other causes			
	Moose	Red deer	Wild reindeer	Roe deer	Moose	Red deer	Wild reindeer	Roe deer	Moose	Red deer	Wild reindeer	Roe deer
1987/1988	2 167	365	279	2 044	1 200	157	6	1 396	967	208	273	648
1988/1989	2 036	444	122	2 140	1 016	200	4	1 632	1 020	244	118	508
1989/1990	2 152	411	137	1 955	962	171	4	1 537	1 190	240	133	418
1990/1991	2 466	485	124	2 684	1 210	201	4	2 065	1 256	284	120	619
1991/1992	2 554	544	132	3 034	1 324	284	5	2 427	1 230	260	127	607
1992/1993	3 748	715	233	4 195	2 048	376	5	3 327	1 700	339	228	868
1993/1994	4 155	1 061	125	6 621	2 481	461	5	4 007	1 674	600	120	2 614
1994/1995	3 405	915	72	4 601	1 757	374	0	3 057	1 648	541	72	1 544
1995/1996	2 915	874	88	4 233	1 650	383	1	3 045	1 265	491	87	1 188
1996/1997	3 378	985	89	4 587	2 010	515	4	3 513	1 368	470	85	1 074
1997/1998	2 962	995	133	3 895	1 582	443	6	3 091	1 380	552	127	804
1998/1999	3 215	958	123	4 097	1 886	488	7	3 259	1 329	470	116	838
1999/2000	3 186	1 183	104	3 893	1 921	543	5	3 118	1 265	640	99	775

Source: Statistics Norway.

Table C.4 Registered mortality of large carnivores and eagles

Hunting year	Total				
	Bear	Wolf	Wolverine	Lynx	Eagle
1993/1994	3	-	13	48	56
1994/1995	1	-	17	64	51
1995/1996	1	-	16	103	47
1996/1997	3	-	17	113	58
1997/1998	3	-	19	127	51
1998/1999	5	1	22	105	59
1999/2000	5	2	31	101	54
Cause of death 1999/2000					
Killed by vechicle or train	1	2	1	5	..
Felled by permit[1]	3	-	7	-	..
Licenced hunting of wolverine	.	.	22	.	.
Quota hunting of lynx	.	.	.	95	.
Other causes[2]	1	-	1	1	..

[1]Applies to aminals dagerous to livestock. [2]Including animals felled in self-defence or illegally, unknown reasons, etc.
Source: Statistics Norway.

Fisheries, sealing, whaling and fish farming

Appendix D

Table D.1 Stock trends for some important fish stocks. 1 000 tonnes

Year	North-East Arctic cod[1]	North-East Arctic haddock[1]	North-East Arctic saithe[2]	Greenland halibut[4]	Barents Sea capelin[3,5]	Norwegian spring-spawning herring[3]	North Sea herring[4]	North Sea cod[3]
1977.	2 120	240	480	80	6 250	280	50	820
1978.	1 800	260	470	70	6 120	350	70	810
1979.	1 480	320	480	80	6 580	390	110	800
1980.	1 200	250	550	70	8 220	470	140	1 020
1981.	1 190	190	530	70	4 490	500	200	860
1982.	990	110	480	70	4 210	500	290	840
1983.	660	60	480	80	4 770	570	450	650
1984.	780	50	400	70	3 300	600	700	720
1985.	970	140	370	70	1 090	500	720	500
1986.	1 310	290	350	70	160	400	720	680
1987.	1 150	230	370	60	110	890	850	570
1988.	910	160	360	60	360	2 720	1 110	430
1989.	880	130	330	60	770	3 370	1 250	420
1990.	970	130	400	50	4 900	3 780	1 150	330
1991.	1 490	160	510	40	6 650	3 970	970	300
1992.	1 960	240	660	30	5 370	3 880	710	400
1993.	2 380	490	710	30	990	3 750	460	340
1994.	2 170	530	680	30	260	4 310	500	420
1995.	1 830	510	690	40	190	4 530	470	420
1996.	1 720	440	660	50	470	4 980	450	380
1997.	1 540	330	560	50	870	8 970	570	500
1998.	1 270	230	610	50	1 860	8 310	700	320
1999.	1 120	210	650	50	2 580	7 790	910	290
2000.	1 150	170	600	..	3 910	6 850	910	300

.	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	470	60	..	..
1979.	670	590	950	470	50	..	..
1980.	1 250	550	840	490	40	..	..
1981.	670	650	640	490	50	3 660	..
1982.	840	690	490	560	60	2 750	..
1983.	760	820	510	550	70	1 850	..
1984.	1 490	850	480	560	70	1 590	2 640
1985.	860	720	440	550	60	1 850	2 620
1986.	720	700	660	660	50	2 150	2 640
1987.	1 070	510	540	640	60	1 830	2 620
1988.	430	490	420	630	70	1 550	2 700
1989.	400	470	560	590	100	1 490	2 730
1990.	340	430	480	560	110	1 450	2 590
1991.	740	470	460	470	100	1 920	2 920
1992.	600	510	410	450	110	2 520	2 970
1993.	850	560	380	400	100	2 410	2 800
1994.	500	570	360	330	90	2 330	2 660
1995.	940	690	360	310	70	2 070	2 920
1996.	620	570	290	290	50	1 940	3 010
1997.	670	540	240	320	50	2 170	3 260
1998.	540	500	230	350	70	2 820	3 400
1999.	390	400	310	350	70	3 010	3 830
2000.	1 620	530	350	380	70	2 760	3 930

[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 August. [6] Including saithe west of Scotland.

Source: ICES working group reports and Institute of Marine Research.

Table D.2 Norwegian catches by species and groups of species. 1 000 tonnes

	1989	1990	1991	1992	1993	1994	1995	1996	1997*	1998*	1999*	2000*
Total	1 971	1 789	2 198	2 619	2 584	2 526	2 702	2 820	3 055	3 031	2 805	2 889
Cod	186	125	164	219	275	374	365	358	401	322	257	220
Haddock	39	23	25	40	44	74	80	97	106	79	53	46
Saithe	145	112	140	168	188	189	219	222	184	194	198	169
Tusk	32	28	27	26	27	20	19	19	14	21	23	22
Ling/Blue ling	29	24	23	22	20	19	19	19	16	23	20	18
Greenland halibut	11	24	33	11	15	13	14	17	12	12	20	13
Redfish	27	41	56	38	33	29	22	30	23	29	31	26
Others and unspecified	29	30	44	43	57	31	27	32	40	35	26	29
Capelin	108	92	576	811	530	113	28	208	158	88	91	375
Mackerel	143	150	179	207	224	260	202	137	137	158	161	171
Herring	275	208	201	227	352	539	687	763	923	832	829	799
Sprat	5	6	34	33	47	44	41	59	7	35	22	6
Other industrial fisheries[1]	696	655	447	527	541	587	745	642	798	963	828	732
Crustaceans and molluscs	64	73	58	57	61	48	49	44	45	60	68	69
Seaweed	183	197	191	189	170	185	185	173	192	180	179	192

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

Table D.3 Consumption of antibacterial agents in fish farming. kg active ingredients

Year	Total	Oxytetra-cyclin-chloride	Nifura-zolidone	Oxolinic acid	Trimetoprim + sulphadiazine (Tribrissen)	Sulpha-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
2000	685	15	-	470	-	-	52	148

Source: Norwegian Medicinal Depot.

Table D.4 Exports of some main groups of fish products. 1 000 tonnes

Year	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	490,5	791,0	247,6	65,6	65,7	17,7	153,6	48,5
2000*	461,4	905,9	248,6	54,9	75,1	15,8	88,1	50,9

Source: External Trade Statistics from Statistics Norway.

Table D.5 Exports of fish and fish products by important recipient country. Million NOK

Year	Total	EU-countries, total	Of this				Other countries, total	Of this	
			France	Denmark	United Kingdom	Germany		Japan	USA
1982	5 931	2 494	420	211	881	338	3 438	230	421
1983	7 368	3 186	569	337	1 022	515	4 181	335	748
1984	7 675	3 233	530	350	1 027	546	4 442	408	920
1985	8 172	3 605	605	377	1 202	633	4 568	464	1 129
1986	8 749	4 294	781	627	1 014	706	4 456	409	1 195
1987	9 992	5 597	1 114	927	1 059	754	4 395	501	1 398
1988	10 693	6 107	1 319	1 115	987	932	4 586	808	1 060
1989	10 999	6 416	1 306	1 196	1 020	893	4 583	756	996
1990	13 002	8 119	1 617	2 046	869	1 047	4 883	1 068	755
1991	14 940	9 115	1 535	2 022	991	1 196	5 826	1 798	436
1992	15 385	10 180	1 851	1 794	1 389	1 309	5 205	1 366	400
1993	16 619	10 365	1 836	1 690	1 542	1 369	6 254	1 810	566
1994	19 537	11 709	2 250	1 768	1 485	1 698	7 828	1 999	723
1995	20 095	13 176	2 138	2 192	1 591	1 605	6 919	1 988	800
1996	22 445	13 839	2 168	2 431	1 765	1 530	8 605	2 504	763
1997	24 632	14 532	2 274	2 641	2 022	1 532	10 101	2 752	963
1998	28 165	17 846	2 540	3 113	2 819	1 948	10 319	2 798	1 000
1999	29 740	18 105	2 669	3 021	2 710	1 722	11 635	4 408	1 351
2000*	31 511	18 328	2 704	3 663	2 692	1 656	13 183	4 224	1 391

Source: External Trade Statistics from Statistics Norway.

Table D.6 Export of salmon

Year	Total		Farmed salmon. Fresh, chilled and frozen		Fresh and frozen fillets, smoked, gravlax, other salmon, etc.[1]	
	Amount	Value	Amount	Value	Amount	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	336,8	10 726,3	295,6	8 385,2	41,2	2 341,1
2000*	343,5	12 285,6	304,3	9 808,5	39,1	2 477,1

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

Table D.7 Catch quantities[1] and export value[2] of fish and fish products. Selected countries

Country[3]	1994		1995		1996		1997		1998	
	Catch quantity	Export-value	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	1000 tonnes	Million USD
World, total	**91 437**	**47 205**	**91 577**	**51 802**	**93 474**	**52 828**	**93 619**	**53 285**	**86 299**	**51 272**
China	10 867	2 320	12 563	2 835	14 182	2 857	15 722	2 937	17 230	2 656
Japan	6 617	743	5 967	713	5 936	709	5 916	889	5 259	718
USA	5 535	3 230	5 225	3 384	5 001	3 148	4 983	2 850	4 709	2 400
Russia	3 705	1 720	4 312	1 635	4 677	1 686	4 662	1 356	4 455	1 168
Peru	11 999	978	8 937	870	9 515	1 120	7 870	1 342	4 338	639
Indonesia	3 316	1 583	3 504	1 667	3 558	1 678	3 791	1 621	3 699	1 628
Chile	7 721	1 304	7 434	1 704	6 691	1 697	5 812	1 782	3 265	1 597
India	3 210	1 125	3 220	1 041	3 474	1 116	3 517	1 128	3 215	1 135
Thailand	3 012	4 190	3 013	4 449	3 005	4 118	2 878	4 330	2 900	4 031
Norway	2 366	2 735	2 524	3 123	2 639	3 416	2 856	3 399	2 850	3 661
South Korea	2 358	1 411	2 320	1 565	2 414	1 509	2 204	1 376	2 027	1 246
Philippines	1 845	533	1 860	502	1 784	437	1 806	435	1 828	445
Iceland	1 557	1 265	1 613	1 343	2 060	1 426	2 206	1 360	1 682	1 434
Denmark	1 873	2 359	1 999	2 460	1 682	2 699	1 827	2 649	1 557	2 898
Mexico	1 192	481	1 329	708	1 464	739	1 489	825	1 181	716

[1]Catch quantities include marine and inland waters fisheries, but not aquaculture production. Whales, seals and other marine mammals and marine plants are not included. [2]Aquaculture production is included in the export figures. [3]The countries are ranked according to catch quantities in 1998.
Source: FAO (1999 and 2000a and b).

Table D.8 Total catches[1] in world fisheries. 1998

	1000 tonnes	Per cent
Total catches	**86 299**	**100,0**
By area:		
Inland waters	8 003	9,3
Marine areas	78 296	90,7
By animal group:		
Fish	72 675	84,2
Crustaceans	6 364	7,4
Molluscs	6 615	7,7
Others	646	0,7
Catches in marine areas by various distributions		
Marine catches, total	**78 296**	**100,0**
By marine fishing areas:		
North Atlantic	12 896	16,5
Central Atlantic	5 352	6,8
Mediterranean and Black Sea	1 406	1,8
South Atlantic	3 698	4,7
Indian Ocean	7 857	10,0
North Pacific	27 551	35,2
Central Pacific	10 641	13,6
South Pacific	8 895	11,4
By continents:		
Africa	3 763	4,8
North America	7 241	9,2
South America	10 441	13,3
Asia	39 103	49,9
Europe	16 475	21,0
Oceania	1 090	1,4
Other, not elsewhere specified	183	0,2
By species:		
Alaska pollock - *Theragra chalcogramma*	4 049	5,2
Atlantic herring - Clupea harengus	2 419	3,1
Japanese anchovy - *Engraulis japonicus*	2 094	2,7
Chilean jack mackerel - *Trachurus murphyi*	2 026	2,6
Chub mackerel - *Scomber japonicus*	1 910	2,4
Skipjack tuna - *Katsuwonus pelamis*	1 850	2,4
Anchoveta - *Engraulis ringens*	1 729	2,2
Largehead hairtail - *Trichiurus lepturus*	1 410	1,8
Atlantic cod - *Gadus morhua*	1 214	1,6
Blue whiting - *Micromesistius poutassou*	1 191	1,5
Yellowfin tuna - *Thunnus albacares*	1 153	1,5
Capelin - *Mallotus villosus*	988	1,3
European pilchard - *Sardina pilchardus*	941	1,2
South American pilchard - *Sardinops sagax*	937	1,2
European sprat - *Sprattus sprattus*	696	0,9
Round sardinella - *Sardinella aurita*	664	0,8
Atlantic mackerel - *Scomber scombrus*	657	0,8
Argentine shortfin squid - *Illex argentinus*	650	0,8
Akiami paste shrimp - *Acetes japonicus*	587	0,7
Japanese Spanish mackerel - *Scomberomorus niphonius*	552	0,7
Argentine hake - *Merluccius hubbsi*	516	0,7
Pacific herring - *Clupea pallasii*	498	0,6
Gulf menhaden - *Brevoortia patronus*	497	0,6
European anchovy - *Engraulis encrasicolus*	492	0,6
Patagonian grenadier - *Macruronus magellanicus*	473	0,6
Pacific cod - *Gadus macrocephalus*	411	0,5

[1]Not including farmed fish. Not including whales, seals and other sea mammals and aquatic plants.
Source: FAO (2000a).

Transport

Appendix E

Table E.1 Domestic passenger transport. Million passenger-kilometres

Year	Total	Road transport	Private car	Private car as share of total. Per cent	Bus, etc.	Taxi, etc.	Motorcycle, moped	Air transport	Rail transport	Water transport
1946	4 591	2 051	1 053	22,9	687	218	93	3	2 081	456
1952	6 524	3 893	1 584	24,3	1 847	291	171	9	2 115	507
1960	11 646	8 739	4 758	40,9	2 776	376	829	93	2 254	560
1961	12 721	9 846	5 676	44,6	2 929	386	855	103	2 199	573
1962	13 893	10 998	6 675	48,0	3 093	396	834	144	2 186	565
1963	14 642	11 824	7 724	52,8	2 866	403	831	185	2 093	540
1964	16 017	13 207	8 875	55,4	3 108	402	822	232	2 035	543
1965	17 384	14 512	10 053	57,8	3 263	398	798	280	2 020	572
1966	18 836	15 893	11 304	60,0	3 426	395	768	295	2 071	577
1967	20 185	17 088	12 495	61,9	3 452	399	742	423	2 088	586
1968	22 244	19 140	14 414	64,8	3 600	407	719	484	2 029	591
1969	23 939	20 833	16 001	66,8	3 707	423	702	558	1 932	616
1970	25 824	22 631	17 781	68,9	3 726	429	695	632	1 930	631
1971	28 734	25 344	20 452	71,2	3 770	441	681	758	1 970	662
1972	30 514	26 946	21 969	72,0	3 867	447	663	858	2 021	689
1973	32 826	29 218	24 207	73,7	3 907	463	641	916	1 991	701
1974	33 792	29 980	24 842	73,5	4 058	452	628	915	2 221	676
1975	35 305	31 353	26 311	74,5	3 963	475	604	1 021	2 271	660
1976	37 310	33 135	28 200	75,6	3 916	481	538	1 139	2 338	698
1977	39 172	34 824	29 760	76,0	3 987	538	539	1 286	2 377	685
1978	39 837	35 326	30 287	76,0	3 930	562	547	1 395	2 449	667
1979	41 229	36 458	31 169	75,6	4 124	613	552	1 482	2 636	653
1980	40 705	35 819	30 436	74,8	4 257	625	501	1 475	2 751	660
1981	40 518	35 582	30 146	74,4	4 297	621	518	1 535	2 767	634
1982	40 443	35 641	30 504	75,4	3 952	635	550	1 626	2 575	601
1983	41 100	36 160	31 112	75,7	3 811	665	572	1 797	2 530	613
1984	42 137	37 066	32 050	76,1	3 712	712	592	1 929	2 525	617
1985	47 657	42 300	36 884	77,4	3 948	838	630	2 147	2 567	643
1986	50 534	45 013	39 488	78,1	3 878	949	698	2 301	2 582	638
1987	52 404	46 704	41 243	78,7	3 743	1 002	716	2 505	2 563	632
1988	52 381	46 734	41 230	78,7	3 901	912	691	2 548	2 463	636
1989	52 707	47 136	41 684	79,1	3 956	792	704	2 469	2 459	643
1990	53 881	48 092	42 696	79,3	3 890	801	705	2 665	2 430	694
1991	53 556	47 648	42 252	78,9	3 935	760	701	2 699	2 573	636
1992	53 867	47 821	42 390	78,7	3 945	782	704	2 946	2 511	589
1993	54 987	48 578	43 128	78,4	3 927	815	708	3 204	2 588	617
1994	56 140	49 433	43 840	78,1	3 956	928	709	3 397	2 703	607
1995	56 132	49 206	43 659	77,8	3 752	1 071	724	3 567	2 681	678
1996	58 763	51 314	45 217	76,9	4 117	1 212	768	3 938	2 776	740
1997	59 367	51 602	44 934	75,7	4 248	1 580	840	4 029	2 941	795
1998	61 061	52 924	45 780	75,0	4 248	1 972	924	4 242	3 064	831
1999	61 683	53 141	45 785	74,2	4 248	2 109	1 000	4 367	3 315	860

Source: Transport and Communication Statistics, Statistics Norway and The Institute of Transport Economics.

Table E.2 Domestic goods transport. Million tonne-kilometres

Year	Total[1]	Water transport	Rail transport	Road transport	Air transport	Timber floating	Oil- and gas transport from the 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	25 885	11 296	1 934	12 636	19	-	20 200
1999	26 170	11 538	1 817	12 796	19	-	21 108

[1]Not including oil and gas transport from the continental shelf.
Source: Transport and Communication Statistics, Statistics Norway and Institute of Transport Economics.

Table E.3 Road traffic: consumption of fuel and emissions from combustion and evaporation

Year	Consumption of fuel	CO_2	CH_4	N_2O	SO_2	NO_X	NH_3	NMVOC	CO	Lead	PM10[1]	PM2,5[1]	PAH[2]	Ben-zene
	Mill. tonnes	1 000 tonnes								Tonnes	1 000 tonnes		kg	1000 tonnes
1973	1,5	4,6	1,9	0,1	4,5	46,8	0,0	51,6	489	496	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	415	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	192	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	196	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	191	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	168	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	127	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	112	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	73	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	12	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	12	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	0,4	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	0,2	3,7	3,5	737	1,9
1998	2,9	9,1	2,4	1,2	1,3	57,0	1,4	49,3	338	0,2	3,5	3,3	717	1,8
1999*	3,0	9,3	2,3	1,4	1,2	54,5	1,5	45,4	308	0,2	3,2	3,1	699	1,6

[1]Does not include wear of asphalt. [2]Includes four selected PAH components: benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene and indeno(1,2,3-cd)pyrene.
Source: Bang et al. (1999) and emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table E.4 Road traffic: exhaust emissions and evaporation. Average of all vehicle categories, technologies and modes. 1999

	Fuel consumption	CO_2	CH_4	N_2O	SO_2	NO_x	NH_3	NMVOC	CO	Lead	PM10[1]	PM2,5[1]	PAHs[2]	Ben-zene
	g/km	g/km								mg/km	g/km		mg/km	g/km
Petrol														
Private cars	0,06	0,19	0,08	0,05	0,01	0,87	0,06	1,41	10,56	0,00	0,01	0,01	0,01	0,06
Vans	0,1	0,31	0,08	0,04	0,02	1,30	0,05	1,79	14,97	0,00	0,02	0,02	0,01	0,08
Lorries	0,16	0,49	0,35	0,01	0,03	8,43	0,00	7,37	41,47	0,00	0,02	0,02	0,03	0,18
Buses	0,16	0,5	0,44	0,01	0,04	8,78	0,00	8,64	42,07	0,00	0,02	0,02	0,03	0,15
Mopeds	0,02	0,06	0,11	0,00	0,00	0,05	0,00	6,93	13,19	0,00	0,00	0,00	..	..
Motorcycles	0,04	0,12	0,19	0,00	0,01	0,28	0,00	4,81	27,97	0,00	0,01	0,01	..	..
Diesel														
Private cars	0,05	0,15	0,00	0,01	0,03	0,38	0,00	0,11	0,5	0,00	0,13	0,13	0,02	0,00
Vans	0,08	0,24	0,01	0,01	0,05	0,56	0,00	0,21	0,94	0,01	0,18	0,17	0,02	0,01
Light goods	0,13	0,4	0,02	0,01	0,08	3,86	0,00	0,46	1,76	0,01	0,21	0,2	0,05	0,01
Medium goods	0,17	0,54	0,02	0,01	0,1	5,20	0,00	0,6	2,03	0,02	0,33	0,31	0,08	0,01
Heavy goods	0,26	0,83	0,04	0,01	0,16	7,75	0,00	0,91	2,95	0,03	0,47	0,44	0,11	0,02
Buses	0,25	0,78	0,03	0,00	0,15	9,32	0,00	0,65	2,21	0,03	0,52	0,49	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.
Source: Bang et al. (1999) and emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Air pollution and climate

Appendix F

Table F.1 Emissions of greenhouse gases to air

	CO_2	CH_4	N_2O	HFC 23	HFC 32	HFC 125	HFC 134	HFC 143	HFC 152	HFC 227	C_3F_8	CF_4	C_2F_6	SF_6	CO_2 equi-valents
	Mill. tonnes	1000 tonnes	Tonnes												Mill. tonnes
GWP[1] . .	1,0	21,0	310,0	11 700,0	650,0	2 800,0	1 300,0	3 800,0	140,0	2 900,0	7 000,0	6 500,0	9 200,0	23 900,0	
1950 . .	..	131,0	7,0	-	-	-	-	-	-	-	-	..	..	..	..
1960 . .	..	175,0	10,0	-	-	-	-	-	-	-	-	..	..	..	..
1970 . .	..	216,0	12,0	-	-	-	-	-	-	-	-	..	..	..	..
1973 . .	30,4	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1974 . .	27,6	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1975 . .	30,5	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1976 . .	33,2	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1977 . .	33,2	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1978 . .	32,5	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1979 . .	34,5	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1980 . .	32,3	257,2	13,2	-	-	-	-	-	-	-	-	..	..	..	..
1981 . .	31,7	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1982 . .	30,8	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1983 . .	31,8	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1984 . .	33,7	..	..	-	-	-	-	-	-	-	-	..	..	..	..
1985 . .	32,1	..	..	-	-	-	-	-	-	-	-	488,8	20,3	199,0	..
1986 . .	34,6	..	..	-	-	-	-	-	-	-	-	479,2	20,3	239,9	..
1987 . .	33,3	291,1	14,5	-	-	-	-	-	-	-	-	463,7	19,1	240,1	52,9
1988 . .	35,4	292,6	14,9	-	-	-	-	-	-	-	-	443,4	18,0	223,5	54,5
1989 . .	34,3	304,8	16,1	-	-	-	-	-	-	-	-	430,2	18,0	107,2	51,2
1990 . .	35,1	311,8	16,7	-	-	-	-	-	0,1	-	-	441,0	18,0	91,6	52,0
1991 . .	33,5	315,6	16,2	-	-	-	0,0	-	0,4	-	-	368,9	13,7	86,5	49,7
1992 . .	34,3	321,8	14,0	-	-	-	0,2	-	0,7	-	-	294,1	11,4	29,0	48,1
1993 . .	35,8	327,6	15,2	-	-	-	1,8	-	0,8	-	-	290,1	10,3	30,1	50,1
1994 . .	37,7	334,6	15,5	0,0	0,0	0,5	5,4	0,2	0,8	-	-	250,6	8,9	35,7	52,1
1995 . .	37,8	337,1	15,7	0,0	0,0	2,4	10,2	1,5	1,0	-	0,0	229,1	7,9	24,1	51,9
1996 . .	40,9	340,5	15,7	0,0	0,0	5,5	17,2	3,9	1,5	0,0	0,0	214,2	5,1	24,4	55,0
1997 . .	41,2	343,0	15,6	0,0	0,2	9,7	26,2	6,8	2,4	0,1	0,1	200,8	7,7	22,7	55,2
1998 . .	41,4	337,9	16,5	0,1	0,3	14,7	38,2	10,4	4,8	0,1	0,1	184,8	7,1	28,9	55,7
1999* .	41,6	337,2	17,2	0,1	0,6	19,9	50,2	14,7	6,0	0,2	0,1	163,7	6,2	34,9	56,2
2000* .	41,0	341,1	16,9	0,2	0,8	24,7	61,4	17,6	6,4	0,3	0,1	130,2	5,0	37,0	55,4

[1]Impact on greenhouse effect of emission of 1 tonne of the gas compared with that of 1 tonne CO_2.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F.2 Emissions to air. 1 000 tonnes

	SO_2	NO_X	NH_3	Acid equivalents[1]	NMVOC	CO	Particulates[2]
1973	156	182	..	..	188	672	24
1974	150	178	..	..	179	632	23
1975	138	183	..	..	200	685	22
1976	147	180	..	..	202	729	21
1977	146	194	..	..	207	774	23
1978	143	186	..	..	167	798	21
1979	145	196	..	..	182	832	22
1980	137	190	23	9,7	176	822	19
1981	128	178	..	..	182	815	22
1982	111	182	..	..	189	824	20
1983	104	187	..	..	201	816	20
1984	96	201	..	..	212	842	21
1985	98	213	..	..	231	844	22
1986	91	228	..	..	249	872	23
1987	73	229	23	8,6	256	832	22
1988	68	224	21	8,2	249	869	22
1989	58	223	23	8,0	276	823	22
1990	53	219	23	7,8	302	821	23
1991	44	210	24	7,4	295	760	22
1992	37	208	25	7,1	323	751	22
1993	35	217	25	7,3	340	746	24
1994	35	214	25	7,2	354	738	25
1995	34	214	26	7,2	369	701	24
1996	33	223	27	7,4	373	670	25
1997	30	224	26	7,4	368	635	25
1998	30	225	27	7,4	350	601	24
1999*	29	231	27	7,5	351	565	23
2000*	..	217	27	..	369	532	22

[1] Total acidifying effect of SO_2, NO_X and NH_3. [2]Process emissions calculated for road dust only

Table F.3 Emissions of greenhouse gases to air y sector. 1998

	CO_2	CH_4	N_2O	HFC[1]	PFC[2]	SF_6	CO_2 equivalents
	Mill. tonnes	1000 tonnes			Tonnes		Mill. tonnes
Total	**41,4**	**337,9**	**16,5**	**68,7**	**192,0**	**28,9**	**55,7**
Energy sectors	**12,5**	**28,3**	**0,1**	**0,8**	**0,0**	**2,3**	**13,1**
Extraction of oil and gas[3]	10,1	27,9	0,1	0,7	0,0	-	10,7
Extraction of coal	0,0	0,2	0,0	0,0	-	-	0,0
Oil refining	2,0	0,1	0,0	0,0	-	-	2,0
Electricity supplies[4]	0,3	0,1	0,0	0,0	-	2,3	0,4
Manufacturing and mining	**12,3**	**30,6**	**5,7**	**12,8**	**191,9**	**24,4**	**16,6**
Oil drilling	0,4	0,2	0,0	0,0	-	-	0,4
Manufacture of pulp and paper	0,6	12,5	0,1	0,0	-	-	0,9
Manufacture of basic chemicals	2,9	1,1	5,5	0,0	-	-	4,6
Manufacture of minerals[5]	2,0	0,0	0,0	0,0	-	-	2,0
Manufacture of iron, steel and ferro-alloys	2,9	0,0	0,0	0,3	-	-	2,9
Manufacture of other metals	2,3	0,0	0,0	0,3	191,9	24,4	4,1
Manufacture of metal goods, boats, ships and oil platforms	0,4	0,0	0,0	7,0	-	0,0	0,4
Manufacture of wood, plastic, rubber, and chemical goods, printing	0,2	16,8	0,0	0,3	-	-	0,6
Manufacture of consumer goods	0,7	0,0	0,0	4,7	0,0	-	0,7
Other	**11,4**	**269,4**	**9,7**	**47,4**	**0,0**	**1,9**	**20,3**
Construction	0,7	0,1	0,1	0,9	-	-	0,7
Agriculture and forestry	0,6	110,0	8,6	0,7	-	-	5,6
Fishing, whaling and sealing	1,6	0,1	0,0	2,8	0,0	-	1,6
Land transport, domestic	3,2	0,2	0,1	4,0	0,0	-	3,2
Sea transport, domestic	1,6	0,1	0,0	1,5	0,0	-	1,6
Air transport[6]	1,0	0,0	0,0	0,2	-	-	1,0
Other private services	2,1	0,5	0,2	34,5	0,0	1,9	2,3
Public sector, municipal	0,3	158,2	0,5	1,7	0,0	-	3,7
Public sector, state	0,4	0,0	0,0	1,0	0,0	-	0,4
Private households	**5,2**	**9,6**	**0,9**	**7,7**	**-**	**0,2**	**5,7**

[1] The distribution by sectors is uncertain. [2] Includes C_3F_8, CF_4 and C_2F_6. [3] Includes gas terminal, transport and supply ships. [4] Includes emissions from waste incineration plants. [5] Including mining. [6] Domestic air transport only, including emissions above 1000 m.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F.4 Emissions to air by sector. 1998. 1 000 tonnes

	SO_2	NO_X	NH_3	Acid equivalents[1]	NMVOC	CO	Particulates[2]
Total	**29,8**	**225,0**	**27,1**	**7,4**	**350,3**	**600,6**	**23,9**
Energy sectors	**3,3**	**50,9**	**0,0**	**1,2**	**214,0**	**8,0**	**0,6**
Extraction of oil and gas[3]	0,6	47,0	-	1,0	201,3	6,9	0,3
Extraction of coal	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Oil refining	2,1	2,6	0,0	0,1	12,2	0,0	0,1
Electricity supplies[4]	0,7	1,3	0,0	0,0	0,5	1,1	0,2
Manufacturing and mining	**20,8**	**30,8**	**0,3**	**1,3**	**24,9**	**52,5**	**0,9**
Oil drilling	0,2	7,1	-	0,2	0,6	0,7	0,0
Manufacture of pulp and paper	2,2	2,4	0,0	0,1	0,3	3,3	0,2
Manufacture of basic chemicals	6,2	4,9	0,3	0,3	2,3	39,6	0,1
Manufacture of minerals[5]	1,9	5,6	0,0	0,2	2,1	0,7	0,2
Manufacture of iron, steel and ferro-alloys	6,3	6,7	0,0	0,3	1,7	0,1	0,0
Manufacture of other metals	2,5	1,2	0,0	0,1	0,0	0,4	0,0
Manufacture of metal goods, boats, ships and oil platforms	0,2	0,7	0,0	0,0	2,5	1,2	0,1
Manufacture of wood, plastic, rubber, and chemical goods, printing	0,3	0,7	0,0	0,0	13,9	5,5	0,1
Manufacture of consumer goods	1,1	1,4	0,0	0,1	1,5	1,0	0,1
Other	**4,4**	**120,3**	**25,8**	**4,3**	**47,0**	**109,5**	**5,7**
Construction	0,2	6,5	0,0	0,1	11,3	5,6	0,7
Agriculture and forestry	0,2	5,5	25,4	1,6	3,4	4,3	0,7
Fishing, whaling and sealing	1,0	35,3	0,0	0,8	0,9	7,1	0,3
Land transport, domestic	0,8	25,0	0,1	0,6	5,3	22,8	2,8
Sea transport, domestic	1,4	33,8	-	0,8	1,7	1,4	0,3
Air transport[6]	0,1	1,6	-	0,0	1,5	2,1	0,1
Other private services	0,5	9,9	0,3	0,2	20,0	65,3	0,7
Public sector, municipal[7]	0,1	0,3	0,0	0,0	1,3	0,3	0,0
Public sector, state	0,1	2,4	0,0	0,1	1,6	0,7	0,1
Private households	**1,3**	**22,9**	**1,0**	**0,6**	**64,4**	**430,5**	**16,7**

[1]Total acidifying effect of SO_2, NO_X and NH_3. [2] Process emissions calculated for road dust only. [3]Includes gas terminals, 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 F.5 Emissions to air by source[1]. 1998

	CO_2	CH_4	N_2O	SO_2	NO_X	NH_3	NMVOC	CO	Particulates
	Mill. tonnes	1000 tonnes							
Total	**41,4**	**337,9**	**16,5**	**29,8**	**225,0**	**27,1**	**350,3**	**600,6**	**23,9**
Stationary combustion	17,4	12,0	0,4	7,3	47,6	-	14,0	162,8	16,0
Process emissions	8,5	322,7	14,4	17,9	11,7	25,8	269,2	39,5	1,7
Mobile combustion	15,6	3,2	1,7	4,6	165,7	1,4	67,0	398,3	6,1
Stationary combustion, total	**17,4**	**12,0**	**0,4**	**7,3**	**47,6**	**-**	**14,0**	**162,8**	**16,0**
Oil and gas extraction	9,0	3,4	0,1	0,3	32,5	-	1,6	6,7	0,1
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
Gas terminals	0,6	0,6	0,0	0,0	0,7	-	0,3	0,5	-
Manufacturing and mining	6,3	0,8	0,2	5,2	11,6	-	2,0	10,3	0,8
Refining	2,0	0,1	0,0	0,1	1,8	-	0,9	0,0	0,1
Manufacture of pulp and paper	0,6	0,4	0,1	1,6	2,4	-	0,3	3,3	0,2
Manufacture of mineral products	0,9	0,0	0,0	0,5	3,8	-	0,0	0,2	0,0
Manufacture of chemicals	1,3	0,1	0,0	0,7	1,5	-	0,1	0,4	0,1
Manufacture of metals	0,3	0,0	0,0	0,2	0,4	-	0,0	0,1	0,0
Other manufacturing	1,2	0,1	0,0	2,0	1,6	-	0,7	6,4	0,3
Other industries	1,1	0,1	0,0	0,7	0,9	-	0,1	0,8	0,1
Dwellings	0,9	7,7	0,1	1,0	1,8	-	10,0	144,8	14,9
Incineration of waste and landfill gas	0,1	0,1	0,0	0,2	0,9	-	0,3	0,1	0,1
Process emissions, total	**8,5**	**322,7**	**14,4**	**17,9**	**11,7**	**25,8**	**269,2**	**39,5**	**1,7**
Oil and gas extraction	0,7	24,6	-	-	-	-	199,4	-	-
Venting, leaks, etc.	0,0	8,3	-	-	-	-	4,0	-	-
Oil loading at sea	0,6	15,7	-	-	-	-	176,2	-	-
Oil loading, on shore	0,1	0,1	-	-	-	-	16,8	-	-
Gas terminals	0,0	0,6	-	-	-	-	2,3	-	-
Manufacturing and mining	7,4	1,2	5,4	17,9	11,7	0,3	15,1	39,5	-
Refining	0,0	-	-	2,0	0,8	-	11,4	-	-
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	-	-	-	-	-
Manufacture of metals	5,6	-	-	11,7	9,8	-	1,9	0,3	-
Iron, steel and ferro-alloys	3,6	-	-	9,0	8,8	-	1,9	-	-
Aluminium	1,7	-	-	1,8	0,7	-	-	-	-
Other metals	0,3	-	-	0,9	0,3	-	-	0,3	-
Other manufacturing	0,0	0,2	-	-	-	-	0,9	-	-
Petrol distribution	0,0	-	-	-	-	-	9,2	-	-
Agriculture	0,2	110,0	8,4	-	-	25,4	-	-	-
Landfill gas	0,0	186,5	-	-	-	-	-	-	-
Solvents	0,1	-	-	-	-	-	45,5	-	-
Road dust	-	-	-	-	-	-	-	-	1,7
Other process emissions	0,0	0,4	0,5	-	-	-	-	-	-

Table F.5 (cont.). Emissions to air by source[1]. 1998

	CO_2	CH_4	N_2O	SO_2	NO_X	NH_3	NMVOC	CO	Particulates
Mobile combustion, total	**15,6**	**3,2**	**1,7**	**4,6**	**165,7**	**1,4**	**67,0**	**398,3**	**6,1**
Road traffic	9,1	2,4	1,2	1,3	57,0	1,4	49,3	338,5	3,5
Petrol engines	5,0	2,1	1,1	0,3	25,9	1,3	40,8	306,8	0,4
Private cars	4,3	1,9	1,0	0,2	22,5	1,3	36,4	272,0	0,4
Other light vehicles	0,6	0,2	0,1	0,0	2,7	0,1	3,8	31,5	0,0
Heavy vehicles	0,0	0,0	0,0	0,0	0,7	0,0	0,6	3,3	0,0
Diesel engines	4,1	0,2	0,1	1,0	30,9	0,0	4,1	15,7	3,1
Private cars	0,4	0,0	0,0	0,1	1,1	0,0	0,4	1,5	0,4
Other light vehicles	1,0	0,0	0,1	0,3	2,6	0,0	1,0	4,1	0,9
Heavy vehicles	2,6	0,1	0,0	0,7	27,2	0,0	2,8	10,1	1,8
Motorcycles, mopeds	0,1	0,1	0,0	0,0	0,1	0,0	4,4	16,0	0,0
Motorcycles	0,0	0,1	0,0	0,0	0,1	0,0	1,9	11,1	0,0
Mopeds	0,0	0,0	0,0	0,0	0,0	0,0	2,5	4,8	0,0
Snow scooters	0,0	0,0	0,0	0,0	0,0	0,0	1,5	2,9	0,0
Small boats	0,2	0,2	0,0	0,0	1,0	-	8,8	19,7	0,3
Motorized equipment	0,8	0,1	0,3	0,2	11,4	0,0	3,8	25,3	1,4
Railways	0,1	0,0	0,0	0,0	0,9	-	0,1	0,2	0,1
Air traffic[2]	1,2	0,0	0,0	0,1	1,7	-	0,5	2,3	0,1
Domestic < 1000m	0,4	0,0	0,0	0,1	1,2	-	0,5	1,9	0,0
International < 1000 m	.	.	.	0,0	0,5	-	0,0	0,3	0,0
Domestic > 1000 m	0,8	.	0,0	.	.	.	.	.	.
Shipping	4,2	0,4	0,1	3,0	93,8	-	3,1	9,5	0,8
Coastal traffic, etc.	2,3	0,2	0,1	1,9	51,7	-	1,7	1,9	0,5
Fishing vessels	1,6	0,1	0,0	1,0	35,3	-	0,9	7,0	0,3
Mobile oil rigs, etc.	0,3	0,1	0,0	0,2	6,8	-	0,5	0,7	0,0

[1]Does not include international sea traffic. [2]Emissions from air traffic that are not included in national emission inventories are marked with the symbol . (Category not applicable).

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

Table F.6 Emissions to air by source[1]. 1999*

	CO_2	CH_4	N_2O	SO_2	NO_X	NH_3	NMVOC	CO	Particulates
	Mill. tonnes	1000 tonnes							
Total	**41,6**	**337,2**	**17,2**	**28,7**	**230,6**	**26,6**	**350,6**	**565,4**	**23,3**
Stationary combustion	17,2	11,9	0,4	6,8	49,1	-	14,2	163,7	15,8
Process emissions	8,3	322,2	14,9	17,6	11,7	25,1	273,1	33,0	1,5
Mobile combustion	16,2	3,1	1,9	4,2	169,8	1,5	63,3	368,6	6,0
Stationary combustion, total	**17,2**	**11,9**	**0,4**	**6,8**	**49,1**	**-**	**14,2**	**163,7**	**15,8**
Oil and gas extraction	8,9	3,2	0,1	0,3	33,9	-	1,6	6,6	0,1
Natural gas	6,2	2,4	0,1	-	16,6	-	0,6	4,5	-
Flaring	1,6	0,2	0,0	-	8,1	-	0,1	1,0	-
Diesel combustion	0,5	0,0	0,0	0,2	8,6	-	0,6	0,6	0,1
Gas terminals	0,6	0,6	0,0	0,0	0,7	-	0,3	0,5	-
Manufacturing and mining	6,0	0,8	0,2	4,7	11,4	-	2,1	11,5	0,8
Refining	2,1	0,1	0,0	0,0	1,8	-	0,9	0,0	0,1
Manufacture of pulp and paper	0,4	0,4	0,1	1,6	2,2	-	0,4	3,8	0,2
Manufacture of mineral products	0,8	0,0	0,0	0,4	4,0	-	0,0	0,2	0,0
Manufacture of chemicals	1,3	0,1	0,0	0,7	1,4	-	0,0	0,2	0,1
Manufacture of metals	0,3	0,0	0,0	0,2	0,4	-	0,0	0,1	0,0
Other manufacturing	1,1	0,1	0,0	1,8	1,5	-	0,7	7,2	0,3
Other industries	1,2	0,1	0,0	0,7	0,9	-	0,2	0,9	0,1
Dwellings	0,9	7,6	0,1	0,9	1,8	-	10,0	144,5	14,7
Incineration of waste and landfill gas	0,1	0,1	0,0	0,2	1,1	-	0,4	0,2	0,1
Process emissions, total	**8,3**	**322,2**	**14,9**	**17,6**	**11,7**	**25,1**	**273,1**	**33,0**	**1,5**
Oil and gas extraction	0,7	22,9	-	-	-	-	204,9	-	-
Venting, leaks, etc.	0,0	7,6	-	-	-	-	4,0	-	-
Oil loading at sea	0,6	14,1	-	-	-	-	186,2	-	-
Oil loading, on shore	0,0	0,1	-	-	-	-	12,5	-	-
Gas terminals	0,0	1,2	-	-	-	-	2,2	-	-
Manufacturing and mining	7,2	1,0	6,1	17,6	11,7	0,3	13,7	33,0	-
Refining	0,0	-	-	2,1	0,8	-	10,0	-	-
Manufacture of pulp and paper	-	-	-	0,4	-	-	-	-	-
Manufacture of chemicals	0,7	0,8	6,1	2,8	1,2	0,3	0,9	32,0	-
Manufacture of mineral products	0,9	-	-	0,7	-	-	-	-	-
Manufacture of metals	5,6	-	-	11,7	9,8	-	1,9	1,0	-
Iron, steel and ferro-alloys	3,5	-	-	9,1	8,7	-	1,9	-	-
Aluminium	1,8	-	-	1,7	0,8	-	-	-	-
Other metals	0,3	-	-	1,0	0,2	-	-	1,0	-
Other manufacturing	0,0	0,2	-	-	-	-	0,9	-	-
Petrol distribution	0,0	-	-	-	-	-	9,0	-	-
Agriculture	0,2	109,9	8,3	-	-	24,8	-	-	-
Landfill gas	0,0	188,0	-	-	-	-	-	-	-
Solvents	0,1	-	-	-	-	-	45,5	-	-
Road dust	-	-	-	-	-	-	-	-	1,5
Other process emissions	0,0	0,4	0,5	-	-	-	-	-	-

Table F.6 (cont.). Emissions to air by source[1]. 1999*

	CO_2	CH_4	N_2O	SO_2	NO_X	NH_3	NMVOC	CO	Particulates
Mobile combustion, total	**16,2**	**3,1**	**1,9**	**4,2**	**169,8**	**1,5**	**63,3**	**368,6**	**6,0**
Road traffic	9,3	2,3	1,4	1,2	54,5	1,5	45,4	308,2	3,2
Petrol engines	4,9	2,0	1,3	0,3	23,2	1,5	36,5	275,3	0,4
Private cars	4,3	1,8	1,2	0,3	20,2	1,4	32,6	244,3	0,3
Other light vehicles	0,6	0,2	0,1	0,0	2,4	0,1	3,4	28,2	0,0
Heavy vehicles	0,0	0,0	0,0	0,0	0,6	0,0	0,5	2,8	0,0
Diesel engines	4,3	0,2	0,1	0,8	31,1	0,0	4,1	15,4	2,9
Private cars	0,5	0,0	0,0	0,1	1,2	0,0	0,4	1,6	0,4
Other light vehicles	1,1	0,0	0,1	0,2	2,6	0,0	1,0	4,4	0,8
Heavy vehicles	2,7	0,1	0,0	0,5	27,3	0,0	2,8	9,4	1,6
Motorcycles, mopeds	0,1	0,1	0,0	0,0	0,1	0,0	4,7	17,5	0,0
Motorcycles	0,1	0,1	0,0	0,0	0,1	0,0	2,2	12,6	0,0
Mopeds	0,0	0,0	0,0	0,0	0,0	0,0	2,5	4,8	0,0
Snow scooters	0,0	0,0	0,0	0,0	0,0	0,0	1,6	3,0	0,0
Small boats	0,2	0,2	0,0	0,0	1,0	-	8,8	19,7	0,3
Motorized equipment	0,8	0,1	0,3	0,1	11,5	0,0	3,8	25,4	1,4
Railways	0,1	0,0	0,0	0,0	0,8	-	0,1	0,2	0,1
Air traffic[2]	1,4	0,0	0,0	0,1	1,9	-	0,6	2,6	0,1
Domestic < 1000m	0,4	0,0	0,0	0,0	1,4	-	0,5	2,2	0,1
International < 1000 m	.	.	.	0,0	0,6	-	0,0	0,4	0,0
Domestic > 1000 m	0,9	.	0,0	.	.	.	.	.	.
Shipping	4,5	0,4	0,1	2,8	100,0	-	3,2	9,6	0,9
Coastal traffic, etc.	2,7	0,2	0,1	1,9	59,4	-	2,0	2,1	0,6
Fishing vessels	1,6	0,1	0,0	0,9	34,8	-	0,8	6,9	0,3
Mobile oil rigs, etc.	0,3	0,1	0,0	0,1	5,7	-	0,4	0,6	0,0

[1]Does not include international sea traffic. [2]Emissions from air traffic that are not included in national emission inventories are marked with the symbol . (Category not applicable).
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Table F.7 Emissions to air by county. 1998

	CO_2	CH_4	N_2O	SO_2	NO_X	NH_3	NMVOC	CO	Particulates[1]
	Mill. tonnes	1000 tonnes							
Total	**41,5**	**337,9**	**16,5**	**30,4**	**227,5**	**27,1**	**350,4**	**600,7**	**23,9**
Of this, national emission figures	41,4	337,9	16,5	29,8	225,0	27,1	350,3	600,6	23,9
Of this, international sea traffic[2]	0,1	0,0	0,0	0,6	2,5	-	0,1	0,1	0,0
Østfold	1,5	16,4	0,7	3,1	6,4	1,8	8,6	32,6	1,5
Akershus	1,6	18,2	0,8	0,5	8,8	1,7	14,7	61,5	1,8
Oslo	1,3	4,7	0,2	0,6	6,1	0,1	12,5	35,0	0,9
Hedmark	0,8	20,1	1,0	0,3	4,9	2,5	6,5	36,3	1,9
Oppland	0,7	23,4	0,9	0,2	4,3	2,6	5,6	28,4	1,4
Buskerud	1,1	18,5	0,6	0,9	6,4	1,1	7,1	34,0	1,4
Vestfold	1,2	11,9	0,4	1,4	5,3	1,0	8,7	26,1	0,8
Telemark	3,2	11,4	4,0	1,1	7,0	0,8	6,6	25,4	1,2
Aust-Agder	0,6	7,8	0,2	2,1	2,0	0,3	3,4	50,5	0,9
Vest-Agder	1,1	12,3	0,3	1,9	4,0	0,6	5,0	20,6	0,9
Rogaland	2,9	36,1	1,2	1,5	8,7	3,4	14,2	38,2	1,3
Hordaland	3,5	29,3	0,6	2,5	10,0	1,4	38,4	44,5	1,8
Sogn og Fjordane	1,4	13,1	0,5	1,7	4,1	1,3	3,1	13,1	0,7
Møre og Romsdal	1,4	17,7	0,7	0,6	5,8	1,8	7,3	29,9	1,6
Sør-Trøndelag	1,3	17,6	0,7	2,9	6,2	1,8	7,2	34,5	1,2
Nord-Trøndelag	0,6	15,8	0,8	0,9	3,5	2,2	4,1	21,6	1,2
Nordland	2,4	20,6	2,3	3,4	8,9	1,5	6,3	24,5	1,1
Troms	0,7	9,3	0,3	1,1	4,0	0,6	3,9	16,7	0,8
Finnmark	0,3	6,7	0,2	0,2	2,1	0,2	2,4	10,7	0,5
Svalbard and Jan Mayen	0,1	0,2	0,0	0,4	0,2	0,0	0,1	0,2	0,1
Continental shelf	12,5	27,0	0,2	2,7	108,7	-	184,3	14,2	0,8
Airspace[3]	1,0	0,0	0,0	0,0	1,0	-	0,2	0,9	0,0
Open sea[4]	0,4	0,0	0,0	0,2	8,9	-	0,2	1,0	0,1

[1] Process emissions calculated for road dust only. [2] Emissions from international sea traffic in Norwegian ports. [3] Emissions of CO2 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 F.8 Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
	1000 tonnes	Tonnes		
Total	**41 514**	**30 369**	**227 480**	**23 877**
Of this, national emissions	41 396	29 765	224 962	23 851
Of this, international sea traffic[1]	118	604	2 518	26
Østfold	**1 506**	**3 120**	**6 435**	**1 494**
Halden	90	165	480	170
Moss	210	384	777	167
Sarpsborg	572	2 017	2 154	295
Fredrikstad	325	474	1 262	358
Hvaler	13	3	84	32
Aremark	6	2	38	12
Marker	17	5	104	24
Rømskog	2	1	11	5
Trøgstad	16	4	95	32
Spydeberg	15	4	92	29
Askim	44	12	181	57
Eidsberg	40	10	237	63
Skiptvet	8	2	51	21
Rakkestad	29	8	161	49
Råde	40	8	258	53
Rygge	48	13	257	70
Våler	14	4	74	27
Hobøl	20	5	119	29
Akershus	**1 600**	**506**	**8 820**	**1 780**
Vestby	59	11	388	69
Ski	71	16	383	84
Ås	73	14	432	72
Frogn	38	9	217	52
Nesodden	35	8	195	66
Oppegård	47	10	254	65
Bærum	299	74	1 591	312
Asker	155	31	837	166
Aurskog-Høland	44	13	272	67
Sørum	59	12	340	63
Fet	31	7	174	39
Rælingen	54	69	281	41
Enebakk	16	4	95	31
Lørenskog	67	17	337	79
Skedsmo	180	115	900	153
Nittedal	48	10	260	63
Gjerdrum	10	2	58	15
Ullensaker	143	40	785	112
Nes	51	12	293	76
Eidsvoll	87	23	537	103
Nannestad	23	8	128	36
Hurdal	10	2	64	16
Oslo	**1 261**	**578**	**6 111**	**893**
Hedmark	**802**	**303**	**4 944**	**1 915**
Kongsvinger	65	32	397	158
Hamar	84	30	391	180
Ringsaker	133	54	724	303
Løten	29	7	186	75
Stange	96	31	582	187
Nord-Odal	14	5	93	58

Table F.8 (cont.). Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
Hedmark (cont.)				
Sør-Odal	42	15	240	83
Eidskog	27	8	167	64
Grue	23	12	164	76
Åsnes	31	10	203	95
Våler	17	25	158	60
Elverum	66	20	381	160
Trysil	31	17	226	89
Åmot	21	6	147	56
Stor-Elvdal	29	7	217	53
Rendalen	16	4	122	37
Engerdal	9	2	58	21
Tolga	9	2	56	22
Tynset	31	8	210	61
Alvdal	17	5	124	32
Folldal	7	2	46	22
Os	8	2	53	23
Oppland	**722**	**229**	**4 314**	**1 385**
Lillehammer	69	23	374	141
Gjøvik	112	37	555	171
Dovre	22	5	153	32
Lesja	16	4	121	26
Skjåk	13	3	96	25
Lom	12	4	81	24
Vågå	17	4	117	34
Nord-Fron	29	10	167	54
Sel	31	8	191	54
Sør-Fron	16	4	102	31
Ringebu	27	6	181	47
Øyer	30	8	195	45
Gausdal	19	6	121	48
Østre Toten	43	21	251	100
Vestre Toten	49	22	230	89
Jevnaker	19	6	99	38
Lunner	30	8	189	56
Gran	43	12	268	92
Søndre Land	21	6	134	51
Nordre Land	22	6	142	56
Sør-Aurdal	15	6	109	34
Etnedal	7	2	50	16
Nord-Aurdal	30	8	182	55
Vestre Slidre	8	2	58	22
Øystre Slidre	13	3	92	27
Vang	8	2	57	17
Buskerud	**1 075**	**888**	**6 378**	**1 385**
Drammen	184	52	865	146
Kongsberg	66	18	361	133
Ringerike	141	109	739	197
Hole	30	6	173	37
Flå	15	3	102	16
Nes	17	4	104	28
Gol	21	6	131	33
Hemsedal	9	3	57	14
Ål	20	8	120	44
Hol	24	6	151	38
Sigdal	15	4	99	32
Krødsherad	21	6	137	25

Table F.8 (cont.). Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
Buskerud (cont.)				
Modum	58	82	254	90
Øvre Eiker	88	96	436	116
Nedre Eiker	44	14	214	85
Lier	136	84	620	125
Røyken	33	9	173	72
Hurum	119	371	1 412	89
Flesberg	13	3	87	23
Rollag	8	2	54	15
Nore og Uvdal	13	3	89	27
Vestfold	**1 186**	**1 384**	**5 269**	**839**
Borre	59	16	364	73
Holmestrand	87	7	240	40
Tønsberg	437	849	1 479	133
Sandefjord	137	130	717	127
Larvik	191	239	1 144	189
Svelvik	48	3	93	18
Sande	59	99	310	50
Hof	12	3	68	14
Våle	32	7	186	28
Ramnes	10	2	63	16
Andebu	12	3	72	19
Stokke	36	7	216	41
Nøtterøy	42	11	176	55
Tjøme	12	2	67	21
Lardal	12	3	75	15
Telemark	**3 177**	**1 111**	**6 989**	**1 201**
Porsgrunn	2 178	890	3 889	226
Skien	123	107	596	288
Notodden	45	11	251	94
Siljan	6	1	34	16
Bamble	601	17	899	90
Kragerø	45	39	260	89
Drangedal	12	3	82	37
Nome	28	5	118	56
Bø	17	5	95	38
Sauherad	17	5	99	38
Tinn	20	6	117	59
Hjartdal	8	2	56	18
Seljord	17	5	104	31
Kviteseid	13	3	87	28
Nissedal	7	2	47	15
Fyresdal	6	1	36	14
Tokke	12	3	81	26
Vinje	21	6	137	39
Aust-Agder	**561**	**2 105**	**2 010**	**889**
Risør	23	9	137	63
Grimstad	55	16	299	131
Arendal	239	1 334	577	310
Gjerstad	12	4	76	29
Vegårshei	6	2	38	19
Tvedestrand	24	6	150	63
Froland	13	3	89	41
Lillesand	116	706	223	78
Birkenes	27	5	106	40
Åmli	9	6	69	26
Iveland	2	1	18	11

Table F.8 (cont.). Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
Aust-Agder (cont.)				
Evje og Hornnes	13	6	83	35
Bygland	9	5	65	19
Valle	8	2	50	16
Bykle	6	1	29	8
Vest-Agder	**1 112**	**1 933**	**4 006**	**850**
Kristiansand	423	1 242	1 820	314
Mandal	42	11	254	80
Farsund	164	297	342	53
Flekkefjord	37	18	202	53
Vennesla	128	295	376	92
Songdalen	18	4	107	31
Søgne	28	7	158	45
Marnardal	8	2	56	16
Åseral	5	1	41	8
Audnedal	5	1	37	11
Lindesnes	24	7	129	33
Lyngdal	33	25	187	46
Hægebostad	7	1	42	11
Kvinesdal	176	18	180	41
Sirdal	12	2	75	16
Rogaland	**2 902**	**1 509**	**8 696**	**1 301**
Eigersund	111	194	498	66
Sandnes	138	37	774	159
Stavanger	283	220	1 971	286
Haugesund	65	21	340	96
Sokndal	33	41	228	33
Lund	17	5	121	21
Bjerkreim	17	3	104	17
Hå	45	11	246	54
Klepp	56	15	245	50
Time	38	9	166	43
Gjesdal	28	6	176	34
Sola	313	415	657	76
Randaberg	18	5	109	25
Forsand	9	3	90	7
Strand	26	9	133	35
Hjelmeland	17	6	145	18
Suldal	20	6	191	27
Sauda	328	65	59	22
Finnøy	20	10	123	15
Rennesøy	22	9	158	16
Kvitsøy	1	0	10	2
Bokn	7	3	76	6
Tysvær	597	8	878	44
Karmøy	667	401	1 036	118
Utsira	1	1	7	1
Vindafjord	25	5	154	29
Hordaland	**3 480**	**2 538**	**10 019**	**1 818**
Bergen	555	187	2 883	385
Etne	19	7	132	34
Ølen	14	4	94	28
Sveio	17	5	134	36
Bømlo	25	9	187	62
Stord	38	14	270	88
Fitjar	9	3	71	22
Tysnes	9	4	83	26

Table F.8 (cont.). Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
Hordaland (cont.)				
Kvinnherad	245	317	396	97
Jondal	4	1	34	11
Odda	373	228	453	65
Ullensvang	15	5	127	34
Eidfjord	9	3	78	12
Ulvik	5	2	46	11
Granvin	8	4	73	12
Voss	48	14	283	102
Kvam	236	668	986	70
Fusa	12	5	93	31
Samnanger	10	2	63	21
Os	33	11	226	80
Austevoll	15	16	116	26
Sund	12	4	79	27
Fjell	40	11	240	77
Askøy	61	108	291	96
Vaksdal	20	6	121	37
Modalen	2	1	16	3
Osterøy	18	8	134	49
Meland	11	3	60	31
Øygarden	68	2	102	18
Radøy	12	4	74	31
Lindås	1 521	877	1 916	159
Austrheim	7	3	63	17
Fedje	1	1	12	4
Masfjorden	9	3	84	18
Sogn og Fjordane	**1 364**	**1 655**	**4 106**	**660**
Flora	48	40	345	53
Gulen	16	8	143	18
Solund	4	2	47	7
Hyllestad	5	2	39	11
Høyanger	156	250	168	30
Vik	9	3	80	18
Balestrand	11	5	89	14
Leikanger	7	3	71	17
Sogndal	25	7	149	36
Aurland	10	2	65	13
Lærdal	12	3	95	17
Årdal	548	380	348	48
Luster	13	3	82	33
Askvoll	8	3	71	19
Fjaler	7	2	58	17
Gaular	14	4	89	22
Jølster	15	3	97	23
Førde	38	10	193	53
Naustdal	7	2	48	15
Bremanger	277	838	962	25
Sogn og Fjordane (cont..)				
Vågsøy	57	60	343	34
Selje	8	3	59	17
Eid	21	6	147	34
Hornindal	4	2	28	8
Gloppen	18	5	123	36
Stryn	28	8	168	43

Table F.8 (cont.). Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
Møre og Romsdal	**1 396**	**608**	**5 760**	**1 576**
Molde	58	19	367	119
Kristiansund	37	21	211	87
Ålesund	129	62	776	198
Vanylven	17	5	188	37
Sande	9	4	82	22
Herøy	42	92	210	55
Ulstein	15	5	100	33
Hareid	10	4	77	26
Volda	18	8	150	53
Ørsta	31	12	239	68
Ørskog	9	2	60	17
Norddal	8	4	73	17
Stranda	21	10	120	34
Stordal	3	1	24	8
Sykkylven	16	7	119	45
Skodje	16	4	103	28
Sula	20	14	151	39
Giske	14	4	83	31
Haram	24	10	184	53
Vestnes	24	8	152	49
Rauma	34	10	247	65
Nesset	14	4	89	29
Midsund	6	4	57	14
Sandøy	3	2	31	9
Aukra	7	3	69	18
Fræna	27	10	183	64
Eide	13	4	107	25
Averøy	22	11	122	42
Frei	10	3	57	30
Gjemnes	11	3	76	25
Tingvoll	11	4	86	29
Sunndal	316	228	322	65
Surnadal	19	7	138	53
Rindal	6	2	44	19
Aure	357	10	495	25
Halsa	7	3	69	19
Tustna	4	2	39	10
Smøla	7	2	59	19
Sør-Trøndelag	**1 338**	**2 875**	**6 227**	**1 227**
Trondheim	482	712	2 200	338
Hemne	199	692	780	33
Snillfjord	10	2	76	14
Hitra	11	5	94	32
Frøya	12	5	97	28
Ørland	14	6	92	29
Agdenes	6	2	51	17
Rissa	22	7	173	51
Bjugn	18	6	131	37
Åfjord	11	4	90	28
Roan	3	1	24	10
Osen	4	1	36	11
Oppdal	38	10	259	60
Rennebu	21	4	150	32
Meldal	12	4	74	34
Orkdal	294	1 370	682	73
Røros	19	5	117	47
Holtålen	8	2	60	22
Midtre Gauldal	27	6	193	53

Table F.8 (cont.). Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
Sør-Trøndelag (cont.)				
Melhus	50	12	336	97
Skaun	20	4	130	44
Klæbu	6	2	36	24
Malvik	35	8	239	69
Selbu	12	3	78	35
Tydal	4	1	28	9
Nord-Trøndelag	**614**	**908**	**3 545**	**1 170**
Steinkjer	72	25	468	186
Namsos	31	22	177	94
Meråker	122	658	311	30
Stjørdal	80	21	434	151
Frosta	8	3	43	22
Leksvik	9	3	65	32
Levanger	68	64	508	168
Verdal	49	17	300	114
Mosvik	2	1	18	9
Verran	10	4	48	28
Namdalseid	9	2	62	21
Inderøy	37	54	240	51
Snåsa	14	4	114	30
Lierne	7	2	57	17
Røyrvik	3	1	19	7
Namsskogan	11	3	102	18
Grong	20	5	158	34
Høylandet	8	2	50	15
Overhalla	14	4	84	33
Fosnes	3	1	29	8
Flatanger	3	1	28	13
Vikna	11	5	77	29
Nærøy	19	8	130	53
Leka	2	1	23	8
Nordland	**2 404**	**3 398**	**8 921**	**1 124**
Bodø	107	51	520	137
Narvik	50	21	320	83
Bindal	7	3	65	13
Sømna	6	2	53	12
Brønnøy	22	6	154	34
Vega	4	2	31	9
Vevelstad	3	2	46	4
Herøy	5	2	36	9
Alstahaug	17	6	120	27
Leirfjord	8	2	57	14
Vefsn	247	217	383	68
Grane	16	4	134	19
Hattfjelldal	6	3	41	11
Dønna	5	2	39	9
Nesna	5	2	57	10
Hemnes	18	5	130	28
Rana	702	1 347	1 780	119
Lurøy	5	3	51	12
Træna	1	0	12	3
Rødøy	5	2	51	10
Meløy	22	13	379	31
Gildeskål	9	3	70	15
Beiarn	3	1	24	9
Saltdal	20	5	162	34
Fauske	31	8	196	56

Table F.8 (cont.). Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
Nordland (cont.)				
Skjerstad	4	1	36	8
Sørfold	382	1 336	1 448	20
Steigen	9	3	64	18
Hamarøy	13	3	98	17
Tysfjord	474	277	1 077	15
Lødingen	10	3	78	14
Tjeldsund	7	2	50	10
Evenes	12	3	69	12
Ballangen	13	4	77	18
Røst	2	1	17	3
Værøy	2	1	15	3
Flakstad	4	2	30	6
Vestvågøy	28	9	172	43
Vågan	24	9	168	33
Hadsel	24	9	167	34
Bø	9	2	61	16
Øksnes	12	5	74	15
Sortland	28	8	170	37
Andøy	20	5	118	23
Moskenes	3	1	22	5
Troms	**742**	**1 146**	**4 040**	**800**
Harstad	55	23	316	96
Tromsø	148	76	819	217
Kvæfjord	12	5	93	21
Skånland	13	4	86	25
Bjarkøy	2	2	28	5
Ibestad	5	3	45	12
Gratangen	7	2	52	12
Lavangen	5	2	33	9
Bardu	21	7	118	30
Salangen	7	3	42	16
Målselv	40	14	208	50
Sørreisa	13	6	61	20
Dyrøy	4	2	37	11
Tranøy	6	2	42	14
Torsken	3	2	21	6
Berg	6	3	31	7
Lenvik	279	924	1 293	63
Balsfjord	34	10	211	48
Karlsøy	18	32	75	19
Lyngen	10	5	66	20
Storfjord	12	3	76	17
Gáivuotua - Kåfjord	10	4	73	21
Skjervøy	7	5	48	12
Nordreisa	19	6	120	35
Kvænangen	6	2	48	13
Finnmark	**325**	**191**	**2 102**	**521**
Vardø	8	9	57	15
Vadsø	22	13	184	32
Hammerfest	25	23	148	46
Guovdageaidnu - Kautokeino	20	6	182	33
Alta	81	32	439	122
Loppa	4	3	34	11
Hasvik	6	10	28	8
Kvalsund	11	3	71	15
Måsøy	4	3	30	10
Nordkapp	18	20	125	21

Table F.8 (cont.). Emissions to air by municipality. 1998

	CO_2	SO_2	NO_X	Particulates
Finnmark (cont.)				
Porsanger	23	8	141	39
Káráš johka - Karasjok	15	5	117	28
Lebesby	6	3	36	11
Gamvik	6	9	31	9
Berlevåg	4	2	28	8
Deatnu - Tana	18	7	115	32
Unjarga - Nesseby	8	2	51	12
Båtsfjord	10	13	89	11
Sør-Varanger	37	19	194	57
Other regions	**76**	**398**	**165**	**117**
Spitsbergen	76	398	165	117
Bjørnøya	0	-	-	-
Hopen	0	-	-	-
Jan Mayen	0	0	0	0
Continental shelf south of 62°N	9 536	1 355	65 271	471
Continental shelf north of 62°N	2 926	1 351	43 435	360
Air space[2] above 100 m	1 006	38	973	36
Fishing in distant waters[3]	403	241	8 940	64

[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 F.9 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[2]	Per capita
	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 F.10 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
	1000 tonnes					kg/1000 USD	kg 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	[3]947	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	[3]2 028	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	..	..	[4]903	..	..	..

[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]GDP 1997 expressed in 1991 prices. [4]GDP 1997 expressed in 1991 prices.
Source: OECD (1999).

Table F.11 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
	1000 tonnes					kg/1000 USD	kg 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	[3]1 698	1,5	29,0
Italy	1 638	1 614	1 938	1 768	..	..	..
Netherlands	584	581	579	498	445	1,5	28,5
Portugal	165	..	309	373	..	..	..
United Kingdom	2 460	2 398	2 752	2 145	[3]2 060	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	[3]2 011	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	[4]1 409	..	..	..

[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 F.12 Emissions to air of hazardous substances

	Pb	Cd	Hg	PAH
	Tonnes	kg	kg	Tonnes
1990	187	1 746	1 757	159
1991	142	1 677	1 636	153
1992	125	1 665	1 484	145
1993	85	1 738	1 177	155
1994	21	1 290	1 247	157
1995	20	1 119	1 158	155
1996	8	1 157	1 186	161
1997	7	1 189	1 204	162
1998	7	1 226	1 153	157
1999*	6	1 062	1 198	149

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

Table F.13 Emissions to air of hazardous substances[1] by source. 1998

	Pb	Cd	Hg	PAHs
	Tonnes	kg	kg	Tonnes
Total	**7,4**	**1 225,7**	**1 152,8**	**157,0**
Stationary combustion	1,7	487,9	607,2	63,3
Process emissions	5,1	688,9	394,1	83,6
Mobile combustion	0,7	48,9	151,5	10,1
Stationary combustion, total	**1,7**	**487,9**	**607,2**	**63,3**
Oil and gas extraction	0,0	8,2	11,2	0,5
Natural gas	0,0	5,4	3,2	0,0
Flaring	0,0	0,9	0,5	0,3
Diesel combustion	0,0	1,4	7,2	0,2
Gas terminals	0,0	0,5	0,3	0,0
Manufacturing and mining	0,9	266,5	302,1	0,5
Refining	0,0	0,1	0,2	0,0
Manufacture of pulp and paper	0,3	190,3	205,2	0,3
Manufacture of mineral products	0,1	7,1	6,1	0,0
Manufacture of chemicals	0,1	10,2	17,1	0,0
Manufacture of metals	0,0	2,4	3,6	0,0
Other manufacturing	0,3	56,5	70,0	0,1
Other industries	0,0	25,7	18,0	6,2
Dwellings	0,1	146,3	156,1	55,3
Incineration of waste and landfill gas	0,6	41,1	119,7	0,8
Process emissions, total	**5,1**	**688,9**	**394,1**	**83,6**
Oil and gas extraction	-	-	-	-
Venting, leaks, etc.	-	-	-	-
Oil loading at sea	-	-	-	-
Oil loading, on shore	-	-	-	-
Gas terminals	-	-	-	-
Manufacturing and mining	5,0	642,6	346,7	65,3
Refining	-	-	-	-
Manufacture of pulp and paper	-	-	-	-
Manufacture of chemicals	0,5	64,9	23,5	2,3
Manufacture of mineral products	1,0	0,9	51,0	-
Manufacture of metals	3,5	576,9	272,2	63,0
Iron, steel and ferro-alloys	2,9	326,9	260,8	1,2
Aluminium	0,5	50,0	4,0	59,2
Other metals	0,0	200,0	7,4	2,5
Other manufacturing	-	-	-	0,0
Petrol distribution	-	-	-	-
Agriculture	-	-	-	-
Landfill gas	-	-	-	-
Solvents	-	-	-	17,9
Road dust	0,1	46,2	2,3	0,4
Use of products	-	-	45,0	-
Other process emissions	0,0	0,0	0,1	-
Mobile combustion, total	**0,7**	**48,9**	**151,5**	**10,1**
Road traffic	0,2	29,1	64,4	7,0
Petrol engines	0,0	16,0	-	1,8
Private cars	0,0	13,9	-	1,6
Other light vehicles	0,0	1,9	-	0,2
Heavy vehicles	0,0	0,1	-	0,0
Diesel engines	0,1	12,9	64,4	5,1
Private cars	0,0	1,4	6,8	0,6
Other light vehicles	0,0	3,3	16,5	1,4
Heavy vehicles	0,1	8,2	41,0	3,1
Motorcycles, mopeds	0,0	0,2	-	0,0
Motorcycles	0,0	0,2	-	0,0
Mopeds	0,0	0,1	-	0,0

Table F.13 (cont.). Emissions to air of hazardous substances[1] by source. 1998

	Pb	Cd	Hg	PAHs
Snow scooters	0,0	0,0	-	0,0
Small boats	0,0	0,5	0,7	0,1
Motorized equipment	0,0	2,4	11,3	0,8
Railways	0,0	0,2	0,9	0,1
Air traffic[2]	0,3	1,7	5,0	0,1
Domestic < 1000 m	0,3	1,2	3,7	0,1
International < 1000 m	0,0	0,4	1,3	0,0
Domestic > 1000 m	.	.	.	.
Shipping	0,1	15,0	69,2	2,1
Coastal traffic, etc.	0,1	8,9	39,3	1,2
Fishing vessels	0,1	5,0	25,1	0,8
Mobile oil rigs, etc.	0,0	1,0	4,8	0,2

[1] Does not include international sea traffic. [2]Emissions from air traffic that are+A19 not included in national emission inventories are marked with the symbol . .

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

Waste

Appendix G

Table G.1 Wet organic waste by origin and method of disposal. 1000 tonnes

	1993	1995	1998
Total	**1 156**	**1 243**	**1 295**
Origin			
Households	334	366	420
Manufacturing	461	416	398
Construction	1	1	1
Service industries . . .	71	82	103
Fisheries.	262	346	335
Fish farming.	7	8	15
Other industries	21	24	24
Treatment			
Material recovery . . .	398	403	417
Compost	12	52	140
Incineration	112	145	170
Landfill.	371	310	242
Dumped in sea	252	320	317
Other/unspecified . .	17	18	16

Source: Statistics Norway.

Table G.2 Paper waste by origin, method of treatment and product type. 1000 tonnes

	1990	1995	1999
Total	**1 051**	**1 027**	**1 039**
Origin	355	411	480
Households	186	187	173
Manufacturing	480	396	350
Service industries . . .	31	32	36
Other industries			
. . . .	683	525	389
Treatment	182	346	491
Landfill.	154	120	121
Material recovery . . .	32	36	38
Incineration			
To sewer system . . .	441	489	501
. . . .	294	225	284
Product type	90	132	79
Printed matter	95	75	79
Packaging	131	106	95
Building paper			
Sanitary and household goods			
Production waste. . .			

Source: Statistics Norway.

Table G.3 Wood waste by origin, method of treatment and product type. 1000 tonnes

	1990	1996	1997
Total	**1 266**	**1 144**	**1 153**
Origin			
Households	77	98	111
Service industries	30	46	47
Construction	205	209	226
Manufacturing	954	791	769
of this, production waste	918	757	735
Other industries	0	1	1
Treatment			
Material recovery	..	328	..
Incineration	..	496	..
Landfill	..	310	..
Other treatment	..	11	..
Product type			
Furniture	87	123	128
Packaging	35	35	44
Construction	205	209	226
Other products	22	21	21
Production waste	918	757	735

Source: Statistics Norway.

Table G.4 Plastic waste by origin, method of treatment and product type. 1000 tonnes

	1990	1995	1997
Total	**280**	**353**	**368**
Origin			
Households	150	176	188
Service industries	80	111	104
Manufacturing	34	47	56
Construction	9	8	9
Other industries	8	11	11
Treatment			
Material recovery	..	0	2
Incineration	..	15	14
Landfill	..	63	60
Export	..	2	3
Other treatment	..	20	20
Product type			
Packaging	80	87	83
Electrical/electronic	41	45	45
Machinery and tools	5	6	6
Buildings	39	48	52
Printed matter	27	56	63
Furniture	10	13	16
Means of transport excl. ships	16	21	21
Other products	38	40	37
Production waste	23	37	46

Source: Statistics Norway.

Table G.5 Glass waste by origin, method of treatment and product type. 1000 tonnes

	1993	1995	1998
Total	**117**	**136**	**131**
Origin			
Households	44	48	55
Manufacturing	13	19	14
Construction	42	42	44
Service industries and other	18	27	19
Treatment			
Material recovery	31	31	35
Landfill	86	105	96
Product type			
Packaging	39	58	48
Buildings	47	47	48
Means of transport	3	3	4
Furniture	1	1	2
Electrical/electronic	7	7	8
Sanitary and household goods	17	16	15
Products for scientific, technical and medical use	1	1	1
Other products	3	3	5

Source: Statistics Norway.

Table G.6 Metal waste by origin, method of treatment and product type. 1000 tonnes

	1992	1995	1996
Total	**524**	**507**	**717**
Treatment			
Re-use (car parts)	3	4	11
Material recovery	305	367	479
Landfill or dumped	131	133	210
Exports	84	3	17
Product type			
Construction	16	16	22
Electrical/electronic	40	41	55
Packaging	14	11	14
Machinery and tools	51	49	69
Furniture	14	11	17
Ships and other large structures	35	36	52
Means of transport excl. ships	95	81	109
Roads and outdoor installations	12	13	19
Sanitary and household goods	3	3	4
Pipes and other products	245	246	355

Source: Statistics Norway.

Table G.7 Textile waste by origin, method of treatment and product type. 1000 tonnes

	1993	1996	1998
Total	**85**	**97**	**106**
Treatment			
Material recovery and re-use	3	7	8
Incineration	18	18	21
Landfill	64	72	77
Other treatment	0	0	0
Origin			
Households	65	75	83
Manufacturing	5	5	6
Construction	0	0	0
Fisheries, sealing, whaling and fish farming	8	8	8
Service industries and other industries	7	9	9
Product type			
Packaging	3	4	5
Textiles	28	38	44
Leather products and shoes	11	13	15
Fishing tackle	8	8	8
Interior and household goods	19	19	18
Furniture	5	6	8
Means of transport	1	2	3
Other products	8	5	3
Scrap from production	2	4	4

Source: Statistics Norway.

Table G.8 Hazardous waste by treatment. Tonnes

	1994	1996	1997	1998	1999
Total	**640 000**	**577 704**	**565 892**	**679 173**	**588 900**
Treated by approved external facilities	335 000	410 920	387 079	496 163	440 752
On-site treatment by companies	240 000	151 686	152 833	169 307	109 637
Export	37 000	15 098	25 980	13 703	38 511
Unknown disposal	30 000	..	..	..	..

Source: Norsas (1996 and 2000).

Table G.9 Quantities of household waste. Total and delivered for material recovery[1]. Kg per capita

	Total	For recovery
1974	174	..
1985	200	..
1992	235	20
1995	269	49
1996	272	60
1997	287	83
1998	308	102
1999	314	118
2000	324	130

[1]The figures have been adjusted downwards to correct for the intermixture of waste from industrial sectors.
Source: Statistics Norway.

Table G.10 Household waste by material. Total and for recovery. 1000 tonnes

	Total	For recovery
Total	**1397**	**524**
Paper and cardboard	490	247
Glass	45	28
Plastic	106	3
Metals	84	36
Wet organic waste	350	84
Wood waste	112	58
Textiles	68	8
Other	141	59

Source: SSB, Søre Sunnmøre reinhaldsverk (1991) and Heie (1998).

Table G.11 Manufacturing waste by material. 1000 tonnes

	1993	1996	1999
Total	**3 288**	**3 132**	**3 547**
Hazardous waste	320	401	432
Production and consumer waste	2 967	2 731	3 115
Category			
Paper and board	207	173	173
Plastic	34	53	45
EPS	.	1	2
Glass	55	19	15
Iron and other metals	180	253	200
Textiles	16	5	6
Food and organic waste	447	426	451
Tyres	0	4	2
Other rubber	1	2	3
Wood waste	879	839	671
Park and garden waste	.	6	1
Soil, gravel etc.	.	.	169
Concrete and bricks	143	224	166
Asphalt	.	4	4
Ash	18	25	36
Dust	74	34	61
Sludge	250	170	237
Slag	272	331	653
Chemicals	19	5	17
Other	214	70	77
Mixed and unknown waste	158	88	124

Source: Statistics Norway.

Table G.12 Manufacturing waste[1] by industry and material. 1999. 1000 tonnes

	Total	Food products, beverages, tobacco	Wood and wood products	Pulp, paper and paper products; publishing and printing	Chemicals and chemical products	Other non-metallic mineral products	Basic metals and fabricated metal products	Other
Total	**3 115**	**619**	**453**	**451**	**143**	**269**	**773**	**406**
Paper and board	173	31	2	44	3	2	2	88
Plastic	45	12	1	5	3	1	0	24
EPS	2	1	0	0	0	0	0	0
Glass	15	5	1	0	0	9	0	0
Iron and other metals	200	5	2	4	7	5	40	136
Textiles	6	0	-	0	0	0	0	6
Food and organic waste	451	449	0	0	0	0	0	2
Tyres	2	0	0	-	0	0	0	2
Other rubber	3	0	1	0	0	0	0	2
Wood waste	671	6	428	195	4	3	3	31
Park and garden waste	1	0	0	0	0	0	0	0
Soil, gravel etc.	169	35	1	4	17	71	35	6
Concrete and bricks	166	1	0	3	7	91	54	11
Asphalt	4	-	0	0	0	3	0	1
Ash	36	0	4	24	5	2	-	1
Dust	61	0	6	0	11	23	15	7
Sludge	237	8	0	130	64	20	14	2
Slag	653	0	0	6	7	3	601	35
Chemicals	17	6	0	8	2	-	1	0
Other	77	35	1	1	3	32	0	6
Mixed and unknown waste	124	25	5	27	10	4	8	47

[1]Excluding hazardous waste.
Source: Statistics Norway.

Table G.13 Manufacturing waste[1] by treatment/disposal and material. 1999. 1000 tonnes

	Total	Material recovery or re-use	Incinerated with energy recovery	Incinerated with energy recovery	Landfilled	Delivered to sorting plant	Composted	Deposition onto land other than landfill	Other	Percent-age of waste treated on-site
Total.	**3 115**	**928**	**508**	**24**	**712**	**191**	**121**	**590**	**39**	**32,3**
.										
Paper and board.	173	98	11	1	20	41	0	0	1	1,7
Plastic.	45	14	5	0	15	11	-	0	0	2,8
EPS.	2	0	0	0	1	1	-	0	0	2,8
Glass.	15	6	0	-	7	1	-	0	0	0,1
Iron and other metals.	200	141	0	-	14	43	-	0	2	1,0
Textiles.	6	1	0	-	4	1	-	-	0	0,7
Food and organic waste.	451	382	3	19	5	24	12	0	6	1,8
Tyres.	2	0	-	-	1	0	-	-	0	0,1
Other rubber.	3	-	1	-	2	0	-	-	0	27,4
Wood waste.	671	152	367	5	40	13	80	3	12	51,7
Park and garden waste.	1	-	0	0	0	0	0	0	0	25,3
Soil, gravel etc.	169	22	-	-	47	1	0	100	0	54,4
Concrete and bricks.	166	11	-	-	68	3	0	81	3	33,3
Asphalt.	4	-	-	-	3	-	-	1	-	0,9
Ash.	36	0	.	.	34	0	0	1	1	89,4
Dust.	61	5	5	0	50	0	0	-	0	76,3
Sludge.	237	6	100	-	115	5	7	0	4	72,4
Slag.	653	78	.	.	197	1	-	373	3	32,9
Chemicals.	17	4	0	-	9	1	0	-	3	56,7
Other.	77	7	1	-	13	4	22	30	1	16,6
Mixed and unknown waste.	124	.	14	0	69	38	-	0	2	5,8

[1]Excluding hazardous waste.
Source: Statistics Norway.

Table G.14 Waste generated by building, restoration and demolition. 1998. 1000 tonnes

	Total	Construction	Restoration	Demolition
Total	**1 543**	**210**	**372**	**961**
Concrete and bricks	1 057	77	181	799
Wood	241	42	123	77
Metals	43	3	9	31
Plaster	37	14	21	2
Paper, board and plastic	17	8	2	7
Hazardous waste	8	0	3	5
Of this, asbestos	6	-	3	4
EPS	6	4	2	1
Glass	5	1	2	2
Waste of unknown composition	130	61	29	40

Source: Statistics Norway.

Table G.15 Waste from wholesale trade by industry and material. 1999

	Total[1 4]	Paper and cardboard	Plastic[1]	Wood waste	Metals	Soil, gravel etc.	Hazardous waste	Unsorted waste[1]
Total	**637**	**299**	**4**	**24**	**15**	**3**	**11**	**284**
Motor vehicle services	110	43	..	1	10	..	9	46
Wholesale trade[2]	206	76	4	20	5	..	2	99
Retail trade, repair of personal and household goods	370	179	..	3	..	..	..	138
Of which from retail sale of food, beverages and tobacco[3]	200	91	..	..	..	..	..	59

[1]Figures are based on waste delivered to Norsk Gjenvinning only. Some of the waste from the enterprises included in the survey is not delivered to Norsk Gjenvinning. The actual ammonts of waste may therefore be somewhat grater than the figures indicate. [2]Except NACE 51.1 Wholesale trade on a fee or contract basis and NACE 51.57 Wholesale of waste and scrap. [3]Includes NACE 52.11 Retail sale in non-specialized stores with food, beverages and tobacco predominating, and NACE 52.2 Retail sale of food, beverages and tobacco in specialized stores. [4]37 000 tonnes putrescibles, 7 000 tonnes glass waste, 5 000 tonnes plastic waste and tyres are not included in the figures.
Source: Statistics Norway.

Water resources and water pollution

Appendix H

Table H.1 Water sources, number of water works and number of people supplied. By county. 1999

	Total		Lake[1]		River/stream		Ground water	
	Number of water works	Number of people	Number of water works	Number of people	Number of water works	Number of people	Number of water works	Number of people
Whole country[3]	**1 620**	**3 926 791**	**669**	**3 156 045**	**423**	**473 497**	**530**	**428 379**
01 Østfold	22	235 837	12	160 267	3	56 800	7	18 770
02 Akershus	36	414 363	22	277 036	3	112 766	11	24 561
03 Oslo	1	505 000	1	505 000	-	-	-	-
04 Hedmark	105	152 512	12	73 576	10	103 008	83	75 928
05 Oppland	77	118 212	22	65 625	8	3 500	47	78 866
06 Buskerud	70	220 445	20	141 489	1	90	49	78 866
07 Vestfold	41	191 100	16	184 877	-	-	25	6 223
08 Telemark	67	141 472	26	110 381	7	14 642	34	16 449
09 Aust-Agder	35	80 425	19	71 940	6	3 000	10	5 485
10 Vest-Agder	45	128 823	20	109 785	4	516	21	18 522
11 Rogaland	53	327 368	36	321 768	5	582	12	5 018
12 Hordaland	172	363 331	99	314 024	41	32 640	32	16 667
14 Sogn og Fjordane	107	78 950	43	49 685	41	16 177	23	13 088
15 Møre og Romsdal	160	208 636	57	162 858	61	29 458	42	16 320
16 Sør-Trøndelag	118	245 518	63	225 467	16	3 336	39	16 715
17 Nord-Trøndelag	79	104 627	42	95 194	8	1 960	29	7 473
18 Nordland	216	208 542	89	161 009	94	42 100	33	5 434
19 Troms	132	134 098	30	94 887	87	33 720	15	5 491
20 Finnmark	84	67 532	39	30 052	27	18 977	18	18 503
21 Svalbard[2]	-	-	1	1 125	1	225	-	-

[1]Including two water works supplying 140 persons from sea water in Nordland county. [2]One water works in Svalbard has two main water sources of different types. [3]The table contains information from 1578 water works. As some water works use several sources of water of different types, the total figure given in the table is higher than 1578.
Source: National Institute of Public Health.

Table H.2 Inputs of phosphorus and nitrogen to the North Sea from Norway. Tonnes

	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Phosphorus (P)											
Total inputs	4 809	3 958	3 988	3 919	3 973	3 855	3 697	3 639	3 447	7 677	7 572
- of which, anthropogenic[1]	3 563	2 711	2 742	2 673	2 727	2 609	2 450	2 392	2 200	6 431	6 326
Agriculture	744	719	713	697	677	664	659	662	662	663	662
Municipal waste water	2 490	1 728	1 794	1 753	1 745	1 713	1 562	1 489	1 281	1 310	1 201
Industry	600	464	464	464	304	230	229	240	257	233	245
Aquaculture[2]	..	..	..	..	..	..	..	..	..	4 225	4 217
Background runoff	1 246	1 246	1 246	1 246	1 246	1 246	1 246	1 246	1 246	1 246	1 246
Nitrogen(N)											
Total inputs	101 680	101 599	101 450	100 065	101 680	101 599	101 050	101 450	100 065	117 933	117 942
-of which, anthropogenic[1]	46 664	46 584	46 435	45 049	46 664	46 584	46 034	46 435	45 049	62 918	62 927
Agriculture	22 470	22 020	21 992	21 992	22 470	22 020	21 959	21 992	21 992	21 992	21 992
Municipal waste water	20 788	21 503	22 768	22 485	21 253	21 358	20 855	20 534	18 495	18 265	17 383
Industry	2 939	3 205	3 908	4 562	2 939	3 205	3 220	3 908	4 562	2 375	3 371
Aquaculture[2]	..	..	..	..	..	..	..	..	..	20 286	20 180
Background runoff	55 016	55 016	55 016	55 016	55 016	55 016	55 016	55 016	55 016	55 016	55 016

[1]Anthropogenic sources are agriculture, municipal waste water and industry. [2]Inputs from aquaculture are not calculated before 1998.
Source: Norwegian Institute for Water Research(NIVA).

Table H.3 Inputs of phosphorus and nitrogen to the North Sea from Norway. Tonnes

	1985	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Phosphorus (P)											
Total inputs	1 519	1 280	1 228	1 100	1 088	1 019	962	962	948	975	907
of which, anthropogenic[1]	1 154	915	863	735	723	654	597	597	583	610	542
Agriculture	290	266	259	246	223	214	211	214	214	214	214
Municipal waste water	731	541	501	396	390	364	307	301	289	282	239
Industry	133	108	103	93	110	76	79	82	80	105	83
Aquaculture[2]	..	..	..	..	..	..	..	..	..	9	7
Background runoff	365	365	365	365	365	365	365	365	365	365	365
Nitrogen(N)											
Total inputs	44 756	40 756	40 253	39 389	38 456	38 360	38 242	38 314	37 545	37 180	36 599
of which, anthropogenic[1]	28 201	24 201	23 698	22 834	21 901	21 805	21 687	21 759	20 990	20 625	20 044
Agriculture	12 640	12 029	11 769	11 406	10 720	10 267	10 245	10 289	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	8 213
Industry	5 659	2 392	2 214	1 793	1 703	1 769	1 911	2 068	1 866	1 660	1 450
Aquaculture[2]	..	..	..	..	..	..	..	..	..	49	34
Background runoff	16 555	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 are not calculated before 1998.
Source: Norwegian Institute for Water Research(NIVA).

Table H.4 Waste water treatment. Hydraulic capacity (pe) and number of plants by size categories and treatment methods. 1999

Treatment method	Total	Size by hydraulic capacity (PE)					
		50- 99	100- 499	500- 1999	2000- 9999	10000- 49999	50000-
Total PE	**6 250**	**52**	**334**	**550**	**1 148**	**1 478**	**2 688**
Chemical/biological	1 575	2	32	109	133	104	1 195
Chemical	2 189	2	10	64	308	756	1 049
Biological	72	2	12	31	10	17	-
Other/unknown	130	16	48	15	36	15	-
Mechanical	1 743	25	177	211	423	523	384
Untreated	541	5	55	120	238	63	60
Number of plants, total.	**3 415**	**777**	**1 635**	**610**	**295**	**78**	**20**
Chemical/biological	323	25	127	124	37	6	4
Chemical	251	25	39	66	72	38	11
Biological	125	25	61	35	3	1	-
Other/unknown	538	240	270	18	9	1	-
Mechanical	1 634	384	870	234	114	28	4
Untreated	544	78	268	133	60	4	1

Source: Waste water treatment statistics from Statistics Norway.

Table H.5 Hydraulic capacity by type of plant and per capita hydraulic capacity. By county. 1999

	Hydraulic capacity							Proportion		
	Total	Chemical	Biological	Chemical/ biological	Mechanical	Untreated discharges	Other	High-grade[1]	Other type[2]	Per capita capacity
	1000 PE							Per cent		PE
Whole country (01-20)	**6 250,0**	**2 188,7**	**71,9**	**1 575,0**	**1 743,7**	**541,4**	**129,3**	**61**	**39**	**1,41**
North Sea counties (01-10)	3 431,7	1 649,3	37,4	1 477,5	175,0	14,7	77,8	92	8	1,40
Rest of country (11-20)	2 818,3	539,4	34,6	97,5	1 568,7	526,7	51,5	24	76	1,41
01 Østfold	356,1	328,5	0,5	23,1	0,9	0,1	2,9	99	1	1,45
02/03 Oslo og Akershus	1 371,0	269,7	0,2	1 099,7	0,0	0,0	1,4	100	0	1,42
04 Hedmark	215,1	80,6	0,9	108,3	0,0	0,0	25,3	88	12	1,15
05 Oppland	275,6	84,6	0,0	173,1	1,0	0,0	16,9	94	6	1,51
06 Buskerud	326,6	274,7	0,4	29,6	1,1	0,0	20,7	93	7	1,39
07 Vestfold	266,8	209,5	0,0	14,5	42,6	0,0	0,2	84	16	1,27
08 Telemark	251,0	214,3	11,7	13,0	6,4	0,0	5,6	95	5	1,53
09 Aust-Agder	149,1	34,3	22,0	8,0	82,3	0,0	2,6	43	57	1,47
10 Vest-Agder	220,5	153,1	1,7	8,2	40,6	14,6	2,3	74	26	1,43
11 Rogaland	557,0	283,0	2,1	1,4	229,1	20,0	21,5	51	49	1,51
12 Hordaland	522,8	66,5	2,8	25,3	390,9	35,9	1,4	18	82	1,21
14 Sogn og Fjordane	117,0	0,2	3,8	4,5	81,0	24,9	2,6	7	93	1,09
15 Møre og Romsdal	384,6	20,0	0,7	2,8	198,8	159,3	2,9	6	94	1,59
16 Sør-Trøndelag	389,6	138,3	4,4	19,7	206,6	17,3	3,2	42	58	1,49
17 Nord-Trøndelag	184,8	22,2	12,0	14,5	129,1	3,2	3,8	26	74	1,46
18 Nordland	341,7	2,6	7,4	2,1	208,7	118,0	3,1	4	96	1,43
19 Troms	211,6	4,6	1,1	15,7	96,6	83,9	9,7	10	90	1,41
20 Finnmark	109,1	2,1	0,1	11,5	27,8	64,3	3,2	13	87	1,47

[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 discharged.
Source: Waste water treatment statistics from Statistics Norway.

Table H.6 Quantities of phosphorus and nitrogen discharged and removed from waste water at waste water treatment plants. Calculated treatment efficiency. By county. 1999

	Discharged from plants		Removed from waste water		Calculated treatment efficiency	
	Phosphorus	Nitrogen	Phosphorus	Nitrogen	Phosphorus	Nitrogen
	Tonnes		Tonnes		Per cent	
Whole country (01-20)	**836**	**13 494**	**1 848**	**4 306**	**69**	**24**
North Sea counties (01-10)	120	6 942	1 574	3 268	93	32
Rest of country (11-20)	717	6 553	275	1 038	28	14
01 Østfold	14	761	382	211	96	22
02/03 Akershus and Oslo	30	2 740	670	2 152	96	44
04 Hedmark	7	503	94	161	93	24
05 Oppland	5	496	85	202	94	29
06 Buskerud	9	602	103	191	92	24
07 Vestfold	14	655	89	108	86	14
08 Telemark	9	518	74	84	89	14
09 Aust-Agder	17	255	25	88	60	26
10 Vest-Agder	15	413	53	72	78	15
11 Rogaland	82	1 033	74	202	47	16
12 Hordaland	149	1 392	53	253	26	15
14 Sogn og Fjordane	40	313	7	43	15	12
15 Møre og Romsdal	105	832	25	83	19	9
16 Sør-Trøndelag	88	952	55	185	38	16
17 Nord-Trøndelag	44	405	27	81	38	17
18 Nordland	100	773	18	110	15	12
19 Troms	66	505	10	55	13	10
20 Finnmark	42	346	7	24	15	6

Source: Waste water treatment statistics from Statistics Norway

Table H.7 Connection to municipal and separate waste water treatment plants, and the proportion connected. County. 1999

	Connected to municipal waste water treatment plants	Connected to seperate waste water treatnment plants	Proportion connected to municipal waste water treatment plants
	Total number of people		Per cent
Whole country (01-20)	**3 561 353**	**895 272**	**80**
North Sea counties (01-10)	2 043 289	405 133	83
Rest of country (11-20)	1 518 064	490 139	76
01 Østfold	210 526	34 455	86
02/03 Akershus and Oslo	913 513	54 440	95
04 Hedmark	122 580	76 418	62
05 Oppland	108 841	70 137	61
06 Buskerud	180 459	46 052	80
07 Vestfold	179 406	42 725	81
08 Telemark	127 296	34 123	79
09 Aust-Agder	75 067	22 532	77
10 Vest-Agder	125 601	24 252	84
11 Rogaland	314 959	44 635	88
12 Hordaland	333 336	111 405	75
14 Sogn og Fjordane	61 054	40 419	60
15 Møre og Romsdal	173 094	71 421	71
16 Sør-Trøndelag	206 213	54 903	79
17 Nord-Trøndelag	92 580	32 395	74
18 Nordland	170 980	68 614	71
19 Troms	105 002	51 104	67
20 Finnmark	60 846	15 243	80

Source: Waste water treatment statistics from Statistics Norway.

Table H.8 Number of separate waste water treatment plants (scattered settlements). County. 1999

	Total	Type of plant							
		Untreated discharges	Sludge separator	Mini wwtp with precipitation	Mini wwtp without precipitation	Infiltration	Sandfilter	Separate toilet systems	Sealed tank
Whole country (01-20)	**351 750**	**22 789**	**155 643**	**1 130**	**3 353**	**114 219**	**34 604**	**14 614**	**5 398**
North Sea counties (01-10)	160 736	5 648	49 537	582	2 349	73 257	13 471	11 476	4 416
Rest of country (11-20)	191 014	17 141	106 106	548	1 004	40 962	21 133	3 138	982
01 Østfold	13 677	370	7 665	71	462	475	1 833	2 484	317
02/03 Akershus and Oslo	22 097	1 843	9 631	244	1 001	4 911	2 701	500	1 266
04 Hedmark	30 505	341	5 612	37	187	18 714	2 017	3 430	167
05 Oppland	27 580	174	1 974	9	18	22 253	362	2 512	278
06 Buskerud	18 124	402	4 263	37	146	10 040	1 432	888	916
07 Vestfold	17 126	1 634	11 259	139	243	1 702	1 192	347	610
08 Telemark	13 518	188	5 083	17	65	5 341	2 300	78	446
09 Aust-Agder	8 811	532	2 111	13	125	4 574	1 104	187	165
10 Vest-Agder	9 298	164	1 939	15	102	5 247	530	1 050	251
11 Rogaland	17 259	773	11 426	70	164	3 079	1 263	333	151
12 Hordaland	43 694	1 562	24 555	87	623	8 880	7 626	196	165
14 Sogn og Fjordane	16 029	1 114	5 633	22	3	7 184	2 061	-	12
15 Møre og Romsdal	27 232	4 141	16 491	7	20	2 585	2 184	1 616	188
16 Sør-Trøndelag	20 194	1 338	8 354	80	81	6 201	3 306	739	95
17 Nord-Trøndelag	12 742	892	5 852	231	94	1 647	3 555	193	278
18 Nordland	26 731	3 967	17 702	50	15	3 745	1 116	47	89
19 Troms	21 132	2 478	15 173	-	1	3 452	14	14	-
20 Finnmark	6 001	876	920	1	3	4 189	8	-	4

Source: Waste water treatment statistics from Statistics Norway.

Table H.9 Gross investments in the municipal waste water sector, type of investment. County. 1999. 1000 NOK

	Total	Investments (reported)			Estimated investments[1]
		Sewage system (pipes)	Plants without nitrogen removal	Plants with nitrogen removal	
Whole country (01-20)	**1 923 701**	**1 334 587**	**413 592**	**175 522**	**39 251**
North Sea counties (01-10)	1 085 952	709 871	200 612	175 469	18 444
Rest of country (11-20)	837 749	624 716	212 980	53	20 807
01 Østfold	103 299	96 942	6 357	0	5 277
02 Akershus	189 164	177 026	12 138	0	0
03 Oslo	255 904	78 131	2 304	175 469	0
04 Hedmark	55 466	47 864	7 602	0	0
05 Oppland	69 193	37 647	31 546	0	13 094
06 Buskerud	58 800	52 420	6 380	0	0
07 Vestfold	134 551	60 728	73 823	0	73
08 Telemark	67 011	51 879	15 132	0	0
09 Aust-Agder	60 140	53 452	6 688	0	0
10 Vest-Agder	92 424	53 782	38 642	0	0
11 Rogaland	126 095	123 410	2 685	0	0
12 Hordaland	191 928	142 237	49 691	0	0
14 Sogn og Fjordane	29 983	19 587	10 396	0	16
15 Møre og Romsdal	77 694	62 528	15 113	53	0
16 Sør-Trøndelag	99 917	53 813	46 104	0	0
17 Nord-Trøndelag	107 185	47 143	60 042	0	0
18 Nordland	111 598	98 524	13 074	0	20 463
19 Troms	71 912	61 168	10 744	0	0
20 Finnmark	21 437	16 306	5 131	0	328

[1]For municipalities that have not reported investment data, investments have been estimated from previous years' reported investments. These estimates have not been calculated for each type of investment, but only as a total figure for the wastewater sector.
Source: Waste water treatment statistics from Statistics Norway.

Table H.10 Total fees collected and annual costs. Ratio between fees and annual costs in the municipalities (income-to-cost ratio). By county. 1999

	Fees collected[1]	Annual costs[1]	Income-to-cost ratio[2]
	Million NOK		Per cent
Whole country (01-20)	**3 659**	**3 904**	**94**
North Sea counties (01-10)	2 376	2 524	94
Rest of country (11-20)	1 283	1 380	93
01 Østfold	260	285	91
02 Akershus	424	472	90
03 Oslo	574	471	122
04 Hedmark	158	188	84
05 Oppland	172	208	83
06 Buskerud	212	239	89
07 Vestfold	194	196	99
08 Telemark	154	163	95
09 Aust-Agder	95	128	74
10 Vest-Agder	134	175	76
11 Rogaland	251	297	85
12 Hordaland	309	317	98
14 Sogn og Fjordane	51	57	89
15 Møre og Romsdal	128	145	88
16 Sør-Trøndelag	179	181	99
17 Nord-Trøndelag	93	114	81
18 Nordland	127	137	93
19 Troms	104	93	112
20 Finnmark	41	40	102

[1]Figures are estimated for municipalities that did not report maintenance, running and overhead costs or fee income. [2]In calculating mean value for the county as a whole, municipalities are weighted according to their fee income and annual costs.
Source: Waste water treatment statistics from Statistics Norway.

Table H.11 Annual costs per subscriber and average fees quoted by municipality. By county. Current NOK

	Connection fee				Annual fee per 140 m² dwelling				Annual costs per subscriber[1, 2]
	1995	1998	1999	2000	1995	1998	1999	2000	1999
Whole country (01-20)	**10 661**	**11 668**	**12 217**	**12 729**	**1 463**	**1 765**	**1 935**	**2 069**	**2 427**
North Sea counties (01-10)	13 550	14 776	15 717	16 519	2 021	2 343	2 537	2 723	2 788
Rest of country (11-20)	8 730	9 781	9 897	10 226	1 116	1 389	1 536	1 646	1 961
01 Østfold	7 450	8 248	8 252	10 623	1 979	2 576	2 706	2 782	3 305
02 Akershus	17 192	25 809	20 786	23 218	2 195	2 410	2 442	2 628	2 764
03 Oslo	3 570	26 117	32 893	32 893	1 080	1 877	2 066	2 066	1 798
04 Hedmark	13 315	19 147	18 539	17 925	2 485	2 449	2 684	2 895	3 136
05 Oppland	18 151	22 853	23 895	25 015	2 085	2 447	2 726	2 936	3 632
06 Buskerud	11 780	9 642	11 584	11 858	2 462	2 316	2 497	2 791	3 399
07 Vestfold	16 618	20 286	21 094	22 033	1 496	2 023	2 163	2 327	2 717
08 Telemark	8 058	6 146	5 948	6 013	2 002	2 567	2 747	2 812	3 176
09 Aust-Agder	12 372	12 204	12 866	12 549	1 692	2 041	2 393	2 524	4 475
10 Vest-Agder	15 512	12 371	12 769	13 477	1 596	2 094	2 351	2 638	3 737
11 Rogaland	10 951	11 024	11 359	11 649	944	1 281	1 386	1 422	1 959
12 Hordaland	8 495	11 132	11 590	12 137	990	1 284	1 442	1 589	2 039
14 Sogn og Fjordane	11 556	11 954	11 946	11 928	1 179	1 460	1 584	1 752	2 166
15 Møre og Romsdal	8 926	9 247	10 084	10 342	1 025	1 299	1 406	1 491	1 939
16 Sør-Trøndelag	11 810	13 074	12 299	13 163	1 390	1 664	1 856	1 989	1 715
17 Nord-Trøndelag	7 588	10 734	10 867	10 476	1 690	1 953	2 181	2 413	2 668
18 Nordland	5 898	7 837	7 816	8 460	951	1 324	1 470	1 490	2 009
19 Troms	4 198	4 573	4 786	5 285	848	1 101	1 240	1 385	1 789
20 Finnmark	12 588	9 239	8 847	8 808	1 309	1 261	1 363	1 506	1 462

[1]Figures are estimated for municipalities that din not provide reports. [2]In calculating mean value for the county as a whole, municipalities are weighted according to their fee income and annual costs.
Source: Waste water treatment statistics from Statistics Norway.

Land use

Appendix I

Table I.1 Urban settlements, area and residents. Counties 1999

	Residents in counties total	Of which residents in urban settlements	Presentage of residents living in urban settlements	Total area in counties	Of which in urban settlement area	Presentage of area in urban settlements
	Number		Per cent	km²		Per cent
Whole country	**4 445 329**	**3 304 352**	**74,3**	**306 253**	**2 084,1**	**0,7**
01 Østfold	246 018	200 009	81,3	3 889	138,7	3,6
02 Akershus	460 564	399 029	86,6	4 587	235,1	5,1
03 Oslo	502 867	499 174	99,3	427	131,8	30,9
04 Hedmark	186 321	95 190	51,1	26 120	93,9	0,4
05 Oppland	182 239	91 765	50,4	23 827	94,6	0,4
06 Buskerud	235 018	172 270	73,3	13 856	130,9	0,9
07 Vestfold	210 707	172 900	82,1	2 140	120,2	5,6
08 Telemark	164 523	119 356	72,5	14 186	92,7	0,7
09 Aust-Agder	101 487	64 675	63,7	8 485	59,0	0,7
10 Vest-Agder	153 998	115 934	75,3	6 817	75,4	1,1
11 Rogaland	369 059	294 981	79,9	8 553	167,2	2,0
12 Hordaland	431 882	320 977	74,3	14 962	197,2	1,3
14 Sogn og Fjordane	107 648	52 136	48,4	17 864	48,5	0,3
15 Møre og Romsdal	242 538	154 488	63,7	14 596	127,0	0,9
16 Sør-Trøndelag	260 855	189 837	72,8	17 839	108,1	0,6
17 Nord-Trøndelag	126 797	65 423	51,6	20 777	55,5	0,3
18 Nordland	238 547	148 755	62,4	36 434	108,5	0,3
19 Troms	150 200	94 475	62,9	25 015	62,0	0,2
20 Finnmark	74 061	52 978	71,5	45 879	37,9	0,1

Source: Land Use Statistics, Statistics Norway.

Table I.2 Residents in urban settlements 1999. Urban settlement area 1990 and 1999. Urban settlements with at least 20 000 residents

	1999			1990	
	Residents in urban settlements	Urban settlement area	Of which base area of buildings	Urban settlement area	Of which base area of buildings
	Number	km²		km²	
All urban settlements	**3 304 352**	**2 084,3**	**159,8**	**:**	**:**
Oslo	763 957	265,8	26,6	250,9	23,1
Bergen	203 383	84,7	8,9	78,1	7,9
Stavanger/Sandnes	142 937	62,2	7,1	57,9	5,8
Trondheim	138 538	57,8	4,4	55,1	3,8
Fredrikstad/Sarpsborg	91 749	61,9	5,4	56,6	4,8
Drammen	82 955	45,9	3,8	40,8	3,1
Porsgrunn/Skien	82 612	52,6	3,6	50,5	3,3
Kristiansand	60 350	28,9	2,5	25,9	2,2
Tromsø	48 179	20,9	1,8	16,5	1,4
Tønsberg	42 702	29,2	2,3	27,7	2,0
Haugesund	38 224	21,4	1,9	19,0	1,6
Sandefjord	36 527	24,3	1,6	22,1	1,4
Ålesund/Spjelkavik	35 037	20,9	1,8	19,7	1,6
Moss	32 335	15,8	1,3	15,2	1,1
Bodø	30 452	13,0	1,2	11,8	0,9
Arendal	29 798	23,8	1,5	21,5	1,3
Hamar	27 234	16,3	1,7	15,7	1,5
Larvik	21 940	13,0	1,3	12,0	1,1
Halden	21 074	12,5	1,0	11,9	0,9

Source: Land Use Statistics, Statistics Norway.

Table I.3 Indicators for sustainable land use in urban settlements. Settlements with at least 20 000 residents. 1999*

	Residents in urban settlements	Urban settlement area	Residents per km² of urban settlement area	Urban settlement area per resident	Road area per resident[2]	Base area of dwellings per resident[1]	Percentage of urban settlement residents living in centre-areas
	Number	km²	Number	m²	m²	m²	Per cent
Oslo	763 957	265,8	2 874	347,9	43,9	18,7	16,6
Bergen	203 383	84,7	2 400	416,5	74,3	22,7	6,9
Stavanger/Sandnes	142 937	62,2	2 299	435,2	69,3	23,5	3,9
Trondheim	138 538	57,8	2 396	417,2	49,7	17,5	2,8
Fredrikstad/Sarpsborg	91 749	61,9	1 483	674,7	100,3	27,5	4,1
Drammen	82 955	45,9	1 809	553,3	90,2	23,6	3,6
Porsgrunn/Skien	82 612	52,6	1 571	636,7	92,6	26,2	2,4
Kristiansand	60 350	28,9	2 121	478,9	76,9	23,6	5,9
Tromsø	48 179	20,9	2 310	433,8	72,7	18,1	3,3
Tønsberg	42 702	29,2	1 463	683,8	103,1	28,6	4,2
Haugesund	38 224	21,4	1 788	559,9	104,1	25,3	3,8
Sandefjord	36 527	24,3	1 503	665,3	101,5	24,7	3,6
Ålesund/Spjelkavik	35 037	20,9	1 675	596,5	92,6	24,6	7,6
Moss	32 335	15,8	2 040	488,6	72,4	20,0	3,8
Bodø	30 452	13,0	2 349	426,9	76,6	19,9	4,6
Arendal	29 798	23,8	1 251	798,7	113,1	28,0	3,8
Hamar	27 234	16,3	1 676	598,5	103,9	29,2	5,0
Larvik	21 940	13,0	1 691	592,5	100,0	27,6	6,3
Halden	21 074	12,5	1 690	593,1	97,1	26,5	5,9

[1]Base area of buildings estimated based on the GAB-register. [2]Road width: main roads 15 m, Ccounty roads 13,5 m, municipal roads 11 m, private roads 10 m.
Source: Land Use Statistics, Statistics Norway.

Table I.4 Land use in urban settlements with at least 20 000 residents. 1999*. Per cent

	Dwellings, holyday homes and mixed use	Transport	Commercial, public-administration and services	Institution	Industry and storehouses	Sports facilities	Other buildings n.e.s	Not classified/ open areas	Water
Oslo	31,2	13,9	8,8	2,6	1,8	1,5	2,3	37,2	0,8
Bergen	36,6	18,2	6,3	1,7	1,8	0,8	14,6	18,3	1,8
Stavanger/Sandnes	45,5	16,5	9,9	2,7	3,8	1,3	4,2	15,1	0,9
Trondheim	33,3	12,9	7,2	1,9	1,1	0,7	0,6	40,5	1,7
Fredrikstad/Sarpsborg	30,7	15,6	6,6	1,7	5,5	1,3	1,4	34,6	2,6
Drammen	35,1	17,6	6,0	1,3	3,5	1,1	0,9	33,1	1,3
Porsgrunn/Skien	32,3	14,7	4,4	1,7	2,0	1,4	1,2	37,8	4,5
Kristiansand	39,2	16,2	8,9	2,9	2,4	1,2	1,4	26,4	1,3
Tromsø	35,6	17,3	9,9	4,4	2,4	0,5	1,3	28,0	0,5
Tønsberg	32,2	15,5	4,3	1,8	1,4	0,9	1,4	42,3	0,1
Haugesund	35,8	18,8	10,0	2,4	3,6	1,3	1,0	26,9	0,3
Sandefjord	28,2	15,6	3,2	1,0	1,6	0,8	0,8	48,5	0,3
Ålesund/Spjelkavik	31,6	15,8	6,9	1,6	5,4	1,2	2,3	34,2	0,9
Moss	33,1	15,5	6,3	1,7	2,8	1,1	0,6	38,2	0,7
Bodø	38,3	19,1	8,3	2,5	2,1	0,9	1,1	27,7	0,0
Arendal	31,1	14,3	6,0	2,0	2,0	0,8	0,7	42,5	0,6
Hamar	34,5	18,6	7,8	5,0	3,7	1,4	1,1	27,5	0,3
Larvik	35,4	17,6	9,3	2,2	7,8	2,3	1,8	23,3	0,4
Halden	35,0	16,9	4,2	1,2	2,6	0,7	1,6	37,1	0,7

Source: Land Use Statistics, Statistics Norway.

Publications by Statistics Norway in 2000 and 2001 concerning natural resources and the environment

Official Statistics of Norway (NOS)

C 557 Transport and Communication Statistics 1998.

C 560 Agricultural Statistics 1998.

C 580 Oil and Gas Activity, 3rd Quarter 1999. Statistics and Analysis.

C 582 Maritime Statistics 1998.

C 584 Forestry Statistics 1997.

C 592 Oil and Gas Activity, 4th Quarter 1999. Statistics and Analysis.

C 595 Energy Statistics 1998.

C 600 Statistical Yearbook of Norway 2000.

C 601 Electricity Statistics 1997.

C 605 Oil and Gas Activity, 1st Quarter 2000. Statistics and Analysis.

C 608 Salmon and Sea Trout Fisheries 1999.

C 609 Fish Farming 1998.

C 612 Forestry Statistics 1998.

C 615 Oil and Gas Activity, 2nd Quarter 2000. Statistics and Analysis.

C 618 Hunting Statistics 1999.

C 619 Electricity Statistics 1998.

C 623 Fishery Statistics 1996–1997.

C 625 Waste Statistics. Municipal Waste 1998.

C 628 Transport and Communication Statistics 1999.

C 633 Maritime Statistics 1999.

C 642 Agricultural Statistics 1999.

C 647 Oil and Gas Activity, 3rd Quarter 2000. Statistics and Analysis.

C 648 Forestry Statistics 1999.

C 651 Oil and Gas Activity, 4th Quarter 2000. Statistics and Analysis.

Reports (RAPP)

00/1 Flugsrud, K., E. Gjerald, G. Haakonsen, S. Holtskog, H. Høie, K. Rypdal, B. Tornsjø and F. Weidemann: The Norwegian Emission Inventory. Documentation of methodology and data for estimating emissions of greenhouse gases and long-range transboundary air pollutants.

00/2 Skullerud, Ø.: Avfallsregnskap for Norge - Metoder og foreløpige resultater for metaller (Waste accounts for Norway. Methods and preliminary results for metals).

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00/12 Frøyen, B.K. and Ø. Skullerud: Avfallsregnskap for Norge. Metoder og resultater for treavfall (Waste accounts for Norway. Methods and results for wood waste).

00/13 Rypdal, K. and L.-C. Zhang: Uncertainties in the Norwegian Greenhouse Gas Emission Inventory.

00/15 Skullerud, Ø. and S.E. Stave: Avfallsregnskap for Norge. Metoder og resultater for plast (Waste accounts for Norway. Methods and results for plastics).

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Economic Survey (ES)
(English version)

1/00 Economic Survey 1999.

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«Today"s statistics»

06.01.00 Utslipp til luft. Endelige tall 1997 og foreløpige tall 1998: CO_2-utslippene øker fortsatt. (Emissions to air. Final figures for 1997 and preliminary figures for 1998: CO_2 emissions still rising.)

06.01.00 Utslipp til luft, kommunetall 1997: Biler og vedfyring forurenser mest. (Emissions to air, municipal figures 1997. Cars and fuelwood use pollute most.)

12.03.00 Avfallsregnskap for tre, foreløpige tall 1997: 80 prosent gjenvinnes eller energiutnyttes. (Waste accounts for wood. Preliminary figures for 1997: 80 per cent recycled or used for energy recovery.)

17.03.00 Utslipp av NO_X , NH_3 og NMVOC. Foreløpige tall, 1999: Utslippsmål for NO_X og NMVOC ikke innfridd i 1999. (Emissions of NO_x, NH_3 and NMVOCs. Preliminary figures, 1999. Emission targets for NO_x and NMVOCs not achieved in 1999.)

17.03.00 Utslipp av klimagasser. Foreløpige tall, 1999: Fortsatt økning i klimagassutslippene. (Emissions of greenhouse gases. Preliminary figures, 1999. Continued rise in greenhouse gas emissions.)

17.03.00 Energibalanse for Norge. Foreløpige tall, 1999: Moderat økning i energiforbruket i 1999. (Energy balance for Norway. Preliminary figures, 1999. Moderate rise in energy use in 1999.)

15.05.00 Naturressurser og miljø 2000: Ikke entydig miljøutvikling. (Natural Resources and the Environment 2000. A mixed picture of environmental developments.)

29.05.00 Avfallsregnskap for glass, 1993–1998: 26 prosent av glasset gjenvinnes. (Waste accounts for glass, 1993-1998: 26 per cent is recycled.)

16.06.00 Utslipp til luft, 1997. Reviderte kommunetall: Reviderte tall for utslipp til luft. (Emissions to air, 1997. Revised figures for municipalities.)

19.06.00 Naturressurser og miljø 2000: Formidabel økning i veitransporten. (Natural Resources and the Environment 2000. Formidable increase in road transport.)

26.06.00 Utslipp til luft. Svoveldioksid. Foreløpige tall: Svovelutslipp fortsetter å minke. (Emissions to air. Sulphur dioxide. Preliminary figures: emissions are continuing to drop.)

26.06.00 Avfallsregnskap for tre. Revidert utgave, 1990–1997: 75 prosent gjenvinnes eller energiutnyttes. (Waste accounts for wood. Revised edition, 1990-1997: 75 per cent is recycled or used for energy recovery.)

28.06.00 Kommunalt avfall, 1999: Kvar nordmann sorterte 118 kilo avfall. (Municipal waste, 1999: each Norwegian sorted 118 kg of waste.)

11.07.00 Naturressurser og miljø 2000: Har høyere gebyrer gitt bedre avløpsrensing? (Natural Resources and the Environment 2000. Have higher fees improved waste water treatment?)

12.07.00 Jordbruk og miljø, 1999: Tek jordbruket miljøansvar? (Agriculture and environment, 1999: is the agricultural sector taking responsibility for the environment?)

19.07.00 Naturressurser og miljø 2000: Blir Kyoto-kravene oppfylt? (Natural Resources and the Environment 2000. Will the requirements of the Kyoto Protocol be met?)

24.07.00 Naturressurser og miljø 2000: Hvor viktige er naturressursbaserte næringer for norsk økonomi? (Natural Resources and the Environment 2000. How important are natural-resource based industries for the Norwegian economy?)

03.08.00 Naturressurser og miljø 2000: Tre av fire bor i tettsted. (Natural Resources and the Environment 2000. Three out of four Norwegians live in urban settlements.)

21.08.00 Emballasjeavfall, 1998: Stadig mer emballasje. (Packaging waste, 1998: more and more waste is being generated.)

27.09.00 Kommunalt avløp, 1999. Anlegg og hydraulisk kapasitet: Nærare 2 900 avløpsreinseanlegg. (Municipal waste water, 1999. Treatment plants and hydraulic capacity: Norway has almost 2 900 waste water treatment plants.)

02.10.00 Avfallsregnskap for plast, 1986–1997: Jevn økning av plastavfall på 1990-tallet. (Waste accounts for plastic, 1986-1997: steady growth in quantities of plastic waste in the 1990s.)

03.10.00 Kommunalt avløp, 1999. Utslepp, reinsing og slamdisponering: Lågast utslepp på Sør- og Austlandet. (Municipal waste water, 1999. Discharges, treatment and disposal of sewage sludge. Discharges are lowest in Eastern and Southern Norway.)

03.10.00 Kommunalt avløp, 1999. Økonomi: Gebyrsatsene øker mindre enn kostnadene. (Municipal waste water, 1999. Economy: fees are rising more slowly than costs.)

27.10.00 Avfallsregnskap for våtorganisk avfall, 1993-1998: Mer kompost, mindre på fyllinga. (Waste accounts for wet organic waste, 1993-1998: more compost, less land-filling.)

12.12.00 Avfallsregnskap for tekstiler, 1998: Vi kaster mer klær. (Waste accounts for textiles, 1998: we are throwing away more clothes.)

18.12.00 Befolkning og areal i tettsteder. Reviderte tall, 1. januar 1999: En av fire bor i de fire største tettstedene. (Population and land use in urban settlements. Revised figures, 1 January 1999: one in four Norwegians lives in the four largest towns.)

09.01.01 Energibalanse og energiregnskap 1998 og 1999: Økt energiproduksjon i 1999. (Energy balance and energy accounts 1998 and 1999: higher energy production in 1999.)

13.02.01 Utslipp til luft, 1990-1998 (endelige tall) og 1999 (foreløpige tall): Miljøgiftutslipp høyere enn antatt. (Emissions to air, 1990-1998 (final figures) and 1999 (preliminary figures): emissions of hazardous substances higher than assumed.)

13.02.01 Utslipp til luft, 1998. Kommunetall: Utslippstall for din kommune. (Emissions to air, 1998. Emission figures for your municipality.)

14.02.01 Avfall fra tjenesteytende næringer. Varehandelen, 1999: Mye papiravfall fra varehandelen. (Waste from service industries. Wholesale and retail trade,1999: the sector generates a large amount of waste paper.)

19.03.01 Avfall og gjenvinning i industrien, 1999: Mer avfall fra industrien. (Waste and recycling in manufacturing industries, 1999: more waste generated.)

21.03.01 Energibalanse. Foreløpige tall, 1999 og 2000: Betydelig økt energiproduksjon i 2000. (Energy balance. Preliminary figures for 1999 and 2000: substantially higher energy production in 2000.)

26.03.01 Utslipp av klimagasser. Foreløpige tall 2000: Klimagassutslippene svakt redusert i 2000. (Greenhouse gas emissions. Preliminary figures for 2000: slight reduction in emissions.)

26.03.01 Utslipp til luft, NMVOC, NO_X og NH_3. Foreløpige tall, 2000: Vil Norge klare forpliktelsene? (Emissions to air of NMVOCs, NO_x and NH_3. Preliminary figures for 2000: will Norway be able to meet its commitments?)

03.04.01 Arealbruk i tettsteder, 1. januar 1999: Mest areal til bolig og transport. (Land use in urban settlements, 1 January 1999: housing and transport occupy the largest areas.)

22.05.01 Spesialavfall i industrien, 1999: Mer spesialavfall i industrien. (Hazardous waste from manufacturing industries, 1999: more waste generated.)

29.06.01 Kommunalt avfall, 2000: Meir til gjenvinning enn til fylling. (Municipal waste, 2000: more waste recycled than landfilled.)

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