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Preface

Compiling statistics on natural resources and the environment is an important part of Statistics Norway's work. Statistics Norway also conducts extensive analytical research on the interplay between socio-economic and environmental developments.

It is not possible to include the entire portfolio of environmental statistics in one book, but the annual publication *Natural Resources and the Environment* gives an overview of the most important results. To use a highly topical metaphor, the environmental statistics presented in this publication are only the tip of the iceberg. Much more is to be found in other publications by Statistics Norway, news items and the Statistical Magazine, and in more detail in StatBank Norway.

This year's publication starts by presenting Norway's indicators of sustainable development. This is followed by two parts that take a closer look at trends for important natural resources and pollutants, and a chapter dealing with the links between environment and economy. A separate section presents selected research projects on natural resources and the environment.

The publication was produced by the Division for Environmental Statistics with contributions from the Division for Energy Statistics, the Division for Primary Industry Statistics and the Research Department. The 2008 edition was edited by Henning Høie and Svein Homstvedt, with Lisbet Høgset as editorial secretary. The translation is by Alison Coulthard and Veronica Harrington (parts of Chapter 15).

Natural Resources and the Environment 2008 is also available at http://www.ssb.no/english/subjects/01/sa_nrm/. More detailed information on the topics covered may also be found at http://www.ssb.no/english/subjects/ and in StatBank Norway at http://www.ssb.no/english.

Statistics Norway,
Oslo/Kongsvinger 24 April 2009

Øystein Olsen

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1. Introduction

The state of the environment depends on a complex variety of biological and physical processes, both natural and human-induced. Environmental pressures caused by human activity – our use of natural resources and various types of pollution – are having substantial adverse impacts on the world as a whole and on the local environment. Technological advances have improved our ability to limit many of the negative effects of our own activities, but economic growth and the accompanying rise in consumption are putting increasing pressure on natural resources and the environment. Issues relating to the environment and natural resources are constantly in the headlines and in focus in the public debate.

The most important task in the field of environmental statistics is to compile statistics that describe the state of the environment and environmental pressures in a way that clearly illustrates the most important linkages between them. In this publication, Statistics Norway gives an overview of the pressures and impacts on Norway's natural resources and environment.

In this year's edition, Statistics Norway also presents Norway's updated set of indicators for sustainable development, which is intended to serve as a tool for monitoring whether development is becoming more sustainable over time. In addition to natural resource and environmental issues, a description of sustainability includes important economic and social factors, demonstrating how important it is to consider all these crucial elements in conjunction with each other. The sustainability indicators are also intended to provide warning of changes that may require a political and practical response.

Natural Resources and the Environment starts with a presentation of Norway's national core set of indicators for sustainable development, which include selected indicators (see box 1.1) for the environment, the economy and social conditions (Part 1). Part 2 describes the supply and use of natural resources, while Part 3 focuses on pollution and environmental problems. Part 4 describes the links between environment and economy and gives an overview of environmental protection expenditure in industry in Norway. Part 5 presents results from selected research projects on the environmental and natural resources in Statistics Norway.

The statistics presented in this publication are mainly from Statistics Norway (an overview will be found on our website: http://www.ssb.no/english/subjects/01/miljo_en/), but in some cases we have also used figures from other institutions to give a more complete picture. Much of the information has been taken from the white papers on the government's environmental policy and the state of the environment in Norway or from the Norwegian Pollution Control Authority's website State of the Environment Norway (http://www.environment.no/).

Some of the text is in boxes. This includes information on special topics and lists of definitions, classifications and acts of legislation. Information on projects run by Statistics Norway that are still at the development stage, so that the results presented are preliminary and not yet official statistics, is also given in boxes. This introductory chapter includes two boxes, one about environmental and sustainability indicators, and one on the priority areas of environmental policy.

Each chapter and even separate sections of this book can be read independently. However, we recommend reading the introductory section of each chapter before going on to other sections.

Box 1.1. Indicators

Information on the environment includes a variety of topics, and it can be difficult to interpret overall trends. Indicators or key figures have therefore been developed that give simplified or composite descriptions of phenomena and problems. Because they are simplified, they may illustrate a few aspects of a phenomenon clearly, whereas others are not as well described. To provide valuable information, indicators must be firmly based on statistical data and other environmental information.

Environmental policy focuses mainly on environmental problems that are caused by human activity. For environmental indicators to be adequate and function as effective tools, they must be linked to socio-economic factors. One internationally recognised way of structuring environmental indicators is the **DPSIR** model, which uses the following categories:

• ***D**riving forces*)	These include population growth, economic activity, etc., which lead to
• *environmental **P**ressure*,	such as emissions to air and water and extraction of natural resources. These in turn result in changes in
• *the **S**tate of the environment*,	for example changes in water quality or air quality, which cause
• *environmental **I**mpacts*	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
• ***R**esponse*	to environmental problems, e.g. a CO_2 tax, protection of areas, abatement 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 figures compiled by Statistics Norway are mainly related to driving forces and environmental pressures, and show which types of activities exert most pressure on the environment. These statistics are also linked to economic models, analyses and projections.

Important international reports on environmental indicators and reports on environmental indicators for important sectors are listed in the references at the end of this chapter.

A general overview is provided by *Overview of sustainable development indicators used by national and international agencies* (Hass et al. 2002).

A recent report published by Statistics Norway (Brunvoll et al. 2008a) presents and describes the Norwegian set of indicators for sustainable development and provides supplementary information.

A set of indicators for transport was presented in Brunvoll et al. 2008b).

Box 1.2. Priority areas, goals and indicators in Norwegian environmental policy

A set of priority areas has been established in Norwegian environmental policy, some of which are split into subdivisions:

Priority area 1: Biodiversity and outdoor recreation
- Sustainable use and protection of habitats
- Sustainable use and protection of species, populations and genetic resources
- Alien species and genetically modified organisms
- Outdoor recreation

Priority area 2: Protection and use of the cultural heritage

Priority area 3: Clean waters and a non-toxic environment
- Integrated marine and inland water management
- Eutrophication and sediment deposition
- Oil pollution
- Hazardous substances
- Waste and waste recovery

Priority area 4: A stable climate and clean air
- Climate change
- Depletion of the ozone layer
- Long-range air pollution
- Local air quality
- Noise reduction

Strategic objectives and national targets have been established for each of the priority areas. Progress towards these goals is to be followed using a limited number of indicators. The indicators are intended to provide a representative picture of environmental trends and to identify which factors and sectors of society have an impact on the state of the environment in each priority area, and to document whether Norway is achieving its environmental policy goals. A complete list of priority areas, goals and indicators was published in Report No. 26 (2006-2007) to the Storting.

The national indicators are a key element of the white papers on the Government's environmental policy and the state of the environment in Norway. They are also important in other contexts, for example on the website State of the Environment Norway and in international reporting.

Natural Resources and the Environment 2008 describes environmental pressures in several of the priority areas of environmental policy and presents several of the indicators.

More information: Report No. 26 (2006-2007) to the Storting *The Government's environmental policy and the state of the environment in Norway*.

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Part 1
Aspects of sustainable development

2. Indicators of sustainable development

Sustainable development is intuitively easy to understand, but difficult to put into practice and complicated to evaluate. Norway's economic wealth, including human resources, is increasing, indicating that the Norwegian economy is sustainable. However, projected climate change, pollution by hazardous substances and the high proportion of disability pensioners detract from this picture.

The World Commission on Environment and Development defined sustainable development as "a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs." (WCED 1987). Sustainable development has three pillars – economic, environmental and social – and satisfactory progress must be made in addressing all three of these, throughout the world.

In autumn 2007, the new Norwegian strategy for sustainable development was presented in the 2008 National Budget. It focuses on how Norway can contribute to sustainable development globally and ensure sustainable development at national level. The strategy has seven priority areas, and a core set of indicators has been developed to describe trends within these areas (see Box 2.1). Ideally, the indicator set as a whole should give a picture of whether or not Norway's overall development is sustainable.

Sustainable development is primarily a global goal, and is based on the principle of solidarity between generations and between those who are alive today. This means that we should focus on the world's total resources in the broadest sense, and on how these resources are distributed. In a situation with a steadily growing population (the world population is now around 6.7 billion), rising consumption and pressure on natural resources, wars and conflicts, poverty, and the threat of global climate change that may have major social and environmental impacts, it is difficult to imagine that one country alone can achieve sustainable development, even within its own borders.

This chapter gives a brief description of each of Norway's indicators of sustainable development. More details are provided in Brunvoll et al. 2008).

Box 2.1. Norway's national core set of indicators for sustainable development

Priority areas[1]	Indicators
International cooperation for sustainable development and combating poverty	1. Norwegian official development assistance, in NOK and as percentage of gross national income 2. Imports from least developed countries and from all developing countries
Climate, ozone and long-range air pollution	3. Norwegian emissions of greenhouse gases compared with the Kyoto Protocol target 4. Emissions of NO_x, NH_3, SO_2 and NMVOCs
Biodiversity and cultural heritage	5. Bird population index – population trends for breeding bird species in terrestrial ecosystems 6. Proportion of inland water bodies classified as "clearly not at risk" 7. Proportion of coastal waters classified as "clearly not at risk" 8. Trend in standards of maintenance of protected buildings
Natural resources	9. Energy use per unit of GDP 10. Size of spawning stock of Northeast Arctic cod and Norwegian spring-spawning herring, compared with the precautionary reference points 11. Irreversible losses of biologically productive areas
Hazardous chemicals	12. Potential exposure to hazardous substances
Sustainable economic and social development	13. Net national income per capita by sources of income 14. Trends in income distribution 15. Generational accounts: Need to tighten public sector finances as a share of GDP 16. Population by highest level of educational attainment 17. Disability pensioners and long-term unemployed persons as a percentage of the population 18. Life expectancy at birth

[1] The set of indicators does not cover the priority area "Sami perspectives on environmental and natural resource management" in Norway's strategy for sustainable development.
Source: Report No. 1 (2007–2008) to the Storting: National Budget 2008.

2.1. The set of indicators

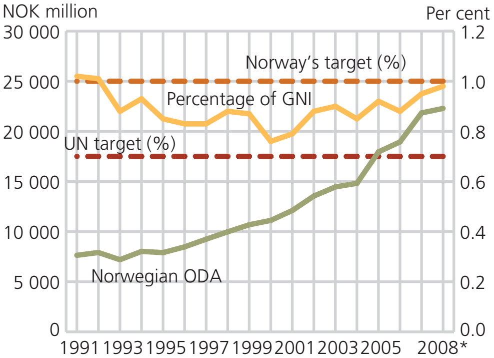
International cooperation for sustainable development and combating poverty

Indicator 1: Norwegian official development assistance, in NOK and as percentage of gross national income

If we are to succeed in advancing global sustainable development, one of the most important tasks is to reduce poverty. This is also the overriding objective of the UN Millennium Development Goals, adopted in 2000. Contributing to sustainable development at global level is therefore also a key part of Norway's sustainable development strategy. However, global poverty reduction is a complex task, and a number of factors are involved. The most important of these are believed to be good governance, appropriate international framework conditions and development assistance.

The UN target is for donor countries to provide 0.7 per cent of gross national income (GNI) as official development assistance (ODA). In its policy platform, the present Government announced that it would, "work to increase Norway's official development assistance (ODA) to the target of 1 per cent of GNI, and ensure that our development cooperation efforts are intensified correspondingly during the period".

Figure 2.1. **Norwegian ODA in NOK million and as a proportion of GNI. UN and Norwegian targets (as percentage of GNI)**



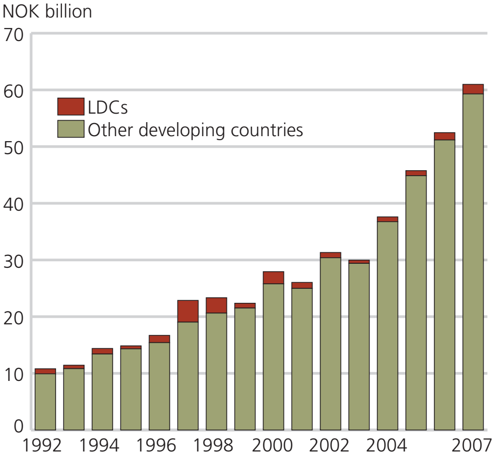
Source: Norad and Statistics Norway.

- Net ODA from Norway rose from NOK 18.95 billion in 2006 to NOK 21.8 billion in 2007, a rise of 15 per cent. In the same period, GNI rose by 6.6 per cent, from NOK 2 156 billion to NOK 2 299 billion. Thus, development assistance grew more strongly than GNI, which was necessary to approach the target of allocating 1 per cent of GNI to ODA. Between 2005 and 2006, GNI grew much more strongly than ODA, with the result that ODA decreased from 0.92 per cent of GNI in 2005 to 0.88 per cent in 2006. In 2007, Norway's ODA was equivalent to 0.95 per cent of GNI, so that the quantitative target in the Government's policy platform has nearly been reached. In monetary terms, the shortfall in 2007 was about NOK 1.1 billion. According to the 2008 National Budget, ODA is expected to correspond to 0.98 per cent of GNI in 2008.
- Norway provides a high level of aid compared with most other OECD countries. Only Sweden, Denmark, the Netherlands and Luxembourg provide a similar level of ODA (more than 0.8 per cent). In most countries, the level is far below the UN target of 0.7 per cent of GNI. In 2006, average ODA from the OECD countries was 0.30 per cent of GNI. In practice, Norwegian ODA is even higher than the official figures indicate, because Norway, with few exceptions and unlike other OECD/DAC countries, does not report bilateral debt cancellation as part of ODA.

Indicator 2: Imports from least developed countries and from all developing countries

Calculations by the World Bank show a close correlation between economic growth and poverty reduction in developing countries. An important means of promoting economic development in these countries is to give them the opportunity to sell their goods and services. An international trade regime is important in this context. This indicator shows imports to Norway from all developing countries, split between the least developed countries (LDCs)[1] and other developing countries.

Figure 2.2. **Imports to Norway from LDCs[1,2] and other developing countries. NOK billion**



[1] LDCs = least developed countries.
[2] Imports throughout the period for the 50 countries defined as LDCs in 2007.
Source: Statistics Norway.

- Imports to Norway from developing countries rose by 16.2 per cent from 2006 to 2007. The rise was about twice as large for the LDCs (30.7 per cent) as for the other developing countries (15.9 per cent). Imports from China made up 46 per cent of total imports from developing countries, as compared with 45 per cent in 2006. Thus, China's share of imports from developing countries is continuing to rise. In 2007, imports from developing countries made up 13.0 per cent of total imports to Norway.
- Imports from LDCs are mainly from Equatorial Guinea, Bangladesh and Liberia. Norway's imports from LDCs totalled NOK 1 690 million in 2007, which corresponds to 0.4 per cent of total imports to Norway. Imports from Equatorial Guinea are dominated by crude oil, valued at NOK 571 million in 2007, or 34 per cent of total imports from LDCs. Imports from Bangladesh are dominated by clothing and accessories. In 2007, the value of goods imported from Bangladesh was NOK 477 million, or 28 per cent of total imports from LDCs.
- Norwegian imports from LDCs have at times been dominated by transactions involving second-hand ships from Liberia, which must be seen in the context of Norwegian shipowners' use of the international ship register in Liberia.

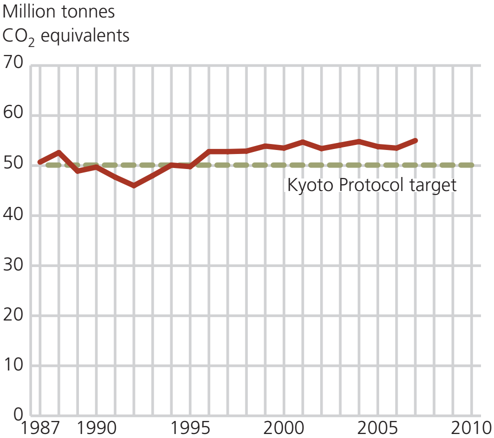
[1] Afghanistan, Angola, Bangladesh, Benin, Bhutan, Burkina Faso, Burundi, Djibouti, Equatorial Guinea, Eritrea, Ethiopia, Gambia, Guinea, Guinea-Bissau, Haiti, Yemen, Cambodia, Cape Verde, Kiribati, Comoros, DR Congo, Laos, Lesotho, Liberia, Madagascar, Malawi, Maldives, Mali, Mauritania, Mozambique, Myanmar/Burma, Nepal, Niger, Rwanda, Solomon Islands, Samoa, Sao Tome and Principe, Senegal, Central African Republic, Sierra Leone, Somalia, Sudan, Tanzania, Togo, Chad, Tuvalu, Uganda, Vanuatu, Zambia and East Timor.

Climate, ozone and long-range air pollution

Indicator 3: Norwegian emissions of greenhouse gases compared with the Kyoto target

The world community is likely to have to address new, serious challenges as a result of global warming. Climate change may have far-reaching effects on the environment, resources, society and economy. It is difficult to quantify the share of climate change for which human activity is responsible. However, the evidence that most of the global warming that has been observed in the last 50 years is anthropogenic has become stronger.

Figure 2.3. **Norwegian emissions of greenhouse gases compared with the Kyoto Protocol target**



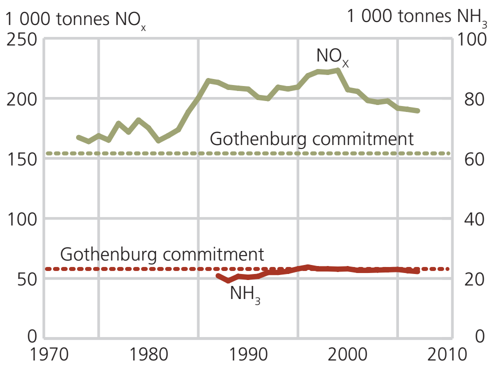
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority..

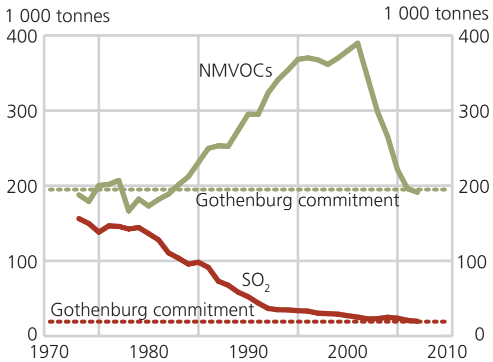
- Norway's greenhouse gas emissions rose by 3 per cent in 2007 to 55.0 million tonnes CO_2 equivalents. The rise since 1990, the base year for the Kyoto Protocol, is almost 11 per cent (more than 5 million tonnes CO_2 equivalents). After two years when emissions showed a downward trend, partly as a result of lower production of crude oil, the level rose again in 2007 to somewhat above that in the previous peak year 2004. The most important reason for the renewed rise in Norwegian greenhouse gas emissions was that technical problems arose in connection with the start-up of the LNG plant at Melkøya near Hammerfest. The most important sources of emissions are the oil and gas industry, manufacturing and road traffic.
- Norway's national emissions quota under the Kyoto Protocol is about 50 million tonnes a year fore the period 2008–2012 (1 per cent above the 1990 level for each year in this period, and 250.6 million tonnes for the whole period). If Norway's emissions exceed this, the country must acquire further emission units through the Kyoto mechanisms.
- In a recently published report (Hansen et al. 2008), it is estimated that Norway's greenhouse gas emissions may rise from 55.0 million tonnes CO_2 equivalents in 2007 to 57.4 million tonnes CO_2 equivalents in 2012. This would mean a rise of just over 15 per cent in Norway's greenhouse gas emissions relative to the 1990 level, 14 per cent more than Norway's Kyoto commitment. This in turn would mean that Norway would have to acquire emission units through emissions trading or approved projects under the Clean Development Mechanism or Joint Implementation equivalent to about 7 million tonnes CO_2 equivalents. Given a carbon price of NOK 200 per tonne, this would cost about NOK 1.4 billion in 2012.

Indicator 4: Emissions of NO_x, NH_3, SO_2 and NMVOCs

Acid rain caused by emissions of NO_x, NH_3 and SO_2 is still a serious environmental problem in Norway, even though reductions in emissions have reduced the extent of acidification. Non-methane volatile organic compounds (NMVOCs) may include carcinogenic substances and contribute to the formation of ground-level ozone. The latest emission figures show that Norway is making progress in relation to its international commitments, but for nitrogen oxides in particular, there is still a long way to go.

Figur 2.4. **Emissions of NO_x, NH_3, SO_2 and NMVOCs, and Norway's emission commitments under the Gothenburg Protocol. 1 000 tonnes**





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

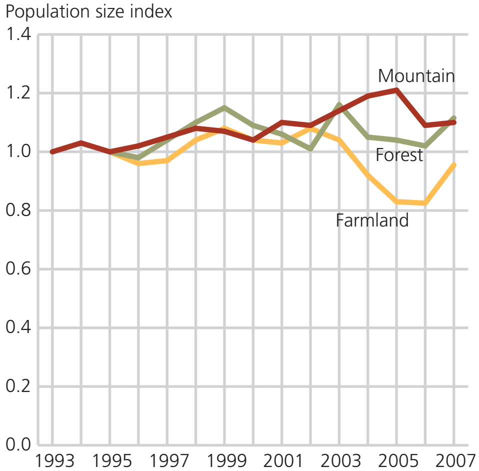
- Emissions of nitrogen oxides (NO_x) dropped slightly in 2007, but there is still a long way to go before the 2010 emissions target is achieved. To achieve the target, NO_x emissions must be reduced by 18 per cent from the 2007 level. Three sources, domestic shipping and fishing vessels, the oil and gas industry and road traffic, accounted for 79 per cent of Norway's NO_x emissions in 2006. Emissions from road traffic and from shipping and fishing vessels were reduced from 2005, but the overall reduction was partly counteracted by large emissions as a result of problems in connection with the start-up of the LNG plant at Melkøya near Hammerfest, and a higher level of activity in the ferro-alloy industry. A new agreement on measures to reduce NO_x emissions has been entered into by the Government and 14 trade organisations. Its purpose is to make it possible for Norway to meet its commitment under the Gothenburg Protocol.
- Ammonia (NH_3) emissions declined slightly from 2006 to 2007, to 22 300 tonnes. This is just under the Gothenburg target, which is 23 000 tonnes. Norway's SO_2 emissions are below the Gothenburg target, and in 2007 reached the lowest level since industrialisation in the 19th century. Process emissions from metal production, stationary combustion in manufacturing industries and shipping are the largest sources of emissions.
- In 2007, Norway's NMVOC emissions were for the first time below the Gothenburg target for 2010. This is the result of the substantial cuts in emissions of hydrocarbons from loading and storage of crude oil offshore that have been achieved in the last few years. Emissions of NMVOCs from road traffic have been reduced by almost 70 per cent since 1990. This is a result of the limits on exhaust emissions that were introduced for petrol cars in 1989.

Biodiversity and cultural heritage

Indicator 5: Bird population index – Population trends of nesting wild birds

Biodiversity is a complex concept, encompassing diversity at many levels from genes via species to ecosystems and landscapes. Our survival depends on the continued functioning of the world's ecosystems. Trends in bird populations are considered to give a good indication of the state of their habitats. Birds represent different levels in the food chain, they are known to respond to relevant threat factors, and they are widely found in all habitats. The EU and UK sustainable development indicators include similar indicators.

Figure 2.5. **Population trends of nesting wild birds in mountain, forest and farmland habitats**



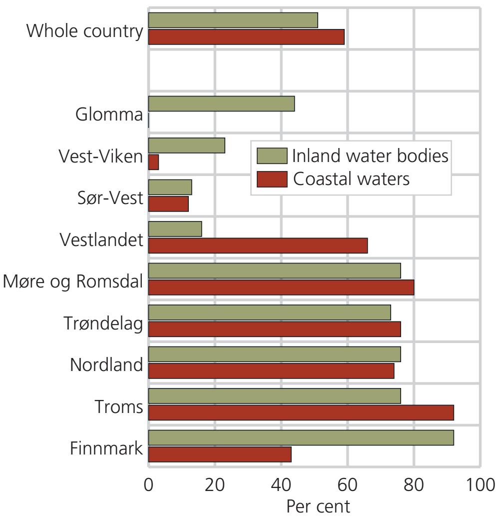
Source: Directorate for Nature Management. Based on preliminary and incomplete data.

- The current figures for bird populations in Norway do not cover the whole country or show clear trends, but a representative network of monitoring sites is being established for the whole country. There appears to be a decline in farmland bird populations, a trend that has been observed in a number of countries, and a rise in mountain bird populations, which may be related to a warmer climate and a denser mountain forest.

Indicators 6 and 7: Proportion of inland water bodies and coastal waters classified as "clearly not at risk"

Norway has a large number of inland water bodies and adjoins large areas of sea. There are also many user interests associated with water. Pressures on the aquatic environment include hydropower developments, discharges from waste water treatment plants and fish farms, runoff from agriculture, erosion and transport of sediments. Investigations of the ecological status of the aquatic environment in Norway show that it compares favourably with other countries in Europe.

Figure 2.6. **Percentage of Norwegian water bodies classified as "not at risk" of failing to meet the objectives of the Water Framework Directive in 2015[1]. Inland water bodies[2] and coastal waters[3], by river basin district. Per cent**



[1] The figure shows the results of a preliminary risk assessment of whether water bodies are expected to meet the directive's objective of good ecological status by 2015. The assessment was based on physical, chemical and biological criteria.
[2] An inland water body means a discrete and significant element of surface water, such as a lake, a reservoir, a stream, river or canal, part of a stream, river or canal.
[3] A coastal water body means a discrete and significant element of surface water, including fjords and other coastal waters, out to a line one nautical mile outside the baseline for mainland Norway.
Source: http://www.vannportalen.no/enkel.aspx?m=31772&amid=1643545

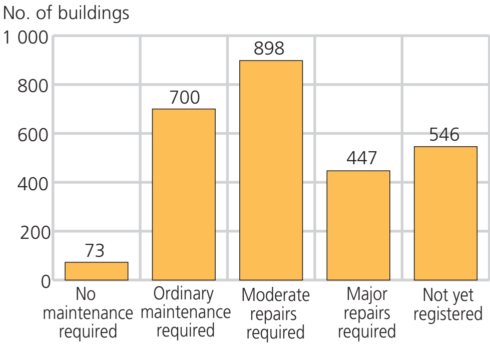
- More than half of the inland water bodies that have been assessed have been placed in the category "not at risk". To be placed in this category, hydromorphological, chemical and biological conditions in a water body must not differ significantly from those found under natural conditions. The proportion of water bodies placed in the category "not at risk" is lowest in lakes west of the Glomma river basin and south of Møre og Romsdal. Conditions are better further east and north.
- None of the coastal waters assessed in the Glomma river basin district was classified in the category "not at risk". The proportion of water bodies "not at risk" is also low in the other two districts furthest south in the country (second and third districts from the top in Figure 2.6).
- The overall results for these two indicators give a general picture of the situation in the roughly 15 000 water bodies that have been investigated throughout Norway. However, the areas studied were selected on the basis of where it was expected that problems would be found, and are therefore not representative. There is not yet sufficient information to make a complete evaluation of ecological status. The results are nevertheless useful as a basis for evaluating measures to be taken at local level.

Indicator 8: Trends in standards of maintenance of protected buildings

Cultural monuments, sites and environments are society's common assets. The cultural heritage is a unique and irreplaceable source of knowledge and enjoyment, and can provide a basis for local development and cultural, social and economic value creation. Appreciation of the cultural heritage opens up valuable perspectives in our efforts to build a sustainable society.

Buildings are an important part of Norway's national wealth. Maintaining and re-using buildings rather than demolishing and rebuilding them results in a more varied built environment. One of the national targets of Norway's cultural heritage policy is for all cultural monuments, sites and environments protected under the Cultural Heritage Act to be safeguarded, and a standard requiring only normal maintenance to be achieved by 2020. (Report No. 16 (2004-2005) to the Storting and Report No. 26 (2006-2007) to the Storting).

Figure 2.7. **Registration of standards of maintenance for protected buildings in private ownership, status October 2008. Number of buildings**



Source: Directorate for Cultural Heritage..

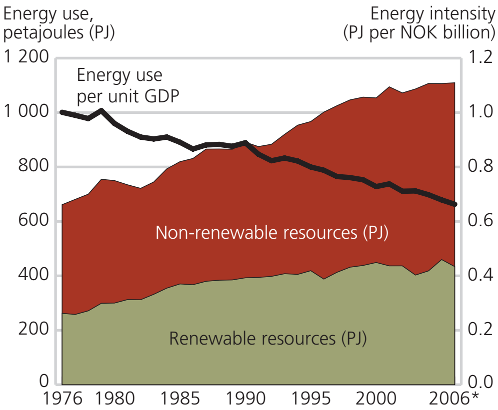
- According to figures from the Directorate for Cultural Heritage, about 80 per cent of all protected buildings had been registered and assigned to one of the categories in the figure by October 2008. A complete overview of standards of maintenance for all protected buildings is expected by the end of 2008. The overview is intended as a tool for use in a systematic programme of repair for protected buildings.
- Of the buildings that have been assessed, about two-thirds need moderate or extensive repairs to achieve a standard where only normal maintenance is required.

Natural resources

Indicator 9: Energy use per unit GDP

In a modern society, energy is an essential input factor, and regardless of the energy source used, energy production and use have some kind of impact. The impacts of energy production and use have caused a great deal of debate in Norway for many years, irrespective of which energy source is being developed. A particularly important impact of energy use is the emission of greenhouse gases, primarily from the use of fossil energy. Efficient energy use is therefore particularly important in the context of sustainability.

Figure 2.8. **Energy use per unit GDP[1] and total energy use (PJ) for renewable and non-renewable energy sources**



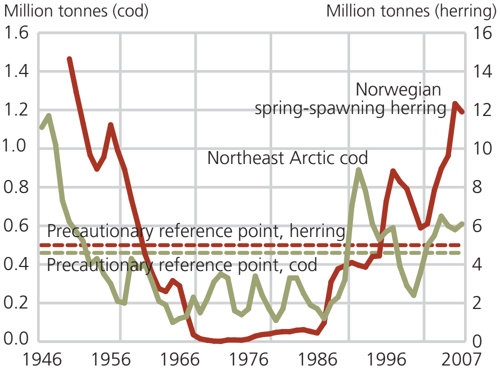
[1] GDP in constant 2002 prices.
Source: Statistics Norway.

- Except for brief periods around 1980 and 1990, GDP has grown more strongly than domestic energy use throughout the period 1976–2006. Thus, energy intensity has decreased. International statistics show a similar trend in other OECD countries. This is explained both by more efficient energy use and by changes in industrial structure, for example a shift towards the production of services rather than more energy-intensive raw material production. Structural changes are an important factor behind the observed reduction in energy intensity in Norway, together with changes in prices and market conditions and greater productivity (Bøeng and Spilde 2006).
- From 1976 to 2006, energy use increased by about 68 per cent. For the period as a whole, non-renewable energy use has risen slightly more (69 per cent) than renewable energy use (66 per cent).

Indicator 10: Size of spawning stocks of Northeast Arctic cod and Norwegian spring-spawning herring

Fishing has been an important basis for settlement and economic activity throughout Norway's history. Sustainable management of fish resources means that they must not be so heavily exploited that there is a danger of poor recruitment to the stocks. Without sufficient recruitment, there is no basis for long-term, sustainable harvesting of these resources.

Figure 2.9. **Spawning stock and precautionary reference points (Bpa) for Northeast Arctic cod and Norwegian spring-spawning herring**



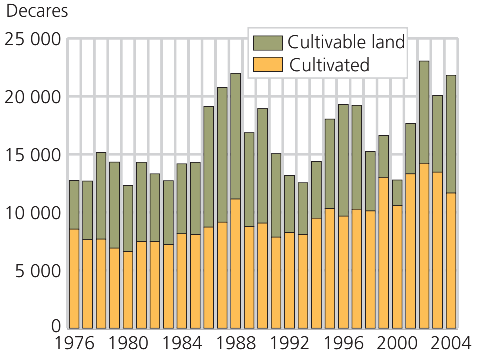
Source: Institute of Marine Research and ICES.

- The spawning stock of Northeast Arctic cod was estimated at 613 000 tonnes in 2007, which is above the precautionary level. The estimated spawning stock in 2008 is about 650 000 tonnes. Earlier maturation is an important reason for the rise in spawning stock biomass since 2000. This is a trend that has been observed in many cod stocks. Possible causes include prolonged high fishing pressure on juvenile fish, higher temperatures and more rapid individual growth. The extent to which genetic factors influence this trend in sexual maturation is still unclear (Skogen et al. 2007).
- Although the size of the spawning stock is reasonably satisfactory, fishing mortality (i.e. the proportion of total mortality that is due to fishing) has at times been higher than intended. Illegal fishing is still a considerable problem. In 2005, the illegal catch was estimated at 166 000 tonnes, or 34 per cent of the total allowable catch, but in recent years the scale of illegal fishing has been reduced.
- The stock of Norwegian spring-spawning herring has increased considerably in recent years, and is now about 12 million tonnes, which is about the same level as in the 1950s. According to the 2008 annual report on marine resources and environment (Gjøsæter et al. 2008), this is because conditions in the sea have been favourable, the spawning stock is large, and the management plan is functioning well.

Indicator 11: Irreversible losses of biologically productive areas

Sound land use with a long-term perspective is important for sustainable development. Norway has large areas of land relative to its population: nevertheless, there is considerable pressure on land resources, particularly in the most densely populated areas, which are often also the most productive in biological terms. The main threats to these areas are the construction of buildings, roads and other infrastructure. Conversion of biologically productive areas for other purposes can in many cases result in permanent loss of biological production.

Figure 2.10. **Loss of cultivated and cultivable land in accordance with the Planning and Building Act and the Land Act. 1976-2004[1]. Decares[2]**



[1] Figures for the loss of land in 2005 and 2006 are available, but their quality is not yet good enough for inclusion here.
[2] 1 decare = 0.1 hectares.
Source: KOSTRA (2004 onwards) and the À JOUR system (up to 2003).

- The conversion of cultivated and cultivable land entails the loss of the biologically most productive areas in Norway. These are also the areas where the development pressure is greatest. In the period 1976–2004, a total of about 273 000 decares of cultivated land has been irreversibly lost as a result of decisions in accordance with the Planning and Building Act and the Land Act. About 200 000 decares of cultivable land has also been lost in the same period.
- The rate of loss of cultivated land has risen over the period as a whole. In the 1970s, soil conservation was a high priority in Norway, but since then there has been some loss of awareness of the importance of Norwegian agriculture, while development pressure has intensified.

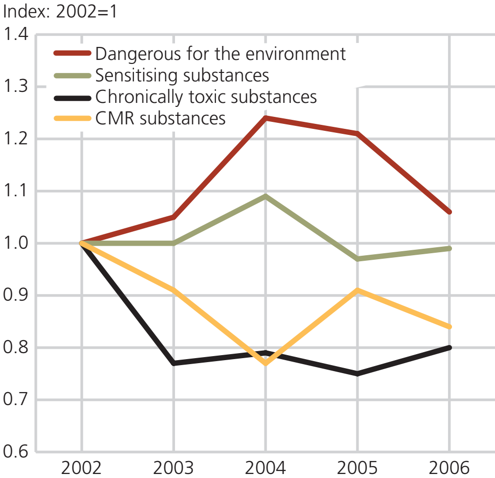
Hazardous chemicals

Indicator 12: Potential exposure to exposure to hazardous substances

Since the 1930s, global production of chemicals has risen from 1 million tonnes a year to more than 400 million tonnes (EC 2006). As yet, we know little or nothing about the properties of many substances. What we do know is that some of them can harm people or the environment if they are not handled safely, and that the use of hazardous substances may have irreversible long-term impacts on people and the environment. It is therefore an important task to ensure that such substances are used responsibly. Pollution problems in Norway caused by hazardous substances are to a large extent linked to long-range transport of pollutants, but releases within the country also make a substantial contribution.

Statistics Norway, in cooperation with the Norwegian Pollution Control Authority and the Product Register, has developed an indicator of the quantity of hazardous substances released each year, and that people and the environment can therefore be exposed to and harmed by.

Figure 2.11. **Releases of hazardous substances 2002-2006 relative to the 2002 level, split by hazard categories**



[1] CMR= Carcinogenic, mutagenic, toxic for reproduction.
Source: Statistics Norway.

- Calculations show that releases of the substances that are most hazardous to health (carcinogenic, mutagenic and reprotoxic substances (CMR substances), and chronically toxic substances) have decreased since 2002.
- Releases of sensitising substances have been relatively stable in this period, while releases of substances that are dangerous for the environment rose between 2002 and 2004, then declined again up to 2006.
- The results must be interpreted with care at present, since the model is still being improved and adjusted.

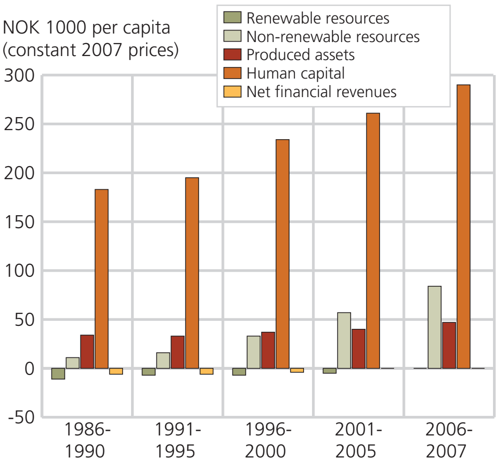
Sustainable economic and social development

Indicator 13: Net national income per capita, by sources of income

Norway's national wealth is an expression of the total value of national resources, and consists of human capital, natural capital, produced assets and financial wealth. Maintenance of Norway's national wealth is an essential but not a sufficient basis for sustainable development. However, if national wealth is stable and increasing, this is an indication that the country is following a sustainable path of development, whereas the opposite would be an indication that sustainable development is in jeopardy.

Norway's net national income (NNI) may be regarded as the market-based return on our national wealth. The return on produced assets, financial revenues and the resource rent from market-priced renewable and non-renewable natural resources are calculated on the basis of figures from the national accounts. Variations in NNI over time may be an indication of changes in national wealth, although more short-term fluctuations in income are often a result of changes in capacity utilisation.

Figure 2.12. **Net national income in NOK 1000 per capita, by sources of income.[1] 1986-2007. Constant 2007 prices**



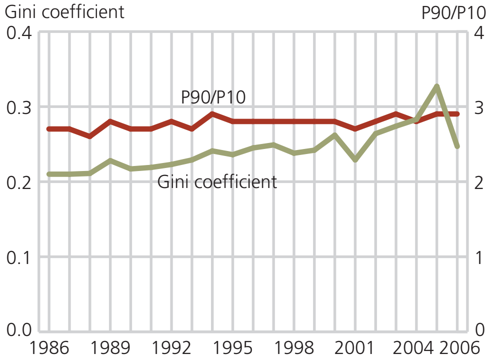
[1] Shown by decomposing average net national income per capita for each period.
Source: Statistics Norway.

- The extraction of non-renewable resources, mainly oil and gas, is a very important source of income in Norway. In the first period shown in Figure 2.12, it accounted for 5 per cent of per capita income, rising to 20 per cent in the most recent period.
- Nevertheless, human capital makes the largest contribution to income. Although it accounts for a smaller proportion of total income now than in the first period shown, it still made up an average of 69 per cent of income in the period 2006–2007.
- The extraction of renewable natural resources, on the other hand, contributes very little to net national income. This is largely because the calculations show a large negative income from agriculture, as a result of the large subsidies to the sector. The positive income from forestry, fish farming and hydropower production compensates for this, but the overall contribution from renewable natural resources is nevertheless close to zero.

Indicator 14: Trends in income distribution

A fundamental part of the original definition of sustainable development (WCED 1987) was solidarity and equitable distribution within the same generation, primarily between rich and poor countries. However, but on the principle that development should benefit everyone, it can also be valid within individual countries. In this perspective, a low level of income inequality can be seen as a goal in itself. It can also be seen as a means of achieving a desired path of development by strengthening or maintaining social capital. Income disparities in Norway, as measured by the Gini coefficient, are low in global terms.

Figure 2.13. **Trends in income distribution.[1,2] Distribution of household equivalent income after taxes. 1986-2006**



[1] Gini coefficient: a measure of statistical dispersion. It is most widely used as a measure of inequality of income distribution or inequality of wealth. It is defined as a ratio with values between 0 and 1. The closer the value is to 0, the more equal the distribution. The Gini index is the Gini coefficient expressed as a percentage.
[2] P90/P10: the ratio between the income of a person with a higher household income than exactly 90 per cent of the population, divided by the income of a person with a higher household income than exactly 10 per cent of the population.
Source: Ministry of Finance and Statistics Norway.

- Two different measures of relative income differences between households are used. Income inequality measured by the Gini coefficient has shown a generally rising trend throughout the period 1986–2005, and has risen from 0.22 to 0.33.
- The recent rising trend in income differences has been explained by changes in capital income, and particularly in share dividends and dividend taxation (the income year 2005 was the last year when shareholders could receive dividends without being subject to personal taxation). This had a considerable effect on the registered level of income inequality. The new tax rules for the income year 2006 made it less favourable to take out dividends. Dividends were considerably reduced, resulting in more even income distribution. The Gini coefficient dropped to 0.25, the lowest level since 2001.
- Unlike the Gini coefficient, which rose fairly steadily from 1986 until the new tax rules entered into force in 2006, the other indicator, P90/P10, has not changed much. This indicator is influenced less by the extreme values at either end of the distribution (Statistics Norway 2007).

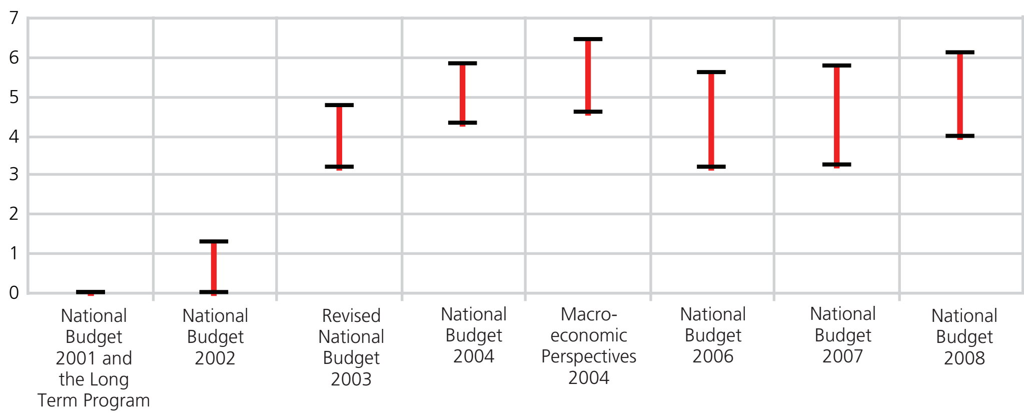
Indicator 15: Generational accounts: Need to tighten public sector finances as a share of GDP

In Norway, the public sector plays an important role for total welfare by facilitating economic activity in the private sector, providing basic educational health and social welfare services, and maintaining an extensive social security system. The expenses for these systems must, over time, be financed within the limits of total public revenues.

The generational accounts are an indicator of whether today's financial policy is sustainable in the long term. For this to be the case, the calculated long-term expenditure must be balanced by corresponding revenues and wealth. This does not involve a requirement as regards the public-sector budget balance each year, whereas the current fiscal rule for the budget policy does. If the fiscal rule is followed with no increase in tax rates or reductions in public benefits or consumption, this will also meet the requirements for a financial policy that is sustainable in the long term.

- The latest estimates in the 2008 National Budget indicate a reduction in the order of NOK 70–110 billion. This is between 4 and 6 per cent of mainland GDP. This indicator shows how much the budget must be tightened to avoid the need to tighten public sector finances at a later date (Official Norwegian Report 2005:5).

Figure 2.14. **Generational accounts: need to tighten public sector finances as a share[1] of GDP**

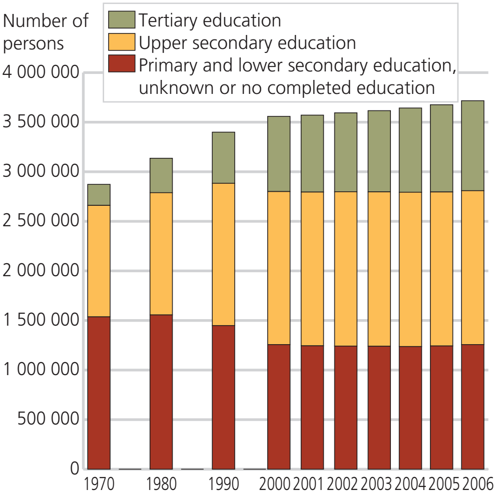


[1] The need to tighten public sector finances is given as an interval, since calculations have been made on the basis of various assumptions concerning real wage growth.
Source: Ministry of Finance.

Indicator 16: Population by highest level of educational attainment

A high level of education in the population is one of the conditions for sustainable economic development in a knowledge-based society. The level of education in the population is an indicator of the supply of qualified labour for the public and private sectors. The OECD report *The Well-being of Nations* states that "Education, training and learning can play important roles in providing the basis for economic growth, social cohesion and personal development."

Figure 2.15. **Population (aged 16 years and over) by highest level of educational attainment**



Source: Statistics Norway.

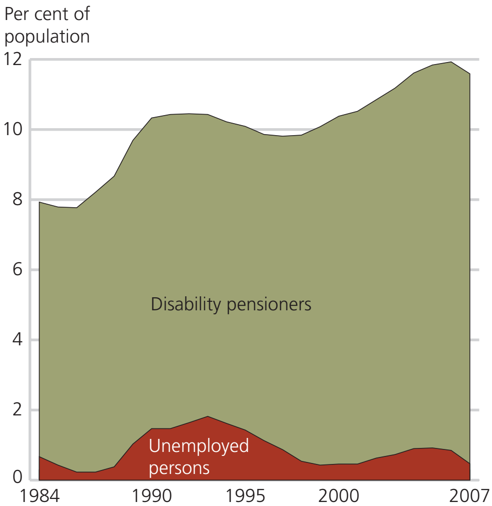
- Level of educational attainment is a widely used indicator, and is used internationally both as a measure of human capital and as an indicator in surveys of living conditions.
- The level of education of the Norwegian population has increased considerably over the last 30 years in both absolute and relative terms. In 1970, about 7 per cent of the population aged 16 years and over had a university-level qualification (tertiary education). By 2006, this had increased to 25 per cent – an increase of 18 percentage points during the last 34 years. In 2006, 6 per cent of the population had completed a long tertiary programme.
- Overall figures for the two sexes show that the proportion of women with a tertiary level qualification is slightly higher than for men (27 per cent and 24 per cent respectively). However, the proportion of men who have completed a long tertiary programme (8 per cent) is almost twice as high as the proportion of women (4 per cent). The difference between men and women is largest for age groups over 50 years.
- The group with the highest level of educational attainment today is young women (aged 25-29 years). Almost 49 per cent of them have completed a tertiary education, while the corresponding figure for men in the same age group is only 32 per cent.
- About 43 per cent of the population has a qualification from upper secondary school, 46 per cent of men and 41 per cent of women. The share of people with only primary and lower secondary education has decreased by over 20 percentage points since 1970, and is now about 30 per cent.

Indicator 17: Disability pensioners and long-term unemployed persons as a percentage of population

For most people, employment is an important basis for their income and a key to social inclusion. Although unemployment is low in Norway by international standards, the proportion of the population who receive a disability pension is high and rising.

If a large proportion of the working age population is outside the labour market, this may be a serious threat to the maintenance of human capital. In the long term, this may affect the productive capacity of the economy and social stability, and thus the sustainability of society.

Figure 2.16. **Disability pensioners and long-term unemployed persons as a percentage of population**



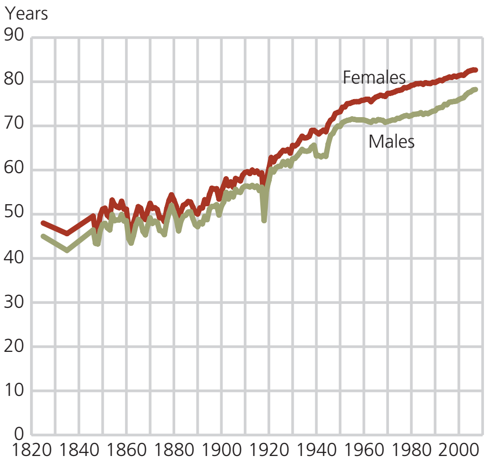
Source: Statistics Norway and NAV.

- During the economic downturn at the beginning of the 1990s, a relatively high percentage of adults were excluded from the labour market. This applied both to disability pensioners (from 2004 onwards also including recipients of time-limited disability benefits) and to the long-term unemployed.
- There was a temporary decrease in exclusion from the labour market until 1998, but since then the percentage has increased again and was just over 11 per cent in 2007. Most people excluded from the labour market are disability pensioners, and they also accounted for most of the rise in total numbers. In 2007, 14 000 people were registered as long-term unemployed and 334 000 as disability pensioners. The number of long-term unemployed was roughly halved from 2006. Far more women (193 000 or 58 per cent) than men (141 000 or 42 per cent) were registered as disability pensioners in 2006. In contrast, more men (8 000) than women (6 000) are registered as long-term unemployed.
- From 2006 to 2007, the number of disability pensioners rose by almost 6 000, while the number of long-term unemployed in the age group 18–66 years decreased by about 11 000.
- The number of young people receiving disability pensions is showing a rising trend. In 2007, there were about 3 500 disability pensioners in the age group 20–25 years, 55 per cent young men and 45 per cent young women. In the population as a whole, women make up a larger proportion of disability pensioners than men.

Indicator 18: Life expectancy at birth

Changes in life expectancy can indirectly give information on general health and living conditions in the population, the quality of health services and medical developments generally, and on changes in health status, lifestyles and quality of life.

Figure 2.17. **Life expectancy at birth. 1825-2007**



Source: Statistics Norway (2008) and Brunborg (2004).

- Life expectancy in Norway has been increasing for nearly two hundred years. In recent years, male life expectancy has been increasing particularly quickly, after levelling off in the 1950s and 1960s. Women still live longer than men, but the gap is shrinking. The difference between the sexes in life expectancy has been reduced by a third in the past 20 years, to 4.4 years in 2007. Male life expectancy at birth is now 78.2 years, and female life expectancy is 82.7 years (Statistics Norway 2008). An important cause of the rise in life expectancy is declining infant and child mortality, but lower mortality in older age groups has also contributed.
- However, the increase in life expectancy did not continue in 2007. It is too early to determine whether this indicates a new trend or is a result of random variations.
- In connection with the ongoing reform of the pension system, there has been great interest in trends in remaining life expectancy for older people. Expected remaining life expectancy for people aged 62 years and over has risen rapidly in recent years, but showed no rise in 2007.
- Another indicator, which takes account of the quality of life, is called “Healthy Life Years” (HLY). This measures the number of years that a person of a certain age is still expected to live without disability. Calculations show that average healthy life expectancy at birth was 65.5 years for men and 63.6 years for women in 2005. This means that on average, about 13 years of men’s life expectancy and 19 years of women’s life expectancy will be years when health problems will limit the opportunity to lead a full and active life.

Box 2.2. Indicators of sustainable development and the precautionary principle

Sustainable development has three dimensions – environmental, economic and social. The purpose of the Norwegian set of indicators of sustainable development, which is updated by Statistics Norway, is to show whether or not progress is being made in important areas and whether important goals in Norway's strategy for sustainable development are being achieved. Uncertainty about the scale of environmental problems may mean that the current indicator set dos not provide clear enough signals of change. In a new project, Statistics Norway is to continue the development of the Norwegian indicators in accordance with the precautionary principle, so that they are better suited to give early warning of adverse impacts and of environmental problems that should be tackled at an early stage.

Norway's current set of indicators of sustainable development

Sustainable development became a much-used concept in the public debate after the publication of *Our Common Future* in 1987, where it was defined as "a form of development that meets the needs of the present without compromising the ability of future generations to meet their own needs."

In an economic perspective, environmental assets form part of the national wealth available to society. Sustainable development involves managing the national wealth so that economic, social and environmental considerations are all taken into account. A set of indicators should be concise enough to give a good overview, but at the same time comprehensive enough to illustrate important problems and if possible give early warning of new problems, especially environmental problems. This involves a difficult balance between the ideal situation and what can be achieved in practice. A UN report describes international efforts to develop sustainability indicators (UNECE 2008).

Norway has chosen a relatively small set of indicators of sustainable development, 18 in all. The Ministry of Finance is responsible for coordinating the sustainable development effort, and Statistics Norway for updating the indicators. The current indicator set is based on recommendations in Official Norwegian Report 2005:5, and a revised set was presented in the 2008 National Budget (Report No. 1 (2007-2008) to the Storting), where the new Norwegian strategy for sustainable development was also launched, as mentioned earlier. The most recent update was presented in a report from Statistics Norway (Brunvoll et al. 2008).

The development of the indicator set represents an important step forward in providing clear information on complex social and environmental issues. The indicators cover environmental issues including greenhouse gas emissions, long-range air pollution, hazardous substances, populations of nesting birds, cod and herring, water quality in inland water bodies and coastal waters, and the loss of cultivated land. The current indicators primarily illustrate areas where we already have well-documented knowledge of the adverse impacts of environmental change. In a new project, Statistics Norway will seek to expand the indicator set to include areas where current trends may have serious impacts, but where the level of uncertainty is high. The indicators would thus be better suited to give early warning of adverse impacts and identify environmental problems that should be dealt with immediately, in accordance with the precautionary principle.

The precautionary principle and sustainability indicators

UNESCO (2005) has proposed the following definition of the precautionary principle: "When human activities may lead to morally unacceptable harm that is scientifically plausible but uncertain, actions shall be taken to avoid or diminish that harm." Thus, the best strategy may be to take action to prevent possible environmental damage rather than waiting for more information, even if we do not know enough about the uncertainty level to quantify it through ordinary risk assessment. If there is uncertainty about whether irreversible damage may occur and how likely this is, the environment should "be given the benefit of the doubt".

The current set of indicators is largely based on generally accepted knowledge. For example, they are based on emission levels laid down in international agreements – the Kyoto Protocol for greenhouse gas emissions and the Gothenburg Protocol for long-range air pollutants. Norway has also ratified the Convention on Biological Diversity, and thus has a responsibility for the management of endangered species. It is therefore important to gain better knowledge of factors that influence endangered species both in the long term and in the short term.

Biodiversity is a good example of a field where knowledge of causal relationships is still very uncertain, and also difficult to generalise from species to species and from habitat to habitat. Valuable but vulnerable ecosystems can for example become too small to survive. For the moment, numbers of breeding birds have been chosen to represent terrestrial biodiversity. This is because birds are found in all habitats, and are vulnerable to pressures that threaten their natural surroundings. However, a great deal of work remains to be done in developing biodiversity indicators. One problem is that there is as yet no systematic census of Norwegian bird populations, and the figures are therefore very uncertain. Secondly, information on other aspects of biodiversity is also needed. Thirdly – and this is the most difficult problem – we need to identify trends in possible factors underlying changes in populations at an earlier stage. Key information here will be the causes of and extent of habitat loss and change. It can be difficult to identify the negative impacts of habitat loss. There is still great uncertainty and considerable scientific debate about the tolerance limits of the environment and the impacts of the loss of irreplaceable environmental assets. Despite this, it is important to consider management of the environment in the light of the precautionary principle.

To capture the uncertainty associated with critical aspects of the state of the environment, data is needed at a more detailed level than provided by the current indicators. This can be an important basis for early warnings of which habitat types are most endangered and make it possible to apply the precautionary principle and take steps to protect important habitat types.

Statistics Norway's new project will seek to identify the types of information scientists consider most important, given the goals of providing early warnings and applying the precautionary principle in practice. The project will focus on how important problems can be identified through cooperation between researchers from different disciplines and between researchers and politicians.

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Useful websites

- Norwegian Ministry of Finance: http://www.regjeringen.no/nb/dep/fin/tema/Barekraftig_utvikling.html?id=1333
- UN: http://www.un.org/esa/sustdev/natlinfo/indicators/isd.htm
- http://unstats.un.org/unsd/mi/mi_goals.asp
- EU: http://ec.europa.eu/sustainable/welcome/idea_en.htm
- OECD: http://www.oecd.org/topic/0,2686,en_2649_37425_1_1_1_1_37425,00.html
- Nordic Council of Ministers: http://www.norden.org/baeredygtig_udvikling/sk/index.asp?lang=3
- Denmark: http://www.mst.dk/default.asp?Sub=http://www.mst.dk/tvær/07000000.htm
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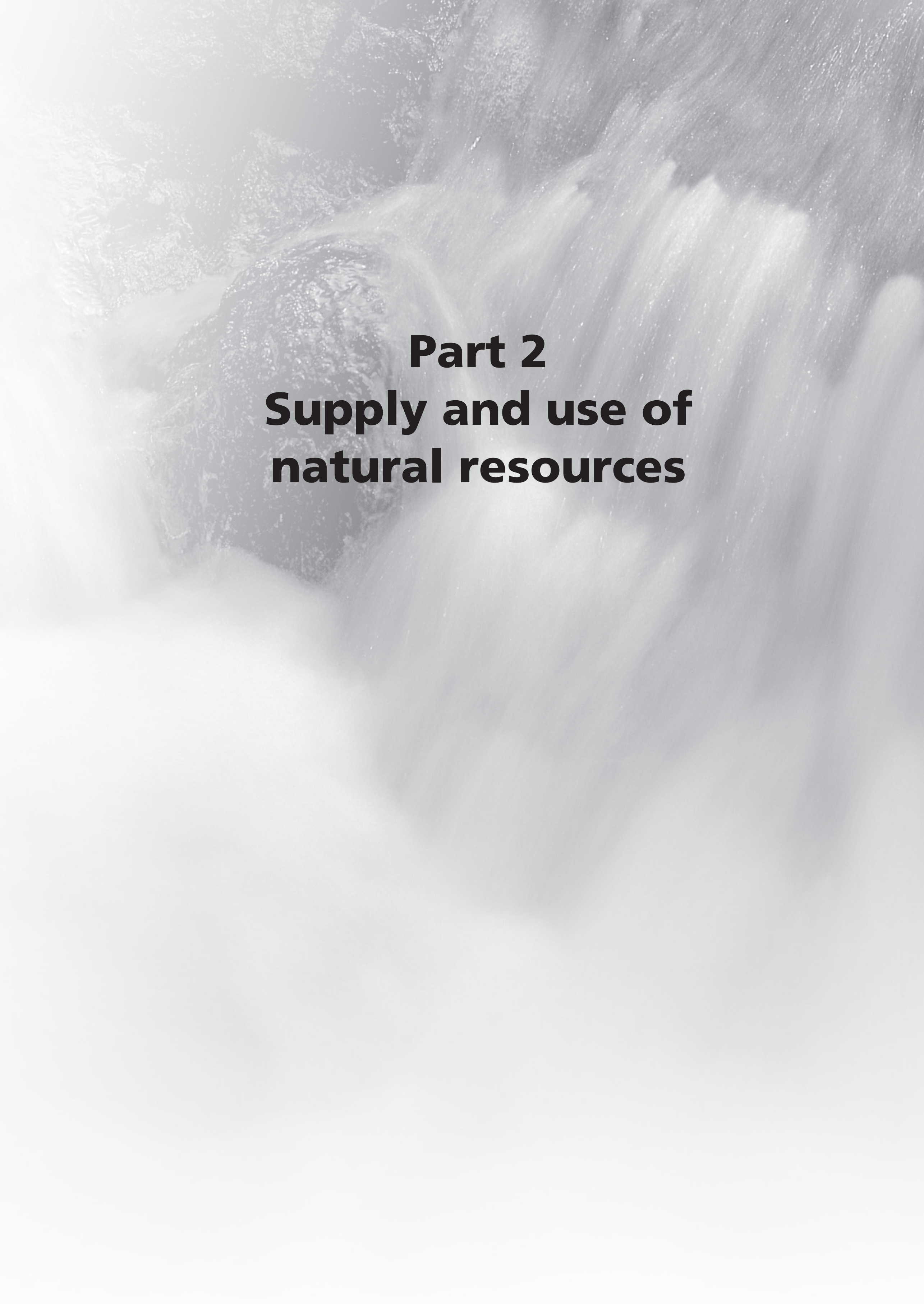


Part 2
Supply and use of natural resources

3. Energy

Norway has rich energy resources, particularly in the form of oil, gas and hydropower, and energy extraction is far higher than the country's energy use. In addition, coal is extracted in Svalbard and Norway has a very high wind power potential. The production, transmission and use of energy cause various pressures on the environment. A large proportion of global air pollution is generated by the combustion of coal, oil and gas

In 2007, extraction of energy commodities in Norway was eight times higher than domestic use. Most of this is accounted for by extraction of oil and gas, which made up 93 per cent of the total. Given the current rate of extraction, the calculated crude oil reserves on the Norwegian continental shelf will be exhausted in eight years' time and the gas reserves in 26 years' time. In practice, production will continue for longer than this, since annual production will gradually decrease from the current high level. The ratio between reserves and production, called the R/P ratio, also changes every year since the lifetime of the remaining resources depends on the rate of extraction, on new finds, on decisions concerning the development of proven fields, and, for fields that are on stream, on improvements in the recovery factor and on the production profile.

Norway has 0.7 per cent of the world's oil reserves, but accounted for 3.0 per cent of world oil production in 2007; the corresponding figures for natural gas are 1.7 and 3.0 per cent. The Norwegian reserves are thus being exhausted more rapidly than those in the rest of the world. However, at the end of 2007 only 36 per cent of Norway's total oil and gas resources (which include all estimated volumes of oil and gas), had been recovered, or 53 and 20 per cent respectively of the oil and gas resources.

The high rate of extraction and high prices make oil and gas Norway's largest export commodities. According to the national accounts, petroleum extraction accounted for about 22 per cent of gross domestic product (GDP) and 46 per cent of Norway's export revenues in 2007, which is lower than the year before. Oil and gas are to a large extent being converted from wealth in the form of natural resource assets to financial assets abroad through the Government Pension Fund – Global (previously called the Government Petroleum Fund).

Hydropower is Norway's other major energy resource, although energy production from this source corresponded to only about 6 per cent of petroleum extraction in 2007 expressed as energy content. However, hydropower is a renewable energy source, unlike petroleum resources, which are depleted as they are extracted.

Domestic consumption of energy commodities, excluding the energy sectors, rose by about 1 per cent from 2006 to 2007. In the last 10 years, it has risen by an average of 0.7 per cent per year, while the average rate of general economic growth, as measured by

GDP for mainland Norway, has been 3.4 per cent per year (see Chapter 14 on the relationship between environmental pressures and economy).

Energy production and use cause major environmental impacts. In 2006, the energy sectors accounted for about 31 per cent of total Norwegian greenhouse gas emissions (24 per cent from oil and gas extraction), and other combustion of fossil energy commodities accounted for 46 per cent of the total (see Chapter 9 Air pollution and climate change). Hydropower developments in watercourses have a significant impact on biodiversity, the cultural landscape and outdoor recreation. About 60 per cent of Norway's hydropower potential has now been developed or is under construction or licensing. Recently, increasing attention has also been focused on the environmental problems associated with wind power.

3.1. Resource base and reserves

World fossil energy reserves

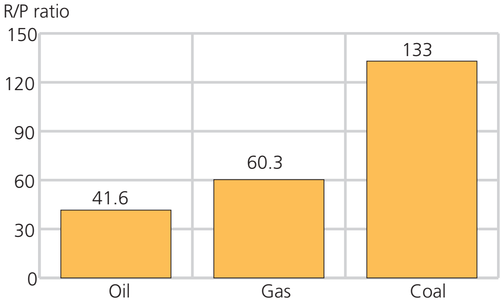
- Reserves are defined as resources that are fairly certainly recoverable given the current economic and technological framework. There is always some uncertainty associated with estimates of reserves, and there is reason to believe that the quality of the data varies widely from country to country. Moreover, assumptions about prices and technology may change over time.
- According to BP (2008), world coal reserves can be expected to last for considerably longer than oil and gas reserves at the current rate of extraction (Figure 3.1). The US has the largest coal reserves, 29 per cent of the world total. Russia, China, India and Australia also have large coal reserves – together, these countries have almost half of the world's total reserves. The Middle East has 61 per cent of the world's oil reserves, and about one third of this is in Saudi Arabia. The Middle East also has 41 per cent of the world's gas reserves, while only about 6 and 5 per cent respectively of the total oil and gas reserves are in North America (Table 3.1).
- The estimates of oil and gas reserves at the end of 2007 are not very different from those for the end of 2006 in BP's annual Statistical Review of World Energy, while the estimate for coal reserves is lower.

Table 3.1. **World reserves of fossil energy commodities as of 31 December 2007**

	Oil		Gas		Coal	
	Billion tonnes	Per cent	Billion m^3	Per cent	Billion tonnes	Per cent
World	168.6	100	177.4	100	847.5	100
North-America[1]	9.5	5.6	8	4.5	250.5	29.6
Latin-America	15.9	9	7.7	4.4	16.3	1.9
Europa incl. former Soviet Union	19.4	11.6	59.4	33.5	272.2	32.1
Middle East	102.9	61	73.2	41.3	1.4	0.2
Africa	15.6	9.5	14.6	8.2	49.6	5.8
Asia og Oceania	5.4	3.3	14.5	8.2	257.5	30.4
OPEC	127.6	75.5	..	..	..	..
OECD	11.9	7.1	15.8	8.9	356.9	42.1
Norway	1	0.7	3	1.7	..	..

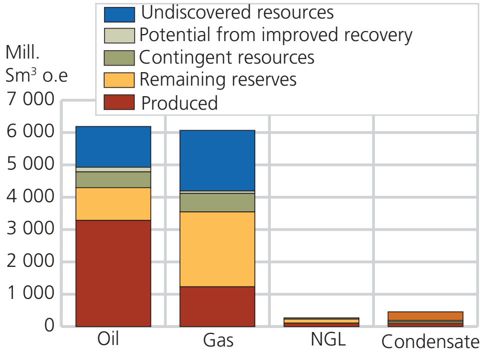
[1] Including Mexico.
Source: BP 2008.

Figure 3.1. **Reserves-to-production ratio[1] (R/P ratio) for world reserves of fossil energy commodities as of 31 December 2007**



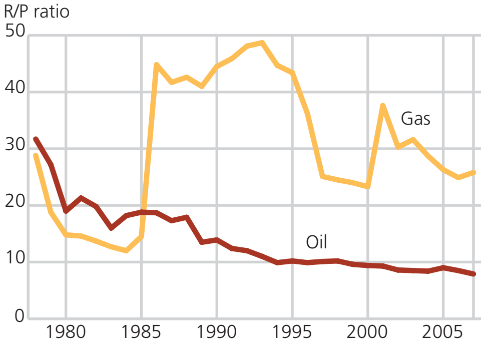
[1] The R/P ratio, or the ratio between total reserves at the end of the year and that year's production, indicates how many years reserves will last at the current rate of production.
Source: BP 2008.

Figure 3.2. **Norway's oil and gas resources, 31 December 2007. Million Sm³ o.e.**



Source: OED/OD (2008).

Figure 3.3. **R/P ratio[1,2] for Norwegian oil and gas reserves. 1978-2007**



[1] The R/P ratio, or the ratio between total reserves at the end of the year and that year's production, indicates how many years reserves will last at the current rate of production.
[2] Because of a change in the classification system for petroleum resources, there is a break in the time series between 2000 and 2001.
Source: Energy statistics from Statistics Norway and Norwegian Petroleum Directorate.

Norwegian petroleum resources

- As of 31 December 2007, Norway's total oil and gas reserves were estimated at 13.0 billion Sm^3 oil equivalents (o.e.) (OED/OD 2008). Of this, 4.7 billion Sm^3 o.e., or 36 per cent, had already been produced. Thus, there are remaining resources of 8.3 billion Sm^3, of which 3.5 billion Sm^3 o.e., or 27 per cent of the total, is classified as reserves (Figure 3.2). On the same date, 53 per cent of the oil resources but only 20 per cent of the gas resources had been extracted.
- Oil and gas made up roughly equal proportions of the total, 48 and 47 per cent respectively of the total resources expressed in Sm^3 o.e., while NGL (natural gas liquids) and natural gas condensate made up 2 and 3 per cent respectively.
- The estimates of reserves in producing fields are revised annually, and new fields are included in the estimates almost every year. The R/P ratio is a measure of the ratio between the remaining recoverable oil and gas resources in fields that are already developed or where development has been approved, and production during the past year. At the end of 2007 the R/P ratios for Norway's reserves were 7.9 (oil) and 25.8 (gas) according to figures from the Norwegian Petroleum Directorate. The R/P ratios change as new fields are approved for development and the quantities in already developed fields are re-evaluated.

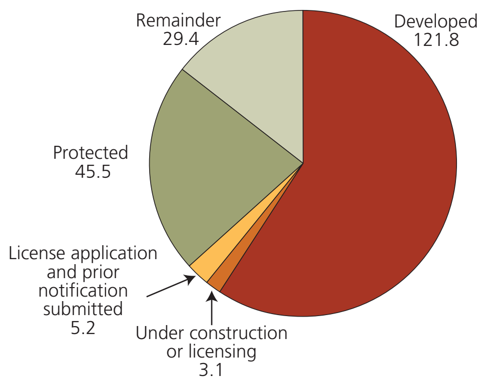
Box 3.1. Explanation of terms used in the resource accounts

The Norwegian Petroleum Directorate draws up annual resource accounts for oil and gas. In these, the term resources means, in addition to oil and gas that has already been produced, all estimated petroleum deposits – those that are marketable now, those that are not marketable given current technology and prices, and those that have not been evaluated.

Reserves are defined as the remaining marketable recoverable resources in fields that are already developed or where development has been approved. *Contingent resources* are those for which no decision has been taken on production, and *undiscovered resources* are believed to be present, but have not yet been discovered by drilling.

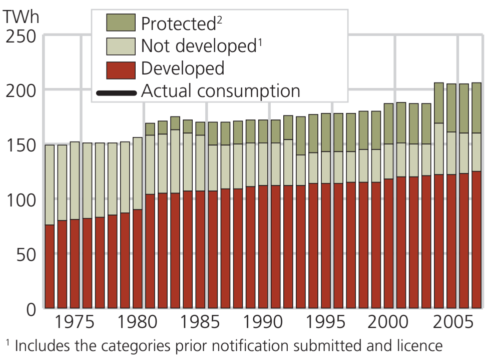
In addition, it is expected that future technological developments will make it possible to recover more oil and gas than is the case today. Rising prices may also result in a rise in estimates of reserves.

Figure 3.4. **Norway's hydropower resources, 31 December 2007[1]. TWh per year**



[1] In 2005, a number of additional river systems were included in the category "protected" in the Protection Plan for Watercourses.
Source: Norwegian Water Resources and Energy Directorate.

Figure 3.5. **Hydropower resources: developed, not developed[1] and protected[2]. Actual consumption. 1973-2007[3]. TWh per year**



[1] Includes the categories prior notification submitted and licence application submitted.
[2] River systems protected by the Storting are not included in the figures before 1981.
[3] From 2004 onwards, power plants of capacity 50-10 000 kW were included. As a result, the resource estimate was revised upwards.
Source: Norwegian Water Resources and Energy Directorate.

Norwegian hydropower resources

- As of 31 December 2007, Norway's hydropower potential was estimated at 205.0 TWh per year. Of this, 59 per cent, or 121.8 TWh, had been developed. This leaves 83 TWh that has not been developed, 45.5 TWh of which is protected.
- Environmental restrictions and the need to consider profitability make it uncertain how much of the remaining hydropower potential is likely to be developed.
- The only large river system in Norway that is untouched by hydropower developments is the Tana in Finnmark.
- Hydropower accounts for about 98 per cent of electricity production in Norway (excluding electricity production on the continental shelf), as compared with 18 per cent for the world as a whole (World Energy Council 2008).
- Norway has the world's highest per capita hydropower production, and is ranked as number one in Europe and number six in the world in absolute terms.

Box 3.2. Energy content and energy units

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/m³	0.85 tonne/m³	..	..	..
Refinery gas	48.6 GJ/tonne	..	0.95	..	0.95
Natural gas (2007)[2]	39.7 GJ/1000 Sm³	0.85 kg/Sm³	0.95	..	0.95
Liquefied propane and butane (LPG)	46.1 GJ/tonne = 24.4 GJ/m³	0.53 tonne/m³	0.95	..	0.95
Fuel gas	50.0 GJ/tonne	..	..	..	..
Petrol	43.9 GJ/tonne = 32.5 GJ/m³	0.74 tonne/m³	0.20	0.20	0.20
Kerosene	43.1 GJ/tonne = 34.9 GJ/m³	0.81 tonne/m³	0.80	0.30	0.75
Diesel oil, gas oil and light fuel oil	43.1 GJ/tonne = 36.2 GJ/m³	0.84 tonne/m³	0.80	0.30	0.70
Heavy distillate	43.1 GJ/tonne = 37.9 GJ/m³	0.88 tonne/m³	0.80	0.30	0.70
Heavy fuel oil	40.6 GJ/tonne = 39.8 GJ/m³	0.98 tonne/m³	0.90	0.30	0.75
Methane	50.2 GJ/tonne	..	..	..	..
Wood	16.8 GJ/tonne = 8.4 GJ/solid m³	0.5 tonne/solid m³	0.65	-	0.65
Wood waste (dry wt)	16.25-18 GJ/tonne = 6.5-7.2 GJ/solid m³	0.4 tonne/solid m³.	..	..	..
Waste	10.5 GJ/tonne	..	..	..	..
Electricity	3.6 GJ/MWh	..	1.00	1.00	1.00
Uranium	430-688 TJ/tonne	..	..	..	..

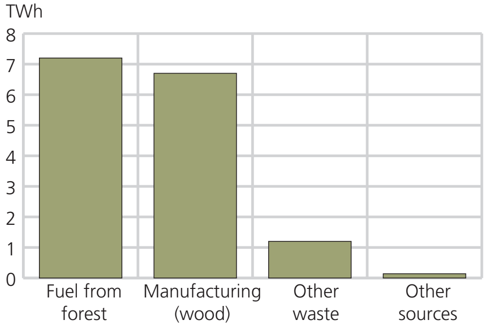
[1] The theoretical energy content of a particular energy commodity may vary. The figures therefore indicate mean values.
[2] Sm³ = standard cubic metre (at 15 °C and 1 atmospheric pressure).
Source: Energy statistics, Statistics Norway, Norwegian Petroleum Industry Association, Norwegian Association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

Energy units

	PJ	TWh	Mtoe	Mbarrels	MSm³ o.e. oil	MSm³ o.e. gas	quad
1 PJ	1	0.278	0.024	0.18	0.028	0.025	0.00095
1 TWh	3.6	1	0.085	0.64	0.100	0.090	0.0034
1 Mtoe	42.3	11.75	1	7.49	1.18	1.058	0.040
1 Mbarrels	5.65	1.57	0.13	1	0.16	0.141	0.0054
1 MSm³ o.e. oil	36.0	10.0	0.9	6.4	1	0.90	0.034
1 MSm³ o.e. gas	39.9	11.1	0.9	7.1	1.11	1	0.038
1 quad	1 053	292.5	24.9	186.4	29.29	26.33	1

1 Mtoe = 1 million tonnes (crude) oil equivalents
1 Mbarrels = 1 million barrels crude oil (1 barrel = 0.159 m³)
1 MSm³ o.e. oil = 1 mill. Sm³ olje
1 MSm³ o.e. gass = 1 billion Sm³ natural gas
1 quad = 10^{15} Btu (British thermal units)
Source: Energy statistics. Statistics Norway and Norwegian Petroleum Directorate.

Figure 3.6. **Use of bioenergy in Norway. TWh**



Source: Energy statistics and survey of fuelwood use, Statistics Norway, and Eid Hohle (2005).

Bioenergy resources in Norway

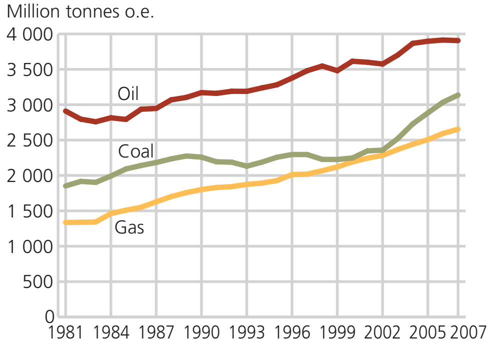
- Annual consumption of bioenergy resources (wood, wood waste, black liquor, pellets, briquettes) in Norway is about 15 TWh.
- A survey of fuelwood use (Statistics Norway 2007) shows that total fuelwood consumption in 2007 was 1.4 million tonnes, which corresponds to a theoretical energy content of about 6.6 TWh. About 13 per cent of this was used in holiday homes. Modern clean-burning stoves (produced after 1998), which utilise the energy in the wood more efficiently than older stoves, accounted for 32 per cent of the wood used in holiday homes, as compared with 41 per cent in year-round residences. The proportion of clean-burning stoves has risen by 23 percentage points since 2002. The overall efficiency of fuelwood stoves was about 50 per cent in 2005.
- Bioenergy sources that are barely used today include energy crops (fast-growing trees and grasses), straw, landfill gas and biogas from manure.

Box 3.3. Commonly used 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}

3.2. Extraction and production

Figure 3.7. **World production of coal, crude oil and natural gas. 1981-2007. Million tonnes o.e.**



Source: BP 2008.

World production of fossil energy commodities

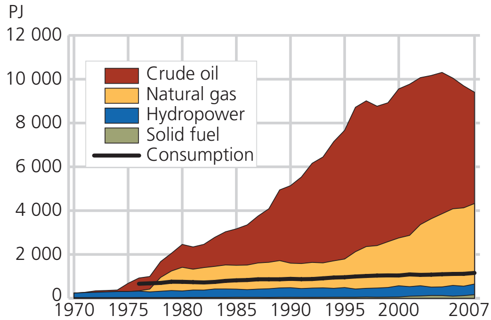
- In 2007, total global extraction of fossil energy commodities increased by 1.6 per cent from the year before to 9.7 billion tonnes o.e. Since 1981, the average annual rise has been 1.8 per cent. In recent years, there has been a particularly marked rise in coal extraction, which had levelled off in the 1990s. Since 2000, coal production has risen by almost 40 per cent; the corresponding figures for natural gas and oil are 21 and 8 per cent. Oil production has levelled off and has been almost unchanged for the past four years, but oil still accounts for the largest proportion of total global extraction of fossil energy commodities, 40 per cent in 2007.
- The US, China and Russia are the largest producers of fossil energy commodities. These three countries accounted for more than 40 per cent of total production in 2007.
- China is by far the largest coal producer, accounting for 41 per cent of world coal production. China is also the country where there has been the largest increase in production. From 2002 to 2007, coal production in China rose by 76 per cent. North America and Europe account for almost two thirds of all natural gas production. This includes the whole of Russia (much of Russia's gas is produced in Siberia).
- For many years, oil production has been rising faster in Russia than in Saudi Arabia. In 2007, oil production was equal in the two countries, each accounting for 12.6 per cent of world oil production.

Table 3.2. **World production of fossil energy commodities in 2007**

	Oil		Gas		Coal	
	Million tonnes	Per cent	Million tonnes o.e.	Per cent	Million tonnes o.e.	Per cent
Regions						
World	3 905.9	100.0	2 654.1	100.0	3 135.6	100.0
OPEC	1 681.3	43.0	..	..	..	..
OECD	899.2	23.0	992.1	37.4	1 033.4	33.0
North America[1]	643.4	16.5	706.3	26.6	629.9	20.1
Latin America	332.7	8.5	135.7	5.1	55.3	1.8
Europe incl. former Soviet Union	860.8	22.0	968.2	36.5	445.4	14.2
Middle East	1 201.9	30.8	320.2	12.1	0.5	0.0
Africa	488.6	12.5	171.3	6.5	154.2	4.9
Asia and Oceania	378.7	9.7	352.3	13.3	1 850.2	59.0
Major producers						
Oil	Million tonnes	Per cent				
Saudi Arabia	493.1	12.6				
Russia	491.3	12.6				
US	311.5	8.0				
Iran	212.1	5.4				
China	186.7	4.8				
Mexico	173.0	4.4				
Canada	158.9	4.1				
United Arab Emirates	135.9	3.5				
Venezuela	133.9	3.4				
Kuwait	129.6	3.3				
Norway	118.8	3.0				
Gas	Million tonnes	Per cent				
Russia	546.7	20.6				
US	499.4	18.8				
Canada	165.3	6.2				
Iran	100.7	3.8				
Norway	80.7	3.0				
Algeria	74.7	2.8				
Saudi Arabia	68.3	2.6				
UK	65.2	2.5				
China	62.4	2.4				
Turkmenistan	60.7	2.3				
Coal	Million tonnes	Per cent				
China	1 289.6	41.1				
US	587.2	18.7				
Australia	215.4	6.9				
India	181.0	5.8				
South Africa	151.8	4.8				
Russia	148.2	4.7				
Indonesia	107.5	3.4				
Poland	62.3	2.0				
Germany	51.5	1.6				
Kazakhstan	48.3	1.5				

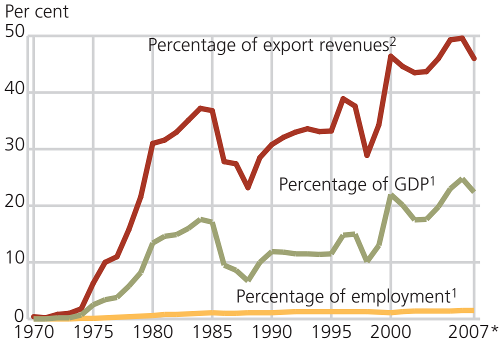
[1] Including Mexico.
Source: BP 2008.

Figure 3.8. **Extraction and consumption[1] of energy commodities in Norway. 1970-2007*. PJ**



[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 3.9. **Oil and gas extraction. Percentage of exports, gross domestic product (GDP) and employment. 1970-2007*. Per cent**



[1] Including services.
[2] Oil and gas only.
Source: National accounts, Statistics Norway.

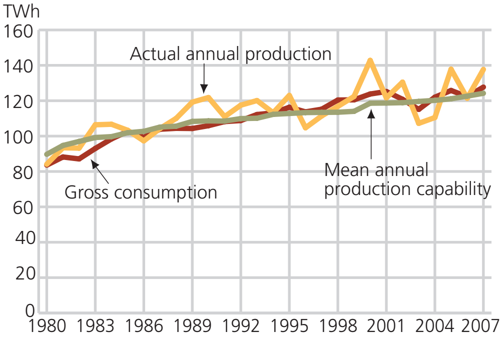
Total extraction of energy commodities in Norway

- Total extraction of energy commodities in Norway declined by 3.0 per cent from 2006 to 2007.
- Oil and gas extraction declined by 4.2 per cent, and accounted for 93 per cent of the total. Norway's oil production (including condensate and NGL) has dropped each year since the peak year 2001, and in 2007 was 26.7 per cent lower than in 2001. Norway accounted for 3.0 per cent of world oil production in 2007. Norway's natural gas production is rising, and has risen from less than 2 per cent of total world production in the late 1990s to 3.0 per cent in 2007.
- Extraction of solid fuels rose by 35.5 per cent from 2006. This is explained by a large rise in coal extraction.
- Hydropower production increased by 12.9 per cent in 2007.
- In 2007, extraction of primary energy commodities (including hydropower) was 8.1 times higher than domestic consumption.

Crude oil and natural gas in an economic perspective

- Extraction of oil and gas is Norway's most important industry measured in terms of export revenue and value added (proportion of GDP). However, oil and gas accounted for a smaller proportion of export revenue and GDP in 2007 than in 2006, and dropped from 49.6 to 46.0 per cent of export revenue and from 24.8 to 22.4 per cent of GDP.
- About 1.5 per cent of total labour input was directly related to oil and gas extraction (including services).

Figure 3.10. **Mean annual production capability, actual hydropower production and gross electricity consumption in Norway. 1973-2007. TWh**

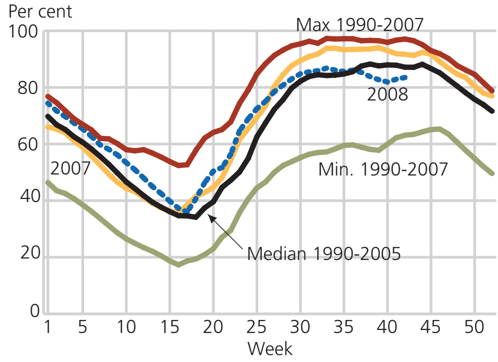


Source: Norwegian Water Resources and Energy Directorate and Energy statistics, Statistics Norway.

Electricity

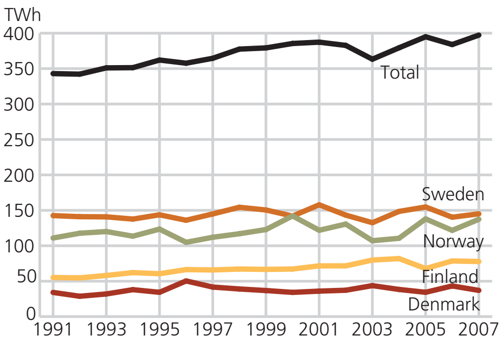
- In 2007, electricity production in Norway totalled 137.7 TWh, a rise of 13.2 per cent from the year before and the third highest level ever recorded. The highest annual production level was 142.8 TWh in 2000. In addition, 7-8 TWh of electricity per year is generated by gas turbines on the Norwegian continental shelf.
- Several wind farms have been constructed in recent years, and wind power production rose by 33.8 per cent from 2006 to 2007. Thermal power production (including gas-based power) rose by 28.1 per cent in the same period. However, thermal power production is still modest compared with hydropower production.
- Electricity production in 2007 (excluding the continental shelf) consisted of 135.3 TWh hydropower, 1.5 TWh thermal power and 0.9 TWh wind power.
- For hydropower, mean annual production capability (i.e. production in a year with normal precipitation) is estimated at 121.8 TWh. High precipitation since 2000 has resulted in average annual hydropower production of 125 TWh so far during this decade, but with considerable variation from year to year.
- Since almost all electricity production in Norway is based on hydropower, water inflow to the reservoirs is of crucial importance for the level of electricity production. Inflow is unevenly distributed over the year, and is normally lowest in winter, when the demand for power is highest. It is therefore necessary to store water in order to be able to produce electricity in winter. The degree of filling of the reservoirs can vary a great deal both between seasons and between years as a result of variations in precipitation and the demand for electricity. The total energy capability of Norway's reservoirs is about 84 TWh, or 70 per cent of annual mean production.

Figure 3.11. **Degree of filling of Norway's reservoirs during the year. 2007 and 2008. Minimum, maximum and median values for the period 1990-2007. Per cent**



Source: Norwegian Water Resources and Energy Directorate.

Figure 3.12. **Electricity production in the Nordic countries. 1991-2007. TWh**



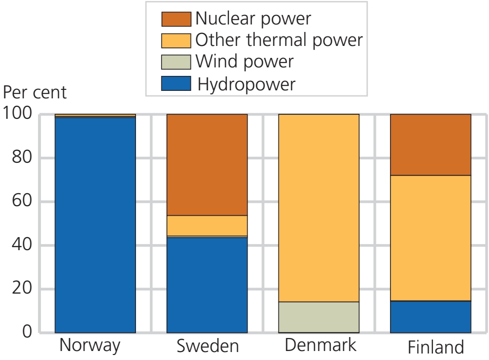
Source: Nordel's secretariat (various years).

- The rise in production from 2006 to 2007 must be seen in the context of the considerably higher water inflow in 2007. Inflow corresponded to 142.0 TWh in 2007, as compared with 110.0 TWh in 2006. Inflow in a normal year is estimated at 121.8 TWh.
- The high level of water inflow also improved the water balance in the course of 2007, even though hydropower production was high. At the beginning of 2007, the degree of filling in Norwegian reservoirs corresponded to 66.0 per cent of total capacity, which is 3.8 percentage points under the normal level for this date for the past 17 years. At the beginning of 2008, the degree of filling was 74.4 per cent, or 4.6 percentage points above normal.

Electricity production in the Nordic countries

- In 2007, total energy production in the Nordic countries excluding Iceland was 397.3 TWh. Sweden and Norway accounted for 36.5 og 34.6 per cent respectively of this, and Finland and Denmark produced 19.6 and 9.3 per cent respectively of the total.
- The technology of electricity production varies widely between the Nordic countries. Almost all electricity production in Norway is based on hydropower, which also accounts for almost half of the total in Sweden. In Finland, about one fifth of electricity production is from hydropower, while Denmark, where natural conditions are not suitable, does not produce hydropower. On the other hand, Denmark is the largest coal power producer in the Nordic region, and in 2007 generated 20.3 TWh, which was more than half of its total electricity production. In addition, Denmark produced 7.2 TWh, or about one fifth of its total production, from wind power. Sweden produced 64.3 TWh of nuclear power

Figure 3.13. **Electricity production in the Nordic countries, by technology. 2007. Per cent**



Source: Nordel.

in 2007, corresponding to 44 per cent of its electricity production. The other Nordic country that generates nuclear power is Finland, which produced 22.5 TWh, almost 30 per cent of its electricity production.

- Power lines link all the Nordic countries except Iceland. Electricity production and demand in the other Nordic countries therefore influences the electricity balance in Norway. Net exports of electricity from Norway (exports minus imports) in 2007 totalled 10.0 TWh. So far during the 2000s, Norway has exported an average annual of 3.4 TWh, but with considerable variations from year to year. The corresponding figures for the 1990s and 1980s were 2.8 TWh and 5.3 TWh respectively.
- In 2007, Denmark was a net exporter (1 TWh), while Sweden and Finland imported more electricity than they exported: their net imports were 1.3 and 12.7 TWh respectively (Nordel 2007). The Nordic region as a whole was more or less in balance in 2007, when net imports totalled only 3.0 TWh. In 2006, net imports to the Nordic region totalled 11.5 TWh.
- Iceland produced 12.0 TWh of electricity in 2007, 70 per cent of which was hydropower and 30 per cent geothermal power.

Figure 3.14. **Norwegian net production of coal in Svalbard. 1950-2007. 1 000 tonnes**

Sources: Historical Statistics, Statistics Norway and Store Norske Spitsbergen Kulkompani.

Norwegian extraction of coal in Svalbard

- Most Norwegian coal production today takes place at Svea Nord, which started production in 2002. The mine extracts coal from the largest deposit ever found in Svalbard, and can be operated very efficiently. As a result, Norway's annual net production in 2003 and 2004 was 2.9 million tonnes, as against 300 000 to 400 000 tonnes in the 1990s. In April 2006, coal production in the Svea Nord mine in Svalbard was resumed after a prolonged closure due to a fire that broke out at the end of July 2005.
- Because of the stoppage, production in 2005 was only half the level in 2003 and 2004. In 2006, production rose sharply again and reached about 80 per cent of the level in 2003 and 2004. In 2007, production reached the record level of 4.0 million tonnes. This is 35.7 per cent higher than in the previous peak year, 2003.

3.3. Environmental impacts of energy production

Emissions to air from the energy sectors

- The energy sectors are responsible for a large proportion of emissions to air in Norway, particularly in the case of CO_2, NO_x and NMVOCs. The proportions of emissions of greenhouse gases, acidifying gases and NMVOCs generated by the energy sectors rose from 1990 to 2006 (Table 3.3).
- Gas turbines on offshore installations are the most important source of CO_2 emissions from the energy sectors. In the 1990s, they generated annual CO_2 emissions of 5-7 million tonnes. In the period 2003-2006, this rose to 9-10 million tonnes a year, which is equivalent to 22 per cent of Norway's total emissions, as compared with 16 per cent for most of the 1990s.
- Gas turbines are also an important source of NO_x emissions, and accounted for almost 35 000 tonnes in 2006, or 18 per cent of Norway's total NO_x emissions. Total NO_x emissions were reduced by 8 per cent from 1990 to 2006, but emissions from the energy sectors rose by 59 per cent in the same period.

Table 3.3. **Emissions to air from the energy sectors as a proportion of total Norwegian emissions. 1990, 1995, 2000, 2005 and 2006*. Per cent**

	1990	1995	2000	2005	2006*
Greenhouse gases (expressed as CO_2 equivalents)	23	26	30	31	31
Carbon dioxide (CO_2)	28	31	35	36	36
Methane (CH_4)	9	14	17	16	15
Nitrous oxide (N_2O)	1	1	1	1	1
Acidifying substances (expressed as acid equivalents)	14	17	21	22	23
Sulphur dioxide (SO_2)	12	10	16	17	18
Nitrogen oxides (NO_X)	18	23	29	30	31
Ammonia (NH_3)	0	0	0	0	0
Hazardous substances					
Lead (Pb)	1	3	5	1	1
Cadmium (Cd)	10	6	8	7	7
Mercury (Hg)	8	9	9	5	6
Arsenic (As)	6	3	4	6	7
Chromium (Cr)	3	2	3	7	8
Copper (Cu)	2	1	2	1	1
Total PAH				1	1
Dioxins	11	6	12	10	10
Other pollutants					
Non-methane volatile organic compounds (NMVOCs)	45	61	68	51	46
Carbon monoxide (CO)	1	1	2	3	3
Particulate matter	1	2	2	2	2

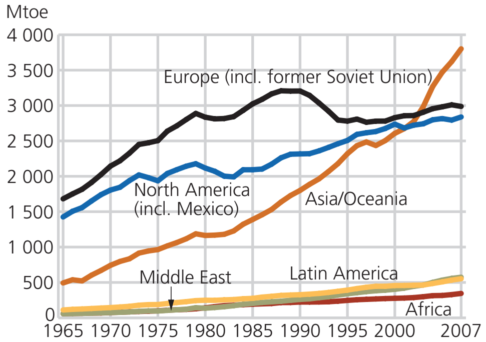
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

- The most important source of NMVOC emissions is evaporation during loading of crude oil offshore. These emissions rose a great deal during the 1990s, and reached a peak in 2001. Since 2002, they have been considerably reduced because of the quantity of oil loaded has dropped while the quantity loaded at facilities with VOC recovery equipment has risen. In 2006, emissions from this source totalled 62 000 tonnes, which is a decrease of 74 per cent from 2001. From 1990 to 2006, total NMVOC emissions and emissions from the energy sectors were reduced to roughly the same degree, so that emissions from the energy sectors now correspond to about the same proportion of the total as in 1990, after having been considerably higher for most of the period.
- In 2006, 18 per cent of Norway's total SO_2 emissions were generated by the energy sectors. Oil refining alone accounted for 9 per cent, mainly in the form of process emissions. From 1990 to 2006, emissions from the energy sectors were reduced by 38 per cent, but since total emissions of SO_2 were reduced by 60 per cent in the same period, the energy sectors accounted for a larger proportion of the total in 2006 than in 1990.

For more information, see Chapter 9: Air pollution and climate change and Chapter 12 (information on oil discharges from petroleum activities on the Norwegian continental shelf, Figure 12.4).

3.4. Energy use

Figure 3.15. **World energy use 1965-2007. Million t.o.e.**

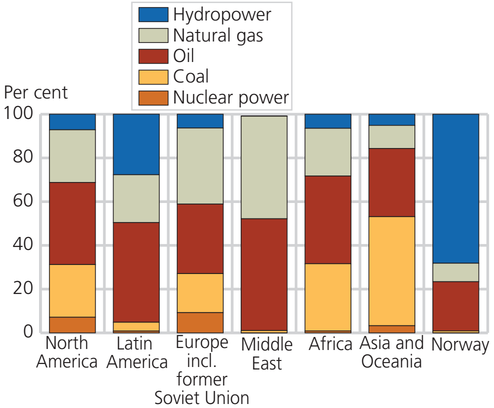


Source: BP 2008.

World energy use

- In 2007, global consumption of energy commodities (excluding bioenergy) totalled 11 099 million tonnes o.e., a rise of 2.4 per cent from the year before. The average annual rise for the past 10 years has been 2.2 per cent.
- In recent years, energy use has been rising particularly rapidly in Asia/Oceania – the average annual growth over the past 10 years has been 4.4 per cent, while the annual average for the past five years is 6.5 per cent. Most of the rise has been in China. In 2007, China accounted for 17 per cent of total world energy use, as compared with 10 per cent in 2000. The US is the only country where energy use is higher than in China.
- Europe (including the former Soviet Union) and North America (including Mexico) account for about one quarter each of world energy use. In Europe, energy use declined from 3 010 to 2 988 million t.o.e., or 0.7 per cent, from 2006 to 2007. In North America, energy use rose by 1.6 per cent to 2 839 million t.o.e. Over the past 10 years, energy use has risen by an average of 0.8 per cent both in North America and in Europe.
- In Latin America, energy use rose by 3.7 per cent in 2007 to 553 million t.o.e. The average annual rise in the past 10 years has been 2.5 per cent. In Africa, the average annual rise over the past 10 years has been 2.8 per cent, and energy use in 2007 was 344 million t.o.e. In the Middle East, energy use in 2007 totalled 574 million t.o.e, and the average annual rise has been 4.5 per cent.

Figure 3.16. **Energy use by energy carrier (excluding bioenergy) in different regions. 2007. Per cent**



Source: BP 2008.

- In 2007, oil accounted for 35 per cent of world energy use, followed by coal and natural gas at 29 and 23 per cent respectively. The rise in consumption of coal was largest, 6.6 per cent from 2006 to 2007; this was to a large extent due to a steep rise of 7.9 per cent in consumption in China.
- The energy mix varies greatly between countries and regions. China accounts for more than 40 per cent of world coal consumption, and Asia/Oceania as a whole accounts for 60 per cent. On the other hand, 79 per cent of all nuclear power consumption and 67 per cent of natural gas consumption is in Europe (including the former Soviet Union) and North America.
- Bioenergy is estimated to make up 15 per cent of total world energy use and is an important source of energy in most developing countries: in some, such as Ethiopia and Nepal, bioenergy accounts for as much as 95 per cent of energy use (Eid Hohle 2005).
- Hydropower is a particularly important energy source in Latin America as well as in Norway.

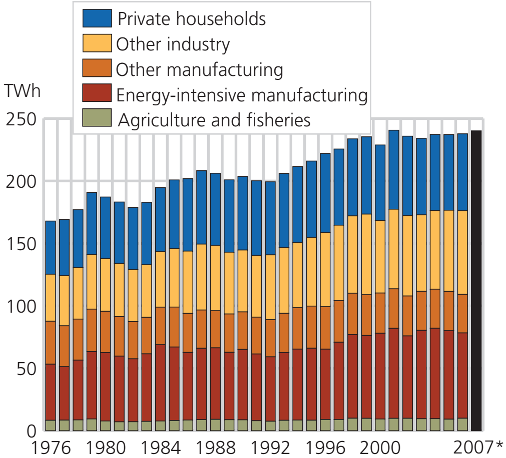
Box 3.4. Environmental pressures caused by the extraction and use of energy

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 9: Air pollution and climate change). Emissions to air from the energy sectors are shown in Table 3.3

Discharges of oil and chemicals to the sea occur during the extraction and transport of oil and gas products. They may for example injure fish, marine mammals and birds.

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.

Figure 3.17. **Domestic energy use[1] by consumer group. 1976-2007*. TWh**

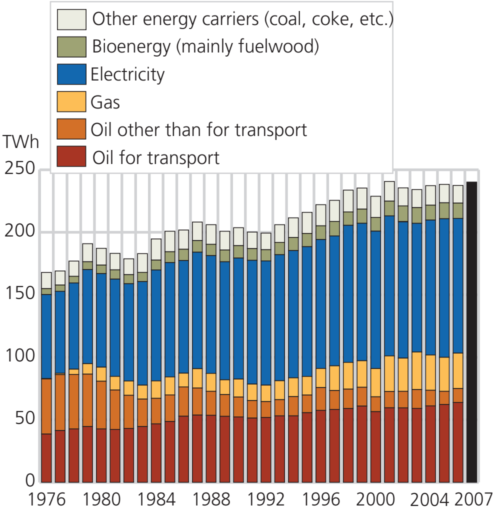


[1] Excluding the energy sectors and international maritime transport. Including energy carriers used as raw materials.
Source: Energy statistics, Statistics Norway.

Norway's energy use in total and split by consumer group

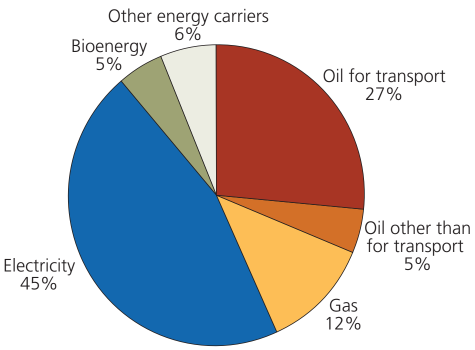
- In 2007, Norway's total energy use was 318 TWh, a rise of about 1 per cent from the year before. This includes energy commodities used as raw materials and use in the energy sectors, but excludes international maritime transport. Of this, 78 TWh was used in the energy sectors, which include oil and gas extraction, gas terminals, oil refineries, coal extraction and the production of electricity and district heating.
- Consumption of energy commodities, excluding the energy sectors and international maritime transport, totalled 240 TWh in 2007. The average annual rise over the past 10 years has been 0.7 per cent. In the same period, GDP excluding the oil and gas sector grew by an average of about 3.4 per cent per year.
- Energy-intensive manufacturing and the category "other industry" are the consumer groups where energy use has risen most in the period 1976-2006. Since these groups are dependent on cyclical changes, the rise has been uneven. Energy use by households rose steadily up to 1996 (which was a relatively cold year). It has since remained at about the same level, but with annual fluctuations. Energy use in agriculture and fisheries and in "other manufacturing" has shown some variation during this period, but no clear trend.

Figure 3.18. **Energy use[1] by energy carrier. 1976-2007*. TWh**



[1] Excluding the energy sectors and international maritime transport. Including energy carriers used as raw materials.
Source: Energy statistics, Statistics Norway.

Figure 3.19. **Energy use by energy carrier. 1980-2006*. Per cent[1]**

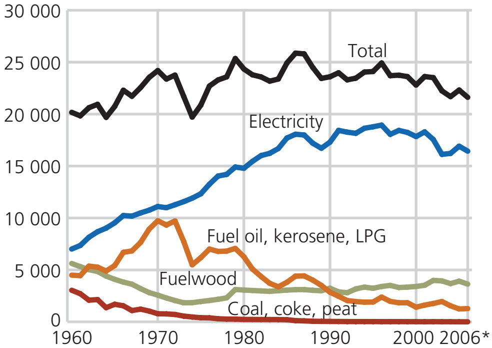


[1] Electricity accounts for a lower proportion of energy use here than in figure 3.16. This is mainly because figure 3.16 does not include the use of bioenergy or energy commodities used as raw materials and reducing agents.
Source: Energy statistics, Statistics Norway.

Consumption by energy commodity

- Total oil consumption, excluding the energy sectors and international maritime transport, dropped by about 9 per cent in the period 1976–2006, despite the fact that consumption of oil for transport rose by 66 per cent in the same period.
- Consumption of oil for transport purposes has been rising steadily, and transport accounted for 85 per cent of total oil consumption in 2006, as compared with 47 per cent in 1976.
- Consumption of oil for stationary purposes had dropped to less than one third of the 1976 level by 1992. It then remained at the same level until the last couple of years, since when there has been a further drop.
- Electricity consumption rose from 67 TWh in 1976 to 111 TWh in 2007. This is a rise of 66 per cent. From 2002 to 2003, high electricity prices resulted in a marked drop in consumption, but there has been a renewed rise since then. This must be seen in the context of a rise in fuel oil prices and growing economic activity.
- Some energy commodities, particularly coal, coke and LPG, are also used as factor inputs or reducing agents.

Figure 3.20. **Average household energy use, in total and by energy carrier. 1960-2006*. kWh energy supplied per household**

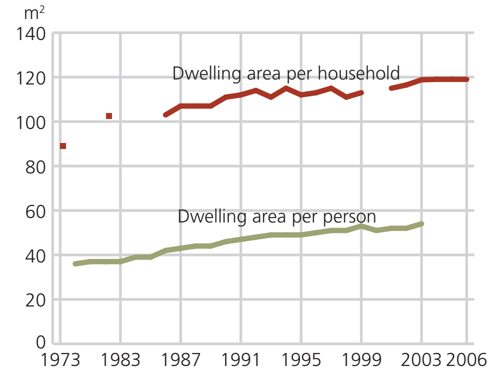


Source: Energy statistics, Statistics Norway.

Energy use per household

- Since 2000, energy use per household has shown a downward trend. In the period 1980-2000, average annual energy use fluctuated around 23 000-24 000 kWh, while in 2006 the corresponding figure was about 21 600 kWh. This is explained partly by higher energy prices (see next paragraph), a greater focus on energy saving, better insulation and the use of more energy-efficient electrical appliances. Climate change is another factor that affects energy use. 2006 was one of the warmest years ever recorded. For Norway as a whole, the temperature in 2006 was 1.8 °C above the normal value for the period 1961-1990, as compared with 1.4 and 1.5 °C above the normal value in 2004 and 2005 respectively.
- Electricity is the most important energy source for Norwegian households, and accounts for about three quarters of total energy use in the home, or about 16 200 kWh in 2006. Fuelwood is the second most important energy source, and accounted for about 18 per cent of energy use in 2006, or about 3 850 kWh. Oil and kerosene accounted for about 6.5 per cent of energy use. Gas and district heating are still not very widely used in Norwegian households, and accounted for barely 1 per cent of energy use.
- Households living in farmhouses and other detached houses use most energy: the average figures for 2006 were 32 900 and 26 700 kWh respectively. The corresponding figures for row houses/semi-detached houses and flats were 17 000 and 12 600 kWh. These differences in energy use are explained by a number of factors, including the area of the dwelling, the number of external walls and windows, and the number of people in the household.

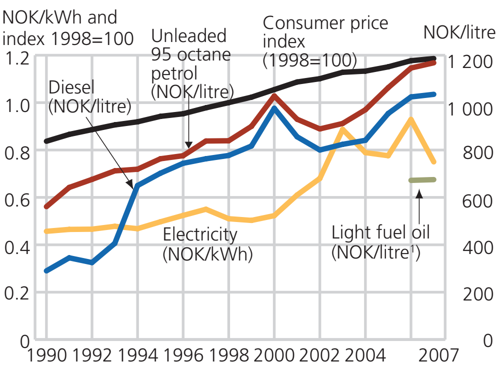
Figure 3.21. **Dwelling area in m², average per household, and per person 1973-2006**[1]



[1] Figures are not available for certain years.
Source: Survey of consumer expenditure and survey of living conditions, Statistics Norway.

- In contrast to the situation in most other countries, electric heating is most common in Norwegian households. This is one reason why worldwide, Norway is the country where household electricity consumption is highest. In 2006, 98 per cent of all households had electrical space heating and/or underfloor heating. Almost 70 per cent had wood-burning stoves, the second most widely used type of heating equipment. Heat pumps are becoming more widespread. In 2006, about 8 per cent of households reported that they had heat pumps, which is twice the level in 2004. This may be explained by relatively high electricity prices in recent years (a record price of NOK 0.929 per kWh was recorded in 2006).

Figure 3.22. **Prices at end-user level. 1990-2007. NOK per kWh and litre, current prices**

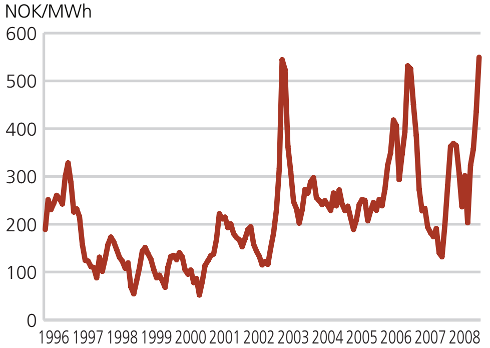


[1] Fuel oil prices are from the consumer price index.
Source: Energy statistics, Statistics Norway.

Prices

- The price of light fuel oil was more or less unchanged from 2006 to 2007. According to the quarterly price statistics, the average electricity price (including transmission charges and taxes) for households was NOK 0.75 per kWh in 2007. This is 19.3 per cent below the record level reached in 2006.
- Lower taxes resulted in a drop in the price of petrol and autodiesel from 2000 to 2002. Since 2002, taxes combined with higher crude oil prices have resulted in a renewed rise in the price of these products.

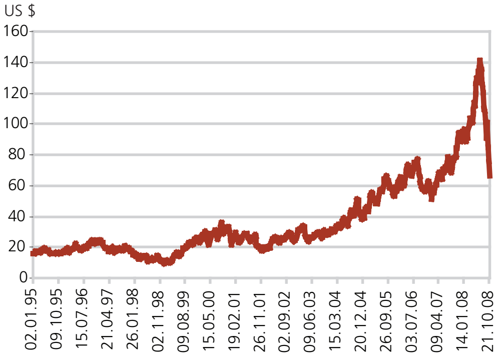
Figure 3.23. **Price trends for electricity, Nord Pool system price[1]. 1996-2008. NOK/MWh**



[1] Theoretical market price without any restrictions on transmission.
Source: Nord Pool.

- Trade in electricity has been deregulated in Norway, and power is traded directly among players (bilateral trade) and in the markets organised by the joint Nordic power exchange, Nord Pool. Nord Pool also organises the Nordic spot market for physical trade in electricity. Hourly prices (spot prices) are quoted for several price areas throughout the day. If there are no constraints in the transmission grid, only one price (the system price) is quoted. Figure 3.21 is a graph of the average monthly Nord Pool system price in the period 1996-2008. It shows that there can be very large variations from one month to another.
- In 2007, the average system price was NOK 0.224 per kWh, while the corresponding figure for 2008 up to mid-October was NOK 0.352 per kWh. System prices were highest in 2006, when the average for the whole year was NOK 0.391 per kWh. One factor behind this high price level was lower inflow than normal to the reservoirs, which resulted in lower hydropower production and thus a higher system price. In 2007, inflow increased considerably and prices dropped. In 2008, inflow to Norwegian reservoirs up to mid-October has been good, 111 TWh as compared with the normal level of 104 TWh. However, there have been large regional price differences in 2008 because of transmission bottlenecks, partly because some power lines were not operational.
- The spot price of Brent Blend rose from USD 76 per barrel in mid-August 2007 to about USD 144 per barrel at the beginning of July 2008. Since then, the price has fallen considerably, and was USD 66 per barrel on 21 October 2008. The average spot price of Brent Blend was about USD 108 per barrel for the first ten months of 2008. In 2007, the average price for the whole year was USD 72.

Figure 3.24. **Spot price of Brent Blend. 1995-2008. USD**



Source: Petroleum Intelligence Weekly.

- Several factors explain the sharp increase in oil prices through much of the second six months of 2007 and the first six months of 2008. In addition to the continued rise in oil demand in Asia, the Middle East and Latin America, oil production was lower than expected in several areas. Moreover, OPEC has had little spare production capacity, which has resulted in greater concern about the consequences of a drop in production.
- The main reason for the sharp drop in oil prices since July is declining demand in the OECD, and particularly in the US. Growth is now slowing in a number of countries outside the OECD as well. In addition, OECD stocks of crude oil and petroleum products are rising and are now above the average level for the past five years. The average price for 2008 as a whole is therefore expected to be lower than the average for the first 10 months of the year.

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Useful websites

Statistics Norway – Focus on Energy: http://www.ssb.no/energi_en/
Statistics Norway – Focus on Oil and gas: http://www.ssb.no/olje_gass_en/
British Petroleum (Statistical Review of World Energy Review): http://www.bp.com/home.do
International Energy Agency: http://www.iea.org/
World Energy Council: http://www.worldenergy.org
Ministry of Petroleum and Energy: http://www.odin.dep.no/oed/
Norwegian Water Resources and Energy Directorate: http://www.nve.no/
Norwegian Petroleum Industry Association: http://www.np.no/
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4. Agriculture

The total size of agricultural areas in use in Norway has remained stable at a time when the relative importance of agriculture to the national economy has declined. There have been major changes in farming that have affected the environment both on farmed land and in adjacent areas and river systems.

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. There has been a particular focus on water pollution as a result of eutrophication and soil erosion. The open cultural landscape we are familiar with today has largely been created by farming, and is continuously being shaped by the farming methods in 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 represent environmental assets that most people perceive as positive, but they can come under threat as agriculture is made more and more effective, both at the level of the individual farm and through merging of holdings to form larger units. Consequently, agricultural policy has given more weight to environment and landscape in recent years, while the focus on production objectives has been toned down

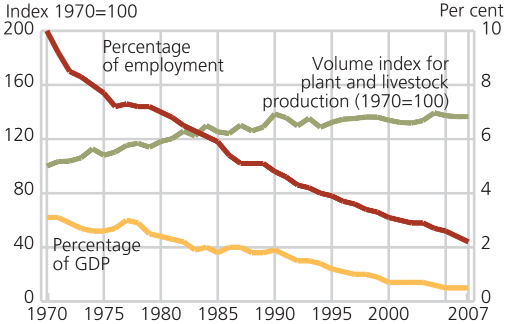
At the same time agricultural areas are also affected by pollution caused by other activities, including ozone and heavy metals, and by pressure to convert farmland for development, which is the most important factor. The food production potential in Norway is primarily restricted by climatic conditions and the availability of land resources suitable for farming. Nevertheless, the priority given to protecting agricultural land resources has varied in recent years.

Farming practices have impacts on the quality of agricultural products and thus on human health through factors such as the nutritional content of food, pesticide residues and animal diseases that are transmissible to humans.

This chapter takes a closer look at the natural resource base (land resources) and activities in the agricultural sector that have environmental impacts in the form of changes in the landscape and releases of pollutants to water and air. A brief summary of the economic importance of agriculture as an industry is also included.

4.1. Main economic figures for agriculture

Figure 4.1. **Trends in agricultural production volume and share of employment and GDP. 1970-2007***



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

Agriculture in an economic perspective

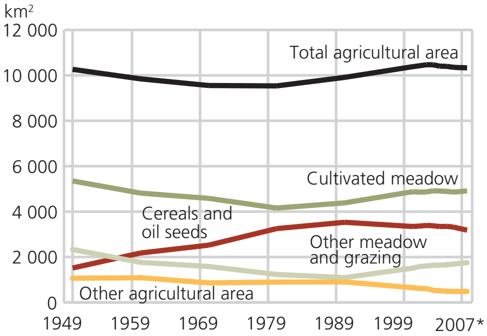
- From 1970 to 2007, employment in agriculture fell by 68 per cent (from 150 000 to 48 000 normal full-time equivalents). In comparison, manufacturing employment fell by approximately 25 per cent.
- Agriculture's share of GDP fell from 3.1 to 0.5 per cent. In comparison, manufacturing declined from 18.3 to 8.8 per cent.
- Agricultural production has increased by about 37 per cent since 1970. However, production volume has not increased since 1990[1].

[1] The production volume index for agriculture is based on trends in production volumes for crops and livestock for sale or used as food by the farming population.

4.2. Land resources

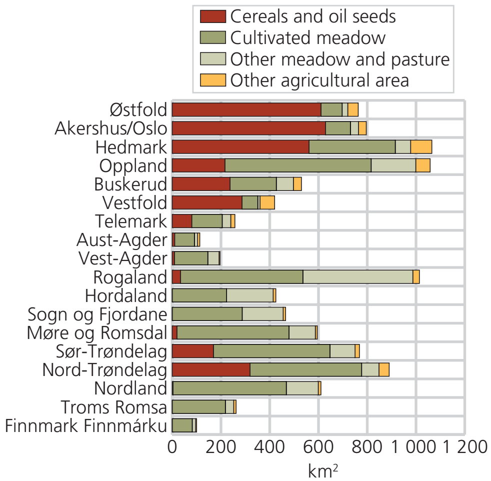
- About 3 per cent of Norway (excluding Svalbard and Jan Mayen) is cultivated, as compared with 11 per cent for the world as a whole.
- Some of the land resources available are not in use for agriculture, either temporarily or on a permanent basis. Agricultural areas that are permanently abandoned generally become overgrown with forest. The last complete census of agricultural areas was in 1989, when the total area was 10 800 km², of which 800 km² was not in use.

Figure 4.2. **Agricultural area in use. 1949-2007***



Source: Agricultural statistics, Statistics Norway.

Figure 4.3. **Agricultural area in use, by county. 2007***

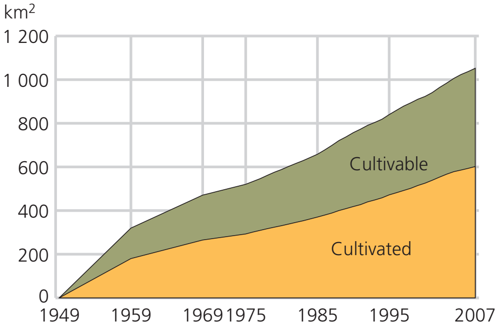


Source: Agricultural statistics, Statistics Norway.

Agricultural area in use

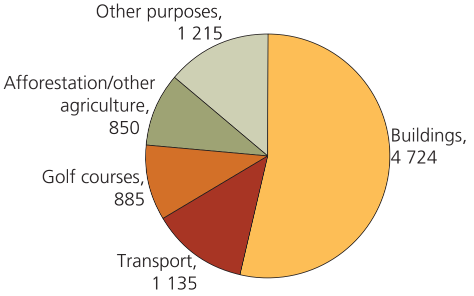
- From 1949 to the mid-1970s, the agricultural area in use decreased from 10 300 km² to less than 9 000 km². After a modest rise in the late 1970s and early 1980s, the area in use remained at around 9 500 km² until the end of the 1980s. It then rose again over the next 10 years. The most recent rise is probably related to the transition from support based on production to support based on the area farmed. As a result of this change, more farmers are applying for grants, and it is important to include as large an area as possible in applications.
- In 2001 and 2002, the agricultural area in use was a little under 10 500 km². Since then it has dropped by 1.3 per cent to 10 330 km² in 2007. In some counties, a considerably larger percentage reduction has been registered: in Aust-Agder, Vest-Agder, Hordaland and Finnmark, the agricultural area in use has dropped by 4-5 per cent. In Oppland, Rogaland and Nordland, the agricultural area in use has risen.
- In 1949, the area of cereals and oil seeds was 15 per cent of the agricultural area in use. This proportion rose until the early 1990s, when it reached 37 per cent. Since then it has dropped again, to 31 per cent in 2007.
- The area of natural meadow, surface cultivated meadow and fertilised pasture dropped by more than half from 1949 to the mid-1980s. It started to rise again from the late 1980s, and accounted for 17 per cent of the agricultural area in use in 2007.

Figure 4.4. **Accumulated conversion of cultivated and cultivable land[1]. 1949-2007***



[1] For the period 1949-1975, 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 in 1976-1997.
Sources: Statistics Norway, Ministry of Agriculture and Food and Norwegian Agricultural Authority.

Figure 4.5. **Conversion of cultivated areas for purposes other than agriculture. 2007. Decares**



Source: Agricultural statistics, Statistics Norway.

Conversion of cultivated and cultivable land

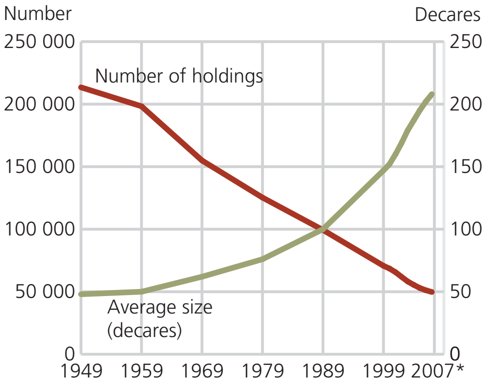
- The most important threat to agricultural land resources is their conversion for purposes that prevent future agricultural production. An estimated 1 052 km^2, or about 5 per cent of the total area suitable for agriculture, has been converted for such purposes since 1949.
- The authorities have set the target of halving the annual conversion of the most valuable soil resources for purposes other than agriculture by 2010. In the period 1994–2003, an average of 13 400 decares of cultivated land per year was converted for other purposes. If land used for tree-planting is deducted, the average area was 11 400 decares per year. In 2007, 8 800 decares of cultivated land were converted for other purposes, including 250 decares for tree-planting.

New cultivation

- The area classified as cultivable is almost as large as that under cultivation. Most cultivable land is in areas with a climate that is most suitable for the production of grass and other fodder crops.
- Until the early 1990s, government grants were provided for new cultivation. In the 1950s, 1960s and 1970s, an annual average of about 80 000 decares was brought under cultivation on the basis of government grants. Since the grant scheme was discontinued, a sharp decrease in new cultivation activities has been recorded. In 2007, the municipalities approved new cultivation of 13 100 decares of land.

4.3. Size of holdings and cultural landscape

Figure 4.6. **Number of holdings and average size of agricultural area in use (decares). 1949-2007***

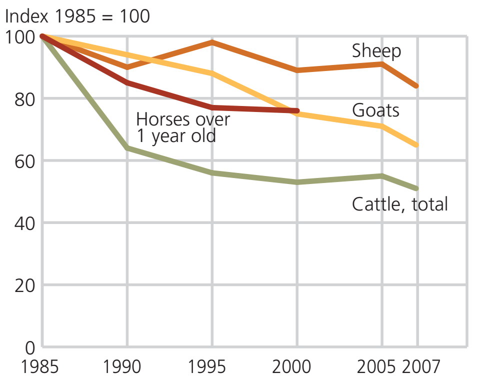


Source: Agricultural statistics, Statistics Norway.

Holdings – number and size

- From 1949 to 2007, the number of holdings in Norway was reduced by 164 000; this is equivalent to a loss of eight holdings a day. Figures for the last few years indicate a rising rate of farm closures. In the ten-year period 1989–1999, the average annual decrease was 2.9 per cent, while the corresponding figure for the period 1999–2007 was 3.7 per cent.
- Much of the land on abandoned holdings is initially taken over as additional land by the remaining holdings, generally as rented area. In 2007, 39 per cent of the agricultural area in use was rented, as compared with 23 per cent in 1989. In Telemark, Aust-Agder, Vest-Agder and Troms, the proportion of agricultural land rented was more than 50 per cent in 2007.

Figure 4.7. **Numbers of livestock spending at least 8 weeks on outlying rough grazing. 1985-2007. 1985 = 100**



Source: Norwegian Agricultural Authority.

- Historically, summer mountain farming was an important means of obtaining sufficient fodder for livestock in Norway. It now maintains an important element of the cultural landscape in some mountainous regions of the country, although the number of summer farms is very much lower than it used to be. In 1949, 22 600 holdings had their own summer farms or a share in a summer farm, as compared with only 1 900 in 2007.
- Grazing livestock play an important role in reducing overgrowing of previously open uncultivated areas such as coastal heaths and summer farm pastureland. Grants are available for farmers who keep livestock on outlying rough grazing for at least 8 weeks.

Box 4.1. Structural changes and the 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 into fewer and larger holdings
- Each holding produces fewer products (specialisation at holding level)
- Production of important products is concentrated to a greater extent in certain regions (specialisation 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 to the means of production have also been affected: this also applies to buildings, which are an important part of Norway's cultural heritage. Larger holdings, technological advances such as increased size of machinery and tools, and greater pressure to increase earnings are all factors that tend to lead to an increase in the size of fields. An increase in the size of fields reduces the length of ecotones and results in less variation in the landscape within a given area. This reduces biological diversity and gives the agricultural landscape a more monotonous appearance.

Box 4.2. Pollution from the agricultural sector

Farming results in air and water pollution. Agriculture is a major source of discharges of the nutrients nitrogen and phosphorus to water (see further details in Chapter 12). In 2006, agriculture accounted for about 45 and 58 per cent respectively of anthropogenic phosphorus and nitrogen inputs to what is termed the North Sea area (the coastal area between the Swedish border and Lindesnes). These inputs are described in more detail in Chapter 12. 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 fertiliser management to reduce the surplus of nutrients in soils
- Better cultivation systems to protect soils against erosion
- Technical measures, such as improving drainage, enlarging manure storage facilities, etc.

Farming also makes a substantial contribution to emissions of ammonia (NH_3), methane (CH_4) and nitrous oxide (N_2O) to air (see Table 4.1). Emissions of ammonia result in acid rain, while methane and nitrous oxide are greenhouse gases (see Chapter 9). No measures have as yet been implemented to reduce emissions to air from the agricultural sector. The use of pesticides in farming also results in various forms of pollution.

4.4. Pollution from the agricultural sector

Table 4.1. **Emissions to air from agriculture. Greenhouse gases and acidifying substances. 2006***

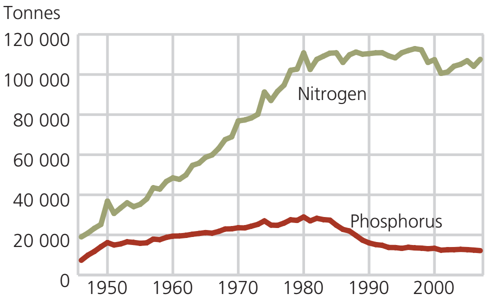
	Emissions from agriculture	Share of total emissions in Norway
	1 000 tonnes	Per centt
Greenhouse gases	**4 750[1]**	**9.1**
Carbon dioxide (CO_2)	493.6	1.1
Methan (CH_4)	102.4	48.8
Nitrous oxide (N_2O)	6.8	48.2
Acidifying substances	**1.3[2]**	**20.6**
Ammonia (NH_3)	19.8	87.5
NO_x	4.2	2.2
SO_2	0.2	1.0

[1] CO_2 equivalent.
[2] Acid equivalents.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Emissions to air

- Agriculture accounts for a relatively modest share of CO_2 emissions in Norway, although larger than its share of Norway's GDP.
- The main source of *methane* emissions is livestock: between 80 and 90 per cent is released directly from the gut.
- Important sources of nitrous oxide emissions are nitrogen runoff, use of commercial fertiliser and manure, livestock, biological nitrogen fixation, decomposition of plant material, cultivation of mires and deposition of ammonia. Calculations of nitrous oxide emissions from agriculture are uncertain.
- Animal manure (about 90 per cent) is the most important source of *ammonia* emissions. Other sources are the use of commercial fertiliser and treatment of straw with ammonia.
- See also Chapter 9. Air pollution and climate change.

Figure 4.8. **Sales of nitrogen and phosphorus in commercial fertilisers. 1946-2007**

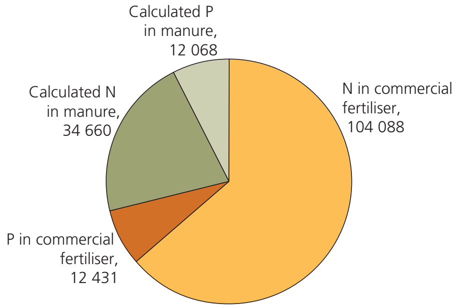


Source: Norwegian Food Safety Authority.

Use of commercial fertiliser and manure

- As a rule, heavy application of fertiliser results in poor utilisation of the nutrients and may therefore increase pollution in lakes and rivers. The amount of fertiliser applied is therefore increasingly determined on the basis of soil samples and recommended standards. Since 1998, a fertilisation plan has been mandatory for holdings that apply for production grants.
- Since the early 1980s, sales of phosphorus fertiliser have been more than halved. Sales in the last few years are the lowest since the late 1940s.

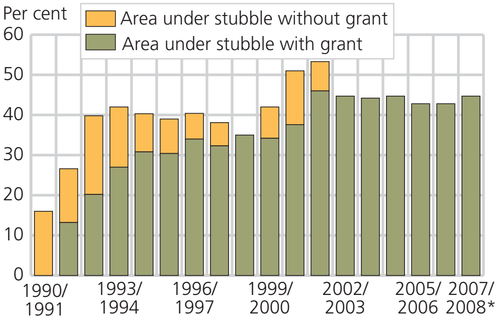
Figure 4.9. **Sales of nitrogen and phosphorus in commercial fertiliser and calculated effective nitrogen and phosphorus content of manure. 2006*. Tonnes**



Sources: Norwegian Food Safety Authority and Agricultural statistics, Statistics Norway.

- Better utilisation of manure reduces losses of nutrients. The nutrient content of manure depends on various factors, including feed composition, manure storage and manure application. For the country as a whole, the calculated effective nitrogen and phosphorus content of animal manure has been stable since 1990.
- Small amounts of sewage sludge are also applied to agricultural areas every year. Sewage sludge contains both organic material and plant nutrients.

Figure 4.10. **Proportion of cereal acreage left under stubble[1] in autumn. 1990/1991-2007/2008***

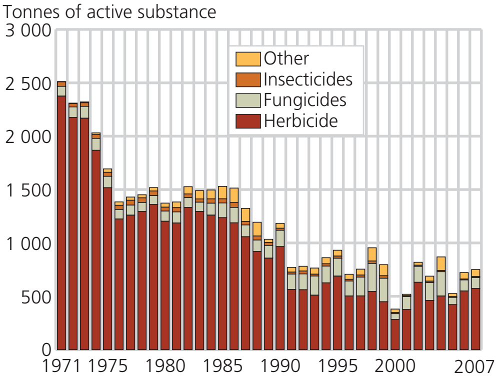


[1] Total area under stubble not recorded in 1998/99 and after 2001/02.
Source: Agricultural statistics, Statistics Norway, Ministry of Agriculture and Food and Norwegian Agricultural Authority.

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. In general, areas with vegetation cover or that are not ploughed in autumn are less vulnerable to erosion and runoff of nutrients than tilled areas. In the long term, erosion reduces the production capacity of the soil.
- To reduce soil erosion, the authorities provide grants for areas that are vulnerable to erosion on condition that the farmers leave them under stubble during the winter, i.e. do not till these areas in autumn. In winter 2007/08, the area under stubble for which support was granted was 1.4 million decares, while the total area under cereal and oil seeds in 2007 was 3.2 million decares.
- Support is also provided for other forms of amended soil management. In all, grants were provided for 338 000 decares of land that was lightly harrowed in autumn, directly sown autumn cereals, autumn cereals sown after light harrowing and catch crops in the season 2007/08. There is also a grant scheme for grassed channels and vegetation zones. From 2005, these schemes have been included in the regional environmental programmes, and the way these are organised varies from county to county.

Figure 4.11. **Sales of chemical pesticides. Tonnes active substances. 1971-2007**

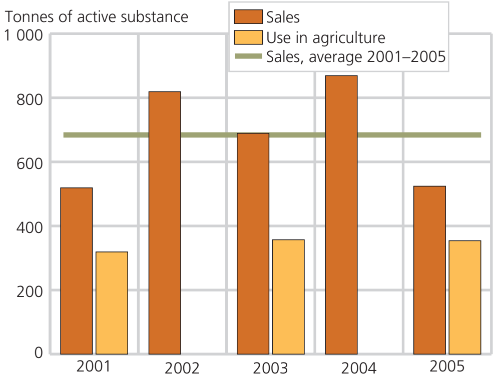


Source: Norwegian Food Safety Authority.

Use of pesticides

- The sales statistics apply to sales by importers to distributors and do not therefore show actual annual usage. Statistics for recent years are influenced by the fact that there have been changes in the taxation system, which have resulted in some hoarding of pesticides.
- The substantial decrease in sales of herbicides since the 1970s is largely due to a changeover from high-dosage to low-dosage preparations in cereal production.

Figure 4.12. **Sales of chemical pesticides compared with registered use in the agricultural sector in 2001, 2003 og 2005. Tonnes active substances**



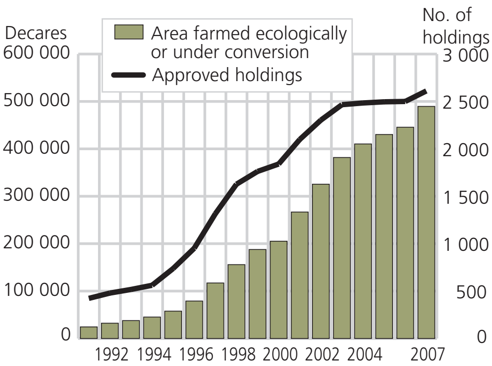
Sources: Norwegian Food Safety Authority and Agricultural statistics, Statistics Norway.

- Pesticide use in agriculture may vary considerably from one year to another because of weather conditions. In 2001, 2003 and 2005, Statistics Norway conducted surveys to collect statistics on the actual use of pesticides. The surveys covered about 97 per cent of the total agricultural area in use. Preparations used to treat seeds or plants before planting were not included in the survey.
- Pesticides are also used outside the agricultural sector, for example in gardens and green spaces, on golf courses, along roads and railways and in forestry.

4.5. Ecological farming

A white paper on Norwegian agriculture and food production (Report No. 19 (1999–2000) to the Storting) laid down the target that 10 per cent of the total agricultural area is to be farmed ecologically within 10 years, provided that there is a market for the products. The Government's goal is for organic food to account for 15 per cent of the food produced and consumed in Norway by 2015.

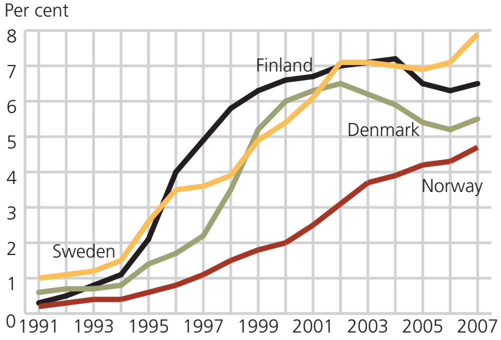
Figure 4.13. **Holdings approved for ecological farming and total area farmed ecologically or in the process of conversion. 1991–2007**



Source: Debio.

- In 2000, the area farmed ecologically and in the process of conversion made up 2.0 per cent of the total agricultural area. By 2007, this had risen to 4.7 per cent. From 2006 to 2007, the area farmed ecologically and in the process of conversion rose by 44 000 decares. This is the largest rise since 2003.
- In 2007, meadow and pasture made up 77 per cent of the area farmed ecologically, while cereals accounted for 14 per cent and other crops for 9 per cent.
- The percentage of the agricultural area farmed ecologically was highest in Sør-Trøndelag (8.6 per cent), followed by Buskerud (8.0 per cent) and Telemark (7.6 per cent). It was lowest in Rogaland (0.8 per cent).
- The proportion of ecologically farmed livestock (including those on holdings under conversion) is low. In 2007, the figures were 5.1 per cent for suckler cows, 2.5 per cent for dairy cows, 0.1 per cent for breeding sows, 1.6 per cent for sheep and lambs and 2.4 per cent for laying hens.
- In 2007, the area farmed ecologically or in the process of conversion totalled 188 decares on average per approved holding. Approved holdings may also have conventionally farmed land. For all agricultural holdings, the average agricultural area in use was 208 decares.

Figure 4.14. **Percentage of the total agricultural area farmed ecologically or in the process of conversion in the Nordic countries. 1991-2007**



Sources: Debio and agricultural statistics, Statistics Norway (Norway); KRAV and agricultural statistics, Statistics Sweden and Swedish Board of Agriculture (Sweden); Danish Plant Directorate and agricultural statistics, Statistics Denmark (Denmark); Evira and agricultural statistics from TIKE (Finland).

- The proportion of the agricultural area farmed ecologically remained stable or dropped slightly in Sweden, Denmark and Finland in the period 2002–2006. This may be because of a reduction in the prices obtained for ecological products as a result of lower demand than expected. In addition, some farmers may be satisfied with meeting the requirements for environmental grants, which are less strict than those for certification for ecological farming. From 2006 to 2007, the proportion of land farmed ecologically rose again. This may be because of a growing demand for ecological products.

Box 4.3. Ecological farming

Ecological farming (or organic farming) is a collective term for various farming systems based on some common principles:
- No use of mineral fertiliser or chemical/synthetic pesticides
- Cultivation of a variety of crops and diversified crop rotation
- Cultivation systems should have a preventive effect on disease and pests
- Organic material recycled as far as possible
- Balance between livestock numbers and areas of farmland with respect to fodder production and use of manure.

Ecological agriculture has certain environmental advantages over conventional farming systems:
- 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
- Product quality often perceived as higher.

Ecological agriculture is considerably more labour-intensive than conventional agriculture, and yields are generally lower. Product prices therefore have to be higher.

Products may only be marketed as ecological if they are produced and controlled in accordance with Norwegian regulations. The organisation Debio is responsible for inspection and control.

More information: Ole Rognstad (ole.rognstad@ssb.no).

Useful websites

Statistics Norway agricultural statistics: http://www.ssb.no/english/subjects/10/04/
Statistics Norway national accounts: http://www.ssb.no/english/subjects/09/01/
Norwegian Institute for Agricultural and Environmental Research:
http://www.bioforsk.no/
Debio: http://www.debio.no/
Ministry of Agriculture and Food: http://www.regjeringen.no/en/dep/lmd.html?id=627
Norwegian Food Safety Authority: http://www.mattilsynet.no/
Norwegian Agricultural Economics Research Institute: http://www.nilf.no/
Norwegian Forest and Landscape Institute: http://www.skogoglandskap.no
Norwegian Agricultural Authority: http://www.slf.dep.no/

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5. Forest and uncultivated land

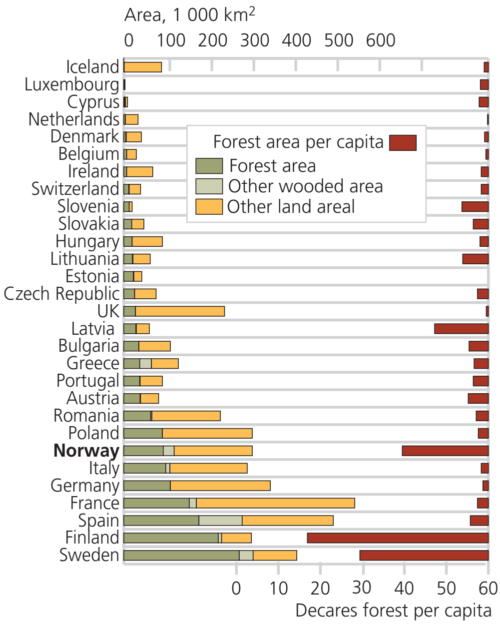
The Norwegian forests contain a wide variety of resources and environmental qualities. In terms of the economy, forests are primarily important as a source of raw materials for the sawmilling and pulp and paper industries. The forest, with its biological diversity, also has considerable value as an ecological resource and as an outdoor recreation area for an increasingly urbanised population. Forests may also become increasingly important as a carbon sink.

However, varying interests in forests and forest resources are continuing to lead to conflicts between different groups of forest users. In order to reduce the adverse effects on ecology of timber production and its disadvantages to recreational users, the forestry industry itself and the authorities have in recent years placed greater emphasis on multi-use considerations.

This chapter describes the forestry industry and the importance of forest and uncultivated areas in a wider perspective. The growing stock in Norway has increased considerably for many years because the rate of roundwood removals has been lower than the natural increment. This accumulation of carbon in forests has resulted in an annual uptake of CO_2 by forest that is equivalent to about 55 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 such as climate change and air pollution. Game species, the large predators and reindeer husbandry are also discussed.

5.1. Distribution of forests in Norway and Europe

Figure 5.1. **Forest area and total land area in selected EU and EFTA countries**



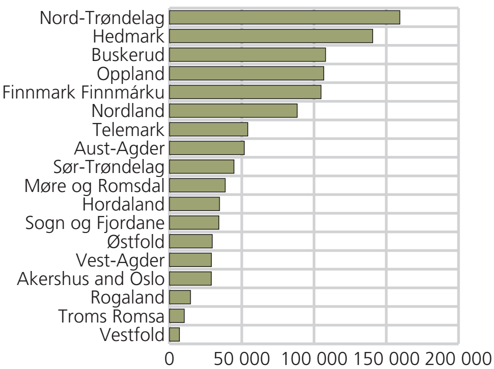
Source: FAO (2005).

Forested area

- 120 000–125 000 km² (37-39 per cent) of Norway's area is forested. Of this, about 75 000 km² is productive forest (Norwegian Forest and Landscape Institute 2008). This equals about 23 per cent of the total land area of Norway. Almost half of this forested area is managed in combination with agricultural operations.
- About 1.45 million km² or 36 per cent of the total area of the EU countries is forested. Sweden and Finland have the largest areas of forest. With Norway, these countries have the largest area of forest relative to population.
- Forestry and forest industries employ 2.2 million persons in the EU area today (UN-ECE/EC 2000).

5.2 Protection of forests in Norway

Figure 5.2 **Area of productive forest protected, by county. 2008[1]. Decares**

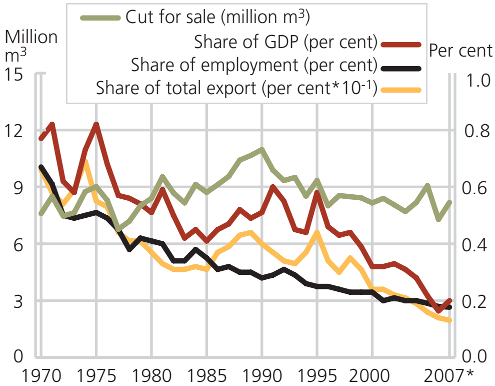


[1] As of 1 September 2008.
Source: Directorate for Nature Management (2008).

- In mid-2008, 1 028 km² or 1.36 per cent of the productive forest area in Norway was protected (Directorate for Nature Management 2008).
- Well over half of the productive forest area is classified as being of low site quality, and only 10 per cent is of high site quality.
- In all, slightly more than 3 000 km² of forest and mire is protected. Of this, 1 120 km² is coniferous forest and 1 080 km² is broad-leaved forest.
- An estimated 22 000 plant and animal species are associated with forests in Norway, and about 1 800 of them are rare or endangered (Norwegian Biodiversity Information Centre 2008).

5.3. Forestry

Figure 5.3. **Forestry: share of exports, employment and GDP. Annual roundwood removals. 1970-2007***

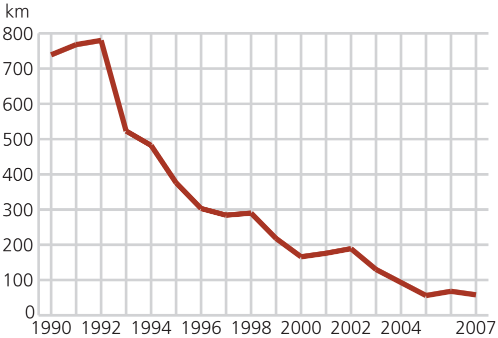


Source: National accounts and forestry statistics, Statistics Norway.

Roundwood removals and economic importance

- In 2007, forestry's share of total employment was 0.18 per cent. This corresponds to 4 560 full-time equivalents, down from about 10 000 in 1970. The relative reduction is somewhat lower than for agriculture.
- Forestry's share of Norway's GDP dropped from 0.77 per cent in 1970 to 0.20 per cent in 2007. Forestry's share of GDP has declined less sharply than that of agriculture.
- The gross value of removals of industrial roundwood was NOK 3 billion in 2007, and wood and wood processing products worth NOK 13.7 billion were exported from Norway, which is 1.3 per cent of the value of the country's total exports.

Figure 5.4. **Annual construction of new forest roads for year-round use. 1990-2007**



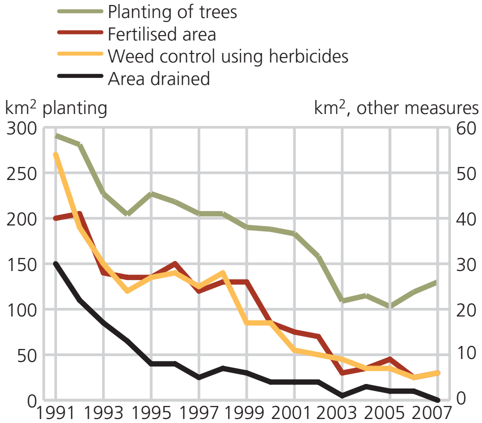
Source: Forestry statistics, Statistics Norway.

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 wilderness-like areas in Norway. At the beginning of 2007, the total registered length of forest roads (whole-year roads and summer roads for lorries) was 48 400 km.
- However, the rate of construction of forest roads has dropped from 780 km forest roads for year-round use in 1992 to 58 km in 2007.
- A total of NOK 84 million was invested in forest roads in 2007, and NOK 26 million of this was in the form of public grants. The volume of grants was NOK 4 million lower than in 2006.

For statistics on areas of natural environment, see Chapter 8 Land and land use.

Figure 5.5. **Silviculture measures[1, 2] that have an environmental impact. 1991-2007**



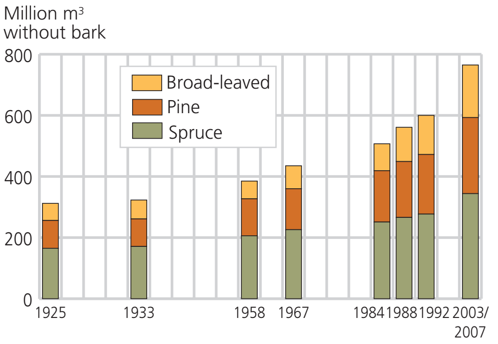
[1] The figures refer to silviculture funded by the Forest Trust Fund and/or government grants.
[2] No figures are available for the county of Finnmark in 1998.
Source: Forestry statistics, Statistics Norway.

Silviculture

- There has been a decrease in silviculture activities since the beginning of the 1990s. Public funding for such activities was discontinued in 2003. However, some funding is now available again in the form of municipal grants.
- The planting of trees is the largest single silviculture investment. A total of NOK 92 million was invested in planting in 2007, and an area of 130 km² was planted.
- There may be several reasons for the decline in the use of chemical herbicides: increased awareness of environmental concerns in forestry, restrictions on the use of pesticides, the discontinuation of grants and reduced profitability in forestry.
- Drainage activities have more or less ceased, and only 51 decares of forest was drained in 2007.

5.4. Increment and uptake of CO_2 by forest

Figure 5.6. **Volume of the growing stock. 1925-2003/2007**

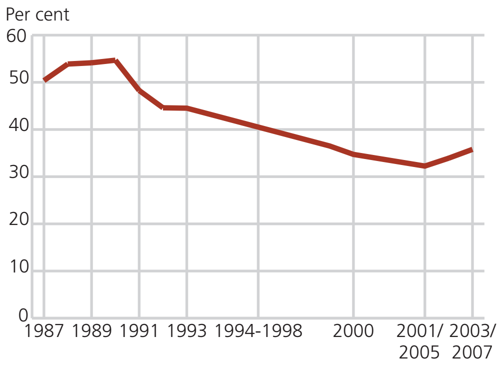


Source: Statistics Norway and National Forest Inventory.

Forest volume and utilisation rate of growing stock

- Since the early 1920s, roundwood removals have been less than the annual increment. In 1925, about 80 per cent of the increment was cut, whereas only just over one third was cut in the period 2002-2006. As a result, the volume of the growing stock below the coniferous forest line has more than doubled since 1925.
- In 2007, the gross increment in Norwegian forests was about 25.3 million m^3.

Figure 5.7. **Utilisation rate of the growing stock[1]. 1987-2003/2007**



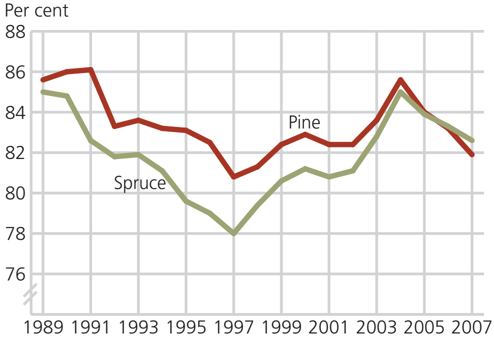
[1] Utilisation rate is defined here as the volume of roundwood removals in relation to gross increment.
Source: Forestry statistics, Statistics Norway and National Forest Inventory.

Uptake of CO_2

- The increase in the biomass (branches and roots included) of forests in 2006 resulted in an uptake of carbon by forest that corresponded to 22 million tonnes of CO_2 or about 51 per cent of total anthropogenic CO_2 emissions in Norway. This figure is based on the methodology used by Rypdal et al. (2005), but the estimate is somewhat higher because improvements have been made in the method for estimating forest biomass, and the figures reported to the UN Climate Change Convention have therefore been changed.
- Estimates of changes in carbon pools in dead wood and soil have also been made. The net rise in carbon volume in 2006 corresponded to 4 million tonnes CO_2 or 10 per cent of total anthropogenic emissions (Rypdal et al. 2005).

5.5. Forest damage

Figure 5.8. **Mean crown condition for spruce and pine. 1989-2007**



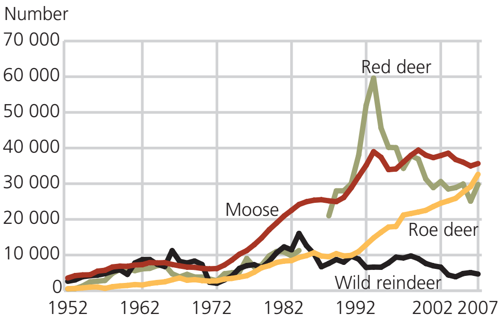
Source: Norwegian Forest and Landscape Institute.

Forest damage in Norway

- Crown density is an indicator of forest health. Decreasing crown density was the trend from the first survey in 1989 and up to 1997. After this, crown density of both spruce and pine improved until 2004, but has since deteriorated somewhat again.
- Mean crown density was 82.6 per cent for spruce and 81.9 per cent for pine in 2007.
- The crown colour status of spruce was somewhat poorer in 2007 than in 2006, which was the best year since the first survey. Pine and birch, on the other hand, showed a significant improvement from the year before.

5.6. Game species

Figure 5.9. **Number of moose, red deer, wild reindeer and roe deer killed. 1952-2007**

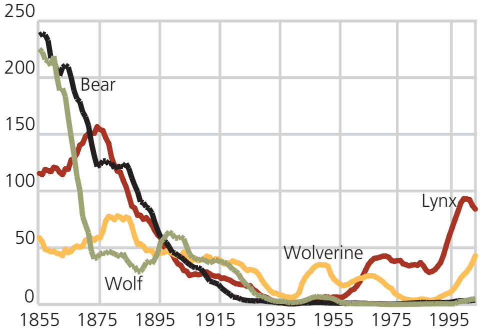


Source: Hunting statistics, Statistics Norway.

Cervids

- The numbers of forest-living cervids have risen considerably in the last 20–30 years, particularly as a result of clear-cutting and selective shooting. In recent years, the moose stock has dropped slightly, while the red deer stock has continued to rise.
- The grazing pressure exerted by large populations of cervids influences the vegetation, and this can affect the landscape and biological diversity.
- Total yields in 2007 (slaughter weight) were 4 768 tonnes moose, 1 848 tonnes venison and 155 tonnes wild reindeer. By way of comparison, Norwegian beef production was 84 700 tonnes in 2007.

Figure 5.10. **Number[1] of predators killed. 1855-2006**



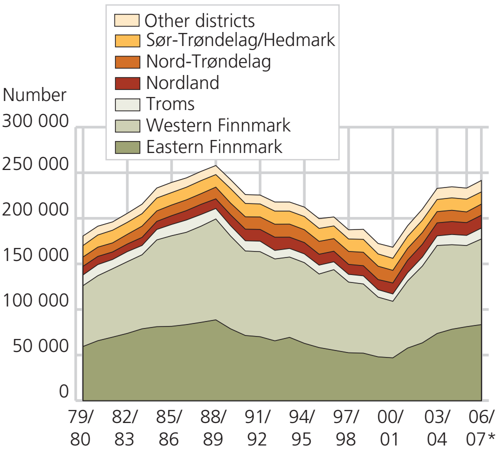
[1] Average number past ten years.
Source: Hunting statistics, Statistics Norway.

The large predators

- Relentless hunting of all four species of large predators had almost exterminated wolves and bears by the middle of the 20th century. Wolves and bears have been protected throughout Norway since 1971 and 1973 respectively.
- 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.
- Today, lynx is classified as a game species, and lynx hunting is regulated by means of quotas. Wolverines, wolves and bears are protected, but in certain cases, licensed hunters may be permitted to take a certain number of animals, or animals that are a danger to livestock may be culled.
- In the mid-1800s, nearly 250 bears and almost as many wolves were killed every year. The number of predators killed declined sharply from then and up to the turn of the century.

5.7. Reindeer husbandry

Figure 5.11. **Trends in the size of the spring herd. 1979/80-2006/07***



Source: Norwegian Reindeer Husbandry Association.

Geographical scope and economic importance

- Reindeer husbandry is a small sector in national terms, but shares user interests with others in an area equivalent to 40 per cent of the total area of Norway.
- There was a large reduction in the size of the spring herd (stock size before calving starts in May) in Finnmark in the period 1988/89–2000/01. This was a result of management measures implemented because of overgrazing, increased losses to predators and several winter seasons with difficult weather conditions at the end of the 1990s. After 2000 the size of the reindeer stock in Finnmark rose substantially for several years due to good calving seasons, primarily as a result of very favourable weather conditions during the winter season.
- The total yield (slaughter weight) of domestic reindeer in 2007 was 1 790 tonnes. This is more than 11 times the yield of wild reindeer.

5.8. Management of uncultivated areas

Table 5.1. **Processing of applications for exemptions under the Act relating to motor traffic on uncultivated land and in watercourses. Whole country. 2001-2007**

	Number of applications processed by the municipalities	Number approved	Percentage approved
2001[1]	12 674	11 863	94
2002[1]	14 186	13 255	93
2003[1]	13 208	12 557	95
2004	18 025	15 926	88
2005	18 218	15 269	84
2006	14 587	13 386	92
2007	13 248	12 225	92

[1] No. of applications in reporting municipalities (between 80 and 95 per cent of all municipalities).

Source: Statistics Norway.

Motor traffic

- Motor traffic in uncultivated areas is in principle prohibited. However, under the Act relating to motor traffic on uncultivated land and in watercourses, local authorities may grant exemptions from the Act, allowing the use of motor traffic for certain purposes. No data on actual traffic is available, but KOSTRA (a system for reporting and publishing local government information) provides information on the use of exemptions by local government authorities. This may give an indication of changes in the volume of such traffic.
- In all, 92 per cent of all applications for exemptions were granted in 2007, about the same proportion as the year before. The number of applications has dropped every year since 2004.
- See also Chapter 8, Land and land use, where municipal land use management and building activity in the coastal zone (100-metre belt) is described.

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Useful websites

Statistics Norway forestry statistics: http://www.ssb.no/english/subjects/10/04/20/
Statistics Norway, hunting statistics: http://www.ssb.no/english/subjects/10/04/10/
Living Forests: http://www.levendeskog.no/sider/tekst.asp?id=English
Norwegian Forest and Landscape Institute: http://www.skogoglandskap.no/english/index.html
Norwegian Reindeer Husbandry Association: http://www.reindrift.no/

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6. Fisheries, sealing, whaling and fish farming

The Barents Sea capelin stock has been low for several years, but is now growing. The spawning stock of Northeast Arctic cod is considered to be within safe biological limits, and illegal fishing has been considerably reduced. Development of the Norwegian spring-spawning herring stock has been very satisfactory, and it has now reached the same level as in the 1950s. Stocks of several important demersal fish species in the North Sea are still very low. In 2007, production of farmed salmon increased to 736 000 tonnes.

Most fish stocks in the Barents Sea are in good condition, and the capelin stock, which has been low for a number of years, has more than doubled from the autumn 2006 level. Illegal fishing for Northeast Arctic cod was considerably reduced in 2007.

The fisheries clearly influence fish stocks, but variations in natural conditions such as temperature are also important, affecting the spawning success and distribution of different fish stocks and the food supplies available to them. The period since 2000 has been the warmest on record in the Barents Sea since 1900 (Gjøsæter et al. 2008). Water temperatures have also been high in the North Sea and the Norwegian Sea.

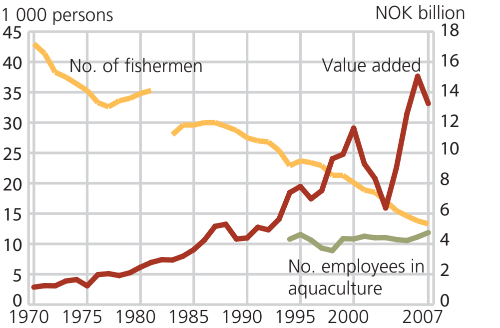
The Norwegian spring-spawning herring stock is the largest herring stock in the world. According to the 2008 annual report on marine resources and environment (Gjøsæter et al. 2008), this is because conditions in the sea have been favourable, the spawning stock is large, and the management plan is functioning well. Of the other major pelagic stocks in the Norwegian Sea, the blue whiting appears to be declining, and the mackerel stock is estimated to be around the precautionary level.

For the last five to six years, there has been poor recruitment to the sandeel, Norway pout, cod, and the North Sea herring stocks. This is mainly a result of changes in physical and biological conditions, although the cod and sandeel stocks have also been overfished. Moreover, illegal, unreported and unregulated fishing (IUU fishing) makes it difficult to calculate the size of certain stocks, particularly mackerel and cod (Gjøsæter et al. 2008).

The total catches in the world's marine fisheries were 82 million tonnes in 2006, a decrease of about 2.6 million tonnes compared with the year before. The species with the highest total catch was Peruvian anchovy, which accounts for a substantial proportion of the total harvest in the Southeast Pacific. In 2006, the catch of this species was 7 million tonnes, which was about 3 million tonnes less than in 2005. Total world aquaculture production (including fish and shellfish) in 2006 was 52 million tonnes, and in addition, production of aquatic plants totalled 15 million tonnes.

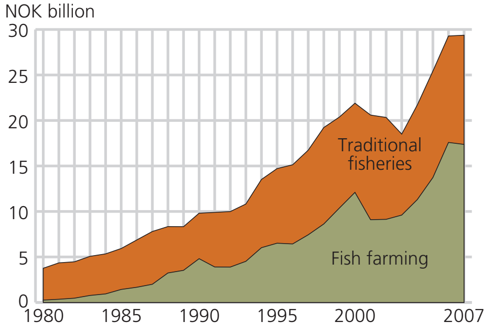
6.1. Principal economic figures for the fisheries

Figure 6.1. **Value added[1] in the fishing, sealing and whaling industry, number of fishermen and number of people employed in the aquaculture industry[2]. 1970-2007**



[1] Value added (production value minus material input) in basic values. Current prices.
[2] For the period 1994-1998: no. of people employed in salmon and trout farming only.
Source: Directorate of Fisheries and National Accounts, Statistics Norway.

Figure 6.2. **First-hand values in traditional fisheries and fish farming. 1980-2007**



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

GDP and employment

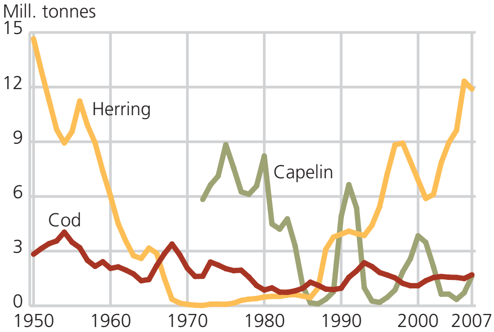
- According to the Norwegian national accounts, fishing, sealing, whaling and fish farming contributed NOK 13.3 billion, or 0.58 per cent, to Norway's gross domestic product (GDP) in 2007. Figure 6.1 shows a sharp drop just after 2000. This was the result of a general fall in demand and low prices in 2002, and even more markedly in 2003, which created difficult conditions for the fisheries industry (Statistics Norway 2004a and b).
- The fishing industry accounted for 0.61 per cent of total employment in 2007. At the end of 2007, 13 336 fishermen were registered in Norway. The number of fishermen has dropped by almost 90 per cent since the late 1930s, and by about half since 1990 alone. Farming of salmon and trout employs about 3 800 people.

Production and prices

- According to preliminary figures from the national accounts, production in fisheries, sealing, whaling and fish farming rose by 17.4 per cent from 2006 to 2007, measured in constant prices.
- In 2003, prices were generally low and the total first-hand value of the catch in the traditional fisheries was NOK 8.9 billion. The total first-hand value was 34 per cent higher in 2007 than in 2003: the rise occurred almost entirely in 2004 and 2005. In 2007, the total value of the catch was NOK 12 billion, and herring and cod accounted for almost 50 per cent of this (Statistics Norway 2008).
- From 2000 to 2003, the average export price of salmon (fresh and frozen) dropped by 34 per cent, while the quantity exported rose by 20 per cent. From 2003 to 2006, the price of salmon rose by 50 per cent, and the quantity exported rose by 22 per cent. In the fourth quarter of 2006, salmon prices began to drop again, and were lower than in 2006 throughout 2007. The average export price of fresh and frozen salmon was 17.5 per cent lower in 2007 than in 2006, but slightly higher than in 2005 (Statistics Norway 2008).

6.2. Trends in stocks

Figure 6.3. **Trends for stocks of Northeast Arctic cod[1], Norwegian spring-spawning herring[2] and Barents Sea capelin[3]. 1950-2007**

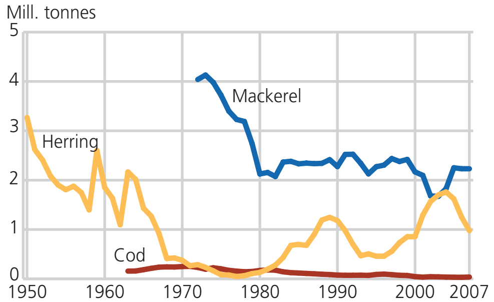


[1] Fish aged three years and over.
[2] Spawning stock.
[3] Fish aged one year and over.
Source: ICES and Institute of Marine Research, Bergen.

Barents Sea–Norwegian Sea

- The spawning stock of Norwegian spring-spawning herring was estimated to be about 12 million tonnes in 2007. Thus, the stock is well above the precautionary level of 5 million tonnes.
- The total stock of capelin in the Barents Sea was estimated to be just under 1.6 million tonnes in autumn 2007. This is a considerable rise since 2006.
- The total stock of Northeast Arctic cod was estimated to be about 1.7 million tonnes in 2007, and the spawning stock was estimated at just above 0.6 million tonnes, rather higher than the precautionary level of 0.46 million tonnes.

Figure 6.4. **Trends for stocks of cod[1] in the North Sea, North Sea herring[1] and Northeast Atlantic mackerel[1,2]. 1950-2007**



[1] Spawning stock.
[2] Southern, western and North Sea mackerel.
Source: ICES and Institute of Marine Research, Bergen.

North Sea

- The spawning stock of North Sea herring was estimated to be about 1.0 million tonnes in 2007, somewhat lower than the precautionary level, which is 1.3 million tonnes. All the year classes after 2001 have been weak.
- The spawning stock of North Sea cod is at a historical low, and the harvest is unsustainable.
- The total spawning stock of mackerel appears to have declined at the beginning of 2000s. The 2007 estimate indicates that the spawning stock is around the precautionary level, which is 2.3 million tonnes, but is very uncertain.

Box 6.1. Reference points for the spawning stock of some important fish stocks

The International Council for the Exploration of the Sea (ICES) has defined reference points for the levels of different species' spawning stocks and fishing mortality. These are important tools for the authorities in their efforts to take a precautionary approach to fisheries management.

The critical spawning stock reference point (B_{lim}) is considered to be a danger level below which there is a high probability of poor recruitment. The level is defined on the basis of historical stock data and current theories on the dynamics of fish stocks. The precautionary reference point (B_{pa}) is somewhat higher, and can be interpreted as a warning level: if a spawning stock falls below this level the authorities should consider taking steps to allow the stock to recover to a higher and safer level in order to safeguard sustainable fisheries.

The table below shows B_{lim} and B_{pa} for some important stocks, and their estimated spawning stocks in 2007.

Stock	B_{lim} (critical reference point) 1 000 tonnes	B_{pa} (precautionary reference point) 1 000 tonnes	Estimated spawning stock 2007. 1 000 tonnes
Northeast Arctic cod	220	460	610
Northeast Arctic saithe	136	220	830
Norwegian spring-spawning herring	2 500	5 000	11 900
North Sea herring	800	1 300	980
North Sea cod	70	150	40
North Sea saithe	106	200	280
Mackerel (total stock)	No biological basis for definition of limit	2 300	2 230

See Chapter 2, Figure 2.9.

Box 6.2. More about stock trends and fisheries management

- The stock of Norwegian spring-spawning herring is now about 12 million tonnes, which is well above the precautionary level of 5 million tonnes, and the same level as in the 1950s. According to the 2008 annual report on marine resources and environment (Gjøsæter et al. 2008), this is because conditions in the sea have been favourable, the spawning stock is large, and the management plan is functioning well.

- The Barents Sea capelin stock is growing. It declined considerably at the beginning of the 2000s due to weak recruitment, increased natural mortality and reduced individual growth. Predation by cod and herring on capelin and capelin larvae is an important cause of higher natural mortality. There has been no commercial fishery for capelin in the Barents Sea since 2003. The Norwegian-Russian Fisheries Commission decided not to open the fishery in 2008.

- The spawning stock of Northeast Arctic cod was in excess of 600 000 tonnes in 2007, and above the precautionary level, which is 460 000 tonnes. Illegal fishing is a serious problem, but its scale seems to have been considerably reduced since 2005. The TAC for 2008 was 430 000 tonnes, a moderate increase from the year before.

- The blue whiting stock is declining, although the spawning stock is still above the precautionary level, which is 2.25 million tonnes. There has been a substantial international fishery for this species for a number of years, and total catches have been around or above 2 million tonnes since the turn of the century.

- The spawning stock of North Sea herring was substantially depleted in the period 1989-1994, from about 1.2 million tonnes to about 500 000 tonnes. The poor state of the stock in 1990s was a result of years of overfishing. A strict management regime has resulted in low fishing mortality of mature herring and limited catches of young herring, and has given satisfactory results. The current spawning stock is just under 1 million tonnes, somewhat below the precautionary level, which is 1.3 million tonnes. However, recruitment to the stock has been only moderate in recent years, and the year classes since 2001 are the weakest registered since the late 1970s. The fishing pressure is also considered to be high.

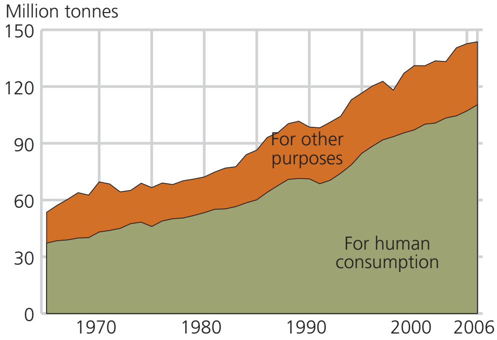
- Several of the stocks of demersal fish in the North Sea have remained low for many years. The cod stock in the North Sea has been heavily fished, and the spawning stock is at an all-time low. Recruitment to the stock has been poor in recent years. The stock size of whiting is uncertain, but seems to be close to the lowest level ever estimated. The stocks of saithe and haddock have shown positive trends in recent years. The spawning stocks of Norway pout and sandeel have been low, but both appear to have grown in 2007.

- For management purposes, the 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 (Northeast Atlantic mackerel). These stocks mix on feeding grounds in the North Sea and Norwegian Sea. The largest component of the stock is found off Ireland. Stock estimates for mackerel are made every three years. Because there are uncertainties in the catch data and considerable quantities are discarded or unregistered, the estimates of the stock size are also uncertain. The spawning stock is estimated to be close to the precautionary level, which is 2.3 million tonnes.

Source: Marine Resources and Environment 2008 (Gjøsæter et al. 2008) and ICES (www.ices.dk).

6.3. Fisheries

Figure 6.5. **World fisheries production[1], by main uses. 1965-2006**



[1] Production data does not include marine mammals (seals, whales, etc.) or plants. Aquaculture is included.
Source: FAO (2008).

Table 6.1. **World fisheries production. 2006**

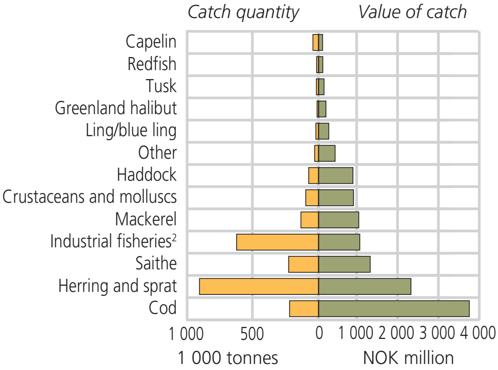
	1 000 tonnes	Per cent
Total production	143 648	100
Marine fisheries	81 931	57.0
Freshwater	10 064	7.0
Aquaculture (fish, crustaceans, etc.) in marine waters	21 799	15.2
Aquaculture (fish, crustaceans, etc.) in inland waters	29 854	20.8

Source: FAO (2008).

World catches

- Production in the world's fisheries, including both inland and marine catches and aquaculture production, has increased substantially: from slightly more than 50 million tonnes in 1965 to about 144 million tonnes in 2006.
- Of this, 77 per cent was used for human consumption in 2006. Table 6.1 shows production split by type.
- The species with the highest total catch in 2006 was Peruvian anchovy (*Engraulis ringens*) at 7 million tonnes: this figure is about three million tonnes lower than in 2005. The next two species were Alaska pollock (*Theragra chalcogramma*) and skipjack tuna (*Katsuwonus pelamis*), with catches of 2.9 and 2.5 million tonnes respectively. Atlantic herring (*Clupea harengus*) came in fourth place, with a total catch of 2.2 million tonnes.

Figure 6.6. **Norwegian catches[1] by groups of fish species, molluscs and crustaceans. 2007**

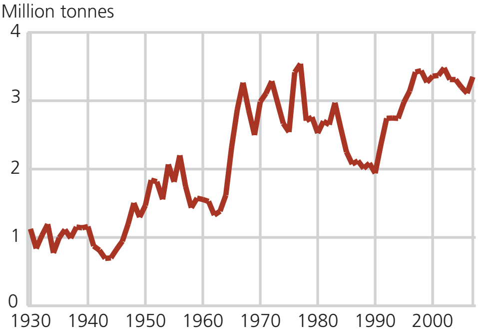


[1] Catches delivered by Norwegian vessels in Norway and abroad.
[2] Includes greater and lesser silver smelt, Norway pout, sandeel, blue whiting and horse mackerel.
Source: Directorate of Fisheries.

Norwegian catches

- In 2007, the total catch in Norwegian fisheries (including crustaceans, molluscs and seaweed) was 2.5 million tonnes, and the value of the catch was NOK 12.0 billion. The total catch was about 100 000 tonnes higher than in 2006, and its value was more than NOK 300 million higher.
- Cod and herring were the species with the highest catch value, NOK 3.7 and 2.2 billion respectively.
- In 2007, the blue whiting catch was 540 000 tonnes, about 100 000 tonnes less than in 2006. The mackerel catch was 131 000 tonnes, slightly higher than in 2006.

Figure 6.7. **Total production[1] in Norwegian fisheries. 1930-2007**



[1] Fish farming production is included.
Source: Fisheries statistics, Statistics Norway, and Directorate of Fisheries.

- In the last 10 years, total catches in traditional fisheries, including seaweed, have varied from 3 million tonnes in 1997 and 1998 to 2.5 million tonnes in 2007.
- The highest level of catches in the traditional fisheries in the period since 1930 is 3.5 million tonnes in 1977. In the same year, more than 2 million tonnes capelin was caught.
- Total production in the fisheries and fish farming in 2007 was about 3.3 million tonnes.

Box 6.3. World catches and Norwegian catches

Total catches in the world's marine fisheries in 2006 dropped by about 2.6 million tonnes from the year before to about 82 million tonnes. Total catches in freshwater fisheries rose to 10 million tonnes.

The catches in the Southeast Pacific dropped by 2.5 million tonnes from 2005. Total landings of anchoveta dropped by 3 million tonnes, while the catch of Chilean jack mackerel rose somewhat to about 1.8 million tonnes. These two species made up 73 per cent of the catches in the Southeast Pacific. There were no dramatic changes in catches in other marine areas. The Northwest Pacific is the world's most productive fishing area, and catches have varied between 20 and 24 million tonnes since the end of the 1980s. In 2006, catches in this area totalled 21.6 million tonnes. Total catches in the Northeast Atlantic have remained stable at about 10-11 million tonnes for a number of years, but dropped to 9.1 million tonnes in 2006.

According to *The State of World Fisheries and Aquaculture 2006* (FAO 2007), on a global scale 23 per cent of the fish stocks that are monitored are underexploited or moderately exploited. A further 52 per cent are fully exploited, meaning that catches are near the maximum sustainable yield and there is little room for expansion, and the remaining 25 per cent are overexploited or depleted.

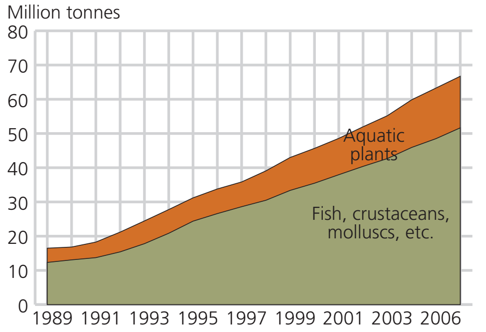
Norway ranks as number 11 among the world's largest fishing nations (excluding farmed production), with a total catch of 2.3 million tonnes in 2006. At the head of the list are China (17.1 million tonnes), Peru (7.0 million tonnes), the US (4.9 million tonnes), Indonesia (4.8 million tonnes), Japan (4.2 million tonnes) and Chile (4.2 million tonnes).

In the Norwegian fisheries, the catch of herring in 2007 was about 174 000 tonnes higher than the year before, but the value of the catch was about the same, NOK 2.2 billion. The catch of cod decreased by 3 000 tonnes from 2006, but the value of the catch rose by about NOK 400 million to NOK 3.7 billion. The saithe catch dropped by about 30 000 tonnes to 225 000 tonnes, with a value of NOK 1.3 billion. The mackerel catch rose by about 10 000 tonnes to 130 000 tonnes, with a value of just under NOK 1 billion. The 2007 capelin catch was 41 000 tonnes, and its value was NOK 95 million. There was no fishery for Barents Sea capelin in 2007. The shrimp catch was 37 000 tonnes and its value was NOK 653 million. The Norwegian catch of blue whiting was 540 000 tonnes, a decrease of about 100 000 tonnes from 2006. However, the value rose to almost NOK 850 million.

See also Figures 6.5 - 6.7. More information about Norwegian fisheries and fish stocks at: http://www.ssb.no/english/subjects/10/05/fiskeri_en/, http://www.fiskeridir.no/ and http://www.imr.no/

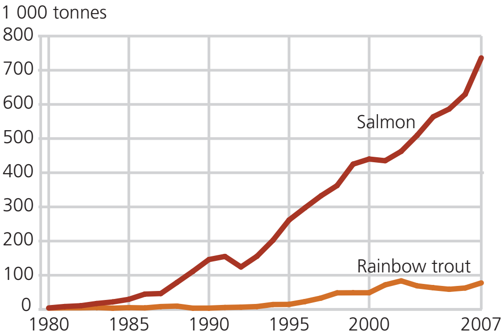
6.4. Aquaculture

Figure 6.8. **World aquaculture production. 1989-2006**



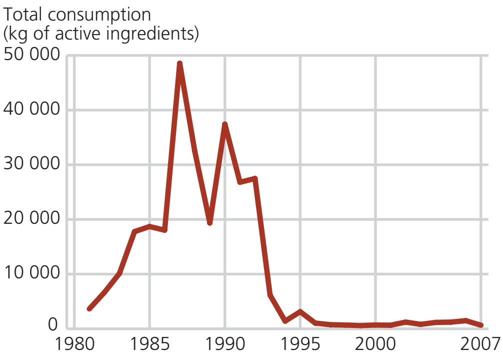
Source: FAO (2008).

Figure 6.9. **Fish farming. Volume of salmon and rainbow trout sold. 1980-2007**



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

Figure 6.10. **Consumption of medicines[1] (antibiotics) in fish farming. Kg active ingredients. 1982-2007**



[1] Based on sales figures from pharmaceutical wholesalers and feed suppliers. This explains deviations from the prescription-based statistics discussed in the next section.
Source: Norwegian Institute of Public Health.

World aquaculture production

- In 2006, world aquaculture production totalled 51.7 million tonnes fish, crustaceans, molluscs, etc. corresponding to about 56 per cent of the total catch in marine and inland fisheries for that year.
- Production of aquatic plants totalled 15 million tonnes in 2006.
- World aquaculture production has more than trebled since 1989.

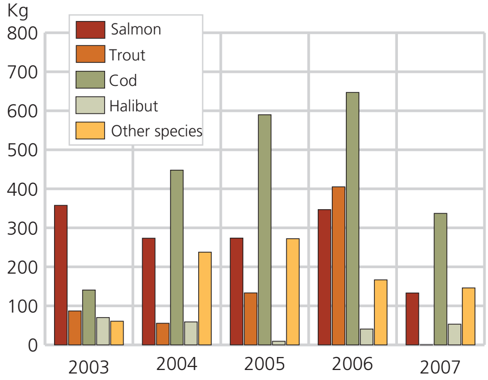
Salmon and trout farming in Norway

- Production of farmed salmonids has increased dramatically since the industry was established in the early 1970s. According to preliminary figures, salmon production (sold quantity) rose to 736 000 tonnes in 2007.
- Production of trout was 78 000 tonnes in 2007.
- In 2006, Norwegian production of Atlantic salmon accounted for a little under half the total global production of this species (1.31 million tonnes). Over 80 per cent of farmed salmon is exported.

Fish health in salmon farming

- Health problems include viral, bacterial and parasitic diseases, and other problems such as winter ulcers, gill inflammation, heart and skeletal muscle inflammation and deformities.
- The consumption of antibiotics peaked in 1987 at 49 tonnes. Consumption in 2007 was 649 kg, which is a reduction of about 800 kg or 56 per cent from 2006. These figures apply to all species of farmed fish.
- Thus, consumption has been substantially reduced. In 1987, antibiotic consumption was almost 0.9 kg per tonne slaughtered salmon and trout, but has now been reduced to well below 1 g per tonne.

Figure 6.11. **Use of antibiotics[1] in fish farming, by species. Kg active ingredients. 2003-2007**



[1] Prescription-based statistics. The total quantity (668 kg) therefore differs somewhat from the sales-based statistics figures (649 kg).
Source: Norwegian Food Safety Authority.

- An analysis of prescription-based statistics carried out by the Norwegian Food Safety Authority showed that cod farming accounted for 337 kg or 50 per cent of the total consumption of antibiotics in fish farming in 2007 (668 kg). However, consumption of antibiotics in cod farming has been reduced by half since 2006, and the only species where a rise in consumption of antibiotics has been registered is halibut. According to the Food Safety Authority, the reason for this is not known, but is probably related to random variations in the incidence of bacterial diseases in farmed fish.
- Consumption of antibiotics for salmonids (salmon and trout) is low relative to the production volume, and the Food Safety Authority's statistics for 2007 show that consumption in trout farming was almost zero.

Box 6.4. More about aquaculture production

In 2006, world aquaculture production of fish, crustaceans, molluscs, etc. totalled 52 million tonnes, and freshwater production accounted for just under 58 per cent of this (see Table 6.1). World aquaculture production excluding plants rose by 3.2 million tonnes (6.5 per cent) in 2006. In addition, 15.1 million tonnes of aquatic plants were produced. China is by far the largest aquaculture producer, accounting for almost 70 per cent of total production (animals and plants) in 2006.

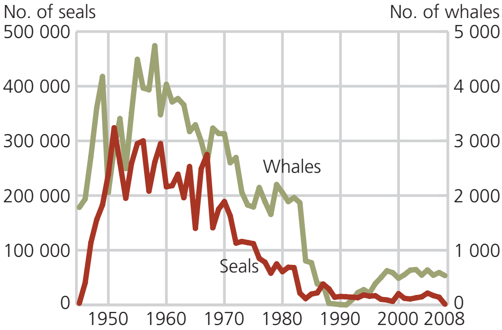
The species farmed in the largest volume was the Pacific oyster (*Crassostrea gigas*), at 4.6 million tonnes, followed by a number of species of carp. On a list of 29 farmed species of which over 210 000 tonnes were produced in 2006, Atlantic salmon ranked as number 13. World production of Atlantic salmon in 2006 was 1.3 million tonnes.

According to preliminary figures from the Directorate of Fisheries, mussel production in Norway in 2007 was about 2 700 tonnes, which is a reduction of about 1 000 tonnes from 2006. Production of other fish species than salmon and trout for human consumption is still relatively modest in volume. In 2007, 9 600 tonnes of cod and about 4 300 tonnes of other species (Arctic char, halibut, turbot, etc.) were sold in Norway.

According to preliminary figures from the Directorate of Fisheries, total losses from seawater rearing units in 2007 were 42.6 million fish (about 38 million salmon and 4 million trout). This included 379 000 salmon and trout that were reported to have escaped from fish farms. In addition, 71 000 fish of farmed marine species (cod and halibut) were reported to have escaped. The number of escaped fish was considerably lower than in 2006. Other losses are attributed to mortality, fish discarded at slaughtering plants and unknown causes.

6.5. Sealing and whaling

Figure 6.12. **Norwegian sealing and whaling[1]. 1945-2008***



[1] In the period 1988-1992, scientific whaling only.
Source: Directorate of Fisheries.

- In 2007, the total seal catch was 13 981 harp seals (7 828 in the West Ice and 6 153 in the East Ice). Preliminary figures for 2008 indicate that the total catch of harp seals was 1 263, all taken in the West Ice. Hunting of hooded seals was prohibited in 2007 and 2008, but a limited number were taken for research purposes. Sealing is currently not profitable, and is largely financed through government grants.
- The quota for the small whale hunt in 2007 was 1 052 animals, but only 593 were caught. The value of the small whale catch in 2007 was about NOK 24 million. Preliminary figures for 2008 indicate a catch of 535 whales with a value of NOK 22 million. The quota for 2008 was set at 1 052 whales.

Box 6.5. Some important diseases and health problems associated with salmonid farming

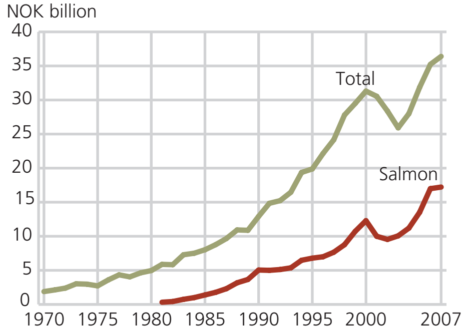
This information on the incidence of disease in salmon farming in 2007 is based on figures in *Annual report on the coastal zone and aquaculture 2008* (Boxaspen et al. 2008). Serious diseases include the following:

- Furunculosis, caused by the bacterium *Aeromonas salmonicida* (5 cases in 2007: 4 seawater sites and one river with a wild salmon stock).
- Bacterial kidney disease (BKD), caused by the bacterium *Renibacterium salmoninarum* (not registered in 2007).
- Infectious salmon anaemia (ISA), a virus disease (7 registered cases in 2007).
- Infectious pancreatic necrosis (IPN), a virus disease (165 registered cases in 2007).
- Pancreas disease (PD), a virus disease (registered at 98 seawater sites in 2007).
- Heart and skeletal muscle inflammation, a virus disease (registered at a minimum of 162 sites in 2007).

Other serious diseases that cause considerable losses include cardiomyopathy syndrome (CMS), viral haemorrhagic septicaemia (VHS) and winter ulcers.

6.6. Exports

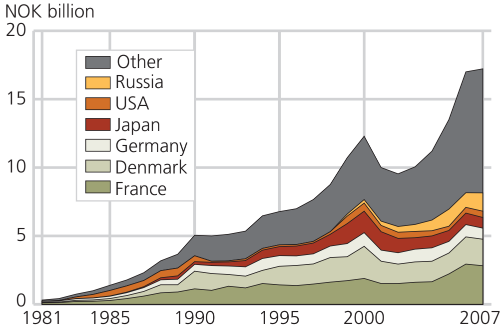
Figure 6.13. **Value of Norwegian fish exports. Current prices. 1970-2007**



Source: National accounts and forestry statistics, Statistics Norway.

- In 2007, Norway exported about 2,2 million tonnes of fish and fish products to a value of almost NOK 37 billion. Exports to EU countries accounted for 63 per cent of the export value.
- According to FAO, Norway was in 2006 the world's second largest exporter of fish in terms of value, behind China and ahead of Thailand, the US, Denmark, Canada, Chile, Vietnam and Spain. Norway's fish exports accounted for about 6 per cent of the value of total world fish exports.

Figure 6.14. **Exports of salmon[1], by main importing countries. 1981-2007. Current prices**



[1] Mostly farmed fish, although other salmon is also included.
Source: External trade statistics, Statistics Norway.

- Salmon exports were worth in excess of NOK 17 billion in 2007. This was a rise of NOK 225 million from 2006. The quantity exported rose by more than 100 000 tonnes.
- France and Denmark have for a number of years been the most important importers of Norwegian farmed salmon. There was a moderate decrease in the value of exports to both France (NOK 2.8 billion) and Denmark (NOK 1.9 billion) from 2006 to 2007.
- In 2007, the value of exports to Russia and China totalled NOK 1.3 billion and NOK 200 million respectively.

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Useful websites:

International Council for the Exploration of the Sea: http://www.ices.dk/
FAO - UN Food and Agriculture Organization: http://www.fao.org/
Directorate of Fisheries: http://www.fiskeridir.no/
Institute of Marine Research: http://www.imr.no/
Norwegian Food Safety Authority: http://mattilsynet.no/
Statistics Norway, Fishery statistics: http://www.ssb.no/english/subjects/10/05/
Statistics Norway, Export of salmon: http://www.ssb.no/laks_en/

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7. Water resources and water supply

Water is of vital importance to life and health and to society as a whole. Providing good quality water and sufficient water at all times is therefore a primary objective in the supply of water. The authorities 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.

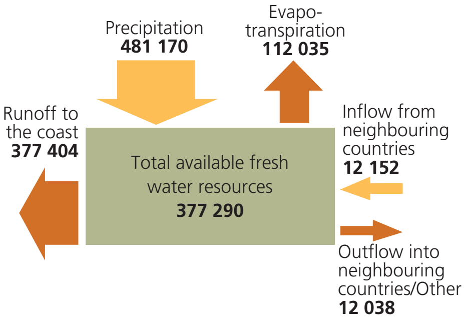
Figures from the Norwegian Institute of Public Health's water works register show that in 2006, a total of 1 570 water works (municipal and private) were subject to reporting requirements, and 284 of these recorded unsatisfactory results for pH. Furthermore, 163 water works recorded unsatisfactory results for water colour, and thermo-tolerant intestinal bacteria in the water were found at 93 water works (Norwegian Institute of Public Health 2008). Thus, the quality of drinking water supplied by a number of water works is still not satisfactory. There are many reasons for this, which vary from one water works to another.

Surface water is the main source of drinking water, and supplies about 90 per cent of the population in Norway (see Table 7.1). Even though the drinking water regulations (Ministry of Health 2001) require all water from surface water sources to be disinfected, many small water works still do not do this adequately. This means that the microbiological quality of drinking water may at times be unsatisfactory and may, at worst, cause illness. Warnings that water must be boiled before use must therefore sometimes be issued, as happened in Oslo in October 2007. Despite these problems, the quality of drinking water for most users in Norway is good (Norwegian Food Safety Authority 2006).

Norwegian lakes and rivers are vulnerable to acid rain, which for a long time has been regarded as one of the major environmental problems in Norway. However, a substantial reduction in sulphur and nitrogen releases in Europe has reduced the acidification load in Norwegian inland waters. Nonetheless, there is still a long way to go before the natural ecosystems in the most vulnerable areas have recovered, and new international agreements, such as the Gothenburg Protocol, have been concluded to reduce discharges of harmful substances even further.

7.1. Availability and consumption of freshwater resources

Figure 7.1. **Annual available freshwater resources in Norway[1]. Average for 1971-2000. Whole country. Million m³**

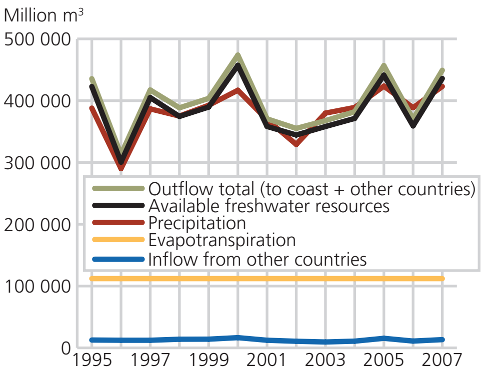


[1] Records of precipitation do not make it possible to calculate inputs with the same accuracy as runoff. As a result, there is a discrepancy between total inputs and total runoff in the figure. See also footnote to Figure 7.2. Based on normal values for precipitation and evapotranspiration in the period 1961–1990.
Source: Norwegian Water Resources and Energy Directorate 2004 (methodology) and 2007 (data).

Available freshwater resources

- The water resources available in Norway in a normal year – runoff to the coast and outflow to neighbouring countries minus inflow from neighbouring countries – total about 377 billion m³.
- 98 per cent of the annual input of water resources is in the form of precipitation, while the remainder is in the form of incoming water flows via rivers from our three neighbouring countries.
- About 79 per cent of the annual input of water drains to the sea and to neighbouring countries through watercourses and runoff. The rest evaporates.

Figure 7.2. **Trends in available freshwater resources, precipitation and runoff[1,2] in Norway. 1995-2007**



[1] This figure appears to show that runoff is higher than water input through precipitation. This is a well-known phenomenon in hydrology, and can partly be explained by the fact that not all precipitation is recorded at meteorological stations, particular in mountainous areas (but other factors may also be involved).
[2] Evapotranspiration is shown as the normal value for the period 1961–1990, as in Figure 7.1.
Source: Norwegian Water Resources and Energy Directorate 2007 and Norwegian Meteorological Institute 2008.

Box 7.1. The EU Water Framework Directive

As a party to the EEA Agreement, Norway is required to implement the Water Framework Directive (Directive 2000/60/EC of the European Parliament and of the Council of 23 October 2000). The Directive, which entered into force in 2003, provides a framework for other EU directives of importance to water resource management, including the Urban Waste Water Treatment Directive (see Box 12.3). The main objective of the Directive is to protect and, if necessary, improve water quality in inland waters, estuaries, coastal waters and groundwater. Other objectives include promoting sustainable water resource use, and protecting terrestrial ecosystems that directly depend on water, such as wetlands.

The main principle in the framework directive is that inland waters, coastal waters and groundwater should have «good status» with regard to water quality. This means that by 2015, the volume and quality of bodies of water should not deviate substantially from the «natural» conditions that would have existed without the impact of human activity.

The key elements in the directive as regards water resource management are as follows:

- coordination of administrative arrangements
- specified environmental objectives for all water and a stronger focus on ecological conditions
- greater need for investigation and monitoring.

A management regime based on river basins means that all water within a river basin district and all activities that may affect the quality or amount of water are viewed as a whole, irrespective of administrative boundaries such as municipal, county or national borders. A management plan is to be drawn up for each river basin district, and must include

- environmental objectives
- action plans (programmes of measures) for the bodies of water
- description of the river basin(s)
- impact of human activity
- protected areas (e.g. designated protected areas, recreation areas, areas defined as a result of other directives)
- the results of the monitoring of water bodies required by the directive.

Progress in Norway

The Ministry of the Environment has coordinating responsibility for the Directive, with the county governors responsible at the regional level. A steering group with representatives from the relevant directorates has been established to oversee the implementation of the directive in Norway.

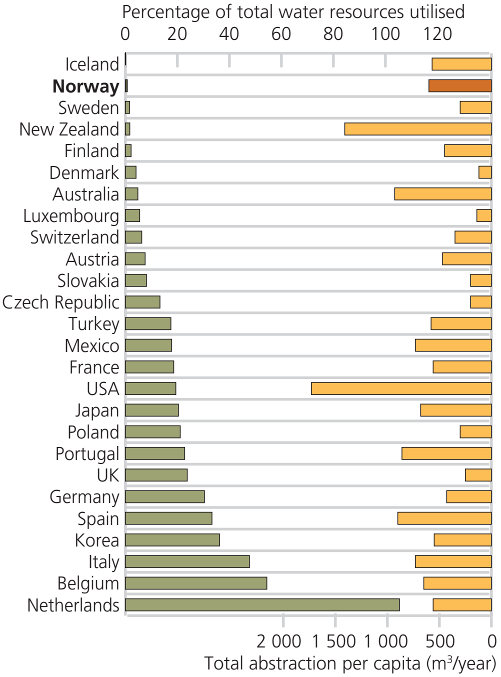
Management plans are to be drawn up for at least one river basin in each river basin district by 2009. Public consultations are being held on the proposed work programmes for this process.

The Ministry of the Environment is responsible for reporting to the EFTA Surveillance Authority on the progress of the various processes and developments in the status of water bodies.

See also the indicators for ecological status in aquatic ecosystems in the indicator set for sustainable development presented in Chapter 2.

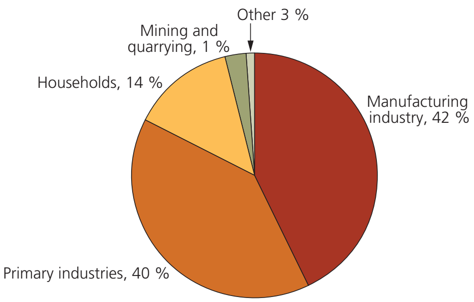
Source: Norwegian Institute for Water Research and Water Framework Directive (http://ec.europa.eu/environment/water/water-framework/index_en.html l).

Figure 7.3. **Percentage of total freshwater resources utilised and abstraction per inhabitant in OECD countries at the turn of the century**



Source: OECD (2006). Figures for Norway have been updated on the basis of new calculations, see Statistics Norway (2008).

Figure 7.4. **Freshwater consumption by sectors and households[1]. 2005 or latest year for which figures are available. Per cent**



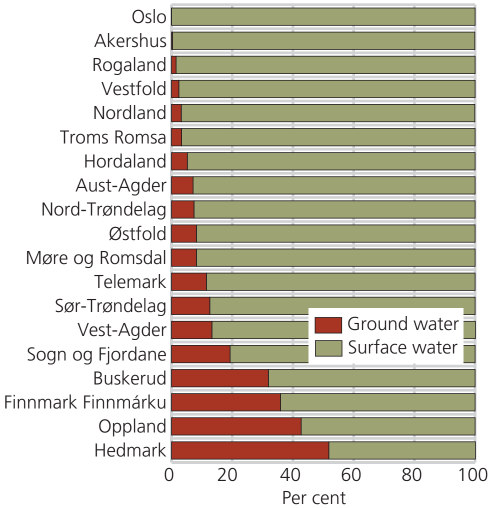
[1] Leakages not included.
Source: Provisional figures from Statistics Norway.

Water consumption

- Only 0.7 per cent of the freshwater resources available each year in Norway is utilised (water used in hydropower production is not included).
- The only OECD country that utilises a smaller percentage of its total available freshwater resources than Norway is Iceland (0.1 per cent).
- Per capita abstraction of freshwater in Norway is about 600 m^3 per year. This is well below the average for the OECD countries (880 m^3). The average in the US is 1 730 m^3, and in Denmark 120 m^3.
- A total of about 2.7 billion m^3 of freshwater is used annually in Norway, and the manufacturing industries use about 1.3 billion m^3 of this.
- The metal industry, the chemical industry, the pulp and paper industry and the food industry are the most important consumers of freshwater among the manufacturing industries. The primary industries use roughly the same amount of water as the manufacturing industries.
- Households use about 358 million m^3 of freshwater. Manufacturing industries and the primary industries (agriculture, forestry and fish farming) largely meet their water needs from their own sources.

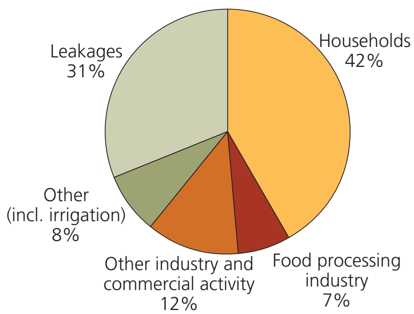
7.2. Public water supplies

Figure 7.5. **Percentage of population connected to municipal water works, split by type of water source. By county. 2006[1]**



[1] Surface water includes four water works in Sør-Trøndelag and Nordland which supply 445 people using seawater as the water source.
Source: National Institute of Public Health, water works register.

Figure 7.6. **Percentage of public water supplies used by various sectors[1]. 2006**



[1] The figure is based on data for 1 570 water works in 2006.
Source: National Institute of Public Health, water works register.

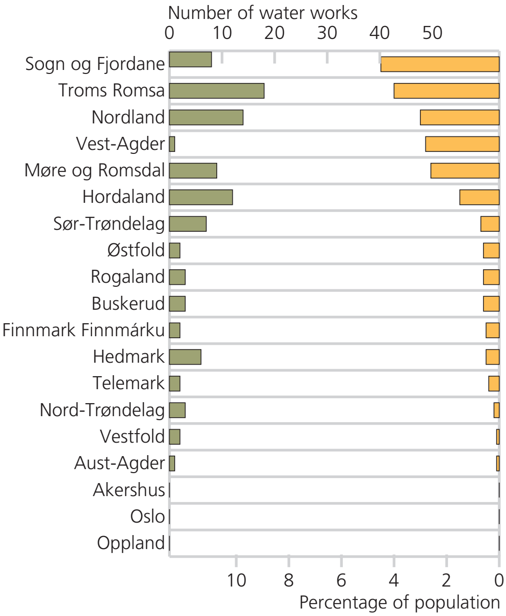
Water sources

- In 2006, about 90 per cent of Norway's population was served by public water supplies from 1 570 water works. These water works, which include municipal, intermunicipal, state-owned and privately-owned water works, are subject to reporting requirements and registered in the water works register of the National Institute of Public Health. Water works that only supply holiday homes are not included. The remaining 10 per cent of the population was supplied by smaller water works or from their own water sources.
- In 2006, 38 per cent of Norway's public water works used groundwater as their source of water, while the remainder used surface water. A limited number of people were supplied with desalinated seawater (see footnote to Figure 7.5).
- Only 10 per cent of the population was supplied with drinking water by water works using groundwater as their water source.
- The counties that in 2006 had the highest percentage of the population connected to water works using groundwater as their source were Hedmark, Oppland and Finnmark.

Production and consumption of water

- Water production at Norwegian water works in 2006 was calculated to be 743 million m^3. Households used 42 per cent of this.
- About a third of the water produced was lost due to leakages from pipelines.
- Average household consumption was estimated at 197 litres per person per day in 2006.
- There is substantial uncertainty associated with these figures as they are largely based on estimates from the water works.

Figure 7.7. **Number of water works where E. coli was registered, and percentage of the population who had to boil drinking water. By county. 2006**[1]

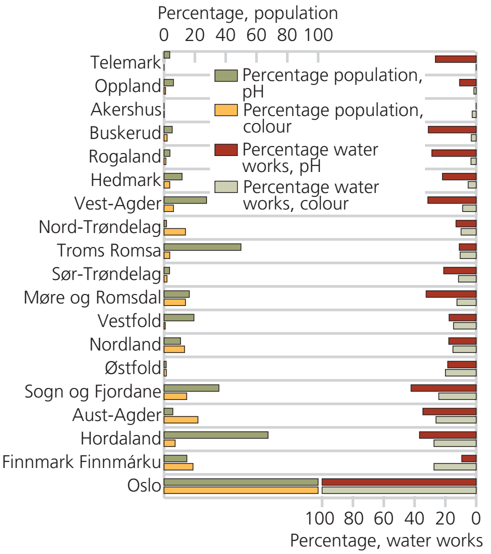


[1] Based on information from 1 301 water works that took samples to test for the presence of *E. coli*.
Source: National Institute of Public Health, water works register.

Water quality

- It is important to ensure that drinking water does not contain pathogenic bacteria, since their presence is an indication of faecal contamination of the water. The drinking water regulations therefore contain an absolute requirement for all water to be disinfected or treated to prevent the spread of infection. The treatment of drinking water involves adding chemicals (primarily chlorine), the use of UV radiation or membrane filtration.
- A number of water works using surface water as their source are finding it hard to comply with the requirements with respect to thermo-tolerant coliform bacteria in water. In 2006, the proportion of the population not receiving water of satisfactory quality was highest in the counties of Sogn og Fjordane, Troms and Nordland.
- Figures from 2006 for a sample of water works that supply 4.1 million people in Norway show that just under 1 per cent are supplied with drinking water that does not satisfy water quality with regard to E .coli. The E. coli bacterium is a common indicator of the presence of faecal contamination in water.

Figure 7.8. **Percentage of public water works that do not satisfy the requirements with respect to pH and colour, and percentage of population affected. By county. 2006**[1]



[1] The figure is based on information from 1 223 water works that have made pH tests and 1 255 water works that have conducted colour tests. In Oslo, the information refers to one water works comprising several treatment plants. The main treatment plant is currently not satisfactory, but a new plant is under construction.
Source: National Institute of Public Health, water works register.

- A number of water works are finding it difficult to meet the pH and colour requirements. Figures from 1 223 water works that have taken samples to test pH values show that 23.2 per cent of them did not have satisfactory results. For colour, the proportion of unsatisfactory results is somewhat lower, 13.0 per cent of 1 255 water works.
- The proportion of people connected to water works with unsatisfactory results for water colour was highest in Oslo, Aust-Agder and Finnmark: for pH, the counties with the highest proportion of unsatisfactory results were Oslo, Hordaland and Troms.
- Acidic water (with a low pH) corrodes pipelines and can result in a high metal content in drinking water. High humus content colours the water brown and may cause sludge and unwanted bacterial growth in water pipeline systems. Chlorination of water containing humus may result in the formation of organochlorine compounds, with potential effects on odour, taste and health

Table 7.1. **Water sources, number of water works and number of people supplied. By county. 2006**

	Total		Lakes[1]		Rivers/streams		Groundwater	
	No. of water works[3]	No. of people supplied[4]	No. of water works	No. of people supplied	No. of water works	No. of people supplied	No. of water works	No. of people supplied
Whole country[3]	1 487	4 228 554	576	3 466 562	352	349 088	560	412 904
Østfold	27	230 571	15	153 502	4	58 061	8	19 008
Akershus	28	477 541	19	353 576	1	122 385	8	1 580
Oslo	1	548 000	1	548 000	0	0	0	0
Hedmark	97	153 528	11	73 332	3	732	83	79 464
Oppland	74	127 612	19	69 751	7	3 358	48	54 503
Buskerud	62	237 188	16	161 622	0	0	46	75 566
Vestfold	29	219 663	9	214 488	0	0	20	5 175
Telemark	54	141 932	18	113 846	3	11 714	33	16 372
Aust-Agder	33	88 528	19	79 736	5	2 516	9	6 276
Vest-Agder	36	146 365	12	125 833	4	1 111	20	19 421
Rogaland	50	379 741	33	371 043	4	2 992	13	5 706
Hordaland	146	396 432	76	350 745	32	25 021	38	20 666
Sogn og Fjordane	104	79 067	42	48 159	35	15 649	27	15 259
Møre og Romsdal	152	225 119	54	183 040	52	23 575	46	18 504
Sør-Trøndelag	107	258 237	44	223 584	11	2 126	52	32 527
Nord-Trøndelag	72	106 148	36	97 070	7	1 227	29	7 851
Nordland	210	211 509	91	169 599	80	35 232	39	6 678
Troms Romsa	128	132 838	29	101 920	78	26 533	21	4 385
Finnmark Finnmárku	76	66 785	31	26 603	25	16 219	20	23 963
Svalbard[2]	1	1 750	1	1 113	1	637	-	-

[1] Includes four water works in Sør-Trøndelag and Nordland which supply 445 people using seawater as the water source.

[2] One water works in Svalbard has two main sources of different types.

[3] The table is based on information from 1461 water works that have supplied information on their water sources. Since some water works have several sources of different types, the figures in the column for total number of water works add up to more than the number of water works in the sample.

[4] There are 174 people who are supplied by water works that have not provided information about their water source or that they receive water from other water works.

Source: National Institute of Public Health, water works register.

Box 7.2. Waterborne communicable diseases

Norwegian drinking water is generally considered to be of high quality. Nevertheless, outbreaks of disease caused by waterborne pathogens are reported every year. In the period 1988–2002, 72 outbreaks of waterborne disease were reported, involving a total of 10 616 registered cases (Nygård et al. 2003). In the period 2003–2007, 15 outbreaks of disease were registered (Nygård pers. comm.). The real number of outbreaks is probably higher. Short-term contamination of drinking water can result in sporadic cases of gastro-intestinal infection, and it is often difficult to identify the cause of such problems. People who experience short-term problems rarely seek medical attention, and several people in the same area may therefore be ill at the same time without this being registered as a disease outbreak (Nygård et al. 2003).

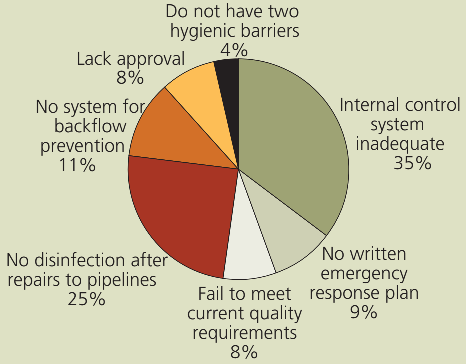
Outbreaks of waterborne disease can be acute and involve large numbers of people, since the inhabitants in a particular area generally receive drinking water from the same source, and are therefore likely to be infected at about the same time. It is therefore important to identify the source of an infection quickly. Under Norwegian legislation, the municipal medical officer is required to report outbreaks of disease to the Norwegian Institute of Public Health if food or drinking water is suspected to be the source.

Outbreaks of waterborne diseases are generally caused by animal or human faecal contamination. Cholera, bacillary dysentery, salmonellosis, typhoid fever and hepatitis A are examples of waterborne diseases that used to be common in Norway. Today, diseases (mainly gastro-intestinal) are more often caused by bacteria such as Yersinia enterocolitica and Campylobacter jejuni and viruses such as Norovirus (Norwegian Institute of Public Health 2007). Parasites such as Giardia intestinalis and Cryptosporidium parvum are a common cause of outbreaks of waterborne disease in other developed countries (Nygård pers. comm.). An outbreak of Giardia in Bergen in 2004 was the first involving such parasites to be registered in Norway.

In a study of disease outbreaks in Norway in the period 1988–2002, Campylobacter and Norovirus were most frequently identified as the cause, but in many cases the cause was unknown. Contamination of raw water and inadequate disinfection were the most frequent reasons for disease outbreaks (Nygård et al. 2003).

In 2006 and 2007, the Norwegian Food Safety Authority carried out a nationwide inspection campaign for drinking water. This was done in response to the failure of some Norwegian water works to obtain approval and draw up emergency plans, and because drinking water is still linked to disease outbreaks in Norway. The campaign focused on approval of water works and on compliance with the legislation in general, and looked particularly at distribution systems and emergency planning. The campaign covered 357 water works, which were chosen on the basis of a risk assessment. This corresponds to 26 per cent of all the separate water works listed in the Authority's drinking water register in March 2007. The water works in the sample supply 2.8 million people. No breaches of the rules were found at 43.5 per cent of the water works. In all, 943 breaches of the rules were found at 202 water works (see the figure). However, few of these were so serious that there was a health risk associated with drinking the water. Most of the water works were found to supply consumers with drinking water of satisfactory quality, but serious breaches of the rules at a small number were considered to represent a substantial health risk for consumers (Norwegian Food Safety Authority 2007).

The most serious breaches of the rules at water works. Per cent



Source: Norwegian Food Safety Authority.

Sources:

Norwegian Institute of Public Health: Smittsomme sykdommer i vann (Communicable waterborne diseases). http://www.fhi.no/eway/default.aspx?pid=233&trg=MainArea_5661&MainArea_5661=5631:0:15,3310:1:0:0:::0:0.

Norwegian Food Safety Authority: Nasjonal tilsynskampanje på drikkevann 2006. (Nationwide inspection campaign for drinking water 2006) http://www.mattilsynet.no/mattilsynet/multimedia/archive/00029/Sluttrapport_-_Matti_29907a.pdf

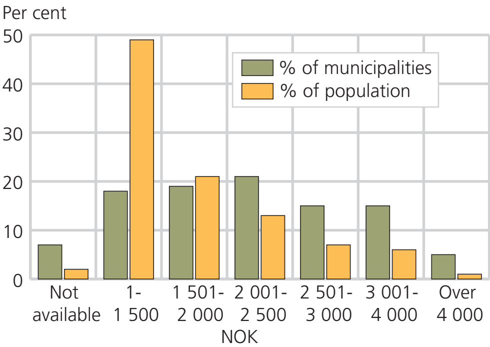
Nygård, K., B. Gondrosen and V. Lund: Sykdomsutbrudd forårsaket av drikkevann i Norge (Outbreaks of disease in Norway caused by drinking water). T*idsskr Nor Lægeforen 2003; 123: 3410–3.*

Nygård, K.: Giardiasis - et undervurdert problem i Norge? (Giardiasis – is the extent of the problem in Norway underestimated?). *Tidsskr Nor Lægeforen 2007; 127:155.*

7.3. Fees in the municipal water sector

Norwegian legislation lays down that municipal water and waste water fees may not exceed the necessary costs incurred by the municipalities in these sectors. The fees must follow the principle of full costing, and must be based on estimates of the direct and indirect operating, maintenance and capital costs of water supply services. The annual fees must be calculated on the basis of measured or stipulated water consumption, or in two parts, one fixed and one variable. For properties where no water meter is installed, water consumption is as a general rule stipulated on the basis of the size of the buildings.

Figure 7.9. **Variation in annual water supply fees shown as proportion of municipalities and population in different price classes. 2008**



Source: KOSTRA, Statistics Norway.

Water supply fees

- The average water supply fee for the county as a whole rose by 7 per cent from 2007 to 2008.
- The fees vary significantly between municipalities, from NOK 659 to NOK 5 720.
- The reasons for the large variations in water supply fees have not been systematically surveyed, but in general, local conditions such as the size of the water works (economies of scale), the state of the water source, topography and population density will be important for the costs of providing water supplies and thus for the fees.
- The average fee is less than NOK 2 000 in 37 per cent of all municipalities. In all 71 per cent of the country's population lives in these municipalities, which illustrates the fact that annual fees are lower in the larger municipalities.

More information: Kari B. Mellem (kbm@ssb.no) (financial data) and Jørn Kristian Undelstvedt (jku@ssb.no).

Useful websites

Statistics Norway – Water and waste water statistics: http://www.ssb.no/english/subjects/01/04/20/
Statistics Norway – Environmental protection expenditure statistics: http://www.ssb.no/english/subjects/01/06/20/
Norwegian Institute of Public Health: http://www.fhi.no/eway/?pid=238
State of the Environment Norway: http://www.environment.no/
Norwegian Pollution Control Authority: http://www.sft.no/aktuelt____29292.aspx

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Ministry of Health (2001): *Drikkevannsforskriften* (Regulations relating to water supplies and drinking water). FOR 2001-12-04 nr 1372: Forskrift om vannforsyning og drikkevann.

Norwegian Food Safety Authority (2007): *Nasjonal tilsynskampanje på drikkevann 2006* (Nationwide inspection campaign for drinking water 2006). http://www.mattilsynet.no/mattilsynet/multimedia/archive/00029/Sluttrapport_-_Matti_29907a.pdf

Norwegian Food Safety Authority (2006): *Utfordringer og mål for norsk drikkevannsforvaltning* (Norwegian drinking water management – problems and targets). Link here [Published on http://www.mattilsynet.no/ 29.05.06, accessed 28.07.08]

Norwegian Meteorological Institute (2008): *Nedbørsmengder for Norge 1900-2007* (Precipitation figures for Norway 1900–2007).

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Norwegian Water Resources and Energy Directorate (2007): Pettersson, L-E., *Totalavløpet for Norge, gjennomsnitt for perioden 1971–2000* ((Precipitation figures for Norway, average for the period 1971–2000), unpublished.

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8. Land and land use

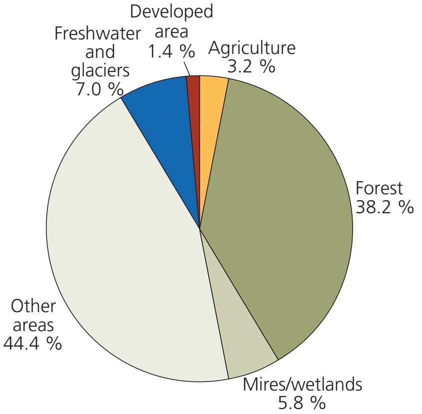
With a land area excluding freshwater of 304 280 km^2 and a population of barely 4.7 million, Norway has the second lowest population density in Europe after Iceland, only 15 inhabitants per km^2. Because of Norway's climate, geology and topography, a large proportion of the country has not been developed for settlement and agriculture. Nearly 80 per cent of the population lives in urban settlements, where population density is over 100 times the national average. These densely built-up areas, and the productive agricultural and forest areas surrounding them, are therefore under considerable pressure. But land use intensity is increasing in many sparsely settled areas too, as a result of road construction, the building of holiday cabins, the construction of power lines, and so on.

How the land is used is of great importance in terms of economics and the environment, and it affects people's lives. Changes in land use result in changes in the cultural landscape and the local environment. This may have a considerable impact on human health and the quality of life, and on the productivity and ecological qualities of the natural environment.

Resource and environmental conflicts often result as settlement patterns become increasingly concentrated along the coast in the southern half of Norway and in the most productive agricultural areas. 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 pollution. On the other hand, population concentrations provide opportunities for environmental gains such as reduced energy use for transport and in homes, a greater range of play and recreational areas and more efficient water, sewage and waste disposal schemes.

8.1. Land use in Norway

Figure 8.1. **Proportion of different types of land cover[1]. Mainland Norway. 2008**



[1] Land cover is the physical coverage of land, e.g. forest, cultivated land, buildings, roads.
Source: Norwegian Mapping Authority (2008) and Statistics Norway.

The most common types of land cover

- Developed land under buildings, asphalt, etc., contains almost 3.8 million buildings and 4 100 km of rail track (Norwegian Mapping Authority 2008 and Norwegian National Rail Administration 2008). There are also 93 000 km of public roads and about 76 000 km of private roads (Directorate of Public Roads 2008). Roads, including verges and pavements, cover about 2 100 km^2, while the area actually covered by buildings is about 420 km^2.
- Agricultural areas in use cover about 10 200 km^2, and forests about 125 000 km^2 (Norwegian Forest and Landscape Institute 2007), of which 75 000 km^2 is classified as productive forest.
- The remaining land area comprises other cultivated land, non-developed coastal areas, scrub and heaths, marginal forest, and mountains. According to the Norwegian Mapping Authority (2008), 3 100 km^2 of the mainland is under permanent ice and snow.

Box 8.1. Norway's main geographical features

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 vary widely. The Kingdom of Norway consists of the mainland, the Svalbard archipelago and the island of Jan Mayen.

The mainland includes all islands and skerries within the baselines. The mainland covers 323 802 km^2 in total (304 280 km^2 land and 19 522 km^2 freshwater). In terms of altitude, 31.7 per cent of the land area lies 0–299 metres above sea level, and as much as 20.1 per cent lies at least 900 metres above sea level, where productivity (in terms of vegetation) is low. The mainland (excluding islands) stretches from Skjernøysundet in the south (58°00'13''N) to Kinnarodden in the north (71°08'02''N).

Svalbard consists of Bjørnøya, Spitsbergen, Nordaustlandet, Barentsøya, Edgeøya, Kong Karls Land, Hopen, Prins Karls forland, Kvitøya and all other islands and skerries between 74° and 81°N and 10° and 35°E. The Spitsbergen Treaty of 9 February 1920 recognises Norway's full and absolute sovereignty over Svalbard, subject to the limitations imposed by the treaty. Svalbard was incorporated into the Kingdom of Norway by the Act of 17 July 1925.

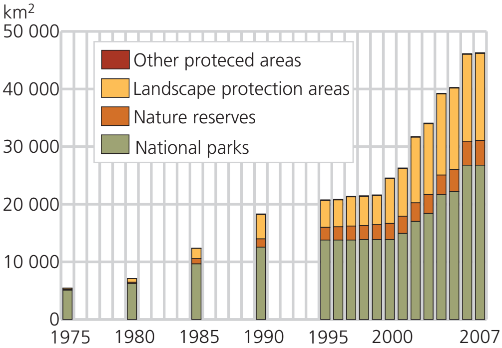
Jan Mayen is an island in the North Atlantic. It was placed under Norwegian sovereignty on 8 May 1929, and according to the Act of 27 February 1930 No. 2, it is part of the Kingdom of Norway.

Bouvet Island, Peter I's Island and Dronning Maud Land in Antarctica (stretching from 20°W to 45°E) are Norwegian dependencies. They were placed under Norwegian sovereignty by the Act of 27 February 1930 No. 3, Storting resolution of 23 April 1931 and Royal Decree of 14 January 1939, respectively, but are not part of the Kingdom of Norway.

(see Statistical Yearbook of Norway 2008, http://www.ssb.no/english/yearbook/).

8.2. Protection and development

Figure 8.2. **Areas protected under the Nature Conservation Act. Whole country. 31 December 1975-2007. km²**



Source: Directorate for Nature Management (2008).

Areas protected under the Nature Conservation Act

- The total area protected under the Nature Conservation Act has expanded considerably since 1975. As of 1 January 2008, protected areas included 29 national parks, 1 822 nature reserves, 174 protected landscapes and 122 other types of protected area.
- The total area protected rose from 46 168 km² in 2007 to 46 274 km² in 2008, or about 14 per cent of Norway's total area. The rise in the past year is due to the establishment of new nature reserves.
- As of 1 January 2008, about 1 027 km² of productive forest was protected, which is equivalent to just over 1 per cent of the total area of productive forest. Included in this figure are protected forest areas in the national parks (Directorate for Nature Management 2008).
- In 49 municipalities, more than 25 per cent of the total area is protected under the Nature Conservation Act. Most of the municipalities with a high proportion of protected areas include large areas of mountain, glacier or other marginal areas.

Box 8.2. Protected areas. Overview of legislation

Most of the protected areas in Norway are protected under the Nature Conservation Act. Other legislation and treaties of importance in this connection include:

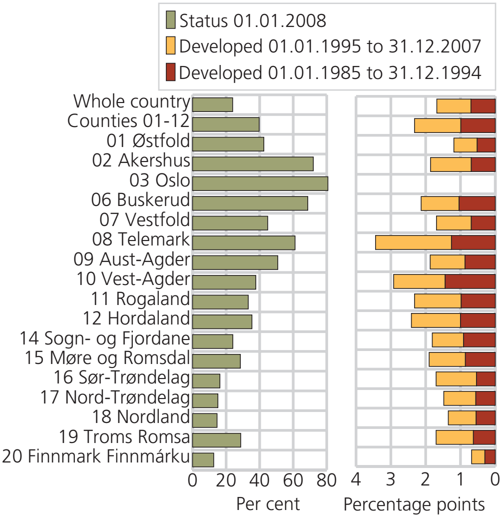
- Wildlife Act
- Planning and Building Act
- Act relating to salmonids and fresh-water fish
- Forestry Act
- Cultural Heritage Act
- Svalbard Environmental Protection Act
- Act relating to Jan Mayen
- Act relating to Bouvet Island, Peter I's Island and Queen Maud Land
- Antarctic Treaty

In addition there are so-called administratively protected areas. These are areas or individual trees or groups of trees on public ground. Rivers protected under the protection plans for water resources are generally only protected against further hydropower developments, and are not included in areas designated as protected areas.

Loss of access to coastal areas

Norway's strategic objective for outdoor recreation, which is a priority area of environmental policy, is that "everyone will have the opportunity to take part in outdoor recreation as a healthy and environmentally sound leisure activity that provides a sense of well-being both near their homes and in the countryside". Coastal areas are very valuable for outdoor recreation. At the same time, there is great pressure to allow development of these areas, which means that public access for recreation purposes is becoming more and more restricted.

Figure 8.3. **Proportion of the coastline less than 100 m from the nearest building[1] in 2008. Change from 1985 to 2008**



[1] Large numbers of buildings were registered in the GAB register (the official Norwegian register for property, addresses and buildings) in 1993-1994, and figures for changes before 1995 are therefore uncertain. Figures for changes in Oslo are not included.
Source: Statistics Norway 2008c.

- For the country as a whole, 24 per cent of the coastline is less than 100 m from the nearest building. In the counties around the inner Oslofjord, more than two thirds of the coastline is less than 100 m from the nearest building.
- Since 1965, the Planning and Building Act has restricted developments along the shoreline, and tighter restrictions have been introduced since then. Despite this, buildings were constructed or altered along 1.7 per cent, or 1 550 km, of the shoreline from 1985 to 2008.
- The greatest changes have taken place in the southern parts of the country, where the largest proportion of the coastline was already developed.

Box 8.3. Building activity in the 100-metre belt along the coast

Protecting areas of recreational value is an express national target. Several specific indicators have been drawn up as operational tools to monitor developments in relation to the national targets for the priority area outdoor recreation in environmental policy.

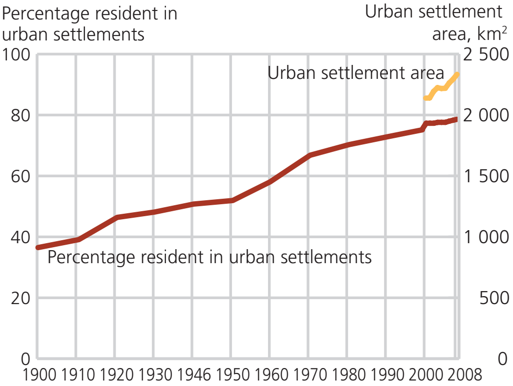
Access to the 100-metre belt along the coast is one such indicator. The mainland coastline is 92 100 km long, including islands, fjords and bays. This is equivalent to over twice the circumference of the earth at the equator. Most of the urban settlements and a large proportion of other built-up areas, including holiday cabins, are concentrated along the coast. As much as 24 per cent of the total length of the coastline is less than 100 metres from the nearest building (registered in the GAB, the official Norwegian register for property, addresses and buildings, as of 1 January 2008). From Halden in the south-east to Hordaland in the west, a stretch of the coast specifically mentioned in the context of the indicators, as much as 40 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 in some parts of this stretch of the coast.

More information: *Bygging i strandsonen (1985-2008) Jevn utbyggingstakt langs strendene*.(Development in the shore zone (1985-2007) Steady building activity in the shore zone). Today's statistics, http://www.ssb.no/emner/01/01/20/strandsone//, Statistics Norway.

8.3. Land use and activity in urban settlements

Urban settlements make up about 1 per cent of the area of Norway, but are home to four fifths of the population. Land use and the services available locally affect the environment in which children grow up, transport needs, pollution levels and opportunities for outdoor recreation activities, which in turn have effects on people's health. It is therefore important to monitor trends in land use and activity in urban areas.

Figure 8.4. **Percentage of population resident in urban settlements/densely populated areas 1900-2008 and area of urban settlements 2000-2008**



Source: Statistics Norway 2008a.

Population trends and area of urban settlements

- In 2007, the number of people living in urban settlements rose by 67 400 or about 1.8 per cent. A high rate of immigration was an important reason for this. In all, 79 per cent of the Norwegian population now lives in urban settlements. The total area of urban settlements in Norway is 2 334 km². The area of urban settlements increased by 40 km² from 2007 to 2008.
- As of 1 January 2008, the average population density in Norwegian urban settlements was 1 595 inhabitants per km². The corresponding figure for 2000 was 1 588 inhabitants per km². A slow but marked densification of urban settlements is taking place.
- More than 1.5 million people now live in the five largest urban settlements, Oslo, Bergen, Stavanger/Sandnes, Trondheim and Fredrikstad/Sarpsborg, each of which has a population of 100 000 or more.
- As of 1 January 2008, 708 urban settlements (77 per cent) had fewer than 2 000 inhabitants. These settlements accounted for only 13 per cent of the total population living in urban settlements, but 24 per cent of the total area of urban settlements..

Table 8.1. **Urban settlements[1]. residents and area. by size of population. 1 January 2008. Change from 2007 to 2008**

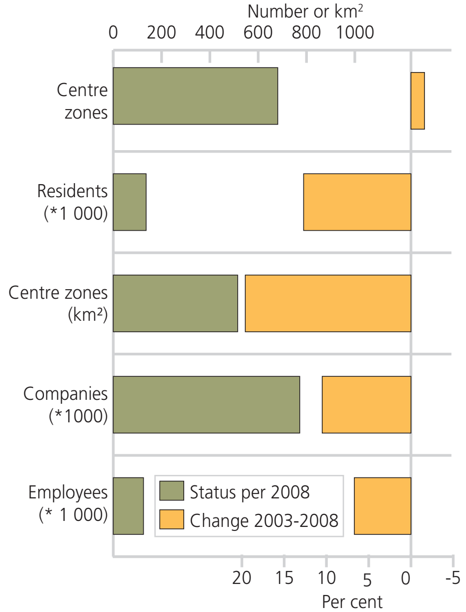
	2008			Change from 2007 to 2008		
	Number of areas	Population	Area km²	Number of areas	Population	Area km²
Total	922	3 722 786	2 333.73	5	67 395	39.65
200 - 499	344	117 726	170.12	4	1 139	3.11
500 - 999	218	152 820	190.38	-2	-185	0.26
1 000 - 1 999	146	206 861	209.09	-1	-536	-1.57
2 000 - 19 999	195	1 059 849	796.62	4	27 954	22.95
20 000 - 99 999	14	661 875	383.16	-1	-90 666	-58.90
over 100 000[2]	5	1 523 655	584.36	1	129 689	73.80

[1] An urban settlement is an area with at least 200 residents. and the distance between the buildings does not normally exceed 50 metres. Urban settlement boundaries are thus dynamic. changing with building developments and changes in the population.
[2] Fredrikstad/Sarpsborg is now in the category population 100 000 or more.
Source: Statistics Norway 2008a.

Centre zones

The establishment of shopping centres outside central parts of towns and urban settlements leads to increased transport by private car and adds to environmental pressures such as noise and pollution. A growing volume of traffic gives children a less safe environment in which to grow up. The statistics on centre zones are intended to quantify developments in this area.

Figure 8.6. **Number of centre zones, centre zone area, residents, employees in wholesale and retail trade and companies in centre zones. 2008. Change from 2003 to 2008. Per cent**



Source: Statistics Norway 2008d.

- Centre zones (see Box 8.5) only figured in 227 of Norway's 430 municipalities as of 1 January 2008, and tend not to be formed in the smallest municipalities (Statistics Norway 2008c).
- As of 1 January 2008, there were 681 centre zones in Norway, with a total population of about 515 000. Even though the number of centre zones has varied since 2003, there has been relatively stable but slow growth in their area and population in the same period. As companies become established and close down, small centres may be formed one year and disappear the next, but this has little effect on the total area and number of inhabitants in such centres.
- As of 1 January 2008, the number of employees in centre zones was 772 000.
- Norway is becoming more and more urban in the sense that more people are living in centre zones. About 11 per cent of the population now lives in centre zones, a weak rise from earlier years. The population density in these zones is 3 800 persons per square kilometre, as compared with 1 600 per square kilometre in urban settlements. In other words, population density is twice as high in centre zones as in urban settlements as a whole.

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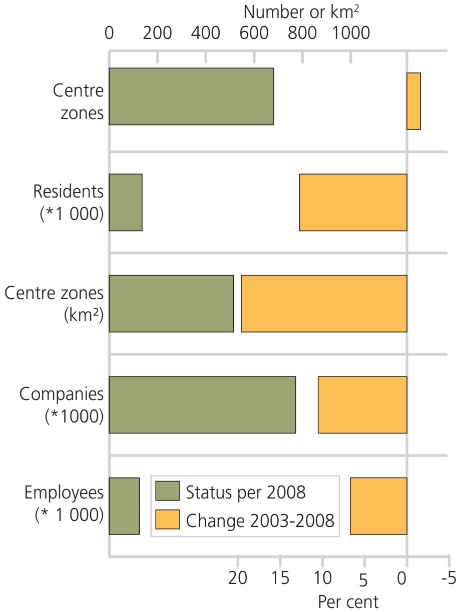

Source: Statistics Norway 2008d.

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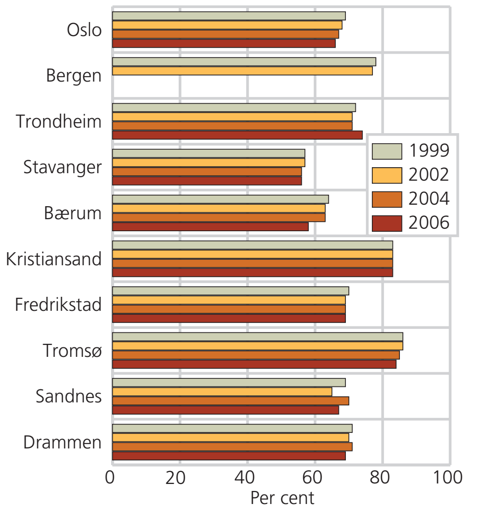
Access to play and recreational areas in urban settlements in the 10 largest municipalities

Strong growth in settlement and employment in the towns is putting growing pressure on land in and around urban settlements. When necessary buildings and infrastructure are constructed within an already existing urban settlement, its density increases, which is in accordance with Norway's urban development policy, as set out in Report No. 23 (2002–2002) to the Storting. The goal of high-density urban development means that there is great pressure on land in central urban areas. This can mean that green spaces are developed, reducing access to play and recreational areas. If there is a lack of good play areas, or they are too small or too far away, children will often play in streets and car parks, putting themselves in danger. Thus, the goal of increasing density in urban settlements to make them environmentally friendly must be considered in conjunction with the effects on the quality of the residential environment and safe access to adequate green spaces. The Government has encouraged municipalities to safeguard neighbourhood play and recreational areas in connection with urban development and densification, for example in Report No. 26 (2006–2007) to the Storting.

Figure 8.7. **Residents with safe access[1] to play and recreational areas in urban settlements. The 10 largest municipalities. Per cent**



[1] Defined as open areas larger than 0.5 hectares within a distance of 200 metres without having to cross main roads or railway.
Source: Haagensen (2007).

- In most of the 10 municipalities, between 60 and 70 per cent of the population have safe access to play and recreational areas from their homes.
- In Tromsø and Kristiansand, more than 80 per cent of the population had safe access to such areas in 2006. In, Bærum and Stavanger, the corresponding figure was only just over 50 per cent.
- Trondheim is the only municipality where the proportion of the population with safe access to play and recreational areas rose in the period 1999-2006.

Box 8.5. Operationalisation of the concept of the centre zone

In January 1999, a national policy decision, applicable for up to five 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 1999). 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 therefore launched by Statistics Norway in cooperation with the Oslo and Akershus county administration to operationalise the concept of the centre core based on criteria of physical concentration and diversity of activity:

- retail trade must take place
- there must be either a public administration 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.

See map showing centre zones and urban settlements http://www.ssb.no/emner/01/01/20/.

Box 8.6. Targets and indicators for outdoor recreation

The strategic objective for outdoor recreation in Norway's environmental policy is "everyone will have the opportunity to take part in outdoor recreation as a healthy and environmentally sound leisure activity that provides a sense of well-being both near their homes and in the countryside". One of the national targets for outdoor recreation is "Near housing, schools and day care centres, there will 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" (Report No. 26 (2006–2007) to the Storting).

On the basis of this target, two indicators have been developed to measure performance over time:

- Percentage of dwellings, schools and day care centres with safe access to play and recreational areas (at least 0.5 hectares) within a distance of 200 metres.
- Percentage of dwellings, schools and day care centres with access to nearby outdoor recreation areas (larger than 20 hectares) within a distance of 500 metres.

These indicators were described in more detail in *Tilgang til friluftsområder - metode og resultater 2004* (Access to outdoor recreational areas – method and results 2004) (Engelien et al. 2005).

8.4. Municipal land use management

The status of biodiversity, recreation and cultural heritage in municipal land-use planning

A municipality uses the land-use part of the municipal master plan as the basis for safeguarding areas of special value. This can be done in various ways, for example by adopting plans with a special focus on environmental assets such as biodiversity, opportunities for outdoor recreation and the cultural heritage.

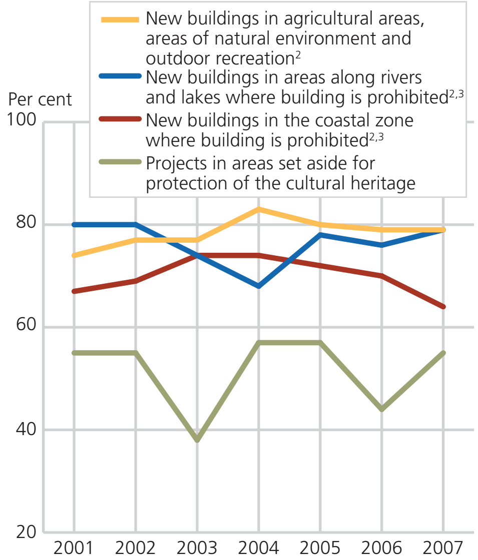
- Of these environmental assets, the municipalities place greatest emphasis on outdoor recreation. Biodiversity has been given less priority, but the share of municipalities with plans has increased substantially since 2001. This is probably related to the funds allocated to municipalities to register and classify the value of biodiversity.
- The decisive factor underlying these differences may be municipalities' perception of their areas of responsibility. Classic nature conservation and cultural heritage conservation has traditionally been regarded as a central government responsibility, while outdoor recreation has to a greater extent been delegated to local government.
- Densely populated municipalities seem to incorporate these aspects in their municipal master plan to the greatest extent.
- Over the last year, the average age of the plans, except for those relating to the cultural heritage, has been rising, indicating that they are being updated less frequently.
- See Chapter 5.8. Management of uncultivated areas.

Table 8.2. **Proportion of municipalities that have adopted a plan focusing specially on biodiversity, outdoor recreation, protection of the cultural heritage and climate and energy. Average age of plans in the reporting year**

	Biodiversity		Outdoor recreation		Cultural heritage		Climate and energy	
	Percentage of munici-palities with plan	Age. Years	Percentage of munici-palities with plan	Age. Years	Percentage of munici-palities with plant	Age. Years	Percentage of municipalities with plan	Age. Years
Whole country							..	..
2001	17	4.6	62	3.7	28	5.5	..	..
2002	20	4.2	57	3.4	..	5.3	..	..
2003	29	2.3	59	2.3	30	5.2	..	..
2004	32	2.7	61	2.6	30	4.8	..	..
2005	39	3.1	60	2.8	30	4.7	..	..
2006	48	4.3	62	3.9	31	5.6	..	..
2007	53	3.9	62	3.4	33	4.9	9	2
By population in municipalities, 2007								
Over 300 000	100	5	100	1	0	..	..	..
50 000-300 000	92	2.4	92	1.5	83	3.5	58	1.4
30 000- 50 000	83	4.8	75	3.6	58	6.6	33	4.8
20 000- 30 000	68	5.7	82	6.3	62	4.5	19	2.4
10 000- 20 000	58	3.5	57	3.6	38	6.3	10	1.8
5 000- 10 000	54	4.3	76	3.4	29	5.2	8	1.3
2 000- 5 000	42	3.1	57	2.7	29	4.4	5	1.5
Under 2 000	46	4	47	3.7	19	4.6	0	..

Source: Statistics Norway 2008b, KOSTRA

Figure 8.8. **Proportion of applications for exemptions granted in areas of particular environmental value[1]. 2001-2007**

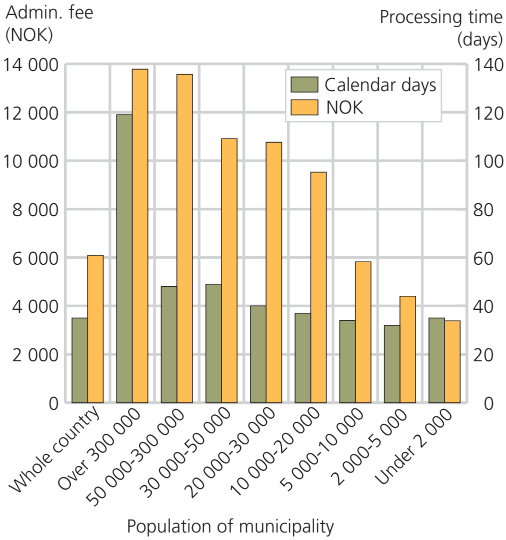


[1] The number applies to municipalities that reported for the years 2001-2003. From 2004 the figures apply to the whole country. From 2005, agriculture is not included.
[2] For 2001 and 2002, the figures include all projects, from 2003 new buildings only
[3] For 2001-2004, applications for exemptions only
Source: Statistics Norway 2008b.

Administration of plans in areas of particular environmental value

- Plans may be binding or in the form of guidelines indicating which projects may be implemented. Reports on projects in areas of particular environmental value (defined as agricultural areas, areas of natural environment and outdoor recreation areas, the 100-metre belt along the coast and special areas set aside for the protection of the cultural heritage) show that most applications are in accordance with plans and are approved.
- Applications for exemptions from adopted plans are granted more often than they are rejected. This applies to all types of area.
- The percentage of exemptions granted along the coastline has decreased somewhat in recent years. For areas along rivers and lakes where building is prohibited, the picture is less clear.
- The case load in a municipality does not seem to influence the percentage of exemptions granted.

Figure 8.9. **Administrative municipal fee for building of single-family dwelling and average case processing time for projects for which application is required, by size of population. 2007**



Source: Statistics Norway 2008b, KOSTRA.

Fees and case processing time in municipal land use management

- In 2007, net expenses for land use planning made up just over 0.6 per cent of total net municipal operating expenses and just over 1 per cent of gross expenses. Fees have been rising much faster than prices generally in recent years.
- The size of fees increases with the size of the municipality, measured by population. This may be because more interests are affected by cases involving regulation or building in larger municipalities.
- The low level of fees compared to expenses in small municipalities may, in addition to less complicated administration, be partly related to the use of low fees as an incentive to attract new businesses.
- Case processing time is longest in the largest municipalities. This may be due to higher case complexity, which puts greater demands on case processing.

Box 8.7. Towns and the environment. Indicators of environmental trends in Norway's 10 largest towns

Guiding Principles for Sustainable Spatial Development of the European Continent were presented to the European Conference of Ministers responsible for Regional Planning (CEMAT) in September 2000. These were adopted by the members of the Council of Europe, including Norway. They provide advice on how to control urban sprawl, how to manage the urban ecosystem and how to develop effective and environmentally friendly public transport (Report No. 23 (2001–2002) to the Storting).

The physical structures in urban settlements are the development pattern, the urban centre structure, the transport system and the green structure (Report No. 21 (2004–2005) to the Storting). These structures change gradually over time as a result of all the large and small development projects that are carried out. To find out whether urban settlement structures are becoming more functional and environmentally friendly, it was necessary to develop statistics and indicators for the urban environment. This was emphasised in Report No. 23 (2001–2002) to the Storting, which discusses the most important elements of environmentally friendly urban settlements. These have played an important role in the development of indicators. The indicators are intended to give a picture of the state of the environment and environmental trends in the 10 largest municipalities in terms of population, and also to provide a basis for comparison between these and the rest of the country.

The distance to day care centres, schools and shops, recreation areas and areas of natural environment has a strong influence on transport needs, the environment and people's welfare. Children, people with disabilities, old people and other people whose radius of action is limited are dependent on their local environment and community in both social and physical terms. For many people, an important consideration when choosing where to live is that they can get around without a car. The possibility of walking or cycling to their destination may also make it possible for people to achieve the recommended goal of being physically active for half an hour every day. Report No. 23 (2001–2002) to the Storting also makes it clear that public health concerns should be better integrated into land-use and transport planning. The following indicators have been developed:

- The proportion of residents who live less than 200 metres from a recreation area larger than 0.5 hectares
- The proportion of children who live less than 500 metres from a day care centre
- The proportion of the population who live less than 500 metres from a food store
- The proportion of schoolchildren who live less than 500 metres from a school.

More information: Erik Engelien (erik.engelien@ssb.no; land cover, urban settlements, settlement centres, urban environment and outdoor recreation areas), Ola Erik Nordbeck (ola.erik.nordbeck@ssb.no; the 100-metre belt along the coast and nature conservation), Jørn Kristian Undelstvedt (jku @ssb.no; municipal land use management).

Useful websites

Statistics Norway, land use statistics: http://www.ssb.no/english/subjects/01/01/20
Statistics Norway, environmental statistics: http://www.ssb.no/english/subjects/01/miljo_en/
Directorate for Nature Management: http://english.dirnat.no/
Ministry of the Environment: http://www.regjeringen.no/en/dep/md.html?id=668
Geological Survey of Norway: http://www.ngu.no/en-gb/
Norwegian Forest and Landscape Institute: http://www.skogoglandskap.no/
Norwegian Institute for Air Research: http://www.nilu.no/index.cfm?lan_id=3
Norwegian Institute for Water Research: http://www.niva.no/symfoni/infoportal/portenglish.nsf
Norwegian Water Resources and Energy Directorate: http://www.nve.no/
Norwegian Pollution Control Authority: http://www.sft.no/aktuelt____29292.aspx
Norwegian Mapping Authority: http://www.statkart.no/

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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. 25 (2002-2003): *Regjeringens miljøvernpolitikk og rikets miljøtilstand* (The Government's environmental policy and the state of the environment in Norway), Ministry of the Environment.

Part 3
Pollution and environmental problems

9. Air pollution and climate change

Preliminary calculations show that in 2007, greenhouse gas emissions in Norway were almost 11 per cent higher than in 1990. From 2006 to 2007, these emissions rose by 2.7 per cent, after declining during the two previous years. The rise in greenhouse gas emissions since 1990 is mainly due to the growth in emissions from oil- and gas-related activities and road traffic.

Emissions of greenhouse gases, acidifying substances and ecological toxins contribute to a number of environmental problems, for example climate change, acidification, depletion of the ozone layer, the formation of ground-level ozone and disease in humans and animals. Some emissions result in local environmental problems, whereas other pollutants are transported over long distances and result in regional or global problems (see boxes 9.2, 9.3, 9.8, 9.9, 9.10, 9.11, 9.12 and 9.13).

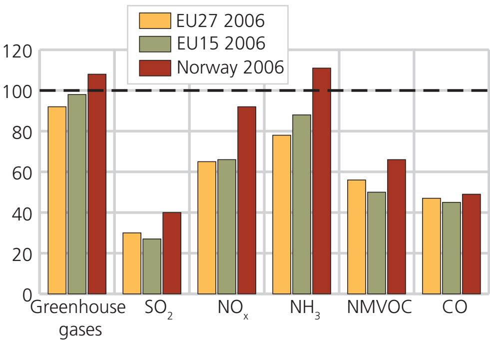
International cooperation is essential as a means of reducing emissions that have regional or global effects. Norway is party to various multilateral environmental agreements, and is committed to reducing emissions of the most important air pollutants.

The Kyoto Protocol to the United Nations Framework Convention on Climate Change (UNFCCC) sets out quantitative commitments for reductions of greenhouse gas emissions by developed countries. Under the Protocol, each developed country has an assigned amount of emissions for the period 2008–2012 (see Box 9.5).

There are eight protocols under the Convention on Long-Range Transboundary Air Pollution. One of them is the Gothenburg Protocol, which is intended to reduce acidification, eutrophication and the formation of ground-level ozone by introducing emission ceilings for acidifying substances and ozone precursors. Norway has also undertaken to reduce its emissions of certain other substances under the LRTAP Convention.

The Norwegian emission inventory (see Box 9.1) makes it possible to identify the major sources of each pollutant and to follow emission trends over time. This information is important when considering which measures to implement and evaluating their effects. Figures from the emission inventory are used to evaluate whether Norway has met its commitments under multilateral environmental agreements.

Figure 9.1. **Changes in emissions from 1990 to 2006, EU[1] and Norway. Index: 1990=100**



[1] The EU provides figures for SO_x rather than SO_2.
Sources: EEA (2008a), EEA (2008b).

Figure 9.1 provides a comparison of how emission levels for various gases have changed from 1990 to 2006 in Norway and in the EU. "EU15" means the countries that were EU member states before enlargement in 2004 and 2007, when a number of countries, mainly from the old Eastern bloc, became members: "EU27" means all the current member states. The reductions in emissions relative to 1990 are smaller in Norway than in either EU group, and emissions of greenhouse gases and ammonia (NH_3) (which are smaller in absolute terms) have actually risen in Norway. Definitions and further information on the various gases are provided later in this chapter.

Box 9.1. 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 a number of ecological toxins. The inventory covers only anthropogenic emissions, not natural emissions for example from oceans and forests. The Norwegian Pollution Control Authority and the Ministry of the Environment are responsible for reporting Norway's figures for emissions to air under multilateral environmental agreements such as the Kyoto Protocol. Figures from the emission inventory are used in such reports.

Emission figures are compiled partly from data reported by industrial plants, based on measurements or calculations at these plants, and partly from 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.

Recalculations

The Climate Change Convention, the Kyoto Protocol and other environmental agreements require developed countries to follow a strict regime for calculating and reporting emissions to air. Emission figures are based on calculations with varying levels of certainty, and the environmental agreements therefore require countries to continue efforts to improve the methodology for calculating emissions. As new research results in improvements in methodology, emission figures for all years have to be recalculated. During the commitment period 2008–2012 under the Kyoto Protocol, it will be even more important for countries to make these recalculations, and to do so regardless of whether they result in higher or lower emission figures. For more information, see Haakonsen and Rosland (2006).

For documentation of the emission inventory, see Aasestad, K.: *The Norwegian Emission Inventory 2008. Documentation of methodologies for estimating emissions of greenhouse gases and long-range transboundary air pollutants*. Reports 2008/48, Statistics Norway.

Box 9.2. Environmental problems caused by air pollution

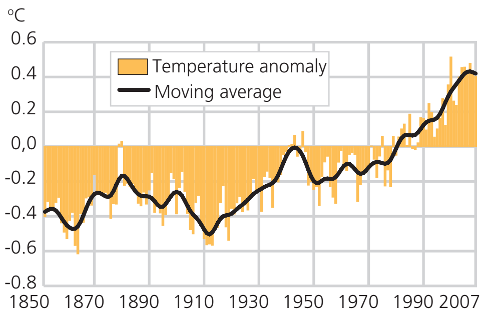
Enhanced greenhouse effect	Anthropogenic emissions of greenhouse gases, sulphur dioxide (SO_2) and particulate matter can alter the natural chemical composition of the atmosphere. Greenhouse gases cause warming of the atmosphere, whereas SO_2 and particulate matter mainly have a cooling effect. It is 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 2007). Impacts of global warming may include a rise in sea level, changes in precipitation patterns and more frequent extreme weather events.
Acidification	Emissions of SO_2, nitrogen oxides (NO_x) and ammonia (NH_3) acidify soils and water when deposited and can alter living conditions for all living organisms. Acid rain increases leaching of nutrients and metals from the soil, and has had serious impacts on life in rivers and lakes. For example, formerly abundant fish stocks have been lost from river systems across large parts of the southern half of Norway. The extent of the damage depends on the type of soil and vegetation. Lime-rich soil can withstand acidification better than other soil types because it weathers to release calcium. Deposition of acidifying substances in Norway is mainly caused by emissions in other countries. In recent years, clear improvements have been observed in water chemistry and in the content of acidifying substances in precipitation in Norway. Acid rain can cause corrosion damage to buildings.
Ozone depletion	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 and northern latitudes has dropped. 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).
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 methane (CH_4), carbon monoxide (CO), nitrogen oxides (NO_x) and non-methane volatile organic compounds (NMVOCs) in the presence of sunlight. It may also be transported to Norway from other parts of Europe.
Ecological toxins	Norway categorises hazardous substances as ecological toxins if they are persistent (do not break down easily), bioaccumulative (build up in food chains and the environment) and are toxic to living organisms. The most serious toxic effects are cancer, genetic damage, disruption of reproduction and fetal development, and other forms of chronic toxicity.

9.1. Greenhouse gases

Climate change

As a result of the natural greenhouse effect, the global mean temperature is about 15°C instead of -18°C. Human activities are now raising the concentrations of greenhouse gases in the atmosphere. From 1750 to 2005, concentrations of the three most important greenhouse gases, carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O), rose by 30, 150 and 17 per cent respectively (NILU 2005). 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 at least 650 000 years (Brook 2005), maybe for several million years. As concentrations of greenhouse gases rise, the atmosphere retains more of the thermal radiation from the earth, which causes the global mean temperature to rise and results in climate change. This phenomenon is called the anthropogenic or enhanced greenhouse effect. Norway's total greenhouse gas emissions are shown in Figure 9.4. If emissions of greenhouse gases continue to rise, there will also be a growing risk of serious, far-reaching impacts, such as flooding, drought and other extreme weather events. To solve the problem will require a reorganisation of world energy use, which is the most important source of greenhouse gas emissions. Many countries are trying to organise emission reductions within the framework of the Kyoto Protocol (see Box 9.5).

Figure 9.2. **Global mean temperature[1]. 1850-2007**



[1] Deviation from the normal value for the period 1961-1990.
Source: Climate Research Unit, University of East Anglia and Hadley Centre, UK Meteorological Office.

Global mean temperature and annual mean temperature in Norway

- The global mean temperature rose by about 0.6°C during the 20th century. 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 (IPCC 2007). 1998 was the warmest year registered since records began in 1850. In 2007, the global mean temperature was 0.40°C above the normal value the period 1961–1990.
- 2007 was the 10th warmest year registered in Norway since 1900. The mean temperature for the whole year was 1.3°C above normal. The warmest years recorded are 1934, 1990 and 2006, all with a mean annual temperature 1.8°C above normal (http://met.no/).
- The mean temperature for 2007 registered at Svalbard airport was -2.5°C, which is 4.2°C above normal. This is the second highest annual mean temperature ever recorded in this time series, which started in 1911. The highest annual mean recorded, -1.7°C, was in 2006.

Box 9.3. Greenhouse gases. Sources and harmful effects

Substance	Most important sources[1]	Effects
Carbon dioxide (CO_2)	Combustion of fossil fuels, changes in land use and deforestation	Enhances the greenhouse effect.
Methane (CH_4)	Agriculture, landfills, production, transport and use of fossil fuels	Enhances the greenhouse effect and contributes to formation of ground-level ozone.
Nitrous oxide (N_2O)	Agriculture, fertiliser production	Enhances the greenhouse effect.
Hydrofluorocarbons (HFCs)	Cooling fluids	Enhance the greenhouse effect.
Perfluorocarbons (PFCs, CF_4 and C_2F_6)	Production of aluminium	Enhance the greenhouse effect.
Sulphur hexafluoride (SF_6)	Production of magnesium	Enhances the greenhouse effect.
Hydrochlorofluorocarbons (HCFCs)[2]	Cooling fluids	Enhance the greenhouse effect and deplete the ozone layer.
Chlorofluorocarbons (CFCs)[2]	Cooling fluids	Enhance the greenhouse effect and deplete the ozone layer.

[1] The table indicates important anthropogenic sources. There are also important natural sources for several of these substances.
[2] Not included in the national greenhouse gas inventory or in the Kyoto Protocol.

Box 9.4. Greenhouse gases and global warming potential

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 fertilisers are the main sources of N_2O emissions in Norway.

The GWP value (Global Warming Potential) 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. GWP values are used to convert emissions of greenhouse gases to CO_2 equivalents. The list below shows GWP values as listed in the Kyoto Protocol for the greenhouse gases to which it 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 (HFK)	
HFC-23	11 700
HFC-32	650
HFC-125	2 800
HFC-134	1 000
HFC-134a	1 300
HFC-143	300
HFC-143a	3 800
HFC-152a	140
HFC-227ea	2 900
Perfluorocarbons (PFK)	
CF_4 (PFK-14)	6 500
C_2F_6 (PFK-116)	9 200
C_3F_8 (PFK-218)	7 000
Sulphur hexafluoride (SF_6)	23 900

Table 9.1. **Emissions of CO_2[1] by country, 2004 and changes from 1990**

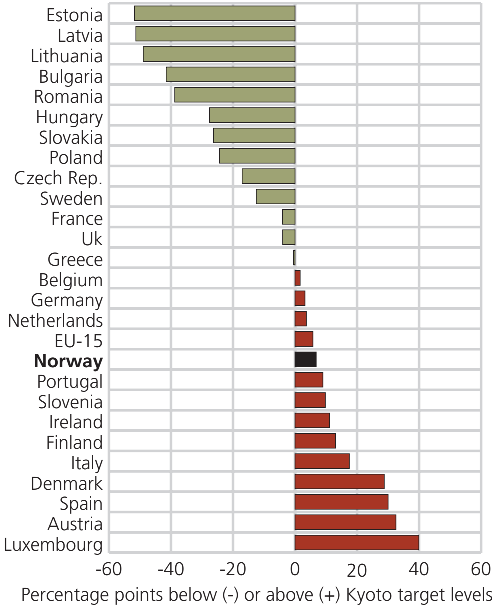
	CO_2 emissions 2004, million tonnes	Per cent of world total	Change from 1990. Per cent
US	5 988	21.6	19.6
China	5 010	18.1	108.7
Russia	1 618	5.8	-32.4
India	1 343	4.8	96.9
Japan	1 286	4.6	12.4
Germany	886	3.2	-14.0
Canada	593	2.1	28.8
UK	562	2.0	-4.7
Italy	490	1.8	12.7
South Korea	466	1.7	93.0
Mexico	438	1.6	5.9
South Africa	437	1.6	31.6
Iran	434	1.6	98.5
France	417	1.5	5.6
Australia	382	1.4	36.7
Indonesia	378	1.4	76.8
Spain	355	1.3	55.1
Brazil	332	1.2	58.2
Ukraine	317	1.1	-55.9
Poland	317	1.1	-16.8
Saudi Arabia	308	1.1	21.0
Thailand	268	1.0	179.8
Turkey	242	0.9	73.3
Kazakhstan	200	0.7	..
Algeria	194	0.7	151.8
Netherlands	181	0.7	13.5
Malaysia	178	0.6	221.1
Venezuela	173	0.6	47.0
Egypt	158	0.6	109.6
Norway	44	0.2	26.5

[1] Note that the table includes CO_2 only, not other greenhouse gases.
Source: UN Statistics Division.

Greenhouse gas emissions in other countries

- Figures from the UN Statistics Division show that the US and China together accounted for 40 per cent of total global CO_2 emissions in 2004.
- Since 1990, emissions have dropped considerably in countries such as Russia, Germany, Ukraine and Poland, whereas they have risen sharply in several countries in Asia. In recent years, China's energy use, and in particular its consumption of coal, has risen explosively, and there has been a corresponding rise in CO_2 emissions. In addition to the rapid rise in emissions from fuel combustion in China, the country has an expanding cement industry that generates considerable process emissions. China has probably overtaken the US as the world's largest CO_2 emitter, or is about to do so. By 2010, the growth in China's emissions after 2000 will correspond to emissions that are several times larger than the cuts agreed in the Kyoto Protocol. The US has not been willing to ratify the Kyoto Protocol, and an important argument for its position has been that the protocol does not include emissions from less developed countries such as China.
- Among the major emitters, per capita CO_2 emissions in 2004 were highest in the US, Australia and Canada at 20.4, 19.0 and 18.5 tonnes respectively. The corresponding figures for China and India were only 3.8 and 1.2 tonnes CO_2.
- According to UN figures, Norway generated only 0.2 per cent of total global CO_2 emissions in 2003, but emissions measured in per capita terms were 9.6 tonnes.

Figure 9.3. **"Distance-to-target" for greenhouse gas emissions[1] in 2002 (deviation of actual emissions from Kyoto targets) Percentage points below (-) or above (+) Kyoto target levels[2]. EU countries and Norway**



[1] Under the Kyoto Protocol, the base year for emissions of CO_2, N_2O and CH_4 is 1990. Some countries have chosen to use 1995 as the base year for fluorinated gases.
[2] The targets do not mean that there is an absolute limit for these countries' emissions in the Kyoto commitment period (2008–2012), see Box 9.5.
Source: EEA (2008a) and emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

- Aggregate greenhouse gas emissions from the EU-15 decreased by 0.8 per cent from 2005 to 2006 (EEA 2008a). The EU member states must reduce their overall emissions by 8 per cent by 2008–2012 compared with the 1990 level in order to meet their Kyoto commitments, unless they decide to make use of emissions trading and the other Kyoto mechanisms (see Box 9.5). The EU has adopted a burden-sharing agreement to divide this overall reduction among the member states.
- Germany is the EU state with the highest greenhouse gas emissions, almost 20 per cent of the EU total in 2006. In that year, its emissions totalled 1 005 million tonnes CO_2 equivalents, a reduction of 18.2 per cent since the base year. Germany has undertaken to reduce its greenhouse gas emissions by 21 per cent compared with the base level.
- In Spain, greenhouse gas emissions rose by 50 per cent in the period 1990–2006. This is the greatest rise in any EU state, and far above its target of 15 per cent under the burden-sharing agreement.
- Emissions from the former Eastern bloc countries in the EU have dropped considerably in the period 1990–2006. There has been a weak rise in emissions in Slovenia, but emissions have dropped by 24–58 per cent in the other nine countries in this group.

Box 9.5. The Kyoto Protocol and the Kyoto mechanisms

By May 2008, 181 countries and the EU had ratified the Kyoto Protocol. However, the US has not done so. Once it had been ratified by the required number of countries, the Protocol entered into force on 16 February 2005. Thirty-seven developed country parties have undertaken to keep their greenhouse gas emissions below a national quota ("assigned amount") over the period 2008–2012. The assigned amount was defined in the Protocol as a percentage of the country's greenhouse gas emissions in a base year (most often 1990). In 2007, final figures for the assigned amounts were calculated. Norway, for example, has an emission ceiling that is 1 per cent above the 1990 level for each of the years in the period 2008–2012, giving a total of 250.6 million tonnes CO_2 equivalents. However, this does not mean that there is an absolute limit for emissions from developed countries during the commitment period. As a supplement to national emission reduction measures, they may acquire further emission units through the Kyoto mechanisms. These are emissions trading, joint implementation and the Clean Development Mechanism (see explanation below). It has not yet been decided how large a proportion of their commitments countries may meet by means of the Kyoto mechanisms. Emissions from developing countries are not limited in this period, but negotiations on commitments for the period after 2012 have started.

Emissions trading

The developed countries may trade emission units among themselves. A country that can reduce emissions by more than its Kyoto commitment at relatively low cost may sell part of its assigned amount to countries where the cost of achieving the target is relatively high. Countries that sell units must reduce their emissions more than the Protocol requires, and purchasing countries can reduce them less.

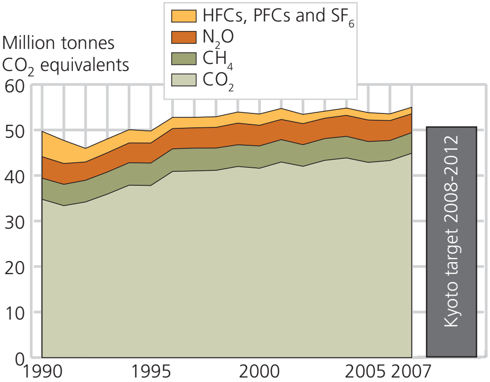
Joint Implementation and the Clean Development Mechanism

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, both countries will benefit from using this system rather than carrying out the emission reductions within their own borders. This mechanism for reducing greenhouse gas emissions is called Joint Implementation (JI). The Clean Development Mechanism is similar to joint implementation, but is applicable in cases where one party has undertaken a commitment to reduce emissions and the other has not.

Norway's assigned amount of emissions and measures to reduce emissions

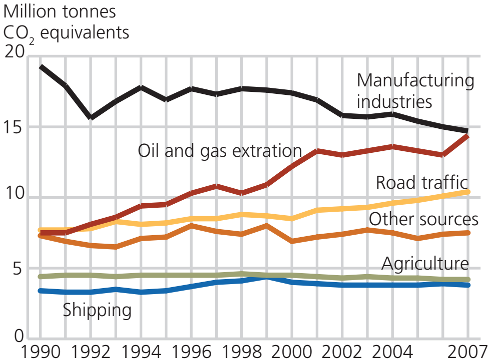
Norway is one of the countries allocated an assigned amount of emissions under the Kyoto Protocol. Norway's assigned amount is 101 per cent of its 1990 emissions on average for each of the years in the period 2008–2012.

Figure 9.4. **Total emissions of greenhouse gases in Norway. 1990-2007*. Million tonnes CO_2 equivalents**



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

Figure 9.5. **Greenhouse gas emissions by source. 1990-2007*. Million tonnes CO_2 equivalents**

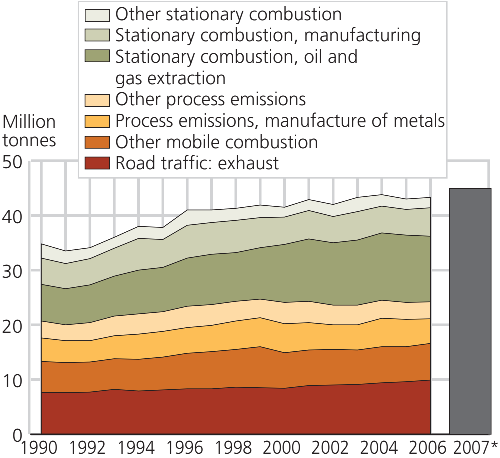


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Totale nasjonale utslipp av klimagasser

- Preliminary calculations show that greenhouse gas emissions in Norway rose by 2.7 per cent from 2006 to 2007. The overall rise since 1990, the base year for the Kyoto Protocol, is almost 11 per cent. Emissions totalled 55.0 million tonnes CO_2 equivalents in 2007.
- The most important reason for the rise in 2007 was that technical problems arose in connection with the start-up of the LNG (liquefied natural gas) plant at Melkøya near Hammerfest. The continued growth in road traffic and an increase in metal production also added to the rise in emissions, while lower crude oil production and the installation of new emission abatement technology in manufacturing industries counteracted this trend to some extent.
- The increase in emissions since 1990 is mainly due to the growth in emissions from oil- and gas-related activities, which were 73 per cent higher in 2006 than in 1990. Emissions from road traffic have also risen considerably, which is related to a rise in the level of economic activity.
- However, during this period emissions from manufacturing industries have been reduced by one quarter due to the closure of some emission-intensive plants and improvements in technology, and to some extent to a switch from the use of fossil fuels to electricity.
- In 2007, CO_2 accounted for 82 per cent of Norway's greenhouse gas emissions. The rise in emissions has also been greater for CO_2 than for other greenhouse gases, 29 per cent since 1990. Emissions of fluorinated gases have dropped by 74 per cent since 1990.
- It is estimated that emissions will continue to rise and reach 58.5 million tonnes CO_2 equivalents in 2010 unless new climate-related measures are introduced. Projections indicate that the oil and gas and transport sectors will account for most of the rise in emissions up to 2010 (Report No. 1 (2007-2008) to the Storting).
- If emissions are stable at the 2010 level throughout the Kyoto period, Norway will need to buy emission units corresponding to roughly 42 million tonnes for the whole period 2008–2012.

Figure 9.6. **Emissions of CO_2 by source. 1990-2007***

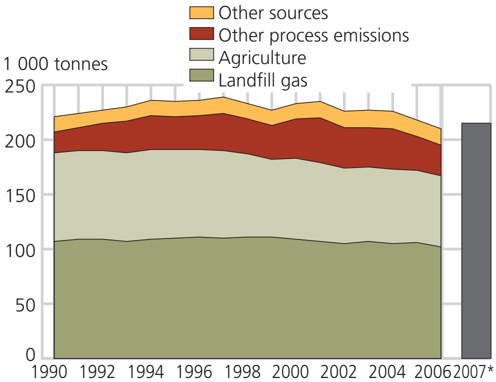


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Carbon dioxide (CO_2)

- In 2007, CO_2 emissions totalled 44.9 million tonnes: this is a rise of 3.7 per cent from the year before. The overall rise since 1990 is ca 29 per cent.
- The most important sources of CO_2 emissions are oil and gas extraction and road traffic, which accounted for 29 and 23 per cent respectively of the total in 2006. Process emissions from metal production accounted for 10 per cent of the total.

Figure 9.7. **Emissions of CH_4 by source. 1990-2007***

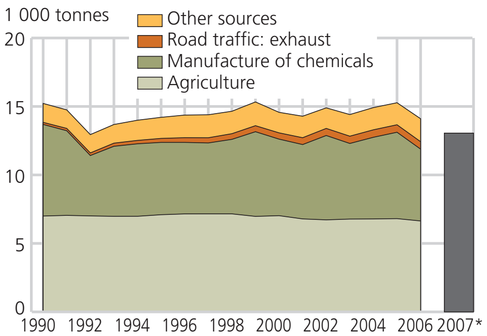


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority..

Methane (CH_4)

- In 2007, CH_4 accounted for 8 per cent of Norway's aggregate greenhouse gas emissions.
- In 2007, CH_4 emissions totalled 215 100 tonnes, 2.5 per cent more than the year before. There has been a 2.5 per cent decrease in emissions since 1990.
- The most important sources of CH_4 emissions are agriculture (livestock and manure) and landfills, which in 2006 accounted for 49 and 31 per cent of Norwegian emissions respectively. Oil and gas extraction accounted for 13 per cent of CH_4 emissions.
- From 1990 to 2006, emissions from landfills dropped by 21 per cent, but this was counteracted by emissions from the oil and gas industry, which rose by 77 per cent.

Figure 9.8. **Emissions of N_2O by source. 1990-2007***



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

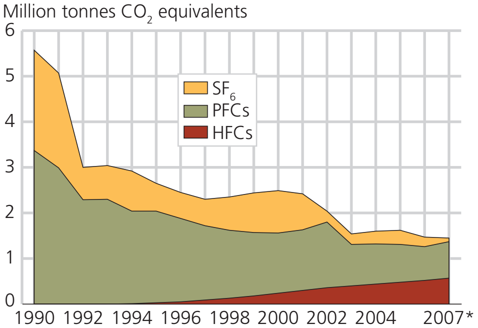
Nitrous oxide (N_2O)

- In 2007, N_2O accounted for 7.5 per cent of Norway's aggregate greenhouse gas emissions, about the same proportion as methane.
- N_2O emissions totalled 13 300 tonnes in 2007, which is a drop of about 5 per cent from 2006.
- The most important sources of N_2O emissions are agriculture and the manufacture of chemicals (mainly commercial fertiliser), which accounted for 47 and 37 per cent respectively in 2006. The marked drop in emissions from 1991 to 1992 reflects a cut in emissions from fertiliser manufacturing as a result of technological improvements.

Box 9.6. Analysis of uncertainty in estimates of greenhouse gas emissions

In 2006, Statistics Norway carried out an analysis of uncertainty in the Norwegian greenhouse gas inventory in a project that also received funding from the Norwegian Pollution Control Authority. The uncertainty in the 1990 figures was estimated at ±7 per cent. In a similar analysis carried out in 2000, the level of uncertainty in the 1990 figures was estimated at ± 21 per cent (Rypdal and Zhang 2000). This reduction in the level of uncertainty is explained partly by new and improved methodology used in the emission inventory, but more importantly by new, lower estimates of uncertainty for methods that have been in use for a number of years. Thus, the level of uncertainty is being steadily reduced both by methodological improvements and by improvement of the underlying data used for recalculation of emissions. Some of the methods that were considered to be good enough in the 1990s were no longer adequate and have therefore been changed. This is a result of a continual process of improvement.

Figure 9.9. **Emissions of other greenhouse gases (HFCs, PFCs and SF_6). 1990 -2007***

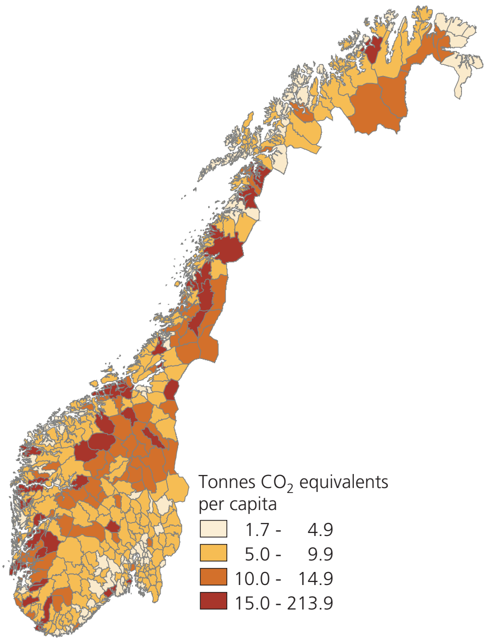


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Other greenhouse gases

- The most important sources of SF_6 and PFC emissions are the process industry (magnesium and aluminium production). The most important source of HFC emissions is leakages from cooling equipment.
- In 2007, emissions of sulphur hexafluoride (SF_6) totalled 3 tonnes or 76 000 tonnes CO_2 equivalents, which is a drop of 64 per cent from the year before. In 2002, emissions of SF_6 were reduced by two thirds as a result of discontinuation of primary production of magnesium. From 2007, magnesium recycling was also discontinued.
- Emissions of perfluorocarbons (PFCs) rose by 8 per cent from 2006 to 2007, and now equal about 800 000 tonnes CO_2 equivalents. Emissions of hydrofluorocarbons (HFCs) increased by 8.5 per cent in the same period, and totalled 570 000 tonnes CO_2 equivalents in 2007.
- Measured in CO_2 equivalents, these pollutants together accounted for almost 3 per cent of Norway's aggregate greenhouse gas emissions in 2007, as compared with 11 per cent in 1990. Emissions of these pollutants were also reduced substantially before 1990, from 9.0 million tonnes CO_2 equivalents in 1986 to 5.6 million tonnes CO_2 equivalents in 1990. In 2007, emissions of all these pollutants totalled only 1.4 million tonnes CO_2 equivalents.
- The reduction in emissions of these gases played a considerable role in limiting the rise in Norway's overall greenhouse gas emissions. However, there will be a very limited potential for further reductions in the years ahead.

Figure 9.10. **Per capita emissions of CO_2 equivalents by municipality. 2006**

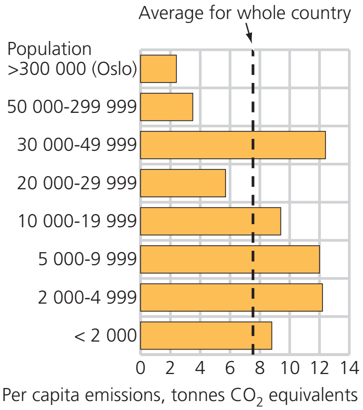


Map data: Norwegian Mapping Authority.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority

Greenhouse gas emissions at local level

- CO_2 is the most important greenhouse gas in all counties.
- About 69 per cent of Norway's greenhouse gas emissions in 2006 can be allocated to household and industrial activities in the municipalities. The rest is generated at sea and in Norwegian airspace, mainly by the oil and gas industry, shipping and air traffic.
- Manufacturing, road traffic, agriculture and landfills are the largest sources of greenhouse gas emissions in most municipalities. In some municipalities, one or a few large industrial enterprises may raise the overall level of emissions, while in others, through traffic is important. There are complex relationships between settlement patterns and business and industry, which result in variations in emission levels and trends between municipalities.

Figure 9.11. **Average per capita greenhouse gas emissions from Norwegian municipalities grouped by population size. 2006. Tonnes CO_2 equivalents**

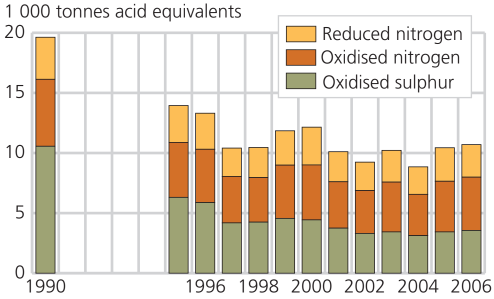


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority. .

- Per capita greenhouse gas emissions are lower in the municipalities with the highest populations than in those with smaller populations. In Oslo, per capita greenhouse gas emissions were 2.4 tonnes in 2006. The corresponding figure for the 12 other municipalities with populations of over 50 000 was 3.5 tonnes, while it was 12.4 tonnes in municipalities with a population of 30 000-50 000. The average for the country as a whole in 2006 was 7.7 tonnes.
- There are several reasons why per capita emissions are below average in the municipalities with the highest population. CO_2 emissions from the process industry are high in Norway, and most plants in this sector are located outside the largest towns. There is little room for agriculture in the largest urban areas, so that major sources of methane and nitrous oxide emissions are more or less absent.
- Landfills generate substantial emissions in many municipalities. In several of the largest towns, however, most waste is incinerated, thus generating considerably lower greenhouse gas emissions. In a city like Oslo, car use is much lower than the average for Norway. This is partly because distances are relatively short and public transport is better than in municipalities with a smaller population. In addition, there is less need for heating in densely built-up areas, which results in lower emissions.

9.2. Acidification

Figure 9.12. **Deposition of acidifying substances in Norway. 1990-2006**



Source: Norwegian Meteorological Institute and EMEP.

Deposition of acidifying substances in Norway

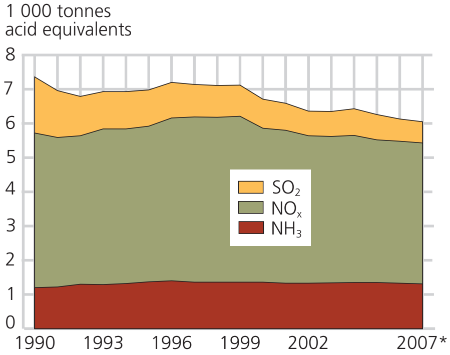
- Acidification of the Norwegian environment is being reduced. Sulphur emissions have been cut elsewhere in Europe, thus reducing the deposition of pollutants over Norway. Reductions in nitrogen emissions have been much smaller, so that the relative importance of nitrogen deposition is increasing.
- Although total deposition has been reduced since 1990, critical loads are still being exceeded in large parts of the southern half of Norway. In the last two years there has been a slight rise in acid deposition.
- Emissions from Norway are largely deposited in Norway or over the sea (EMEP/MSC-W 2008). A certain proportion of the Norwegian emissions is also deposited in Sweden.
- The UK, Germany and Russia are the countries outside Norway that make the largest contributions to the total deposition of acidifying substances in Norway.

Table 9.2. **Emissions and emission targets for SO_2 and NO_x under the Gothenburg Protocol. 1 000 tonnes**

	SO_2			NO_x		
	Emissions		Target	Emissions		Target
Country:	1990	2006	2010	1990	2006	2010
UK	3 717	676	625	2 968	1 595	1 181
Germany	5 353	558	550	2 862	1 394	1 081
Russia[2]	6 113	1 847[1]	2 470	3 600	2 795[1]	2 500
Sweden	108	39	67	314	175	148
Denmark	178	25	50	274	185	127
Norway	52	21	22	208	191	156

[1] Emissions in 2005.
[2] Data source is gap-filled emissions used in EMEP models. The figures apply to the European part, within the EMEP area.
Source: EMEP (2008).

Figure 9.13. **Emissions of acidifying substances in Norway. Acid equivalents. 1990-2007***



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

Aggregate emissions of acidifying substances

- In 2007, Norway's aggregate emissions of acidifying substances, expressed as acid equivalents, amounted to 6 053 tonnes. NO_X accounts for 68 per cent of this and NH_3 and SO_2 for 22 and 10 per cent respectively.
- Emissions of acidifying substances were reduced by 1 per cent from 2006 to 2007: they have been reduced by 18 per cent since 1990 and by 35 per cent since 1980.
- The reduction has been particularly large for sulphur emissions. Emissions of the other gases have not changed as much.
- The dispersal potential of SO_2 and NO_x emissions is greater than that of NH_3 emissions.

Box 9.7. Acidification

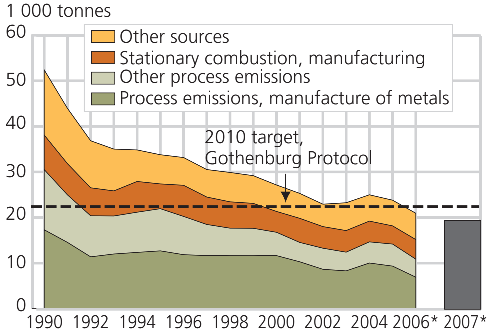
Acidification of the environment is caused by inputs of acidifying substances with rain and snow or direct deposition of gases or particles on vegetation (dry deposition). Both of these processes are normally included in the definition of acid rain. Acid rain is caused mainly by emissions of sulphur dioxide (SO_2) and nitrogen oxides (NO_x) from the combustion of fossil fuels. In addition, ammonia (NH_3) and ammonium ions (NH_4) contribute to acidification through various chemical processes that take place in soil and water. Air pollutants are often transported for long distances, for example from central Europe or Britain, before ending up as acid rain in Norway. 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. The damage has been particularly severe 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.

Acidification of soils results in leaching of nutrients and metals (especially aluminium). Fresh-water organisms have suffered the most serious damage, and the most obvious effect has been serious depletion of freshwater fish stocks in the southern half of Norway. In addition to its impact on the flora and fauna, acid rain results in corrosion damage to buildings and cultural monuments.

Sulphur dioxide acts only as an acidifying substance, but the problems related to releases of nitrogen compounds are more complicated. Nitrogen also has a fertilising effect and can result in changes in the species composition of the vegetation. Species that can make use of an extra nitrogen supply benefit at the expense of other species. Increased nitrogen supplies can lead to eutrophication in aquatic ecosystems. Nitrogen has an acidifying effect if inputs are larger than the amount the vegetation can absorb.

The regional emissions of acidifying substances that result in acid rain in Norway are to a large extent regulated by the Gothenburg Protocol under the LRTAP Convention. In the last few years, as reported releases of these substances in Europe have declined, clear improvements have been observed in water chemistry and in the content of acidifying substances in precipitation. Nevertheless, the latest report summarising the results of Norway's monitoring programmes for long-range pollutants (Norwegian Pollution Control Authority 2006a) states that despite the positive trends, much still remains to be done to deal with the problem of acidification in Norway. The problems are decreasing, but critical loads for acidifying substances in rain and snow are still being exceeded in much of the southern half of the country. As a result, acidification is still occurring, causing serious damage to biological communities.

Figure 9.14. **Emissions of SO_2 by source. 1990-2007***



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

Sulphur dioxide (SO_2)

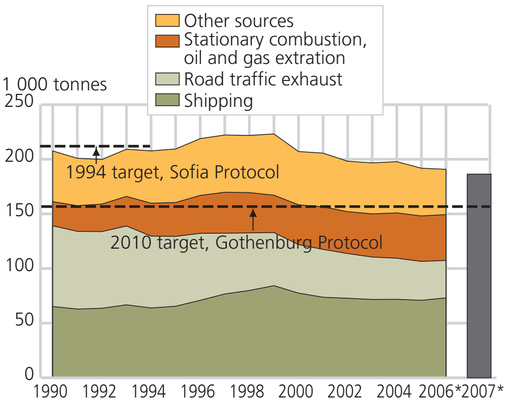
- In 2007, sulphur dioxide emissions totalled 19 735 tonnes, the lowest level since industrialisation in the 19th century. Emissions were 6 per cent lower than the year before. These emissions have been reduced by 62 per cent since 1990 and by 86 per cent from 1980. These cuts have been achieved through measures to cut industrial emissions, a changeover from fossil fuels to electricity, and reduction of the sulphur content of oil products and raw materials.
- Process and space-heating emissions from the manufacturing industries accounted for almost three-quarters of SO_2 emissions in Norway in 2006. More than half the total was generated by industrial processes, especially metal manufacturing. The manufacture of iron, steel and ferro alloys alone accounted for one fifth of Norway's overall SO_2 emissions. Stationary combustion outside the manufacturing industries accounted for 5 per cent of the total, and mobile combustion generated 21 per cent of the total
- Industrial emissions account for the largest proportion of Norway's SO_2 emissions, with shipping in second place. Domestic shipping and fishing vessels accounted for 17 per cent of total emissions in 2006. Air traffic, road traffic and use of motorised equipment together generated barely 5 per cent of Norway's SO_2 emissions in 2006.
- Under the Gothenburg Protocol, Norway has undertaken to reduce its annual SO_2 emissions to below 22 000 tonnes by 2010. In 2006, emissions were below this level for the first time, and with the continued reduction in emissions in 2007, Norway should be able to meet its emission commitment for SO_2.

Box 9.8. Acidifying substances, sources and harmful effects

Substance	Important sources[1]	Effects
Ammonia (NH_3)	Agriculture	Contributes to acidification of water and soils
Nitrogen oxides (NO_x)	Combustion (industry, road traffic)	Increase the risk of respiratory disease (particularly NO_2). Contribute to acidification, corrosion and formation of ground-level ozone.
Sulphur dioxide (SO_2)	Combustion, metal production	Increases the risk of respiratory complaints. Acidifies soil and water and causes corrosion.

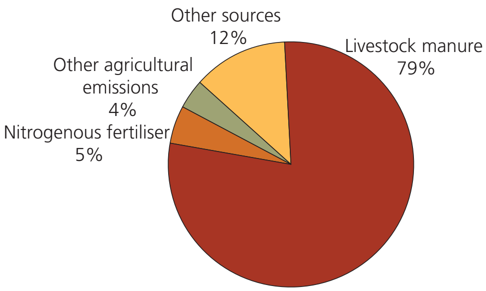
[1] The table indicates important anthropogenic sources.

Figure 9.15. **Emissions of NO_x by source. 1990-2007***



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

Figure 9.16. **Emissions of ammonia by source. 2006*. Per cent**



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

Nitrogen oxides (NO_x)

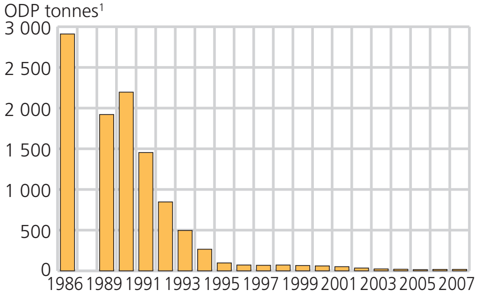
- In 2007, NO_x emissions totalled 189 600 tonnes, 0.6 per cent lower than the year before. Since 1990, NO_x emissions have been reduced by 8.7 per cent; however, they are now 8 per cent higher than in 1980.
- The largest sources of NO_x emissions in 2006 were domestic shipping and fisheries (38 per cent), stationary combustion in the oil and gas industry (22 per cent) and road traffic (18 per cent). The only reduction since 1990 has been in emissions from road traffic, which have been cut by more than half in this period. This is mainly explained by lower emissions from petrol vehicles and heavy diesel vehicles as a result of limits on exhaust emissions.
- Total emissions must be reduced to 156 000 tonnes if Norway is to meet its commitment under the Gothenburg Protocol. This means a reduction of 18 per cent from the 2007 level by 2010.

Ammonia (NH_3)

- There has been little change in the level of ammonia emissions in the last few years. In 2007, emissions totalled 22 300 tonnes, and were just below the emission ceiling of 23 000 tonnes for 2010 set out in the Gothenburg Protocol, as has been the case every year since 2000.
- Agriculture generated 88 per cent of Norwegian emissions of ammonia in 2006. The main sources are livestock, the use of commercial fertiliser and treatment of straw with ammonia.
- Other sources are petrol vehicles (9 per cent) and manufacturing processes (3 per cent).

9.3. Depletion of the ozone layer

Figure 9.17. **Imports of ozone-depleting substances to Norway. 1986-2007**



[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.

- Measured in ODP tonnes, Norway's consumption of ozone-depleting substances has been reduced by more than 99 per cent since 1986. Norway has met all its commitments under the Montreal Protocol, and the EU targets for ozone-depleting substances.
- Norway imported a total of just over 17 ODP tonnes of ozone-depleting substances in 2007, a marginal increase from 2006.
- Various HCFCs dominate imports of ozone-depleting substances to Norway (expressed as ODP tonnes).
- It has been calculated that the thickness of the ozone layer above Oslo has been reduced by an average of 0.14 per cent per year in the period 1979–2006 (Norwegian Institute for Air Research 2007).

Box 9.9. The ozone layer and ozone-depleting substances

The greatest depletion of the stratospheric ozone layer has been observed over Antarctica. An annual cycle of significant ozone reduction occurs from September to November. In this so-called ozone hole, up to 60 per cent of the total ozone is lost. After a couple of months, new ozone is produced from oxygen under the influence of solar UV radiation, and the ozone layer regenerates until the next cycle starts. This phenomenon was first registered in the 1980s (Norwegian Pollution Control Authority 2006b).

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, but not ozone-depleting.

In accordance with the 1987 Montreal Protocol, the consumption of ozone-depleting substances in Norway has dropped steeply since the mid-1980s. 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 there is a general prohibition against imports of CFCs (small quantities of CFCs are imported for necessary purposes such as laboratory analyses). 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.

Box 9.10. Ground-level ozone and ozone precursors

Ground-level ozone (O_3) is formed by oxidation of ozone precursors (CH_4, CO, NO_x and NMVOCs) in the presence of sunlight. Emissions of ozone precursors are regulated by the Gothenburg Protocol. The formation of ground-level ozone increases the risk of respiratory complaints and damages vegetation and materials. In Scandinavia the background level varies between 40 and 80 µg/m³ and is generally highest in spring. The background level for ozone is much closer to the levels that affect health and vegetation than is the case for most other air pollutants. There are large variations in levels of ground-level ozone from year to year. According to the Norwegian Institute for Air Research (2008) levels in Norway were unusually low in 2007, whereas they were unusually high compared with earlier years in 2006.

The maximum level measured in 2007 was the lowest annual maximum since measurements started in the 1980s. The low concentrations were linked among other things to persistent low pressure systems and high rainfall during the summer in the southern half of Norway.

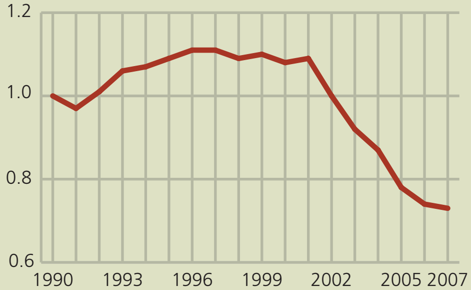
In 2007, no exceedances of the Norwegian information threshold for ground-level ozone, i.e. the concentration at which the authorities are required to inform the public of pollution levels (160 µg/m³, 1-hour average) were registered. In 2006, this concentration was exceeded at six of the eight operative measuring stations. The current EU information threshold is 180 µg/m³ (1-hour average). From 2010, the new EU (and Norwegian) target value for the protection of human health (a maximum daily 8-hour mean of 120 µg/m³) must not be exceeded on more than 25 days per calendar year. This target value was exceeded on eight different dates in 2007, and on 28 different dates in 2006.

The ozone-forming potential of ozone precursors varies. A weighting factor is defined for each of these precursors according to how much ground-level ozone it forms during a specific period of time. These are known as TOFP (Tropospheric Ozone-Forming Potential) factors, and NMVOCs are used as the reference component.

Substance:	TOFP factor (de Leeuw 2002):
NO_x	1.22
NMVOC	1
CO	0.11
CH_4	0.014

Aggregating Norwegian emissions of these gases, weighted with the appropriate factors, we find that total TOFP emissions have dropped by 27 per cent in the period 1990–2007. Emissions of the individual gases are discussed separately elsewhere in this chapter.

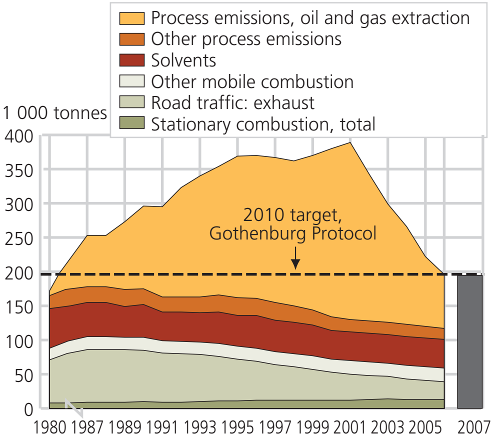
Aggregate TOFP emissions 1990-2007. Index: 1990=1



The marked drop in recent years is mainly explained by a considerable reduction in NMVOC emissions.

9.4. Formation of ground-level ozone

Figure 9.18. **Emissions of NMVOCs by source. 1980-2007***



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

NMVOCs

- In 2007, Norway's NMVOC emissions totalled 191 000 tonnes: this is a reduction of about 2 per cent from the year before, and less than half of the total in the peak year 2001.
- This reductions in the last few years have largely been achieved through measures to reduce emissions during loading and storage of crude oil offshore. This was still the case in 2007, although the reduction was much smaller than in preceding years. Road traffic emissions were also reduced in 2007, but the overall reduction was partly counteracted by large emissions as a result of problems in connection with the start-up of the LNG plant at Melkøya near Hammerfest.
- Under the Gothenburg Protocol, Norway has undertaken to meet an emission ceiling of 195 000 tonnes NMVOCs in 2010. 2007 was the first year Norwegian emissions were below this.

Box 9.11. Ozone precursors, sources and harmful effects

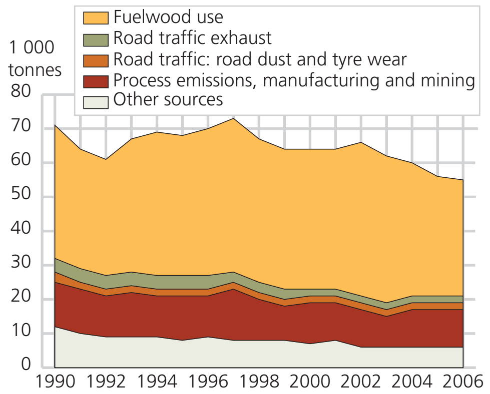
Substance	Important sources[1]	Effects
Non-methane volatile organic compounds (NM-VOCs)	Oil and gas industry, road traffic, solvents	May include carcinogenic substances. Contribute to formation of ground-level ozone.
Methane (CH_4)	Agriculture, landfills, production, transport and use of fossil fuels	Enhances the greenhouse effect and contributes to formation of ground-level ozone.
Nitrogen oxides (NO_x)	Combustion (industry, road traffic)	Increase the risk of respiratory disease (particularly NO_2). Contribute to acidification, corrosion and formation of ground-level ozone.
Carbon monoxide (CO)	Combustion (fuelwood, road traffic)	Increases risk of heart problems in people with cardiovascular diseases.

[1] The table indicates important anthropogenic sources.

9.5. Emissions of substances that particularly affect local air quality

Particulate matter, carbon monoxide (CO) and nitrogen oxides (NO_x) are the pollutants that are most important for local air quality in towns and urban settlements (NO_x is discussed in section 9.2).

Figure 9.19. **Emissions of particulate matter (PM_{10}) to air in Norway, by source. 1990-2006***

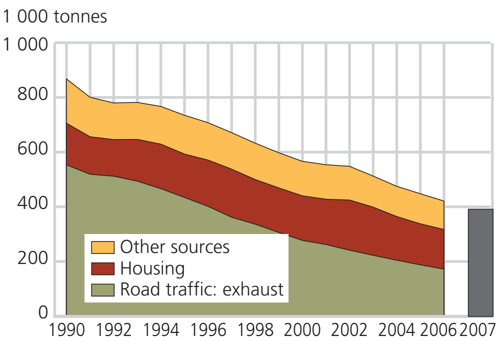


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Particulate matter

- Three different fractions of particulate matter are distinguished: TSP (total suspended particles), PM_{10}, with a diameter of less than 10 m and $PM_{2.5}$, with a diameter of less than 2.5 m (PM_{10} also includes particulate matter defined as $PM_{2.5}$). Total emissions of the three fractions in 2006 were 71 700 tonnes, 54 600 tonnes and 48 000 tonnes respectively.
- Emissions from fuelwood use are the largest source of particulate matter, and accounted for 61 and 69 per cent respectively of emissions of PM_{10} and $PM_{2.5}$ in 2006. For these two fractions, the next most important source of emissions is metal production.

Figure 9.20. **Emissions of carbon monoxide in Norway, by source. 1990-2007***



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

Carbon monoxide (CO)

- In 2007, emissions of carbon monoxide to air totalled 398 000 tonnes.
- The largest sources of CO emissions are road traffic and heating of housing, especially with fuelwood, and these accounted for 41 and 34 per cent respectively of the total in 2006.
- From 1990 to 2007, emissions of CO have been reduced by more than half. The main reason is reduced emissions from road traffic due to catalytic converters in cars: road traffic emissions have been reduced by more than two thirds in this period.

Box 9.12. Emissions to air from fuelwood use

Emissions from fuelwood use are an important source of Norwegian emissions of pollutants including particulate matter, heavy metals, PAHs and dioxins. Statistics Norway's figures for emissions to air show that fuelwood use accounts for about two thirds of all emissions of particulate matter (PM_{10}) in Norway. Fuelwood use accounts for such a large proportion of these emissions because most wood is still burned in old wood-burning stoves, which are estimated to emit five times as much particulate matter as new stoves.

Figures for energy use by households are of key importance for the energy accounts, the emission inventory and analyses carried out by Statistics Norway's Research Department.

Since 2005, quarterly questionnaire-based surveys have been carried out on household fuelwood consumption, the type of stove or fireplace used and its age. Annual surveys of wood consumption in holiday homes have been carried out since 2006. In autumn 2007, Statistics Norway carried out a survey of fuelwood use in the municipality of Drammen. This showed that about 43 per cent of the fuelwood used in Drammen was burned in modern clean-burning stoves, which is five percentage points higher than the national average. Households that had replaced their old stoves with clean-burning ones were also asked for their reasons. Fifteen per cent of the respondents said that they had replaced their stove to improve comfort or because it fitted in better: other common reasons were saving electricity or redecoration. However, the most common reason was that new stoves provide more heat. Only a small proportion, 6 per cent, of the respondents said they had bought a new stove for environmental reasons. However, in earlier surveys only 1–3 per cent of the respondents have given environmental concerns as their reason for replacing a wood-burning stove.

Together, these surveys provide better and more up-to-date figures for fuelwood consumption in households. In addition, figures for emissions from fuelwood use for use in the emission inventory are available earlier than they would otherwise have been. It is particularly important to have good, up-to-date figures for these emissions because fuelwood use, together with road traffic, is one of the most important sources of emissions that result in pollution concentrations exceeding that in the national target for local air quality (particulate matter) in towns and built-up areas.

Read more in:

Haakonsen, G. and E. Kvingedal (2001): *Utslipp til luft fra vedfyring i Norge. Utslippsfaktorer, ildstedsbestand og fyringsvaner.* (Emissions to air from fuelwood use in Norway. Emission factors, numbers of wood-burning stoves and open fireplaces, and heating habits). Reports 2001/36. Statistics Norway

Finstad, A. et al. (2004): *Vedforbruk, fyringsvaner og svevestøv. Resultater fra Folke- og boligtellingen 2001, Levekårsundersøkelsen 2002 og Undersøkelse om vedforbruk og fyringsvaner i Oslo 2002*. (Fuelwood consumption, heating habits and particulate matter. Results of the Population and Housing Census 2001, Survey of Living Conditions 2002 and the 2002 survey of fuelwood consumption and heating habits in Oslo). Reports 2004/5, Statistics Norway.

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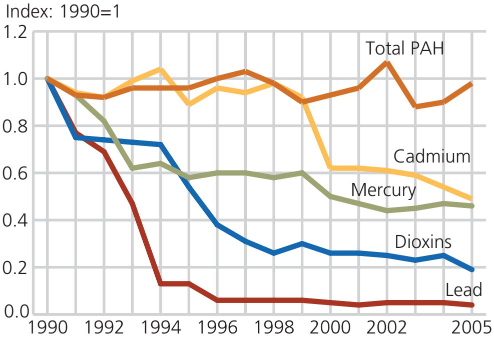
9.6. Ecological toxins

Norway has taken on international commitments to reduce emissions to air of selected hazardous substances in relation to 1990 levels. Under the Protocol on Heavy Metals, Norway has undertaken to reduce its emissions of lead, cadmium and mercury, and under the Protocol on Persistent Organic Pollutants (POPs), has undertaken to reduce emissions of various substances including polycyclic aromatic hydrocarbons (PAHs) and dioxins. The Storting has adopted the substantial reduction of releases of certain substances (categorised as ecological toxins) by 2010 in relation to levels as a national target (Report No. 26 (2006-2007) to the Storting). Releases to air, water and soil are all to be reduced. The figures presented here are only for emissions to air.

Figure 9.21. **Changes in emissions of total PAH, cadmium, mercury, dioxins and lead in Norway. 1990-2005. Index 1990=1**



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

- Emissions of ecological toxins to air were substantially lower in 2005 than in 1990. Lead emissions from road traffic dropped steeply from 1990 to 1997 as leaded petrol was phased out.
- Manufacturing industries are an important source of emissions of several ecological toxins.
- The reductions in these emissions, particularly after 1995, are largely due to the installation of emission abatement equipment and improvements in its operation, and the closure of plants in the chemical and metallurgical industry.

Table 9.3. **Emissions of ecological toxins to air. 1990-2005. kg. Dioxins in g**

	1990	1995	2000	2005
Total PAH, total emissions	**156 957**	**150 180**	**146 273**	**153 761**
Process emissions, aluminium production	57 390	57 110	56 040	77 030
Fuelwood use	50 390	53 059	52 403	42 324
Road traffic	6 867	6 923	5 865	7 611
Solvents	12 896	9 426	7 077	9 492
Other sources	29 414	23 663	24 888	17 305
Lead, total emissions	**187 457**	**23 459**	**9 014**	**7 569**
Process emissions, metal production	4 204	4 265	3 755	3 067
Air traffic	2 311	1 537	1 767	1 582
Road traffic: wear of brake blocks and tyres	1 124	1 172	1 296	1 462
Road traffic: combustion	167 970	12 118	157	198
Combustion in industry	730	914	720	619
Other sources	11 118	3 453	1 319	640
Mercury, total emissions	**1 506**	**877**	**756**	**690**
Combustion in industry	92	92	75	75
Road traffic	35	49	55	76
Waste incineration	168	120	102	79
Use of products	284	75	38	49
Process emissions, metal production	617	285	267	177
Other sources	309	256	219	234
Cadmium, total emissions	**1 112**	**985**	**690**	**542**
Wood processing: combustion	121	138	115	122
Fuelwood use	100	105	116	128
Process emissions, metal production	457	391	170	79
Other sources	433	351	289	213
Copper, total emissions	**22 131**	**19 001**	**19 531**	**20 676**
Road traffic: wear of brake blocks	7 203	7 203	8 386	9 279
Road traffic: exhaust	4 134	4 375	4 517	5 175
Electrical cables, railways	905	943	992	994
Process emissions, metal production	4 791	2 826	2 329	1 814
Combustion in industry	1 233	1 597	1 403	1 496
Other sources	3 866	2 057	1 904	1 916
Chromium, total emissions	**12 548**	**11 122**	**8 444**	**2 692**
Process emissions, metal production	8 287	8 201	6 012	260
Process emissions, chemical industry	1 927	471	209	125
Combustion in industry	1 273	1 697	1 446	1 431
Road traffic: road dust and tyre wear	43	48	53	56
Road traffic: exhaust	122	129	133	152
Other sources	897	575	591	668
Arsenic, total emissions	**3 144**	**2 947**	**2 439**	**1 470**
Combustion in industry	440	465	373	396
Fuelwood use	158	166	185	204
Chemical industry	626	664	711	21
Metal production	1 327	1 274	799	481
Other sources	592	378	370	369
Dioxins, total emissions	**129**	**70**	**34**	**24**
Mining	51	37	-	-
Waste incineration and landfill gas	18	3	2	0
Fuelwood use	6	6	7	8
Process emissions, metal production	34	9	8	4
Other sources	20	15	17	12

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

Box 9.13. Ecological toxins, sources and harmful effects

Substance	Important sources[1]	Effects
Arsenic (As)	Chemical industry, pulp and paper industry, metal production and road traffic	Inorganic arsenic compounds (arsenates) very toxic to most organisms (acute and chronic effects), carcinogenic even at low concentrations. Organic compounds are much less toxic.
Benzene (C_6H_6)	Combustion and evaporation of petrol and diesel, fuelwood use	Carcinogenic, toxic effects on acute exposure to high concentrations.
Lead (Pb)	Air traffic, tyre wear and metal production	Dangerous ecological toxin. No damage to health at concentrations currently found in air in Norway, but accumulates in living organisms, so that formerly high emissions still constitute a health hazard.
Dioxins	Fuelwood use, metal production, pulp and paper industry, shipping and other combustion.	Become concentrated in organisms and food chains. Carcinogenic.
Cadmium (Cd)	Pulp and paper industry, metal production, fuelwood use	Liable to bioaccumulate. Delayed effects such as pulmonary emphysema, cancer, reduced fertility in men and kidney damage.
Copper (Cu)	Road traffic and combustion in industry	Liable to bioaccumulate. Some copper compounds are acutely toxic or irritant to mammals.
Chromium (Cr)	Combustion in industry and mobile combustion	Liable to bioaccumulate. Hexavalent compounds (Cr^{6+}) are carcinogenic and sensitising. May cause kidney and liver damage.
Mercury (Hg)	Combustion in industry, waste incineration, metal production, diesel vehicles	Becomes concentrated in organisms and food chains. Causes kidney damage and harms nervous system. May cause cellular changes.
Polycyclic aromatic hydrocarbons (PAHs)	All incomplete combustion of organic material and fossil fuels, solvents, aluminium production	Several are carcinogenic.
Particulate matter ($PM_{2,5}$, PM_{10} og TSP)[2]	Road traffic, fuelwood use and metal production	Increase the risk of respiratory complaints.

[1] The table indicates important anthropogenic sources. There are also important natural sources for several of these substances.
[2] $PM_{2,5}$: particles measuring less than 2.5 µm in diameter. PM_{10}: particles measuring less than 10 µm in diameter. TSP: total suspended particles.

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Useful websites

Statistics Norway – Climate and air pollution: http://www.ssb.no/english/subjects/01/klima_luft_en/
Statistics Norway – Greenhouse gas emissions: http://www.ssb.no/english/subjects/01/02/
Statistics Norway – Emissions to air: http://www.ssb.no/english/subjects/01/04/10/
Center for International Climate and Environmental Research: http://www.cicero.uio.no/index_e.asp
Norwegian Meteorological Institute: http://met.no/english/index.html
State of the Environment Norway: http://environment.no/
Norwegian Institute for Air Research: http://www.nilu.no/
Norwegian Pollution Control Authority: http://www.sft.no/english/

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10. Noise

Noise is one of the environmental problems that affects the largest number of people in Norway. About 1.7 million Norwegians are exposed to noise levels exceeding 50 dB outside their homes[1] and about half a million of them are annoyed or highly annoyed by noise. Despite a reduction in noise annoyance from air traffic and railways, the overall level of noise annoyance from transport has increased as a result of a rise in the volume of traffic and in the number of people living in urban areas. Noise can be harmful to health, and often has the greatest impact on the most vulnerable groups of the population.

The Norwegian noise annoyance index and most other noise indicators that are in use easure noise annoyance outside peoples homes. This is a limited approach, because noise can also cause annoyance and affect people's well-being outside the areas where they live. Schools, day care centres, offices, hospitals and other institutions can all be exposed to noise. In addition, noise affects enjoyment and discourages use of parks, outdoor recreation areas and other public spaces, reduces travel on foot and by bicycle.

According to the Norwegian noise annoyance index, about three-quarters of all noise annoyance is caused by road traffic. Industry, construction, air traffic and railways account for 4 per cent each. The latest survey of living conditions carried out by Statistics Norway hows that 5 per cent of the population have sleep problems as a result of noise. For more information on the model for calculating the noise annoyance index, see Box 10.1.

[1] For road traffic noise, only the number of people exposed to noise levels exceeding 55 dBA is included.

10.1. Noise and measurement of noise

The Storting has decided that noise annoyance in Norway is to be reduced. Statistics Norway has developed a model to make it possible to monitor developments in noise annoyance. The model calculates the number of people exposed to noise from various sources and transforms the figures into a noise annoyance index. The environmental authorities have decided to use the index to monitor progress towards the noise reduction target. After revision, the target for reduction of noise annoyance is that by 2020, noise annoyance will be reduced by 10 per cent from the 1999 level.

The minimum noise levels used in calculations of the noise index are not the same for all sources. Different levels are used partly to take into account the varying characteristics of noise produced by different sources, which means that the degree of annoyance they cause varies, and partly because the data currently available do not permit calculations using the lowest noise levels. If the minimum noise level used was the same for all other sources as for road traffic, the latter would dominate the index even more than it does at present.

- Despite a marked drop in noise annoyance from railways and air traffic, total noise annoyance in Norway rose by three per cent from 1999 to 2006 (see Table 10.1). Noise annoyance caused by road traffic increased during this period because of a rise in the volume of traffic and in the number of people living in areas where there is heavy traffic. Since road traffic is responsible for such a large share of noise annoyance, 79 per cent, the changes resulted in an overall increase in noise annoyance in Norway.
- Railways accounted for four per cent of estimated noise annoyance in 2006. From 1999 to 2003, noise annoyance from this source dropped by 33 per cent. Several factors help to explain this reduction: a reduction in rail traffic, replacement of older trains with new, quieter models, rail grinding and changes in settlement patterns. There has also been a changeover to shorter trains and smaller carriages in this period, which has reduced traffic measured in metres of train per day.
- Air traffic accounted for four per cent of registered noise annoyance in 2006. The noise annoyance index for air traffic dropped by 26 per cent from 1999 to 2006. From 1999 to 2003, the reduction was explained by a drop in the number of landings and take-offs and a changeover to quieter aircraft types. There was also a reduction in total noise annoyance from airports with a large proportion of military traffic. This was because in 2002 fighter planes were transferred from Rygge airport to Bodø and Ørland, where air traffic noise affects fewer people. Since 2003, air traffic has shown a tendency to increase again, and the reduction in noise annoyance in this period is mainly explained by a further changeover to quieter aircraft types.
- The calculations show that manufacturing accounted for four per cent of total noise annoyance in 2006. Noise annoyance from this source dropped by three per cent from 1999 to 2006. Noise from «other industry», which accounted for three per cent of total noise annoyance, rose by one per cent in the same period. However, the calculations are uncertain. To take account of the characteristics of industrial noise (which includes impulse noise), the minimum noise level used in calculations of the noise annoyance index for this source is somewhat lower (48 dBA) than for other sources.

Table 10.1. **Noise annoyance index, by source of noise[1]. 1999 and 2006**

	Index 1999	SPI 2006	Percentages, 2006	Change 1999-2006, per cent
Total, all sources	563 700	578 400	100	3
Road traffic	423 300	456 400	79	8
Manufacturing	25 800	25 200	4	-3
Other industry	15 300	15 500	3	1
Air traffic	29 000	21 300	4	-26
Railways	31 800	21 500	4	-33
Other sources[2]	38 000	38 000	7	…

[1] In general, noise levels exceeding 50 dBA are used in calculating figures for the noise annoyance index. For some sources, a different lower limit is used: 55 dBA for road traffic, 48 dBA for manufacturing and other industry, and 30 dBA (free field) for shooting ranges (included in «other sources»).
[2] Construction, motor racing tracks and shooting ranges. No new index values were calculated. The 1999 value is also being used for 2006 for the moment. Source for the 1999 figure: Norwegian Pollution Control Authority (2000).
Source: Statistics Norway´s noise model (Engelien and Haakonsen 2007).

Box 10.1. About the noise model

Statistics Norway was commissioned by the Norwegian Pollution Control Authority to develop the model, and has done this in cooperation with the Directorate of Public Roads, Norwegian Air Traffic and Airport Management, the Norwegian National Rail Administration and the Norwegian Defence Construction Service. A GIS model was developed to calculate and record noise levels outside individual dwellings throughout Norway. The model calculates data for noise exposure from various sources (measured as the number of people exposed to different noise levels, L_{eq}) and noise annoyance (measured using the noise annoyance index) in Norway for 1999 and subsequent years. The model is based on existing noise surveys and additional calculations for dwellings that were not included in earlier surveys.

Changes since 2005

Since the last time national figures for exposure to noise and noise annoyance were published in 2005, the method of calculating road traffic noise has been adjusted. A noise emission model developed in Germany and adapted to Norwegian conditions by the SINTEF Group is now being used. This takes into account the composition of the Norwegian vehicle population.

Uncertainty

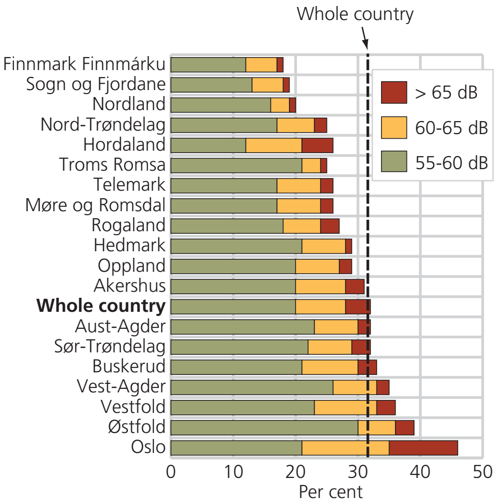
BThe calculations are generally uncertain. However, the level of uncertainty varies from source to source. In general terms, it is lowest for areas where noise levels are high and the model is largely based on existing surveys (for example around Oslo airport (Gardermoen) and areas surveyed using the model VSTØY, which is used by the Norwegian Public Roads Administration to calculate road traffic noise). The calculations for industrial noise are more uncertain. For these sources, the model is oversimplified, and the calculations are not based on existing surveys as they are for road traffic and air traffic noise.

For the largest source of noise annoyance, road traffic, the level of uncertainty is considered to be lower for data taken from the VSTØY model than for data from Statistics Norway's supplementary calculations. Statistics Norway's calculations are considered to be most reliable for the national and county roads for which data on traffic volume is available from the National Road Database. For municipal roads, the figures are mainly calculated on the basis of general assumptions, which results in a higher level of uncertainty.

For more information, see: Støyeksponering og støyplage i Norge. 1999-2006: Kraftig nedgang fra jernbane og flyplasser. (Noise exposure and noise annoyance in Norway 1999-2006. Steep reduction in noise from railways and airports) Magazine: http://www.ssb.no/vis/magasinet/miljo/art-2007-01-30-01.html

10.2. Exposure to road traffic noise

Figure 10.1. **Proportion of the population exposed to road traffic noise levels exceeding 55 dBA. By county. 2006***



Source: Statistics Norway's noise model and Directorate of Public Roads.

Distribution of road traffic noise by county

- About 1.4 million people in Norway are exposed to road traffic noise exceeding a 24-hour average of 55 dBA (decibels). In Oslo, almost half the population is exposed to noise exceeding this level.
- About 30 600 people in Norway were exposed to noise levels above 70 dBA in 2006. Almost half of these, 15 000 people, lived in Oslo.
- The proportion of the population exposed to noise levels above 65 dBA is highest in Oslo and Hordaland, at 11 per cent (59 500 people) and 5 per cent (20 500 people) respectively.

10.3. Perception of noise

The figures for exposure to noise discussed in sections 10.1 and 10.2 are calculated on the basis of map data, data from registers and strictly objective measurements. Statistics Norway's surveys of living conditions, which are based on interviews with a representative sample of the population, have for many years included questions on whether people perceive themselves as being exposed to or annoyed by noise inside or outside their homes. This is a way of registering the subjective perception of noise in the residential environment. Answers to this type of question are influenced by other factors than actual noise levels, such as attitudes to the problem, how much attention it is receiving in the media, local campaigns, and people's background and experience.

Figure 10.2. **Percentage of population who say they are annoyed by noise from different sources, and percentage who suffer from sleep disturbance. 1997, 2001 and 2004**

Source: Statistics Norway, Survey of living conditions.

- In 2004, seven per cent of the population, or more than 300 000 people, stated that they were annoyed by road traffic noise inside their homes.
- Six per cent of the population stated that they were annoyed by air traffic noise outside their home. There has been a marked drop in the proportion of the population who find air traffic noise annoying, probably because in 1998, Oslo Airport was moved from Fornebu to Gardermoen, considerably further away from the city.
- Five per cent of the population, or well over 200 000 people, stated that noise caused sleep disturbance.
- Noise from neighbours is also an important source of noise annoyance.

More information: Erik Engelien (erik.engelien@ssb.no).

Useful websites
State of the Environment Norway: http://www.environment.no/templates/themepage____3032.aspx

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11. Waste

Waste consists of substances and objects that are discarded after production and consumption. Some waste types contain resources that can be recovered and used, while others cannot be used to any great extent, and are largely landfilled or incinerated (final disposal). In 2007, 10.7 million tonnes of waste was generated in Norway, about two-thirds of which was recovered. Waste quantities have increased every year since 1995, and most sharply, by 17 per cent, between 2004 and 2007. Economic growth measured as gross domestic product (GDP) rose by in all 9 per cent over these three years.

Waste management in Norway is regulated through legislation and licensing, which are intended to prevent pollution of soil and water, greenhouse gas emissions, health problems and local problems such as littering and unpleasant smells. For example, there are requirements to collect and control leachate from new landfills, and upper limits for permitted emissions from incineration plants. A general prohibition against landfilling of wet organic waste (food waste, slaughterhouse waste, etc.) was introduced on 1 January 2002. From 1 July 2009 this prohibition will be extended to include other types of biodegradable waste such as wood and paper. To ensure that resources are used as sustainably and cost-effectively as possible, the Government has also adopted national targets to limit the growth in waste generation and increase the proportion recycled. For certain waste fractions, voluntary agreements have been established between relevant industrial sectors and the authorities to ensure sound collection and management routines and a high recovery rate.

Preliminary figures from the waste accounts show that about 10.7 million tonnes of waste was generated in Norway in 2007. The recovery rate was 67 per cent for all waste for which information on treatment/disposal was available (excluding hazardous waste). This proportion has been fairly stable since 2003. Certain waste fractions, such as concrete, slag and contaminated soil and sediments, cannot be used to any great extent and are largely delivered for final disposal. If these fractions are excluded, the recovery rate in 2007 was 78 per cent.

The total quantity of waste generated rose by 17 per cent from 2004 to 2007. This is considerably higher than rate of economic growth measured as GDP (in fixed prices), which was 9 per cent. Thus, since 2004 economic growth has been accompanied by a relatively large rise in waste generation, whereas growth in waste generation before this was more moderate. Quantities of industrial waste have risen most in the last few years, particularly construction waste.

The largest quantities of waste are generated by the manufacturing industries, and the estimated total in 2007 was 3.9 million tonnes. In this sector, considerable quantities of production waste are delivered directly to other firms as raw materials for new production or for energy purposes, sometimes in return for payment. Many manufacturing firms classify such consignments as by-products rather than waste recovery. Both in the EU and in Norway, legislative work is in progress to clarify the distinction between waste and by-products. In the long term, this may have an influence on the waste statistics.

Certain types of waste are particularly dangerous to human health and the environment, and their management is governed by special legislation. With few exceptions, the authorities require hazardous waste to be treated at separate, specially designed treatment facilities. In 2006, 1 020 000 tonnes of hazardous waste was treated at such facilities. Detailed reports on such waste are also required to ensure control of the waste stream. Nevertheless, no information is available on the treatment/disposal of more than 88 000 tonnes of hazardous waste in 2006. A proportion of this was probably treated at approved treatment plants, but some may in the worst case have been dumped in the environment.

Box 11.1. Waste and waste statistics – terminology

Waste: Defined in the Pollution Control Act as discarded objects of personal property or substances. Waste water and waste gases are not defined as waste.

Biogas treatment: Degradation of organic waste by living organisms without access to oxygen (anaerobic biological treatment). Methane gas is formed in the process.

Landfilling: Final disposal of waste at an approved landfill.

EEE waste, or WEEE (waste electrical and electronic equipment): EEE items require an electric current to function, and need batteries and other parts for transmission etc of the current. Means of transport and cooling equipment containing CFCs (fridges, freezers) are not included in this definition.

Energy recovery: Use of the energy released by waste incineration, for example to heat buildings. Energy recovery efficiency is a measure of how much of the waste incinerated is in practice converted to utilisable energy.

Hazardous waste: Waste that cannot appropriately be treated together with municipal waste because it may cause serious pollution or a risk of injury to people and animals. Hazardous waste is governed by special provisions (Chapters 11 and 12 of the Waste Regulations under the Pollution Control Act). Norway's list of hazardous wastes was expanded from 1 January 2003.

Waste recovery: Includes re-use, material recovery, composting, biogas treatment and energy recovery.

Household waste: Defined in the Pollution Control Act as waste from private households.

Waste management: Usually defined to include all operations from the moment when an object or substance is discarded until all treatment, recovery and disposal operations are completed. The term treatment/disposal is used in the waste accounts to include all waste management processes involving physical change (material recovery, composting, incineration) and all forms of disposal (landfilling, illegal dumping, export, re-use).

Composting: Controlled degradation of waste by living organisms with access to oxygen (aerobic biological treatment).

Material recovery (or recycling): Use of the waste in an industrial process in a way that wholly or partly retains the materials of which it consists. One example is the production of writing paper from recycled paper.

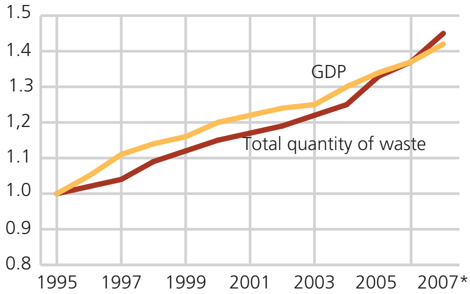
Industrial waste: Defined in the Pollution Control Act as waste from public and private enterprises and institutions. This includes both consumer waste and production waste. In its waste statistics, Statistics Norway further subdivides industrial waste according to the branch of industry from which it originates. The degree of aggregation in the classification varies. Includes all waste that is not defined as household waste.

Final disposal: Means that the resources in the waste are not utilised: either landfilling or incineration without energy recovery.

Wet organic waste (biodegradable waste): Readily degradable organic waste, e.g. food waste and slaughterhouse waste. Park and garden waste is included in this category in the waste accounts unless otherwise specified.

11.1. Waste accounts for Norway

Figure 11.1. **Trends in waste quantities and gross domestic product (GDP), 1995-2007*, index 1995=1**



Source: Waste accounts and national accounts, Statistics Norway.

Trends in waste quantities

- According to the waste accounts, total annual waste generation rose from 7.3 to 10.7 million tonnes from 1995 to 2007, a rise of 45 per cent. In the same period, GDP rose by 42 per cent. Thus, waste generation has increased somewhat more rapidly than GDP in this period.
- The sharpest rise in waste generation, 17 per cent, was from 2004 to 2007. In the same period, GDP rose by 9 per cent. Waste generation has been rising more rapidly in the last few years than waste statistics have previously shown. This is the result of a sharp rise in the quantity of construction waste, and a new survey that has produced updated waste statistics for service industries.
- Household waste generation has risen steadily since 1995, by a total of 71 per cent. This is a higher growth rate than for household consumption, which has risen by 63 per cent, and higher than the growth in GDP (see section 11.3).

Box 11.2. Classification of waste

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.

Standards Norway has drawn up a new standard for waste classification, NS 9431 (NAS 2000), that classifies the waste by material, sector of origin, method of treatment/disposal and place of origin. The objective is to encourage uniform use of categories when registering and reporting waste quantities. The European List of Wastes is the most commonly used waste classification system in Europe. This system classifies waste into about 850 categories according to material characteristics, sector of origin, the pollutants it contains and in some cases the type of product. In addition, the OECD and the Basel Convention have their own waste classification systems.

In the Pollution Control Act, waste was previously divided into three categories: consumer waste, production waste and special waste (including hazardous waste). Amendments that took effect from 1 July 2004 replaced the terms production waste and consumer waste with industrial waste and household waste. According to the Pollution Control Act, the municipalities are responsible for collection and management of household waste, but not for industrial waste. The term municipal waste has been used for waste actually treated or administered in the municipal system. The term municipal waste is now in limited use in Norway, but is still used internationally, for example in various sets of environmental indicators including the EU structural indicators. Often, waste fractions consisting of particular materials are discussed separately (paper, glass, metal, etc.). Waste may also be classified according to product type (packaging, electrical and electronic equipment, etc.). Both material fractions and product types may belong to any of the above-mentioned categories.

Box 11.3. Waste accounts

All data on waste held by Statistics Norway are systematically organised in the waste accounts, which are intended to include all waste generated in Norway. In the waste accounts, waste is categorised by the following characteristics:

- source (e.g. agriculture, manufacturing industries, households)
- material type (e.g. paper, glass, metals)
- form of treatment/disposal (e.g. material recovery, incineration without energy recovery)

The data sources for the waste accounts include existing waste statistics, statistics on external trade and manufacturing statistics. The existing waste statistics are based among other things on questionnaire-based surveys of waste from manufacturing, mining and quarrying firms and of treatment and disposal plants for hazardous and non-hazardous waste. Other sources include the KOSTRA system for reporting and publishing local government information, customer registers kept by waste management firms, waste management plans for building projects and registers of hazardous waste.

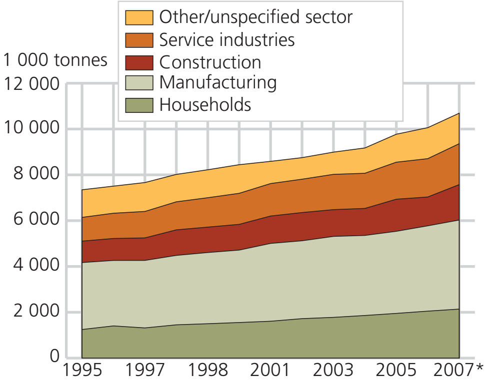
Quantities of certain waste fractions, including paper, glass, plastic and metal, are also calculated indirectly using the material balance. These calculations are based on the principle that all goods supplied will become waste sooner or later. The quantity of waste is therefore equal to the supply of goods after correction for the lifetime of the products. The supply of goods is calculated from statistics on import, export and production of goods.

The quantities of most waste fractions are calculated in several different ways, which in some cases produce different figures for the amounts of waste generated. There are several possible explanations for such discrepancies, for example that discarded products are left where they have been used, or that waste is dealt with illegally. Errors in the statistical calculations will also result in such discrepancies. Calculations based on the material balance normally give the highest figures for waste quantities, and the differences between these and figures calculated by other methods are placed in the categories "sector/industry unknown" og "treatment/disposal unknown". The level of uncertainty for these figures is somewhat higher than for other waste categories.

The waste accounts are published annually. Most of the waste statistics included in the waste accounts are also published separately, and may include more details than the waste accounts. The waste accounts are recalculated when the statistical basis is revised and the methodology is adjusted. There may therefore be differences between the figures in new editions of Natural Resources and the Environment and those presented earlier.

For more information, see: http://www.ssb.no/english/subjects/01/05/40/avfregno_en/

Figure 11.2. **Waste quantities in Norway, by source. 1995-2007*. 1 000 tonnes**

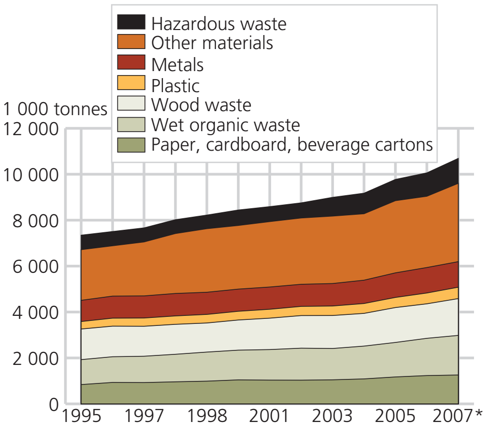


Source: Waste statistics, Statistics Norway.

Waste quantities by source

- The quantity of industrial waste rose by 40 per cent in the period 1995–2007 and by 17 per cent in the last four years of this period.
- Manufacturing industries accounted for 36 per cent of total waste generation in 2007: the quantity of waste generated by this sector has risen by 33 per cent since 1995 and by 11 per cent since 2004. Production waste makes up about 90 per cent of all manufacturing waste.
- The quantity of construction waste rose by 31 per cent from 2004 to 2007, and this category made up 14 per cent of the total quantity of waste in 2007. Waste generated by service industries was calculated to make up 17 per cent of the total in 2007, using a new calculation method that led to a considerable increase in the estimate.

Figure 11.3. **Waste quantities in Norway, by material. 1995-2007*. 1 000 tonnes**

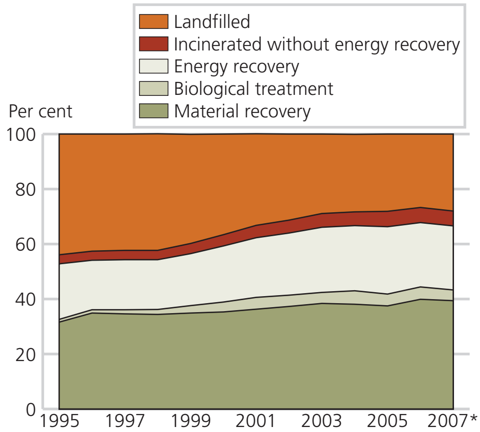


Source: Waste statistics, Statistics Norway.

Materials in waste

- In 2007, a total of 1.7 million tonnes of wet organic waste (food, slaughterhouse waste, etc.) was generated. This is a rise of 21 per cent since 2004. With the exception of "other materials", this was the largest material fraction in 2007.
- A total of 670 000 tonnes of wet organic waste was generated by manufacturing industries, mainly slaughterhouse waste, sludge from dairies and other production residues from the food industry. Households generated 550 000 tonnes of wet organic waste, mainly waste from cooking, food waste and food past its shelf life, but also some garden waste. Service industries such as the retail trade, hotels and restaurants, and hospitals/other institutions and canteens, generated a further 360 000 tonnes. The overall recovery rate for wet organic waste was 73 per cent, while 17 per cent was landfilled. The rest was incinerated without energy recovery.
- The category "other materials" made up 32 per cent of the total. This includes concrete, slag, asphalt, sludge, glass, textiles, rubber, and ceramics. Unpolluted stone and soil and biological waste that is fed back into the natural cycle are not included in the statistics.

Figure 11.4. **Non-hazardous waste in Norway, by treatment/disposal. 1995 – 2007*. Shown as a percentage of waste for which information is available on treatment/disposal**



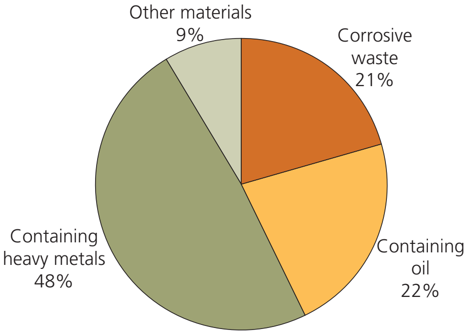
Source: Waste statistics, Statistics Norway.

Treatment/disposal

- In all, 67 per cent of all waste for which information on treatment/disposal is available was recovered in 2007 (excluding hazardous waste). Of this, about three fifths was recycled, while the rest was either incinerated with energy recovery or treated biologically (aerobically or anaerobically). If fractions that cannot be used to any great extent, such as concrete, slag and contaminated soil/sediments, are excluded, the recovery rate was 78 per cent. Both figures for the recovery rate have been stable since 2003.
- The rest of the waste, about one third of the total, was delivered for final disposal, mainly landfilling (28 per cent). About 0.7 million tonnes of biodegradable waste was landfilled in 2007. This generates emissions of the greenhouse gas methane as it rots.
- Calculations show that in 2007, treatment/disposal was unknown for 14 per cent of all non-hazardous waste. This includes discarded products left where they were used, for example oil and other pipelines and underground cables, and Norwegian vessels in foreign trade that are scrapped abroad. The figures in this category are somewhat uncertain.

11.2. Hazardous waste

Figure 11.5. **Hazardous waste handled at approved facilities, by material. 2006. Percentages**



Source: Waste statistics, Statistics Norway.

Origin and materials

- In 2006, a total quantity of 1 020 000 tonnes of hazardous waste was handled at approved facilities. Of this, 840 000 tonnes was registered with the authorities. Waste containing heavy metals (mainly slag), oil-contaminated waste and corrosive waste (acids and bases) are the dominant waste fractions.
- About 60 per cent of all hazardous waste for which the sector of origin is known is generated by manufacturing industries. This includes almost all corrosive waste, about 70 per cent of all waste containing heavy metals and about one sixth of other types of hazardous waste.
- Oil-contaminated waste is generated mainly by petroleum extraction, which accounts for about half of the total, while service industries (especially petrol stations, workshops and transport) account for about one quarter of the total.

Box 11.4. Hazardous waste management in Norway

Normally, individuals who have hazardous waste deliver it to an approved municipal or intermunicipal facility. Waste is collected from such facilities and transferred to firms that specialise in preliminary treatment or directly to firms that can carry out final treatment. Companies that generate up to 400 kg of hazardous waste a year can also make use of these arrangements, while companies that generate large amounts of hazardous waste generally have agreements to deliver it directly to a treatment facility.

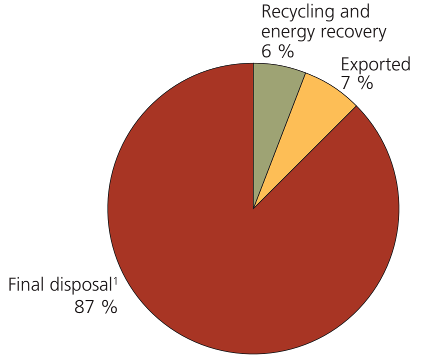
Industrial plants that generate large quantities of hazardous waste and that can document sound management of the waste on site may be granted permits to dispose of their own hazardous waste. This applies mainly to landfilling of slag containing heavy metals.

Some companies, especially in the petroleum extraction and manufacturing sectors, hold permits to export hazardous waste.

In addition, there are collection schemes for certain types of hazardous waste. Individuals can deliver waste batteries, fluorescent lamps and electrical and electronic equipment to shops that sell similar products. Some petrol stations also accept car batteries and clean waste oil free of charge from individuals, since they are reimbursed when they deliver such waste to approved facilities.

If hazardous waste is not reported to the authorities or to Statistics Norway's survey of treatment/disposal of hazardous waste, it is included in the category "no information available on treatment/disposal". This may include waste that is stored by the firm where it is generated in anticipation of changes in the legislation, unregistered export or other illegal forms of treatment or disposal. Hazardous waste that is dealt with illegally may harm people and the environment.

Figure 11.6. **Hazardous waste handled at approved facilities, by type of treatment. 2006. Per cent**



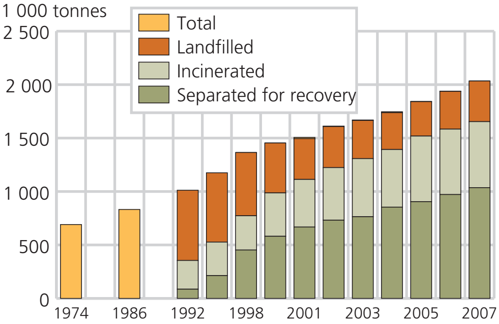
[1] Includes all types of landfilling, permanent storage, incineration without energy recovery and treatment that results only in non-hazardous products.
Source: Waste statistics, Statistics Norway.

Treatment/disposal of hazardous waste

- Most of the hazardous waste delivered for final disposal is deposited at special landfills for hazardous waste, generally after being stabilised by means of chemical reactions. Most hazardous waste consists of materials such as slag, blasting agents and acid sludge and other waste components that are not suitable for material or energy recovery.
- Some hazardous waste is exported either for final disposal or for material recovery. Exports for final disposal are only permitted if the waste cannot be properly dealt with in Norway.
- In 2006, no information on disposal or treatment was available for about 90 000 tonnes of hazardous waste. A proportion of this was probably dealt with at approved facilities but not reported to the authorities. However, some of it may have been treated or disposed of illegally and may have been dumped in the environment. The calculations have been revised since the previous edition of *Natural Resources and the Environment* was published.

11.3. Household waste

Figure 11.7. **Household waste by method of recovery or disposal. 1974-2007**

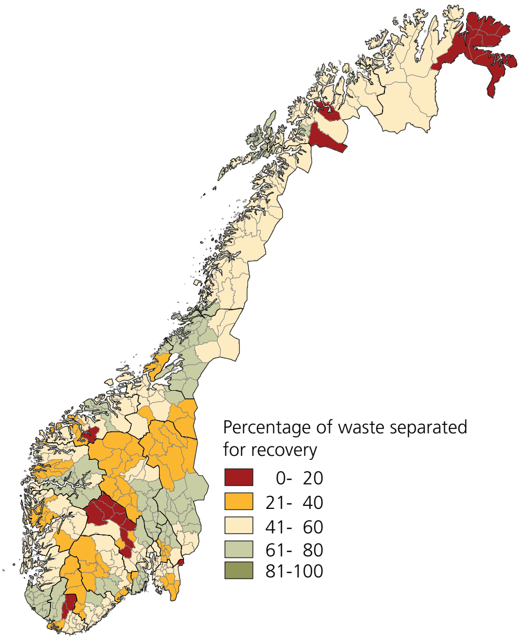


Source: Waste statistics, Statistics Norway.

Quantities and methods of disposal

- In 2007, per capita generation of household waste was 429 kg. This is 192 kg more than in 1992 and 15 kg more than in 2006.
- In all, 1 036 000 tonnes of household waste, or 51 per cent of the total, was separated for recovery in 2007.
- The quantity of household waste landfilled rose by 7 per cent from the year before to 380 000 tonnes in 2007.
- 762 000 tonnes (37 per cent) of household waste was incinerated in 2007.
- Generation of household waste has risen at about the same rate as household consumption for the past five years.

Figure 11.8. **Percentage of household waste separated for recovery, by municipality. 2007**



Source: Waste statistics, Statistics Norway.

Waste recovery

- In 2007, each person in Norway separated 219 kg of household waste for recovery, 11 kg more than in 2006. The proportion of household waste delivered for final disposal (incineration without energy recovery and landfilling) in 2007 was 28 per cent.
- The highest proportions of household waste were separated in Hedmark and Nord-Trøndelag counties, 71 and 67 per cent respectively.
- The county with the highest rate of recovery (including incineration with energy recovery) was Oslo, at 81 per cent.
- The quantity of household waste recycled rose by 11 per cent from 2006 to 2007, to 868 000 tonnes. A total of 762 000 tonnes of household waste was incinerated. Of this, 144 000 tonnes had previously been through a separation process.
- From 2006 to 2007, the proportion of waste separated rose most for park and garden waste and plastics (by 22 and 15 per cent respectively). The largest single fraction separated for recovery was paper and cardboard (324 000 tonnes), while the largest rise was for park and garden waste, where the quantity recovered rose by 26 000 tonnes to 143 000 tonnes in 2007.

Box 11.5. Legislation relating to waste management in Norway

Act of 13 March 1981 No. 6 relating to protection against pollution and to waste (Pollution Control Act)

Regulations of 1 June 2004 No. 930 relating to the recovery and treatment of waste (Waste Regulations)

Regulations of 1 June 2004 No. 931 relating to pollution control (Pollution Regulations)

11.4. Some environmental problems related to waste management

Table 11.1. **Emissions from waste incineration and landfills. Percentages of total Norwegian emissions in 2006 and change since 1990**

	Percentage of total Norwegian emissions	Percentage change from 1990
Incineration plants:		
Sulphur dioxide	0.7	- 56
Nitrogen oxides	0.4	- 31
Carbon dioxide[1]	0.3	+ 74
Particulate matter, PM_{10}	0.0	- 99
Lead	0.4	- 98
Cadmium	0.7	- 96
Mercury	12.2	- 53
Arsenic	0.2	- 98
Chromium	0.4	- 96
Copper	0.1	- 92
Total PAH	0.6	- 32
Dioxins	1.6	- 98
NMVOCs	0.2	+ 75
Landfills:		
Methane (greenhouse gas)[1]	2.5	-21

[1] Calculated as a percentage of total greenhouse gas emissions in CO_2 equivalents.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority (emissions to air).

- Emissions of particulate matter, heavy metals and organic compounds (PAHs and dioxins) from waste incineration have dropped steeply since 1990, even though significantly more waste is being incinerated.
- Emissions to air from waste incineration plants account for only a relatively small share of national emissions. (See Chapter 9 Air pollution and climate change.)
- Emissions of methane (a greenhouse gas) from rotting waste in landfills make a substantial contribution to Norway's total emissions. In 2006, methane emissions from landfills accounted for about 31 per cent of total methane emissions and 2.5 per cent of Norway's aggregate greenhouse gas emissions.
- Leachate from landfills is a form of pollution that has also a long-term impact on the environment after waste has been landfilled. The pollutants in leachate are heavy metals, organic material and plant nutrients such as nitrates and phosphates. These discharges may cause local pollution, but have previously been found to be small compared to total national emissions (Report No. 8 (1999-2000) to the Storting).

Box 11.6. The impacts of waste and waste management on the environment and natural resources

Waste has a variety of impacts on the environment. Waste generation, management and transport, as well as litter, have direct impacts in the form of pollution released to the air, water and soil. However, waste is also a resource that can be used to provide new products through material recovery or heating through energy recovery.

Methane emissions from landfills account for 2.5 per cent of Norway's greenhouse gas emissions (measured as CO_2 equivalents) and contribute to global warming (see Table 11.1). Old landfills generate leachate that contains hazardous substances and nutrients and pollutes the environment. Newer landfills are less of a problem because they are required to meet higher standards for the collection of leachate. Locally, landfills can give rise to problems related to unpleasant smells and vermin.

Successful composting is an environmentally sound method of treatment for wet organic waste, including park and garden waste, and generates no harmful emissions (water vapour is not a pollutant, and the carbon dioxide generated is climate-neutral). If the process is unsuccessful, on the other hand, it may generate methane emissions, give rise to unpleasant smells (for example from hydrogen sulphide) and produce leachate. Such problems may arise when a new composting system is being started up and before it is operating properly. They are not considered to be a serious health threat (Lystad and Vethe 2002). The content of hazardous substances in Norwegian compost has been investigated and found to be low enough to be safe (Norwegian Pollution Control Authority 1997).

On average, 73 per cent of the heat generated by Norwegian incineration plants was utilised in 2005. This reduces the extraction and use of other energy resources. Emissions of ecological toxins and acidifying substances from waste incineration are small compared with those from other sources (see Chapter 9 and Table 11.1). New technology has reduced these emissions, and they will probably be reduced even further as a result of further technological advances and the stricter standards set out in new regulations on waste incineration and landfills.

A marginal but highly visible fraction of our waste ends up as litter in streets and our surroundings otherwise. This is mainly an aesthetic problem rather than a threat to the environment, and generally involves disposable packaging and food waste.

Hazardous waste that is not dealt with appropriately may be a serious environmental problem. Some of the more common types of hazardous waste for which it is not possible to document handling at approved facilities are PCBs (polychlorinated biphenyls), waste oil, solvents and brominated flame retardants.

Few PCBs are acutely toxic, but chronic exposure, even at relatively low concentrations, can impair reproduction, disturb behavioural patterns, weaken the immune system and cause cancer (Thorsen 2000). PCBs provide very good heat and electrical insulation, are flame-retardant, and improve the resistance of certain materials to wear. They were therefore used in a wide variety of products, particularly in the 1960s and 1970s, but their use was prohibited from 1980 onwards. Today, PCBs can still be found in insulating windows, in capacitors (especially ballasts in light fixtures), in concrete and filling compounds, and in smaller amounts in ships' paints and electricity lead-ins, but their use is being phased out. PCBs break down very slowly in the environment and can be transported over long distances. PCBs are readily absorbed by living organisms and stored in fatty tissue, and thus become concentrated in food chains. In Norway, the authorities have advised people not to eat fish and shellfish from a number of fjords and restricted commercial fishing in certain areas because of the presence of PCBs. PCBs spread through the environment by evaporation and with runoff. Once PCBs have entered the environment, their removal is a very costly process.

Waste oil contains carcinogenic tars (PAHs) and small quantities of heavy metals. Degradation of waste oil in the environment is fairly rapid if the oil is finely divided, but after major oil spills, it may take many years before the process is completed. Some harbour basins in Norway have become polluted as a result of discharges of oil-contaminated waste over long periods of time.

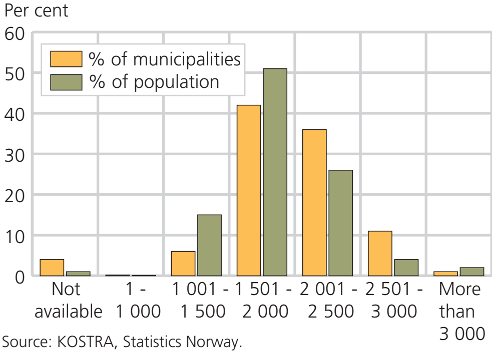
Organic solvents are highly flammable and it is therefore dangerous to mix them with ordinary waste. In most cases, their acute toxicity is not very high and they are easily broken down in the environment. This means that they are not generally very harmful to the environment. Waste containing solvents includes paints, and may also contain both heavy metals and persistent organic pollutants. Chlorinated solvents are particularly hazardous to health and the environment. They break down slowly in the environment, become concentrated in food chains and have a variety of toxic effects. For example, they may be endocrine disruptors, carcinogenic or impair reproduction (Norwegian Labour Inspection Authority 2007).

Brominated flame retardants are a group of substances that are used to prevent fire, for example in electronic circuit boards, textiles and fittings for vehicles. Some of them show similarities to PCBs in associated health risks and dispersal in the environment. The concentrations of some of them in human breast milk have risen by a factor of 50 in the last 25 years. The annual global consumption of brominated flame retardants is estimated at 150 000 tonnes (National Institute of Public Health 2003). The brominated flame retardants that are believed to be most dangerous have been included in the new regulations on hazardous waste, which entered into force on 1 January 2004.

11.5. Fees in the municipal waste management system

Under the Pollution Control Act, municipalities are required to take responsibility for collection of all household waste, and households are required to pay fees for this service. These fees must follow the principle of full costing, which means that they are set to cover all the costs associated with household waste management, but the municipalities may not charge households more than the actual costs of collecting and treating household waste. A large proportion of waste management services in Norway are provided by entities other than the municipalities themselves: intermunicipal companies, municipal limited companies or private companies, but it is the municipal councils that have the authority to set the fees for waste management services

Figure 11.9. **Variation in annual fees for waste management services by percentage of municipalities and of population. Fees in NOK. 2008**



Source: KOSTRA, Statistics Norway.

- The average annual fee per subscriber for household waste was NOK 2 033 in 2008, an increase of 5 per cent from 2006. The annual fees in individual municipalities varied from NOK 600 to NOK 3 300.
- Annual fees are between NOK 1 500 and 2 500 in 78 per cent of the municipalities. Half of Norway's population lives in municipalities where the annual fee is in the range NOK 1 500 to 2 000.
- The municipalities with the highest populations have the lowest fees.

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Useful websites

Statistics Norway – waste statistics: http://www.ssb.no/english/subjects/01/05/
Statistics Norway, StatBank Norway: http://statbank.ssb.no//statistikkbanken/default_fr.asp?PLanguage=1 (select subject 01 Natural resources and the environment and then 01.05 Waste)
State of the Environment Norway: http://environment.no/
Norwegian Resource Centre for Waste Management and Recycling: http://www.norsas.no/norsas/main.nsf
Norwegian Pollution Control Authority: http://www.sft.no/aktuelt____29292.aspx

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12. Water pollution and waste water

Water is vital for all life and is used in almost all production of goods. It is therefore important to monitor the state of water resources and environmental trends, so that it is possible to deal with any problems related to conflicting user interests and water quality. There has been more focus on water quality in Norwegian inland and coastal waters since the 1990 North Sea Declaration was signed, and more recently because of the implementation of the EU Water Framework Directive, which lays down standards for water quality that also apply to Norwegian water bodies. The petroleum sector is considered to be the largest source of acute pollution in Norwegian coastal waters today.

The Water Management Regulations entered into force on 1 January 2007, implementing one of the EU's most important environmental directives in Norwegian legislation. Their main objective is to achieve good status (close to what would be found under undisturbed conditions) for rivers, lakes, groundwater and coastal waters. To determine whether these goals are achieved, an extensive body of knowledge on water bodies is needed. At present, too little is known about Norwegian water bodies, but it has been suggested that at least a quarter of them do not meet the standards for ecological and chemical status required by the directive. (Ministry of the Environment 2008).

In recent years, both Norway and other countries that drain to the Skagerrak and the North Sea basin have invested substantial resources in reducing discharges of pollutants. This is mainly because the pollution load in these waters has resulted in eutrophication and periodical algal blooms. According to Report No. 26 (2006–2007) to the Storting, it is expected that eutrophication will continue to be a substantial environmental problem in Norway. Despite the reductions in anthropogenic inputs of nutrients, further measures to reduce discharges will therefore be necessary to achieve the national targets for this area.

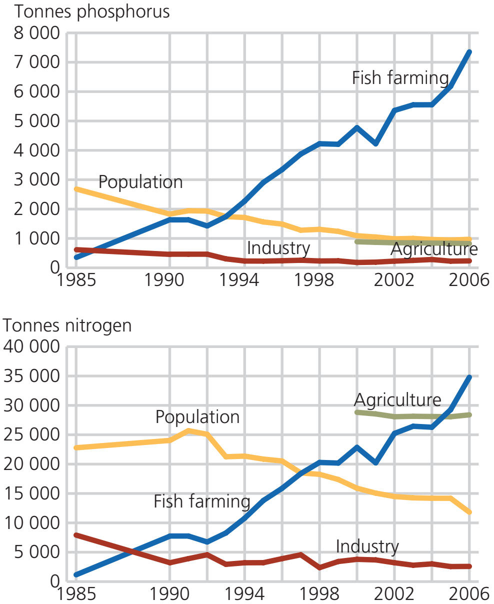
Discharges of the nutrients phosphorus and nitrogen play a particularly important role in the eutrophication of rivers, lakes and coastal areas, which can in turn cause excessive algal growth and oxygen depletion. Municipal waste water, agriculture, aquaculture and manufacturing industries are the main sources of discharges of these nutrients, see Selvik et. al. 2007.

Norway has achieved a better level of treatment efficiency for phosphorus in the municipal waste water treatment sector in the last 20 years, mainly by building waste water treatment plants providing chemical or chemical-biological treatment. Nitrogen removal measures have also been given priority over the last few years in areas where nitrogen has a major impact on eutrophication (as defined in the EU directive concerning urban waste water treatment and the directive concerning protection against pollution caused by nitrate from agricultural sources). These are the area from the border with Sweden to Strømtangen lighthouse near Fredrikstad (Hvaler/Singlefjorden) and 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. Cooperation across national borders is therefore important to achieve the objective of reducing pollution in these sea areas.

Oil and gas activities have had an impact on the seabed environment near offshore installations, particularly as a result of discharges of oil-contaminated drill cuttings. Although these discharges have been prohibited since 1992, it will take many years before the environment is restored to its original condition. Releases of hazardous chemicals from the oil and gas industry have been reduced in the last few years, and now only account for about one per cent of Norway's total releases (Norwegian Pollution Control Authority 2007).

12.1. Inputs of nutrients to coastal areas

Figure 12.1. **Inputs[1] of phosphorus and nitrogen to the Norwegian coast, by households and important industries. 1985-2006**



[1] Inputs from agriculture have not been recalculated/modelled for data sets prior to 2000.
Source: Selvik et al. (2007).

The Norwegian coast

- In the period 2000–2006, total anthropogenic inputs of phosphorus and nitrogen to the coast increased by an estimated 35 and 9 per cent respectively.
- As a result of the expansion of the fish farming industry along the coast from the county of Rogaland and northwards, discharges from this industry have increased substantially since 1985. In 2006, phosphorus discharges were 7 000 tonnes higher and nitrogen discharges 26 700 tonnes higher than in 1985.
- The largest inputs of nitrogen and phosphorus to the Norwegian coast are now from the aquaculture sector, which accounts for 78 and 45 per cent respectively of the total anthropogenic inputs. Historically, agriculture has been the largest source of nitrogen inputs, but in 2005, inputs from aquaculture exceeded those from agriculture for the first time, and in 2006 were about 23 per cent higher. Both phosphorus and nitrogen discharges from aquaculture are showing a rising trend.

Box 12.1. International agreements and concepts related to nutrient inputs to coastal areas and inland waters

North Sea Declarations
The North Sea Declarations are the joint ministerial declarations made by the countries round the North Sea, among other things on the reduction of inputs of nutrients to the North Sea. One of Norway's targets was to halve total inputs of nitrogen and phosphorus during the period 1985–1995. Since the nitrogen target was not reached by the end of 1995, the national time limit was extended to 2005. Figures for 2005 show that the phosphorus target was achieved (reduction of 64 per cent), but not the nitrogen target (reduction of 42 per cent).

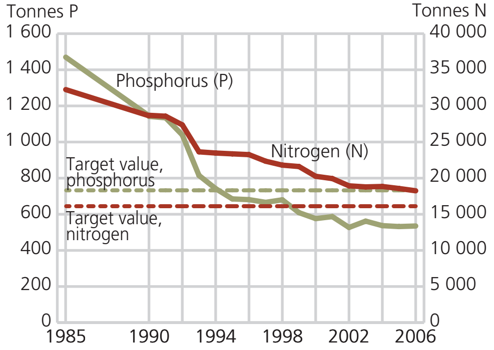
The North Sea counties or North Sea region
In principle, the North Sea Declarations apply to the areas south of 62°N. In Norway, the targets for reducing inputs of nutrients apply to the counties from the border with Sweden to Lindesnes. Thus, the North Sea counties or North Sea region means the following 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 natural process in which inputs of organic matter containing plant nutrients alter biological production conditions in water bodies towards an environment rich in nutrients and high plant production. Excessive inputs of phosphorus, nitrogen and organic matter, often anthropogenic, cause increased eutrophication of inland waters and coastal areas. Important anthropogenic sources include agriculture, waste water from households, industry, fish farms and nitrous gases in air pollution. The effects of eutrophication include cloudy, discoloured water, overgrown bottom and shore, and vigorous vegetation. Excessive algal production may lead to anaerobic decomposition. This may cause fish mortality, the destruction of spawning areas, a sludge layer on the bottom and toxic, sulphuric bottom water.

The sensitive area for phosphorus: the area that drains to the coast from the border with Sweden to Lindesnes is particularly sensitive to an increase in phosphorus inputs.

The sensitive area for nitrogen: The inner Oslofjord, the area Hvaler-Singlefjorden (around the estuary of the river Glomma) and the Glomma and Halden river basins 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 12.2. **Inputs of phosphorus and nitrogen to the North Sea region. 1985-2006**

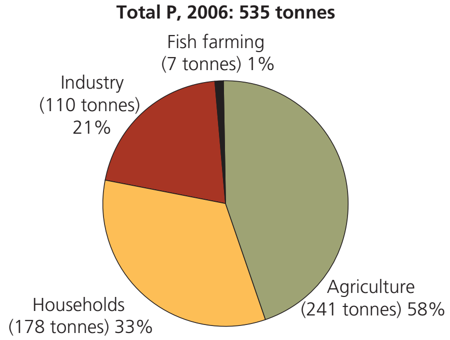


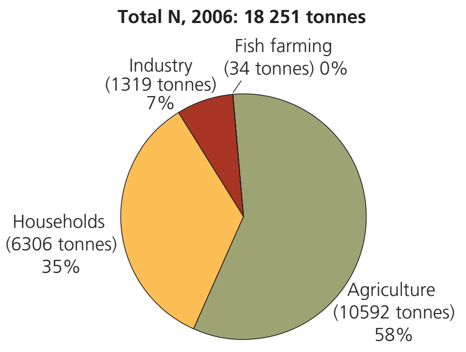
Source: Selvik et al. (2007).

The North Sea area

- In order to achieve the targets of the North Sea Declarations, substantial sums have been invested in new high-grade waste water treatment plants and upgrading of older plants in the North Sea region. Measures have also been implemented in the fish farming and agricultural sectors.
- Phosphorus and nitrogen inputs to the sensitive North Sea region (from the border with Sweden to Lindesnes) were reduced by 63 and 43 per cent respectively from 1985 to 2006.

Figure 12.3. **Inputs of phosphorus and nitrogen to the North Sea region, by households and important industries. 2006**





Source: Selvik et al. (2007).

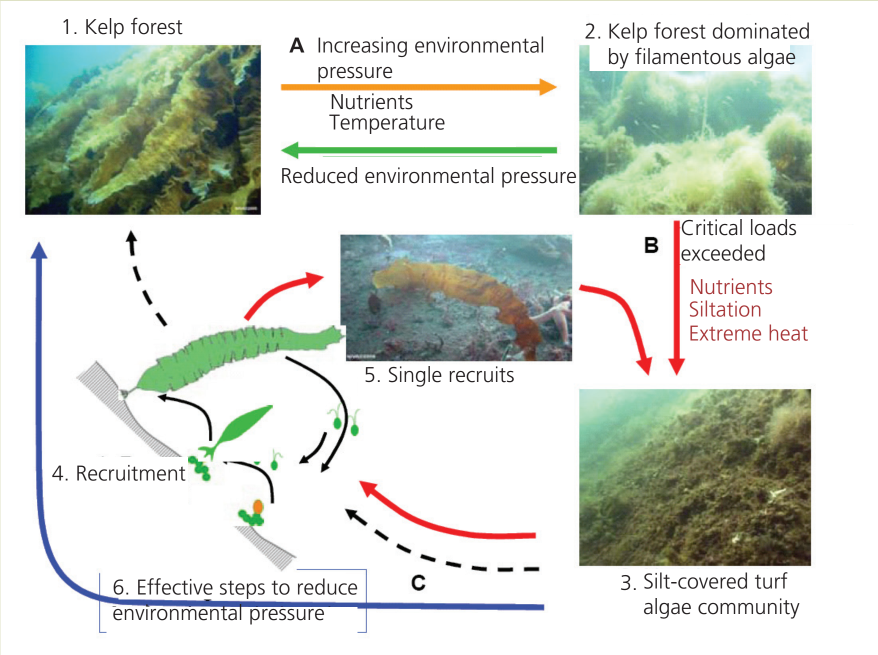
- Phosphorus inputs from municipal waste water treatment plants (mainly from households) have been reduced by 750 tonnes (81 per cent) since 1985 and nitrogen inputs by 5 600 tonnes (47 per cent).
- Phosphorus inputs from agriculture have been reduced by around 40 per cent and nitrogen inputs by 28 per cent since 1985.
- Phosphorus and nitrogen inputs from manufacturing industries have been reduced by 17 and 77 per cent respectively.
- In 1997, open fish farming facilities were prohibited in the North Sea region, and inputs from this industry have thus been considerably reduced. Figures for 2006 show that aquaculture accounts for about 1 per cent of phosphorus inputs and about 2 per cent of nitrogen inputs to this area.

Box 12.2 Dramatic decline of the sugar kelp

The large kelp forests along the Norwegian Skagerrak coast have disappeared, and the sugar kelp is endangered along several parts of the coast of Western Norway. There are many indications that critical loads for eutrophication have been exceeded along the Skagerrak coast, and that this has resulted in an ecosystem shift in the benthic vegetation from sugar kelp forests to a community dominated by ephemeral filamentous algae ("turf algae"). Investigations along the Skagerrak coast have shown that 90 per cent of the kelp forests from the border with Sweden to Lindesnes have disappeared over a period of 10 years.

A rising sea temperature and eutrophication seem to be the most important factors behind the decline of the sugar kelp, and the two factors in combination may have shifted the balance between kelp and filamentous algae in favour of the latter. Kelp forests are productive ecosystems that provide food and shelter for many species at all trophic levels up to fish and birds, and the decline or loss of kelp forests can therefore result in changes in species composition and ecological function in the areas that are affected.

Simple illustration of probable causal relationships behind the vegetation shift from kelp forests to silt-covered turf algae communities:



Source: Norwegian Institute for Water Research 2007.

Box 12.3. The Urban Waste Water Treatment Directive and new Norwegian legislation

The Urban Waste Water Treatment Directive (EU Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment, amended by Directive 98/15/EC) has been incorporated into the EEA Agreement, and therefore applies in Norway as well. Its main objective is to protect people and the environment from the adverse effects of waste water discharges. Waste water from human activities contains nitrogen, phosphorus, organic substances, microorganisms and small amounts of hazardous substances.

The directive focuses on the collection, treatment and discharge of urban waste water, and treatment and discharges of biodegradable waste water from the food industry.

The treatment requirements depend on the area to which waste water is discharged. To prevent adverse effects on the environment from the discharge of insufficiently treated urban waste water, it is generally necessary to carry out secondary treatment of such waste water. It is also necessary to require more stringent treatment in sensitive areas, whereas primary treatment may be sufficient in less sensitive areas.

The Ministry of the Environment has laid down new legislation to ensure coordinated and more effective regulation of waste water. The new provisions form Chapters 11–16 of the Pollution Regulations, and apply to all discharges of domestic waste water and municipal waste water. The standard requirements for discharges both continue Norwegian waste water policy and implement the requirements of the Waste Water Treatment Directive.

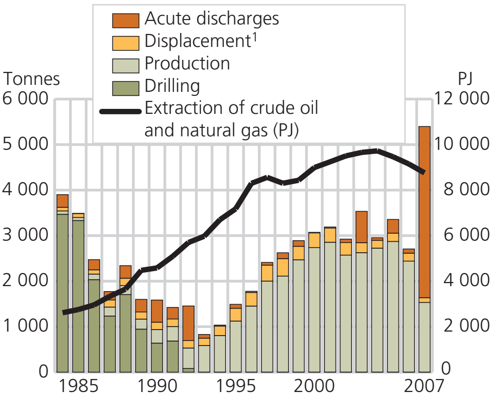
The division of authority between state and municipal level is no longer based only on the size of each waste water treatment plant; it also depends on the size of the urban settlement it serves. The county governors are responsible for enforcing new treatment requirements and requirements relating to inspection and control for waste water treatment plants in larger urban areas. The municipalities have similar responsibility for waste water treatment plants in smaller urban areas, and more authority than previously.

Source: Norwegian Pollution Control Authority (www.sft.no), State of the Environment Norway (http://www.environment.no/), Norway's Pollution Regulations, Urban Waste Water Treatment Directive

12.2. Oil pollution

Discharges of oil and chemicals from shipping, petroleum activities and onshore activities can damage organisms and ecosystems in the open sea, on the sea floor, in the littoral zone and on land. Pollution of coastal areas also reduces their value as recreation areas and for other purposes. The authorities have adequate 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.

Figure 12.4. **Discharges of oil from petroleum activities on the Norwegian continental shelf[2]. Tonnes. Production of crude oil, natural gas and other petroleum products. PJ. 1984-2007**



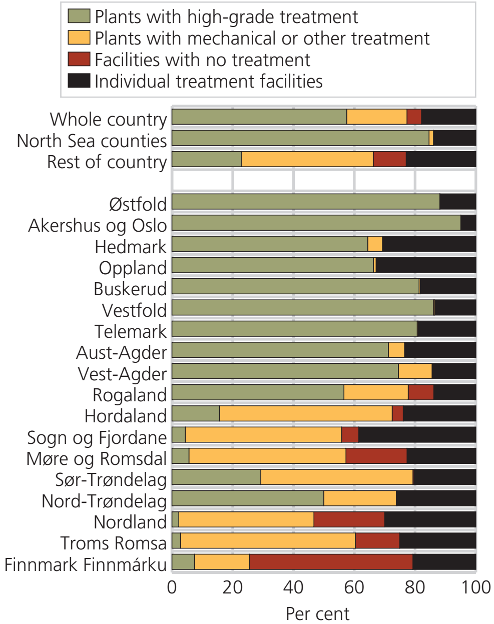
[1] Oil-contaminated ballast water in storage cells on production platforms, displaced when the cells are filled with produced oil.
[2] The analytical method used for discharges of produced water and displacement water has been changed. The figures for 2007 are therefore not directly comparable with those for previous years.
Source: Norwegian Pollution Control Authority and Energy Statistics, Statistics Norway.

Oil discharges

- Oil production results in both uncontrolled (acute) discharges and legal, licensed (operational) discharges during production.
- Operational discharges have been the largest category for many years since the early 1990s, and rose considerably towards 2000. The largest oil discharges from the oil and gas industry today, except in the case of acute oil spills, are of produced water, i.e. water associated with the reservoirs that is produced along with the oil or gas. It contains residues of oil and other chemicals.
- Operational discharges tend to vary in step with the volume of production.
- Acute discharges from oil production and other activities have varied widely in the period 1984–2005. On 12 December 2007, a hose on a loading buoy on the Statfjord field was severed during loading operations, releasing an estimated 4 400 m^3 of crude oil into the North Sea. The incident resulted in the second largest spill on the Norwegian continental shelf after the Ekofisk Bravo blow-out in 1977.

12.3. Municipal waste water treatment

Figure 12.5. **Percentage of population connected to various types of treatment plants. By county. 2006**



Source: Waste water treatment statistics, Statistics Norway.

Connection to waste water treatment plants

- In 2006, 83 per cent of the population of Norway was connected to waste water treatment plants with a capacity greater than 50 p.e. and to municipal sewer systems. The rest of the population was connected to small plants (<50 p.e).
- Just below 58 per cent of the population were connected to high-grade treatment plants in 2006. In the North Sea counties, this proportion was over 86 per cent, while the figure for the rest of the country was 23 per cent.

Box 12.4. Terms, municipal waste water treatment

A sewerage system is any installation for handling of waste water that includes one or more of the following main components: sewer system, pumping stations, treatment plants and discharge pipe.

A sewer system is any of several drainage systems for carrying surface water and sewage for disposal.

Waste water treatment plants are generally divided into three main groups according to the type of treatment they provide: mechanical, biological or chemical. Some plants operate combinations of these basic types.

Sewage sludge is sludge from treatment of domestic and municipal waste water, except screenings.

Waste water means domestic and industrial waste water and run-off rain water (storm 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.

Municipal waste water means domestic waste water and waste water consisting of a mixture of domestic waste water and industrial waste water and/or storm water. Waste water consisting of less than 5 per cent domestic waste water is not regarded as municipal waste water.

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.

The public sewer system is a sewer system to which connection is permitted for the general public.

Storm water is surface runoff (rain, meltwater) from yards, streets, roofs, etc., that is diverted via ditches etc. or channelled into separate storm sewers or into the ordinary sewer system together with domestic waste water.

One population equivalent (p.e.) is the organic biodegradable load having a five-day biochemical oxygen demand (BOD5) of 60 g of oxygen per day. The number of population equivalents 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.

Treatment is generally divided into three types:

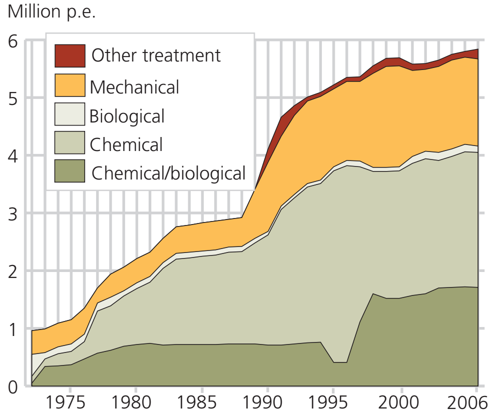
1. **Primary treatment** is the first and in some cases the only step in waste water treatment. It includes removal of some of the suspended solids and organic material in the incoming waste water, usually by means of sedimentation.
2. **Secondary treatment** is the second step in waste water treatment after primary treatment, and includes removal of biodegradable suspended material. This normally involves aerobic biological treatment.
3. **Tertiary treatment** meets the strictest requirements for treatment methods, and includes phosphorus and nitrogen removal before discharge to the recipients. The Pollution Regulations require removal of 90 per cent of the phosphorus and 70 per cent of the nitrogen that enters the waste water treatment plant.

Domestic waste water is waste water that predominantly originates from the human metabolism and household activities, including waste water from toilets, kitchens, bathrooms, utility rooms and the like.

Individual waste water treatment facilities are designed to receive waste water equivalent in amount or composition up to 50 p.e. (generally, private plants in areas with scattered settlement).

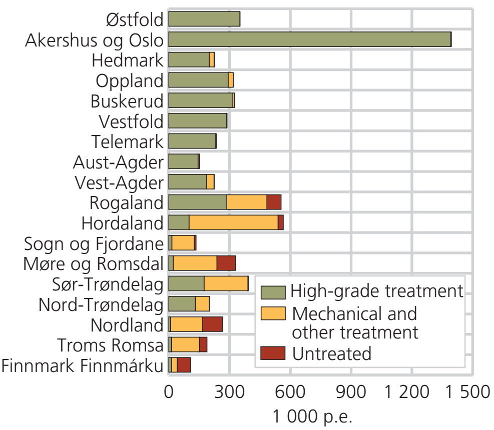
Source: Norwegian Pollution Control Authority

Figure 12.6. **Trends in treatment capacity of waste water treatment plants[1] ≥ 50 p.e. Whole country. 1972-2006**



[1] Direct (untreated) discharges are not included.
Source: Waste water treatment statistics, Statistics Norway.

Figure 12.7. **Hydraulic capacity of waste water treatment plants ≥ 50 p.e., by treatment method. By county. 2006**



Source: Waste water treatment statistics, Statistics Norway.

Treatment capacity at waste water treatment facilities

- In 2006, total waste water treatment capacity in Norway was 5.84 million population equivalents (p.e.), 71 per cent of which was high-grade treatment. In addition, systems with direct discharges of untreated sewage had a total capacity of 0.40 million p.e.
- The trends in treatment capacity reflect investments made in the 1970s in chemical treatment processes for the removal of phosphorus and the upgrading of some large treatment facilities in the inner Oslofjord to chemical-biological treatment facilities since the mid-1990s.
- The substantial increase in mechanical treatment capacity, particularly since 1988, is largely because this is when registration of strainers and sludge separators in mechanical treatment facilities was introduced.

- High-grade treatment of waste water, i.e. biological and/or chemical treatment, is most widespread in southern parts of Eastern Norway, Rogaland, Sør-Trøndelag and Nord-Trøndelag.
- High-grade treatment methods account for over 97 per cent of treatment capacity in the North Sea counties, but only 32 per cent of the total in the rest of the country.
- High-grade treatment capacity in the North Sea region totals 1.31 p.e. per inhabitant, while the equivalent figure for the rest of the country is 0.37 p.e. This is about the same level as in 2004.

Discharges of nutrients from waste water treatment plants

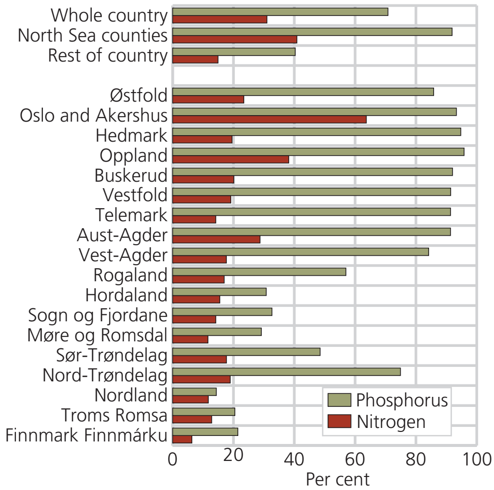
- Discharges of phosphorus and nitrogen from the waste water treatment sector in 2006 totalled 1 205 and 16 467 tonnes respectively. This includes leakages from sewers and discharges from individual treatment facilities (< 50 p.e.).
- Plants in the North Sea counties accounted for 25 per cent of the phosphorus discharges and 51 per cent of the nitrogen discharges. This corresponds to per capita discharges of 0.12 kg phosphorus and 3.19 kg nitrogen per year.
- The equivalent figures for the rest of the country were 0.43 kg phosphorus and 3.89 kg nitrogen.

Table 12.1. **Total discharges of phosphorus and nitrogen from sewerage systems. By county. 2006**

	Phosphorurs					Nitrogen				
	Total	Discharges from municipal treatment plants	Leakages from sewers[1]	Discharges from individual treatment plants	Discharges per inhabitant	Total	Discharges from municipal treatment plants	Leakages from sewers[1]	Discharges from individual treatment plants	Discharges per inhabitant
	Tonnes				kg	Tonnes				kg
Total 2000	**1 296**	**825**	**124**	**346**	**0.29**	**17 374**	**13 191**	**912**	**3 270**	**3.88**
Total 2001	**1 275**	**790**	**123**	**362**	**0.28**	**16 723**	**12 303**	**860**	**3 560**	**3.71**
Total 2002	**1 197**	**730**	**120**	**347**	**0.27**	**15 802**	**11 785**	**830**	**3 246**	**3.49**
Total 2003	**1 247**	**775**	**121**	**351**	**0.27**	**15 599**	**11 426**	**835**	**3 338**	**3.41**
Total 2004	**1 184**	**722**	**122**	**340**	**0.26**	**15 672**	**11 613**	**854**	**3 207**	**3.44**
Total 2005	**1 187**	**735**	**122**	**3318**	**0.26**	**15 901**	**11 880**	**862**	**3 160**	**3.45**
Total 2006	**1 205**	**749**	**128**	**327**	**0.26**	**16 467**	**12 404**	**899**	**3 164**	**3.50**
North Sea counties (01-10)	310	123	76	111	0.12	8 425	6 594	558	1 274	3.19
Other counties (11-20)	894	626	52	216	0.43	8 041	5 810	341	1 890	3.89
01 Østfold	39	20	7	12	0.15	1 119	946	62	111	4.15
02-03 Akershus and Oslo	98	46	34	18	0.09	2 246	1 820	251	176	2.14
04 Hedmark	24	6	6	13	0.13	790	563	35	192	4.10
05 Oppland	26	4	5	17	0.13	686	425	34	227	3.44
06 Buskerud	31	11	7	13	0.13	967	767	48	151	4.04
07 Vestfold	29	10	6	14	0.13	826	674	42	111	3.66
08 Telemark	24	8	5	11	0.13	682	529	31	122	3.82
09 Aust-Agder	15	5	3	7	0.12	380	263	18	98	3.21
10 Vest-Agder	24	14	4	6	0.15	729	607	37	85	4.44
11 Rogaland	128	94	11	24	0.32	1 530	1 241	75	215	3.80
12 Hordaland	205	142	10	53	0.44	1 807	1 283	76	448	3.87
14 Sogn og Fjordane	52	32	2	17	0.50	410	238	14	159	3.96
15 Møre og Romsdal	124	92	6	26	0.50	1 007	740	42	225	4.06
16 Sør-Trøndelag	110	80	8	22	0.45	957	718	44	196	3.91
17 Nord-Trøndelag	42	24	5	13	0.31	510	350	22	138	3.70
18 Nordland	122	81	5	36	0.51	939	612	35	292	3.94
19 Troms Romsa	79	56	4	19	0.51	616	432	25	159	3.95
20 Finnmark Finnmárku	33	25	2	6	0.46	266	197	11	58	3.72

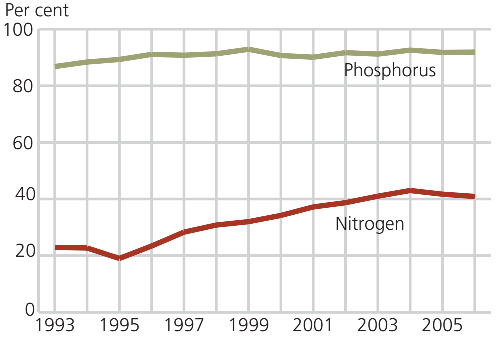
[1] Estimated at 5 per cent of the content of phosphorus and nitrogen in waste water before treatment.
Source: Waste water treatment statistics. Statistics Norway.

Figure 12.8. **Estimated treatment efficiency for phosphorus and nitrogen. By county. 2006. Percentages**



Source: Waste water treatment statistics, Statistics Norway.

Figure 12.9. **Trend in treatment efficiency for phosphorus and nitrogen in the North Sea region. 1993-2006. Per cent**

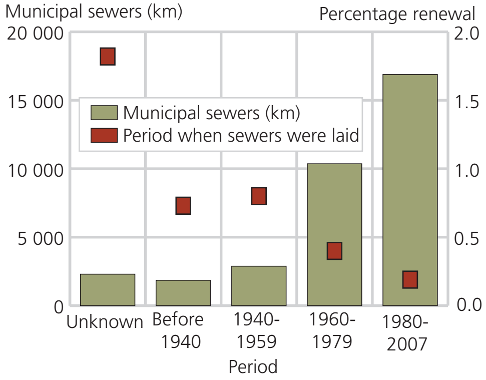


Source: Waste water treatment statistics, Statistics Norway.

Treatment efficiency

- In 2006, waste water treatment plants in the North Sea counties removed on average 92 per cent of the phosphorus and 41 per cent of the nitrogen load processed by the plants. In the rest of the country, treatment efficiency for these nutrients was 40 and 15 per cent respectively.
- In Oslo and Akershus, treatment efficiency for nitrogen is 64 per cent, and this plays an important role in ensuring a level of over 40 per cent for the North Sea region as a whole. Treatment efficiency is also fairly high in Oppland, at 38 per cent, while it is considerably lower in the other counties.
- Treatment efficiency for nitrogen in the North Sea region has apparently levelled off in the past two to three years, after rising fairly steadily for the previous 10 years. The figure shows a drop in treatment efficiency for nitrogen from 2004 to 2006, but this could be a result of uncertainties in the underlying data, and it is too early to say whether the figures indicate a new trend. Actual efficiency varies somewhat from year to year, partly because unusual incidents (operational failure, overload, etc.) at the larger plants can have a substantial effect on the figures.
- The construction of nitrogen removal plants in the Oslofjord area in recent years has given clear results. Since 1995, treatment efficiency for nitrogen in this area has risen steadily from about 20 per cent to just under 42 per cent in 2005.
- Treatment efficiency for phosphorus in the North Sea region has remained fairly steady at just over 90 per cent.

Figure 12.10. **Length of municipal sewers by age, and proportion renewed up to 2007**

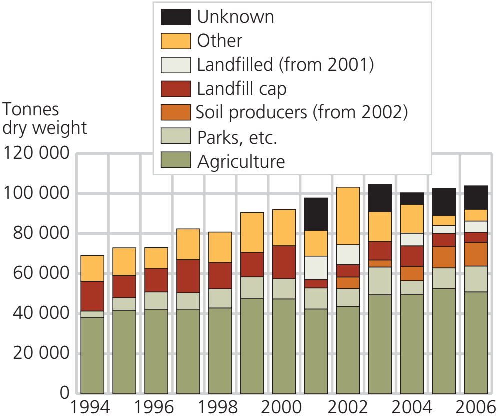


Source: KOSTRA, Statistics Norway.

Sewer systems

- Renewal of the sewer system is essential to prevent damage to buildings and inadvertent environmental pollution as a result of damaged pipes or leaks. Damaged pipes can also allow surface water and groundwater to drain into the sewer system, which can result in higher treatment costs.
- Calculations show that Norway had a total of 34 300 km of municipal sewer systems in 2007. This corresponds to four-fifths of the earth's circumference at the equator.
- In 2007, the average rate of renewal for sewer systems in Norwegian municipalities was estimated at 0.45 per cent per year. The rate of renewal is highest for the oldest sewer systems, varying from 0.73 per cent per year for sewers laid before 1940 to 0.19 per cent for sewers laid after 1980. The rate of renewal is also relatively high (1.82 per cent) for sewer systems of unknown age. It is assumed that these are mainly relatively old sewers.
- The average age of the sewers is estimated to be about 33 years. About 5.4 per cent of the sewers were laid before 1940 and about 49.2 per cent after 1980.

Figure 12.11. **Quantities of sewage sludge used for different purposes[1]. Tonnes dry weight. Whole country. 1994-2006**

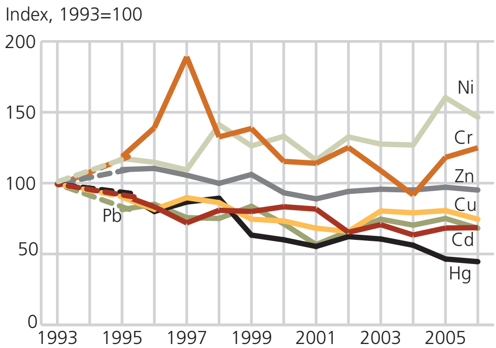


[1] The category "landfilled" was not reported separately in 2003, and was presumably included in the category "other/unknown".
Source: Waste water treatment statistics, Statistics Norway.

Sewage sludge

- Sludge is a residual product of the waste water treatment process, but also a potential resource as a soil conditioner in agricultural areas and parks and other green spaces. Nutrients and organic matter are separated from the waste water, and the sludge is stabilised and hygienised to remove odours and harmful bacteria before utilisation or disposal in landfills.
- Is 2006, just under 104 000 tonnes of sludge, expressed as dry weight, was used for various purposes. The largest category was sludge used for agricultural purposes, which accounted for 50 800 tonnes.
- Sludge used by soil producers and sludge landfilled have only been recorded as separate categories since 2002 and 2001 respectively. It is assumed that these were previously included in other categories.
- In 2006, 82 per cent of the sludge was used as a soil conditioner or in parks and green spaces, or was delivered to soil producers.

Figure 12.12. **Trends for content of heavy metals in sludge. 1993-2006[1]. Whole country. Index, 1993=100**



[1] Figures for 1994 are not available, and straight lines have been drawn between the figures for 1993 and 1995.
Source: Norwegian Pollution Control Authority (SESAM) and Waste water treatment statistics, Statistics Norway.

- If the content of heavy metals exceeds the limit values, the sludge cannot be used as a soil conditioner.
- The concentration of heavy metals varies a good deal over time. However, the main trend in Norway has been a decrease in the content of heavy metals in sludge. The exceptions are nickel, and to some extent chromium, whose concentrations have risen since 1993.
- The content of heavy metals varies, sometimes substantially, from one treatment plant to another. This is because the composition of waste water varies (depending on factors such as the amount of waste water from households, and the proportion of industrial waste water and of rain/melt water).

Table 12.2. **Content of heavy metals in sludge. 2006**

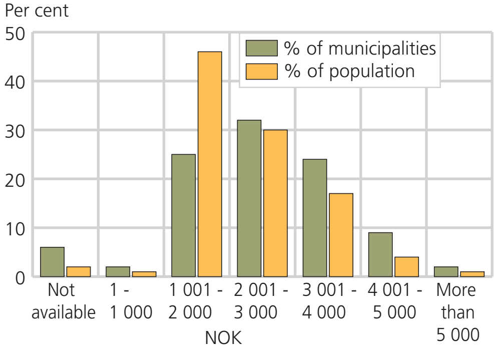
Heavy metal	Mean value	Average of maximum values	Limit value agriculture (quality class II)	Limit value parks, etc. (quality class III)	Change in mean value 2005-2006
	Milligrams per kg expressed as dry weight				Per cent
Cadmium (Cd)	0.8	1.9	2	5	0.4
Chromium (Cr)	26.9	43.4	100	150	5.7
Copper (Cu)	248.3	322.6	650	1 000	-7.5
Mercury (Hg)	0.6	1.1	3	5	-4.1
Nickel (Ni)	16.0	28.9	50	80	-8.6
Lead (Pb)	19.7	32.4	80	200	-9.2
Zinc (Zn)	324.0	456.9	800	1 500	-2.1

Source: Waste water treatment statistics, Statistics Norway.

12.4. Fees in the municipal waste water sector

Norwegian legislation lays down that municipal water and waste water fees may not exceed the necessary costs incurred by the municipalities in these sectors. The fees must follow the principle of full costing, and must be based on estimates of the direct and indirect operating, maintenance and capital costs of waste water services. The annual fees must be calculated on the basis of measured or stipulated water consumption, or in two parts, one fixed and one variable. For properties where no water meter is installed, water consumption is as a general rule stipulated on the basis of the size of the buildings.

Figure 12.13. **Variation in annual waste water fees by percentage of municipalities and of population. 2008**



Source: KOSTRA, Statistics Norway.

Waste water services

- For the country as a whole, the average waste water fee was NOK 2 721. This is 6 per cent more than in 2007.
- The size of the fee varies widely between municipalities, from NOK 300 to NOK 6 614.
- Annual fees are between NOK 1 000 and 3 000 in 57 per cent of the municipalities, which account for 76 per cent of Norway's population.
- The municipalities with the smallest populations have the highest fees, and in general, fees are highest in small municipalities Eastern Norway, where requirements for waste water treatment are strictest (partly linked to the targets of the North Sea Declarations, see Box 12.1).
- Local conditions, such as topography, the need for pumping stations and population density, can also help to explain the large differences in fees between municipalities.

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More statistics on the municipal waste water treatment sector

Background tables and statistics for the municipal waste water sector are available in StatBank Norway: http://statbank.ssb.no/statistikkbanken/ (see subject 01 Natural resources and the environment — 01.04 Pollution — 01.04.20 Water — Municipal waste water)

Useful websites

Statistics Norway – Water and waste water statistics: http://www.ssb.no/english/subjects/01/04/20/
Statistics Norway – Environmental protection expenditure costs: http://www.ssb.no/english/subjects/01/06/20/
Norwegian Pollution Control Authority : http://www.sft.no/
Norwegian Institute of Public Health: http://www.fhi.no/eway/?pid=238
State of the Environment Norway: http://www.environment.no/
Norwegian Institute for Water Research: http://www.niva.no/symfoni/infoportal/portenglish.nsf

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13. Hazardous substances

Chemicals have become an essential part of modern life, both at work and at home. They are used in a wide range of products, including clothes, cosmetics, furniture and electronic equipment, to give these products the desired properties – soft or hard, transparent or colourful, washable or fire-resistant. However, many substances also have negative impacts on health and the environment. In many cases, it is precisely the properties required in products or processes that turn out to cause problems for people and the environment. Statistics Norway maintains statistics on 450 of the hazardous substances we use.

Since the 1930s, global production of chemicals has risen from 1 million tonnes a year to more than 400 million tonnes (EC 2006). More than 100 000 new substances have been synthesised, in addition to all those that occur naturally (EEA 2006). The general rise in the use of chemicals is continuing, and they are being used in new types of products. As yet, we know little or nothing about the properties of many substances. What we do know is that some of them can harm people or the environment if they are not handled safely.

The management of chemicals is an important priority area both of environmental policy and of the strategy for sustainable development (see Chapter 2). One target is to reduce releases and use of substances that pose a serious threat to health or the environment. According to the white paper on Norway's chemicals policy (Report No. 14 (2006–2007) to the Storting), it has been documented that exposure to hazardous substances can cause both acute and chronic injury to health. For example, a clear link has been shown between exposure of children to high levels of mercury and lead and their intellectual capacity and ability to learn. Moreover, many substances are suspected of being contributory factors in the rising incidence of various diseases and health effects. For example, the number of new-born boys with undescended testicles is rising, as is the incidence of certain types of cancer that are hormone-dependent (testicular cancer, prostate cancer and breast cancer) and allergies.

There is also documentation of the serious environmental impacts of many chemicals. The white paper on Norway's chemicals policy mentions reduced fertility in seals, birds and polar bears as a result of exposure to PCBs, and disruption of the development of reproductive organs and reproductive dysfunction in the dogwhelk caused by leaching of organotin substances from anti-fouling systems used on boats. Studies have shown that the extent of certain types of damage has been reduced in pace with reductions in the levels of the relevant chemicals in the environment. Releases of many of the most dangerous substances have been substantially reduced. However, new substances are constantly being added to the List of Dangerous Substances.

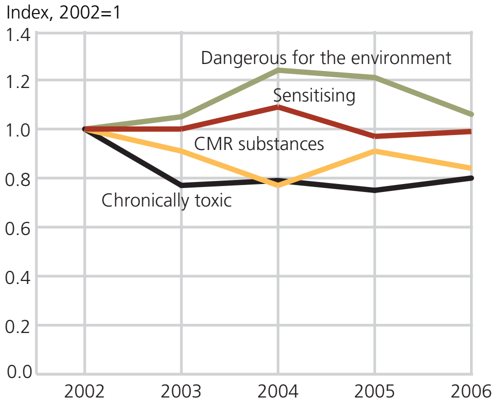
Box 13.1. How do hazardous substances affect our surroundings?

- The use of hazardous substances is believed to be one of the causes of the steadily increasing rates of allergy, asthma, some types of cancer and birth defects and reproductive problems (for example poor sperm quality) in Europe.
- Some substances are endocrine disruptors, and can cause sterility and disrupt sexual development in birds, fish, amphibians and molluscs (EC2006).
- Hazardous substances can be transported over long distances in the atmosphere and with ocean currents. Very high levels of dangerous chemicals have for example been found in polar bears and indigenous peoples in Canada. Hazardous chemicals can also accumulate in breast milk (EC2006).
- According to two European studies, a third of all recognised occupational skin and respiratory diseases in Europe are related to exposure to chemicals (European Agency for Safety and Health at Work 2002 and Pickvance et al. 2005).
- It is estimated that there are about 345 new cases of occupational cancer in Norway every year (Dreyer et al. 1997), many probably as a result of exposure to hazardous substances.
- According to Eurostat, 17 per cent of all cases of occupational disease in Europe in 2001 may have been caused by hazardous substances (Karjalainen and Niederlaender 2004).

13.1. How large are releases of hazardous substances in Norway?

Annual consumption of the approximately 450 hazardous substances on which Statistics Norway maintains statistics is about 6 million tonnes. According to Statistics Norway's calculations, about 0.3 per cent of the total quantity is released to soil, air or water every year. The calculated releases are split into four hazard categories depending on the properties of the substances released: CMR substances, substances with chronic toxic effects, sensitising substances and substances that are dangerous for the environment and may have long-term adverse effects (see Box 13.3, Figure 13.1 and Table 13.1). CMR substances are considered to have the most serious impacts on health. Substances with several of these properties are included in more than one hazard category.

Figure 13.1. **Releases of hazardous substances 2002-2006, by hazard category. Index: 2002 = 1**



Source: Statistics Norway.

- There was a considerable reduction in releases of CMR substances from 2002 to 2006. The main reason appears to be a reduction in fuel consumption by shipping. The quantities declared (which correspond to consumption) by this sector have followed the same pattern as emissions. In the EU, production of CMR substances has risen in the same period.
- Releases of substances with chronic toxic effects have also decreased since 2002 as a result of lower fuel consumption and lower consumption of relevant products in manufacturing.
- Releases of substances that are dangerous for the environment rose at the beginning of the period, but then decreased. The decrease was mainly due to a decline in the use of these substances in manufacturing industries. The decrease was to some extent counteracted by an increase in the use of biocides, mainly copper(I)oxide used as an antifouling agent in fish farms and on boats.
- On the other hand, both consumption and releases of sensitising substances appear to have been fairly stable over the past five years. Although releases from the main source of such substances – paints and varnishes – have been reduced, releases of other substances have risen, so that the total has remained about the same.

Table 13.1. **Use and releases of hazardous substances, by hazard category, 2002-2006. 1000 tonnes**

	2002	2003	2004	2005	2006
Use					
- CMR substances	5 883	6 548	7 474	5 439	5 245
- Chronically toxic substances	264	238	219	187	206
- Sensitising substances	141	144	126	154	148
- Dangerous for the environment	75	83	82	78	63
Releases					
- CMR substances	15.2	13.9	11.7	13.8	12.9
- Chronically toxic substances	1.1	0.8	0.8	0.8	0.9
- Sensitising substances	2.9	2.9	3.2	2.9	2.9
- Dangerous for the environment	4.2	4.4	5.3	5.1	4.5

Source: Kittilsen and Hansen (2008).

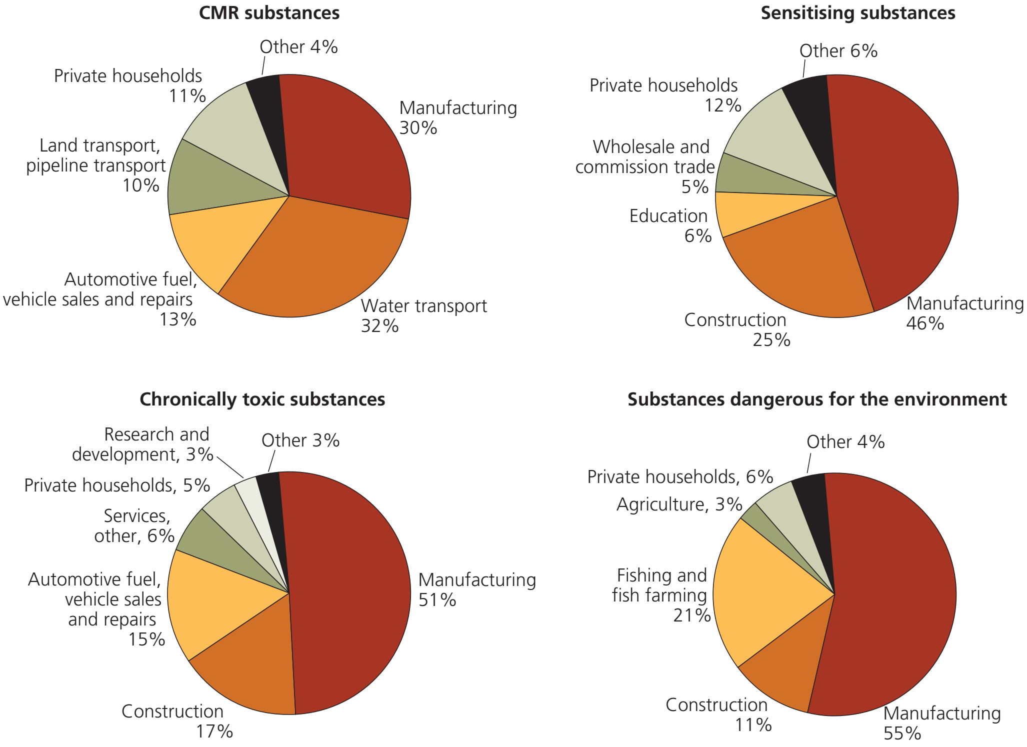
Box 13.2. Categories of hazardous substances

The statistics on hazardous substances deal with chemicals in four hazard categories:

Category	Effects	Examples
CMR substances	May cause cancer (C) or mutations (M), or be toxic for reproduction (R). The use of oil products is the most important source of these substances.	Formaldehyde, toluene, carbon monoxide
Chronically toxic substances	May cause damage after prolonged exposure.	Toluene and phenol
Sensitising substances	Skin contact or inhalation may result in allergies.	Phthalic anhydride, formaldehyde and bisphenol-A
Dangerous for the environment	May be harmful to aquatic organisms.	Copper(I)oxide, sodium chlorate and pentane

13.2. Which sectors use and release hazardous substances?

Figure 13.2. **Releases of hazardous substances in each hazard category, by sector. 2006. Percentages**

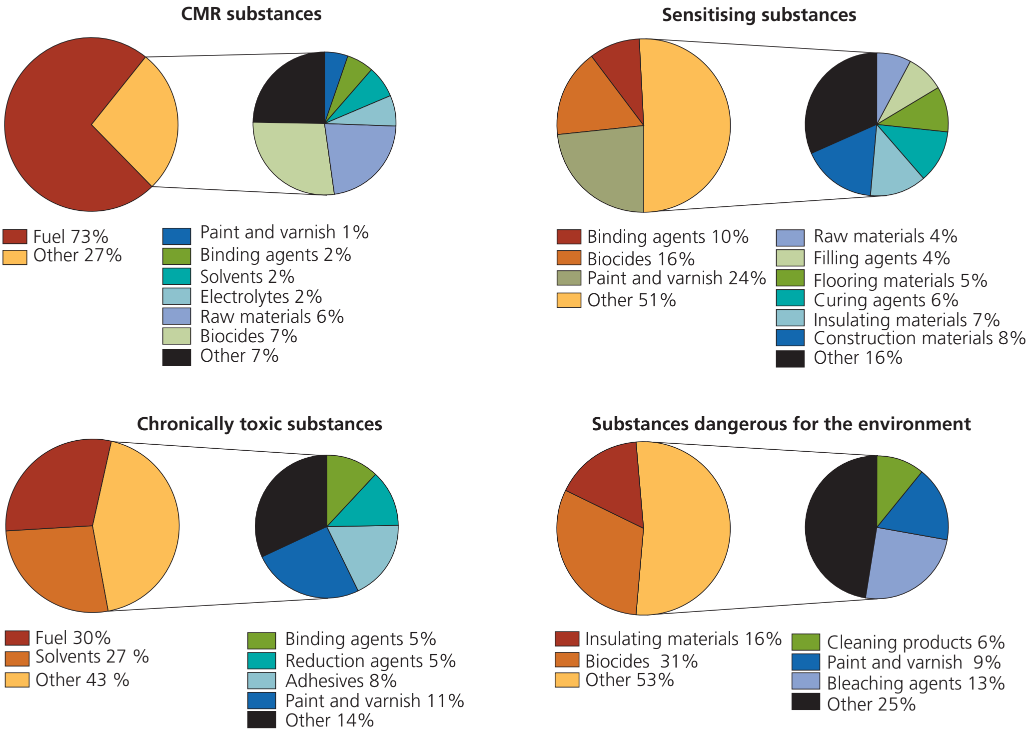


Source: Statistics Norway.

- Manufacturing industries account for a large proportion of releases of substances in all four hazard categories, from 30 per cent for CMR substances to 55 per cent for substances that are dangerous for the environment (see Figure 13.2.). Other important sectors include construction; retail sale of automotive fuel; sale, maintenance and repair of motor vehicles and motorcycles; private households and fish farming.
- Emission factors for hazardous substances used in manufacturing industries are generally low, since such substances are often used as raw materials in production. However, the quantities used in manufacturing are so large that this sector nevertheless makes a large contribution to the total releases of hazardous substances. According to the calculations, releases from the manufacturing sector were somewhat lower in 2006 than in 2002, which is the first year of the time series. The largest decrease was in releases of substances that are dangerous for the environment.
- Releases from other sectors, including agriculture and fishing, service industries and private households, have risen for three of the four hazard categories – substances that are chronically toxic, sensitising and dangerous for the environment.

13.3. Which products result in releases of hazardous substances?

Figure 13.3. **Releases split by product group for each hazard category. 2006. Percentages**



Source: Statistics Norway.

- Fuel consumption, largely by shipping, accounted for more than 70 per cent of releases of CMR substances and 30 per cent of releases of chronically toxic substances in 2006 (Figure 13.3). Between 2002 and 2006, releases of CMR substances from fuel use dropped by 35 per cent.
- Biocides are the largest single source of releases of substances that are dangerous for the environment. Releases of such substances rose between 2002 and 2006 as a result of an increase in the consumption of biocides in the fish farming industry.
- Solvents, paints and varnishes and construction materials are very important for trends in releases of substances in three hazard categories - substances that are chronically toxic, sensitising and dangerous for the environment.

Box 13.3. Development of statistics on hazardous substances

Statistics Norway has cooperated with the Norwegian Pollution Control Authority and the Product Register on the development of statistics on releases of selected hazardous substances in Norway from the use of products that carry warning labelling.

So far, the statistics cover releases of a selection of hazardous substances from the use of products for which warning labelling is mandatory under the Chemical Labelling Regulations and that must be declared to the Norwegian Product Register (see Box 13.4). The substances included were chosen on the basis of the List of Dangerous Substances and the Government's priority list of hazardous substances.

The model takes account of the fact that not all hazardous substances are released to the environment and pose a threat to health and the environment. For example, chemicals may be used in a closed production loop, or a hazardous substance may be converted to a less dangerous chemical during use. Figures for releases of hazardous substances to the environment (air, soil and water) are calculated by multiplying the quantity of a particular substance used in a specific year by an emission factor. The quantity used is the sum of production and imports minus exports, in accordance with declarations submitted to the Product Register.

The emission factor for a substance represents the proportion of the substance that is not incorporated into new products, converted into other substances, or dealt with in a way that prevents its release (e.g. through waste management). The proportion of a hazardous substance released is assumed to depend both on the type of product in which it is used and on how the product is used. The emission factors used are largely based on work carried out by the authorities and research institutions in Sweden (Swedish Chemicals Inspectorate and Swedish Methodology for Environmental Data). Most of the emission factors used in the model are product- and sector-specific. Emission estimates are made for all recipients (air, soil and water) combined. An annual update and recalculation of the entire time series ensures that the most recently available information is included and that the time series are as consistent as possible.

The range of substances and data sources used is limited for the present. Many hazardous substances are not registered with the Product Register, and some products contain hazardous substances but need not be declared, or are not declared despite the requirement to do so. Moreover, hazardous substances used in the oil and gas sector and declared to the Product Register are not included in the calculations, since there is reason to believe that other data sources are more suitable as a basis for calculating releases from this sector. Nor are releases from spills, accidents, etc. included in the figures.

The model has gradually been improved since it was first developed. More and more information has been included to improve the estimates of releases. However, the method is still being developed, and the results must be interpreted with caution. The model is based on a number of assumptions, so that the level of uncertainty in the results is high at present, particularly as regards the emission factors used and therefore the estimated levels of releases. However, since the methodology and time series are consistent, emission trends are less uncertain. Annual evaluations and improvements of the model will gradually improve the results.

Source: Kittilsen and Hansen (2008).

Box 13.4. The Product Register

The Product Register runs the authorities' central register of substances and chemical products that are on the market in Norway. All chemical products for which declaration is mandatory under section 21 of the Chemical Labelling Regulations must be declared to the Product Register. Firms are required to declare the quantity of each product manufactured, imported, etc., the type of product, the branches of industry where it is used and its chemical composition. The regulations apply to establishments that produce, import and/or place chemicals that are classified in one of the danger categories specified in the Chemical Labelling Regulations in quantities exceeding 100 kg per year. Voluntary declaration of products is also possible.

Box 13.5. REACH – the new EU chemicals legislation

The new EU chemicals legislation, REACH, entered into force on 1 June 2007. REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. The legislation is intended to ensure a high level of protection of human health and the environment against chemicals and at the same time maintain a competitive chemicals industry. Under the rules, anyone who manufactures or imports 1 tonne or more of a chemical per year must register this in a central database. Manufacturers and importers are also required to obtain information on these substances, so that risks can be managed appropriately.

The REACH regulation will enter into force in Norway once it has been incorporated into the EEA Agreement.

More information on DG Enterprise website http://ec.europa.eu/enterprise/reach/index_en.htm

More information: Nina Holmengen (nina.holmengen@ssb.no) and Kathrine Loe Hansen (kathrine.loe.hansen@ssb.no).

Useful websites

State of the Environment Norway: http://environment.no/
Product Register: http://sft.no/seksjonsartikkel____41814.aspx
Norwegian Pollution Control Authority: http://www.sft.no/aktuelt____29292.aspx

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Part 4
Environmental accounts and expenditure

14. Links between environment and economy

There are clear links between the production of goods and services and pressures and impacts on the environment. One goal of environmental policy is therefore to encourage producers and consumers to use resources responsibly and to limit the environmental impact of their consumption and other activities. The authorities can encourage more environmentally friendly behaviour through legislation, taxation, voluntary agreements and subsidies. It is a common perception that environmental regulation leads to higher costs. However, if firms can offer goods and services that reduce environmental impacts, they can also find new market opportunities. This chapter presents some key figures that illustrate the interplay between economic activity and environmental impacts, and measures implemented to reduce environmental impacts.

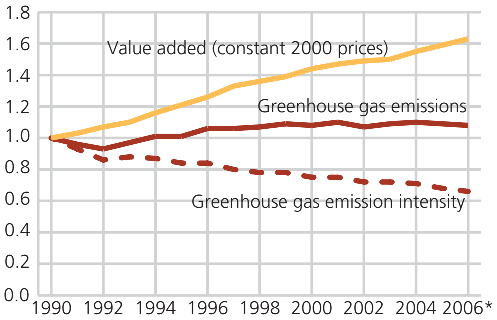
By linking the national accounts and emission statistics, it is possible to calculate how high emissions are in relation to economic activity in different sectors and in the Norwegian economy as a whole. In the period 1990–2006, greenhouse gas emissions rose, while emissions of acidifying gases and ozone precursors were reduced. However, GDP rose so strongly in the same period that there was an overall decrease in emission intensity in Norway.

Environmental protection expenditure means expenses related to activities and measures whose main purpose is environmental protection. Examples are current expenditure on emissions abatement or waste treatment and investments to prevent negative impacts on the environment. Measures may be required by the authorities or undertaken voluntarily by a firm. In 2006, environmental protection expenditure in the manufacturing and mining industries totalled NOK 3.8 billion, about two-thirds of which was current expenditure. Total expenditure was split roughly equally between three environmental domains: waste water, air/climate and solid waste. Environmental protection expenditure was highest in the following sectors: food products, beverages and tobacco; oil refining and chemicals; and manufacture of basic metals.

The environment industry consists of establishments that supply goods and services intended to reduce the environmental impacts of production and consumption, or that offer goods and services produced using cleaner production methods. Many people hope that the environment industry can become a new growth industry that can help to reconcile political goals for economic growth and lower emissions. So far, there is little data on this area, but this is changing as a result of growing demand by the authorities and interest groups. Figures for Sweden show that the environment industry there is growing by 14.5 per cent per year.

14.1. Emissions and economic developments

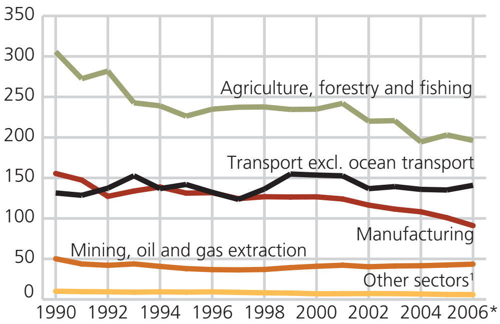
Figure 14.1. **Value added (constant 2000 prices), greenhouse gas emissions and greenhouse gas emission intensity. Norway, excluding ocean transport. 1990-2006*. Index: 1990=1**



Source: Statistics Norway (2008a).

- Since 1990, value added in Norway has grown more rapidly than greenhouse gas emissions. Emission intensity has dropped by 34 per cent between 1990 and 2006. This trend has been particularly marked since 1996.
- Preliminary figures for 2006 show that greenhouse gas emission intensity is continuing to decrease. Emission intensity dropped by 3 per cent from 2005 to 2006. In 2006, it reached the lowest level since 1990, 38 tonnes CO_2 equivalents for every NOK 1 million in value added.
- The drop in overall emission intensity is mainly due to strong economic growth in sectors that are not very emission-intensive, and a shift towards greater value added in these sectors. It is also explained by more efficient use of fossil fuels and the introduction of various environmental measures.

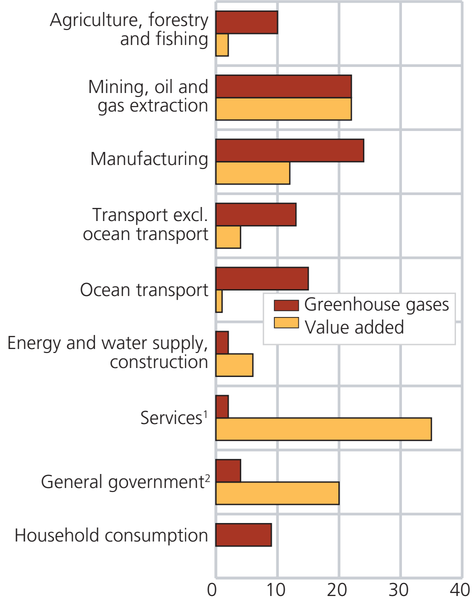
Figure 14.2. **Greenhouse gas emission intensity, by sector. Tonnes CO_2 equivalents per million NOK value added. 1990-2006***



[1] Excluding ocean transport.
Source: Statistics Norway (2008a).

- Most industries except the transport industry have become less emission-intensive between 1990 and 2006.
- However, the picture is complex, and for several specific industries, economic growth has been lower than the growth in emissions.

Figure 14.3. **Total greenhouse gas emissions and value added for industrial sectors and households. 2006*. Per cent**



[1] Services including wholesale, maintenance, hotels and restaurants.
[2] General government including education and health and social work.
Source: Statistics Norway (2008a).

- Greenhouse gas emissions are highest relative to value added in the transport industry, primary industries and manufacturing industries, and lowest in service industries and the general government sector.
- Ocean transport stands out in the Norwegian economy as a sector with particularly high greenhouse gas emissions relative to value added. Ocean transport accounted for 15 per cent of Norway's total greenhouse gas emissions in 2006, but only for 1 per cent of GDP. However, the figures for emissions from ocean transport are uncertain (Kolshus and Flugsrud 2008).
- Selected sectors are discussed in more detail below.

Box 14.1. Emission intensity

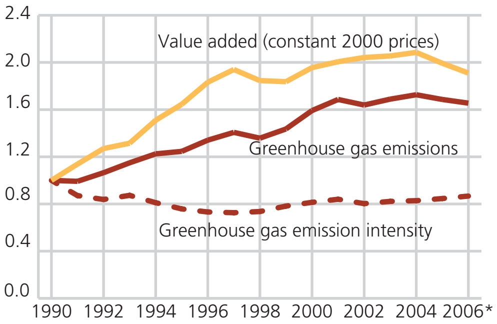
By linking the national accounts and emission statistics, it is possible to derive key figures that illustrate the interplay between economic activity and environmental impacts. Emission intensity is an expression of the relationship between emissions and economic activity. Emissions of various types of pollutants to air are included. Value added at constant prices is used as a measure of economic activity.

There are various reasons why a sector may become more emission-effective, for example:

- Changes in industrial structure: in most growing economies, there is a changeover from secondary industries (manufacturing), which are often energy-intensive, to tertiary industries (services), which are generally less energy-intensive.
- Technological developments that reduce energy use per unit produced and give opportunities for emissions abatement.
- A changeover to non-fossil fuel based energy in response to rising energy prices, taxes, emissions trading, etc.

Emissions of greenhouse gases, acidifying gases, ozone precursors, heavy metals and particulate matter from specific industrial sectors are included in the integrated system of environmental statistics and national accounts, but only greenhouse gases are discussed here. The greenhouse gases included are carbon dioxide (CO_2), nitrous oxide (N_2O), methane (CH_4), perfluorocarbons (PFCs), hydrofluorocarbons (HFCs) and sulphur hexafluoride (SF_6).

Figure 14.4. **Value added (constant 2000 prices), greenhouse gas emissions and greenhouse gas emission intensity. Oil and gas extraction and mining. 1990-2006*. Index: 1990=1**

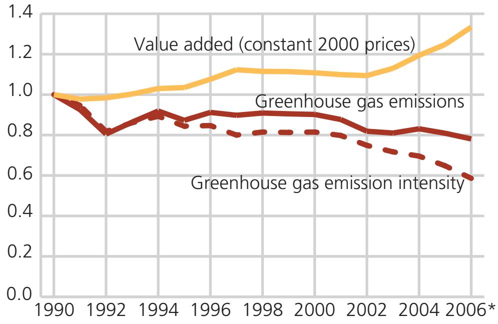


Source: Statistics Norway (2008a).

Oil and gas extraction more emission-intensive

- Oil and gas extraction including mining accounts for a large proportion of total greenhouse gas emissions, but emission intensity (emissions per NOK 1 million value added in constant prices) is about the average for all sectors of the Norwegian economy.
- Greenhouse gas emissions from oil and gas extraction have risen by 72 per cent since 1990. However, value added in this sector has risen even more. The sector accounted for more than one-fifth of Norway's total value added in 2006.
- Up to 1997, emission intensity in oil and gas extraction showed a downward trend, but calculations show that it has been rising in the past 10 years. 2006 was the third year in a row when value added declined more sharply than emissions.
- Different phases of oil and gas extraction result in different types of emissions, and the level of emissions varies during the lifetime of an oil or gas field. Despite more efficient energy use, a reduction in flaring and the introduction of the CO_2 tax in 1991, it has not yet been possible to counteract the increase in energy use as a result of a higher level of activity on the continental shelf.

Figure 14.5. **Value added (constant 2000 prices), greenhouse gas emissions and greenhouse gas emission intensity. Manufacturing. 1990-2006*. Index: 1990=1**

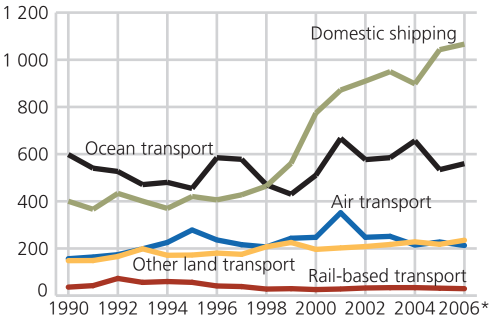


Source: Statistics Norway (2008a).

Manufacturing industries less emission-intensive

- Since 2000, emissions have shown a downward trend, while the manufacturing sector as a whole has experienced strong growth.
- From 1990 to 2006, greenhouse gas emissions from manufacturing industries have dropped by 22 per cent, while value added has risen by 23 per cent.
- Trends in a few industries (basic chemicals, basic metals, refined petroleum products, chemicals and chemical products, and mineral products) strongly influence total greenhouse gas emissions from manufacturing. Since 2000, all these industries except basic chemicals manufacturing have become less emission-intensive, although there are wide variations from year to year and between industries. The reduction in greenhouse gas emissions from emission-intensive manufacturing is largely explained by cuts in emissions of PFCs and SF_6 through measures such as a switch to less polluting production technology and better process management. The closure of metal producers has also resulted in lower emissions, particularly of SF_6.
- In 2006, the industries listed in the previous bullet point accounted for 88 per cent of total greenhouse gas emissions from manufacturing.
- Manufacturing industries where emission intensity is low have contributed most to economic growth in Norwegian manufacturing.
- In 2006, the most important of these were building and repair of ships and oil platforms and manufacture of machinery and other equipment.

Figure 14.6. **Trends in greenhouse gas emission intensities for selected transport industries. Tonnes CO_2 equivalents per million NOK value added. 1990-2006***



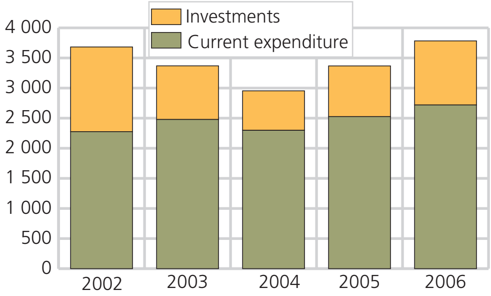
Source: Statistics Norway (2008a).

Transport sector more emission-intensive

- The transport sector includes a number of industries that vary widely in how much pollution they generate and how much they contribute to value added in Norway. Trends for individual transport industries may therefore be very different from those for the sector as a whole.
- If ocean transport is excluded, it is mainly road transport that has resulted in the rise in overall greenhouse gas emissions in the transport sector.
- Land transport accounted for 57 per cent of greenhouse gas emissions and 34 per cent of value added in the transport sector in 2006, and emission intensity has risen steadily in the period 1990–2006. Value added has risen by 50 per cent in this period, while greenhouse gas emissions have risen by 137 per cent, despite the fact that vehicles have become more fuel-efficient.
- Several factors may help to explain these trends. Both the volume of goods transported and transport distances have increased. Increasing activity in land transport is a result of general growth in the economy.
- The use of private cars is included in figures for households and not in the figures for the transport sector.

14.2. Environmental protection expenditure in manufacturing industries and mining and quarrying

Figure 14.7. **Environmental protection expenditure in manufacturing industries and mining and quarrying, split between current expenditure and investments. 2002-2006. Million current NOK**



Source: Statistics Norway (2008b).

- In 2006, environmental protection expenditure in the manufacturing and mining industries totalled NOK 3.8 billion.
- There was a certain decrease in environmental protection expenditure, particularly investments, from 2002 to 2004, followed by an increase until 2006.
- Current expenditure accounts for about two-thirds of the total, and has been stable at about 0.5 per cent of total current expenditure throughout the period 2002–2006. Measured per employee, current expenditure on environmental protection has risen from about NOK 8 000 to 10 000.
- Investments in environmental protection measures by manufacturing and mining establishments totalled more than NOK 1 billion in 2006. A few sectors consisting of a few large firms account for the bulk of these investments, and the level of investments varies more over time than the level of current expenditure. In 2006, investments in environmental protection made up 5 per cent of total investments in manufacturing and mining.
- End-of-pipe investments made up 77 per cent of investments in environmental protection, the rest being process-integrated investments.

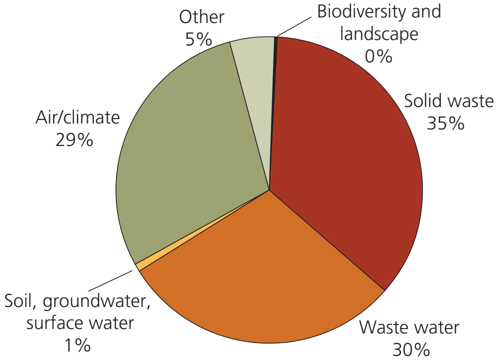
Box 14.2 Environmental protection expenditure – definitions and scope

Environmental protection expenditure means expenditure related to activities and measures whose main purpose is to prevent, reduce or treat pollution or other damage to the physical environment. Such measures may be required by the authorities or voluntary. The statistics are based on actual outlays for environmental purposes (as opposed to recorded costs, which include interest and depreciation).

Limited statistics have been compiled for 2000–2001. From 2002 onwards, the statistics include both current expenditure and investments for all industries within manufacturing and mining. Examples of investments in environmental measures are the replacement of furnaces, tanks, containers, equipment containing PCBs and burners, alterations to treatment, filtering and recovery plants, noise abatement measures and waste compressors. Examples of current expenditure on environmental measures are municipal fees for waste water treatment, expenses related to removal of waste, and the cost of maintaining and operating environmental protection equipment.

The statistics for environmental protection expenditure include Norwegian manufacturing and mining, excluding extraction of oil and gas on the Norwegian continental shelf and related service industries.

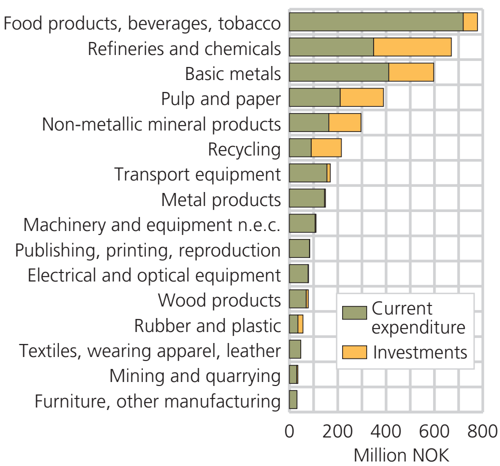
Figure 14.8. **Environmental protection expenditure in manufacturing and mining, by environmental domain. 2006. Per cent**



Source: Statistics Norway (2008).

- Environmental protection expenditure in 2006 was more or less equally divided between the domains waste water, air/climate and solid waste. Expenditure rose most, both as a percentage and in absolute terms, in the domain solid waste, followed by air/climate.
- Environmental protection expenditure focuses most on pollution abatement and prevention. Less than 1 per cent of the total was used on biodiversity and landscape.
- Current expenditure and investments are used to target different environmental domains. In the period 2002–2006, the bulk of current expenditure has been on waste water and solid waste. Investments are increasingly being used to target the air/climate domain.

Figure 14.9. **Investments and current expenditure for environmental protection in manufacturing and mining, by industry. 2006. NOK million**



Source: Environmental protection expenditure statistics, Statistics Norway (2008b).

- Expenditure is unevenly distributed across sectors. In both 2005 and 2006, three sectors accounted for more than half of all environmental protection expenditure: food products, beverages and tobacco (21 per cent), oil refining and chemicals (18 per cent) and manufacturing of basic metals (16 per cent). This is related to the number of firms in these sectors and their size and level of activity.
- The sector with the highest level of investments in 2006 was oil refining and chemicals, and this was also the sector where investments in the air/climate domain were highest.
- The pulp and paper industry made much the highest investments in the waste water domain.

Box 14.3. Survey of the environment industry – a new area of statistics

The production of goods and services has environmental impacts at all stages from the extraction of raw materials, through production processes to distribution, use, and finally the disposal of waste. The production and consumption of products and services that have less environmental impact at all stages of their lifecycle should be promoted. The authorities in Norway and the rest of Europe are therefore showing growing interest in learning about the potential offered by developing and supplying more environmentally beneficial goods and services.

The environment industry consists of establishments that supply technologies, products and services that prevent environmental damage and that reduce pollution and resource use. They may for example be used for measuring, preventing, limiting, minimising or correcting environmental damage to water, air and soil, and problems related to waste, noise, and ecosystems.

The statistics also include internal measures carried out by establishments to reduce the environmental impact of their goods and services, for example changes to production processes to reduce waste generation.

In 2006, Statistics Norway carried out a pilot study of the environmental industry in Norway, based on already existing statistics. The sectors that could be identified using the current standard industrial classification (NACE) are called the "core" environment industry. The most important of these are recycling, electricity production (based on renewable sources), and water, waste water and waste treatment. The study resulted in a first estimate of employment in these sectors of 16 000 people, about half of them employed in waste water and waste treatment. Studies in other countries have given similar results, and in the EU as well, it is estimated that these two sectors account for about 50 per cent of employment in the environment industry.

In 2007, a survey was made of manufacturers of technology for treating water and waste water (Smith 2008). In all, 31 firms with a total of 321 employees were identified within this area. In 2006, these firms had a total turnover of NOK 777 million, a rise of 6.6 per cent from the year before. Exports totalled NOK 313 million, or about 40 per cent of turnover.

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Useful websites

Statistics Norway – Environmental economics and indicators: http://www.ssb.no/english/subjects/01/06/

Statistics Norway: National accounts and environment: http://www.ssb.no/english/subjects/09/01/nrmiljo_en/

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Part 5
Environmental economics analyses

15. Analyses of selected resource and environmental issues

The relationship between economic activity and environmental impacts is an important area of research in Statistics Norway. This chapter describes some research projects in the environmental field.

15.1. Introduction

A key part of this research deals with the issue of climate change. Projects focus on energy markets and climate policy, links between energy prices and CO_2 emissions, international climate agreements, emissions trading, technological advances and renewable energy. Research has shed light on many different aspects related to the issue of which climate measures are most appropriate and effective. The challenge is to synthesise the results so that they can be used to ensure that climate measures and cooperation on climate change are developed in line with political objectives. Other environmental research in Statistics Norway deals with natural resources, biodiversity, genetically modified food, the precautionary principle and, last but not least, sustainable development, which has been the focus of renewed attention in recent years. A recent report on Norway's indicators of sustainable development (Brunvoll et al. 2008) highlights research and statistical challenges. The Government has recently appointed a committee to evaluate Norway's policy on sustainable development.

This chapter presents eleven research projects. The first is a study of the European energy market that focuses on links between energy markets and climate policy, illustrated by a model for energy markets in Western Europe. The analysis shows that energy market liberalisation may result in considerably lower energy prices, but also higher CO_2 emissions. The costs of meeting Western Europe's Kyoto commitments are highly dependent on the policies implemented, while production of renewable energy in Western Europe can be increased at moderate cost.

Another study analyses what opportunities the EU will have to exercise market power in a post-Kyoto regime. The distribution of emission quotas between countries under the Kyoto Protocol means that some countries may become large sellers of emission units. This would allow them to make use of their market power in the emissions trading market. This is also a possibility in a post-Kyoto regime after 2012. A high carbon price is expensive for the EU countries, since they are expected to be net purchasers of emission units. The project also looks at what opportunities the EU will have to act strategically in the carbon market by entering into a bilateral agreement with a potential new participant (China) in international cooperation on climate change.

Allocation of greenhouse gas emission allowances is a key issue in formulating climate policy. A new study analyses a system for allocating emission allowances free of charge (grandfathering) such that firms receive allowances in proportion to their emissions in a base year that is updated at regular intervals. If firms can increase the number of grandfathered allowances they receive in the future by increasing their emissions today, we might expect emissions to rise. However, the analysis, which incorporates important mechanisms from the EU emissions trading scheme, indicates that this allocation system does not necessarily encourage higher production and emissions than auctioning all the emission allowances.

The Kyoto Protocol provides for countries that have undertaken to reduce their emissions to meet part of their commitments by purchasing certified emission reduction credits (CERs) from developing countries that do not have commitments. This is known as the Clean Development Mechanism (CDM) and, in addition to emissions reduction, its purpose is to assist developing countries to achieve sustainable development. Sustainability includes poverty reduction, and an important question is to what extent CDM projects designed to mitigate climate change also reduce poverty. A study analyses the economy-wide impacts of a tree-planting CDM project in Tanzania. It focuses on the effects on income distribution and the net impact on the carbon balance when ripple effects on the economy are taken into account using a general equilibrium model.

Most countries throughout the world agree that greenhouse gas emissions must be reduced, but it is not easy to decide how to distribute the burden of emission abatement. According to the Stern Review, the annual costs of limiting global warming to 3°C will be around one per cent of global GDP. However, it is difficult for developing countries to take on the costs of reducing emissions. An analysis of alternative burden-sharing models finds that if the 10 richest countries meet the entire cost of emissions reduction, they would have to contribute 3.1 per cent of their GDP, while all other countries would pay nothing. Another option is for the countries that are richer than the OECD average to accept the entire burden. There is a difference of less than ½ per cent of GDP in the burden on these 27 countries if they pay all the costs, rather than all countries contributing the same proportion of GDP.

According to economic theory, taxes on greenhouse gas emissions should be equal for all polluters, and equal to the price of emission allowances in the emissions trading market. However, in Norway, tax rates for greenhouse gas emissions vary from zero to NOK 872 per tonne CO_2 equivalent. Compared with the current carbon price in the EU emissions trading scheme, Norwegian households pay about NOK 0.5 billion more than they should for their CO_2 emissions, and the oil and gas extraction sector pays about NOK 1.5 billion too much. In contrast, the other polluters in the process industry, together with the transport sector, gas terminals, oil refineries, and the fisheries sector, pay NOK 2.8 billion less than they should in a cost-efficient system. These sectors receive indirect support in the form of tax exemptions, a reduced CO_2 tax rate and allocation of emission allowances free of charge, and the polluter-pays principle is not being applied to them.

Technological developments will play an important role in reducing future greenhouse gas emissions. Stimulating research and development (R&D) may be a way of spurring technological developments. A new project analyses whether government support for R&D on climate-friendly technologies should be different from support for general R&D. The results indicate that subsidising general technological developments provides greater economic welfare gains than subsidising climate technology developments, but that the difference is reduced if the carbon tax is increased.

The chapter also discusses the model framework for analysing energy, environmental and economic issues. Norway has a long tradition of work on this topic. The development of energy and environmental statistics in the 1980s made it possible to develop Statistics Norway's macroeconomic equilibrium models further to include relatively detailed descriptions of energy production and use, and to link such activities to emissions to air. Over the past 20 years, these models have been used to make consistent projections of economic and environmental conditions and to analyse the impacts of environmental policy.

A study of the petroleum sector analyses which tax rate maximises government petroleum revenues from the Norwegian continental shelf. A robust conclusion seems to be that a reduction in the current tax level will not boost production and investment to the extent that government revenues will increase. This result holds even if the price of oil should fall to USD 20 per barrel.

The last study presented in this chapter analyses households' response to a demand tariff on electricity consumption. Electricity price agreements that give more accurate signals to customers about the costs of their consumption to network companies and power suppliers are attracting more interest. A price that is based not only on total consumption over a period, but also on the highest maximum consumption, may provide more accurate price signals. This study analyses households' response to a demand tariff that sets a price for consumption peaks. The conclusion is that customers reduce consumption by up to 9 per cent. Consumption reductions might have been even higher if more information was accessible to consumers about their consumption and the costs involved in using electricity.

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15.2. European energy policy – a model analysis

Finn Roar Aune and Knut Einar Rosendahl

The European energy market is facing a number of challenges. In a recently published book (Aune et al. 2008), Statistics Norway and the Ragnar Frisch Centre for Economic Research study the effects of various policy measures using a numerical simulation model for energy markets in Western Europe. Our findings show that energy market liberalisation may result in considerably lower energy prices, primarily because large operators cannot exercise market power. Lower prices result in higher energy use, which increases emissions of CO_2. The costs of meeting Western Europe's Kyoto commitments are highly dependent on the policies implemented, while production of renewable energy in Western Europe can be increased at moderate cost.

In this analysis, we study three challenges facing the European energy market. First, this market is traditionally dominated by large companies, and this has limited competition and market efficiency. Second, since most of the energy used in Europe is imported from other countries, with Russia and the Middle East as the most important, there is a risk to supply security. Third, energy use is the largest contributor to greenhouse gas emissions in Europe, and there are national and international ambitions to reduce these emissions substantially in the years ahead.

The EU has focused on these challenges for a number of years and has issued several directives proposing measures to liberalise European energy markets, increase energy security and curb the rise in CO_2 emissions. In Aune et al. (2008), the effect of such measures is analysed using a detailed numerical model for the Western European energy markets (i.e. EU15, Norway and Switzerland).

We use the LIBEMOD model, which explains each country's supply of and demand for various energy products. The markets are integrated, i.e. there is free cross-border trade. The cross-border transport of gas and of electricity are modelled as separate activities. Trade in fossil fuels between Western European countries and other countries is also modelled.

In order to study the effects of energy market liberalisation in Western Europe, we compare the actual situation in year 2000 with a hypothetical situation with fully liberalised markets. In 2000, the liberalisation process in most countries was still in the very early stages. We use the model to simulate a hypothetical case involving fully liberalised markets. This implies that no production, transport or distribution company can exercise market power. Comparing the outcome of the model with the actual situation in 2000 gives us an indication of what energy market liberalisation can lead to. Our findings show that liberalisation results in considerably lower prices for energy, particularly electricity. At the same time, energy use rises sharply, and in particular the production of coal power is much higher compared with the actual situation in 2000, when there was considerable spare capacity. As a result, CO_2 emissions are somewhat higher. These effects are due not least to the sharp fall in transport rates as large transport and distribution companies can no longer exercise market power, which stimulates trade in and demand for power.

European energy policy gives weight to reductions in CO_2 emissions and an increase in the production and use of renewable energy. A range of instruments can be used to achieve this: taxes on energy use, subsidies for renewable energy production, emission taxes, emission allowances, "green certificates" that link implied subsidies for renewable energy with implied taxes on other energy, direct regulation prohibiting particularly polluting energy production and a number of others. In Aune et al. (2008), we analyse the effects of some of these instruments on the Western European energy market.

Under the Kyoto Protocol, EU member countries have committed themselves to reducing their annual CO_2 emissions by 8 per cent in the period 2008-2012 relative to emissions in 1990. The individual member countries' commitments vary from a reduction of 21 per cent in Denmark and Germany to a permitted increase in emissions of 27 per cent in Portugal. Since the cost of achieving reductions varies across countries, the EU has adopted a burden-sharing policy. Using the LIBEMOD model, we have analysed which CO_2 taxes will be required in 2010 in Western Europe to achieve the Kyoto targets. If every country introduced its own national CO_2 tax to achieve its own targets, their average CO_2 tax rate would be USD 50 (price level relative to 2000) per tonne CO_2.

The tax would vary widely across countries, from USD 36 per tonne CO_2 in Greece and Ireland to as much as USD 164 per tonne CO_2 in Norway. One alternative is to introduce a flat CO_2 tax rate for all of Western Europe that is high enough to achieve the overall emission reduction for all the countries involved. Some countries would then reduce their CO_2 emissions more than their national targets would indicate, while other countries would reduce their emissions less. This mechanism is referred to as joint implementation. The flat tax rate in this case would be USD 44 per tonne CO_2.

Another alternative is joint implementation for industry and power production, while national taxes ensure reductions in other emissions. The CO_2 tax would then be USD 34 per tonne CO_2 for industry and power production, while the average national tax rate on other CO_2 emissions would be USD 165 per tonne CO_2, with very wide variations across countries.

The Kyoto targets could also be achieved by taxing energy use at a flat rate, not according to the emissions generated by use, but according to the energy content (measured in tonnes of petroleum equivalents, toe). With joint implementation, this strategy would require a tax of USD 163 per toe.

Cost-efficiency is important when deciding on policy. The different ways of achieving the Western Europe's Kyoto target involve widely differing costs. Joint implementation with a flat CO_2 tax is the cheapest alternative – the total cost for Western Europe is estimated at USD 44 billion in 2010, while national implementation results in a total cost of USD 48 billion. The hybrid policy of joint implementation for industry/power production and national implementation for other sectors would increase the cost to USD 87 billion. A joint energy tax would be the most expensive alternative, with a cost as high as USD 115 billion. The reason that the cost of introducing a joint energy tax would be so high is that CO_2 emissions per energy unit vary across different forms of energy use and production. In this system, the use of energy produced without CO_2 emissions would also be subject to the energy tax.

The EU aims to increase the use of renewable energy in electricity production, partly in order to increase security of energy supply. Renewable energy use is usually based on local and regional resources, whereas fossil fuels are largely imported from countries outside the EU. In the Renewables Directive (EU 2001), the target for the Western European EU members is for 22.1 per cent of electricity to be produced from renewable energy in 2010. By comparison, the actual share in 2000 was 17.5 per cent. Each EU member country also has a national target, and these summed together correspond to the overall target.

We use the LIBEMOD model to study the effects of using green certificates to achieve the target for 2010, assuming that Norway and Switzerland are included in this policy. In a system using green certificates, electricity producers that provide electricity defined as "green" receive tradable certificates for each unit electricity they produce. "Green" in this context is defined as electricity produced from renewable resources (hydropower, wind power, biopower etc.). The value of these tradable certificates is determined either by other electricity producers who must purchase a certain number of green certificates per unit of electricity they produce, or by electricity consumers who must purchase a certain amount of green certificates per unit of electricity they consume.

With national targets, the certificate price for renewable energy varies from USD 0 per MWh in Norway and Sweden, which achieve the target without supporting renewable technologies, to USD 35 per MWh in Belgium. Under joint implementation, where a common market for green certificates is established, the certificate price would be USD 10 per MWh. With national implementation, the overall cost of the green certificate system would be USD 1.019 billion in 2010, while joint implementation reduces the cost very substantially to USD 6 million. One reason for the low cost in this case is that development costs for renewable plants that are able to enter the market because of the green certificate system are not appreciably higher than for the power plants that would have been built without this kind of support policy.

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15.3. What opportunities will the EU have to exercise market power in the carbon market in a post-Kyoto regime?

Cathrine Hagem

The distribution of emission quotas between countries under the Kyoto Protocol means that some countries may become large sellers of emission units. This would allow them to make use of their market power to drive up the price of emission units. This is also a possibility in a post-Kyoto regime. A high carbon price is expensive for the EU countries, since they are expected to be net purchasers of emission units. A recent study looks at what opportunities the EU will have to act strategically in the carbon market by entering into a bilateral agreement with a potential new participant (China) in international cooperation on climate change.

Emissions from the developed countries (except for the US) are regulated under the Kyoto Protocol. Each developed country has been allocated a certain quantity of emission units, and countries can trade these freely between themselves. The EU has established its own emissions trading scheme, which applies to about 50 per cent of emissions from the EU member states. This means that there will not necessarily be any trading in Kyoto emission units during the commitment period 2008–2012. Eyckmans and Hagem (2008) consider a post-Kyoto agreement for the second commitment period 2013–2017, with no restrictions on international trading in Kyoto emission units. They assume that a new agreement would have more stringent emission commitments, and therefore reduce the overall emissions ceiling for the parties by 20 per cent.

The paper looks at a situation where the EU negotiates with China with the aim of persuading the latter to accept a binding emission commitment and join the emissions trading scheme (the possibility of meeting emission commitments by investing in emission-reduction projects in developing countries under the Clean Development Mechanism is not included in the calculations). A numerical model is used to simulate four different scenarios for the second commitment period:

1. Reference scenario. China does not participate. Competitive carbon market.
2. China does not participate. Non-competitive carbon market (Russia and Ukraine are dominant sellers).
3. China participates. Non-competitive carbon market (Russia, Ukraine and China are dominant sellers).
4. China participates. Non-competitive carbon market (Russia and Ukraine are dominant sellers). Bilateral agreement between China and the EU.

Eyckmans and Hagem (2008) give a description of the numerical model and detailed tables showing the outcomes of the four different scenarios. Table 15.1 summarises prices of emission units and the costs of participation in the agreement for each of them.

Table 15.1: **Price of emission units (USD/tonne CO_2) and annual costs (abatement costs + net costs of purchasing emission units, in million USD) for the different scenarios**

Scenario	(1)	(2)	(3)	(4)
Price of emission units	33	41	28	20
Costs EU	32 338	36 234	29 421	24 901
Russia + Ukraine	-24 218	-31 032	-15 721	-8 591
China	-	-	-17 491	-17 491
Rest of Annex B[1]	31 903	37 718	28 237	21 308
Total	40 022	42 919	24 447	20 126

[1] Rest of Annex B means other countries that were assigned emission commitments under the Kyoto Protocol (excluding the US).

Weyant and Hill (1999) and Weyant (1999) showed that Russia and Ukraine could become large sellers of emission units during the first Kyoto commitment period. Eyckmans and Hagem (2008) showed that this would also be the case for the period 2013–2017 if the emissions are capped as described above. This would allow Russia and Ukraine to exercise their market power in the carbon market and increase their revenues by limiting their sales of emission units. Comparing the figures for scenarios (1) and (2) in Table 15.1 shows the effect of such strategic behaviour by Russia and Ukraine. The price of emission units is pushed up to 25 per cent higher than in the competitive carbon market in scenario (1) rising from USD 33 to 41 per tonne. Russia's and Ukraine's profits rise as a result of the higher price of emission units, and costs for the EU and the total global costs also rise. The global costs rise because emission abatement is not cost effective at global level – emissions are cut more in the EU and less in Russia and Ukraine than the optimal levels.

Scenario (3) assumes that to persuade China to join the agreement, its emissions allocation must correspond to the business-as-usual level (i.e. the projected level of emissions if the country does not participate). Thus, China's participation does not have any effect on global emissions, but reduces the overall costs, since there are many low-cost abatement options in China. However, China would be such a large seller that it would also benefit by behaving strategically and limiting sales of emission units to push up the price of emission units. Nevertheless, with China as a net seller, the price of emission units will be lower than in a scenario where China does not take part in emissions trading. In Table 15.1, China's participation results in a drop in the price of emission units to USD 28 per tonne. This benefits the EU, but not the other large sellers in the market, Russia and Ukraine. The total global costs drop considerably (from USD 43 billion to USD 24 billion).

In scenario (4), the EU enters into a bilateral agreement with China that specifies a minimum level for China's sales of emission units. Thus, the EU can influence the carbon market through the design of the agreement with China, even though individual EU countries have to pay the market price when purchasing emission units. China has to be compensated for accepting an agreement that sets a minimum level of sales, and the level of compensation must be set just high enough to ensure that the country does not lose financially by joining the agreement. The EU sets the minimum sales requirement at a level that will minimise the costs incurred by the EU countries in meeting their Kyoto commitments, but still ensures that the level of compensation is just high enough to be acceptable to China. This means that the EU requires China to sell a considerably larger number of emission units than it would do otherwise (as in scenario (3), where there is no bilateral agreement).

Since China receives financial compensation, its net result remains unchanged (USD 17 billion). The EU gains more from the lower price of emission units than it loses by making the necessary financial transfer to China. A lower carbon price means that the EU countries buy more emission units and therefore do not need to make use of the most expensive emission abatement options. The bilateral agreement reduces the costs to the EU by almost USD 5 billion per year. Russia and Ukraine lose substantially under the bilateral agreement, but their annual sales revenues are still almost USD 9 billion, so that they have no incentive to withdraw from the Kyoto Protocol.

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15.4. Allocation of greenhouse gas emission allowances free of charge (grandfathering)

Halvor Briseid Storrøsten

There is growing concern internationally about climate change caused by greenhouse gas emissions. As a result, there is more and more interest in various approaches to limiting emissions, for example by establishing an emissions trading market. A new study analyses an emissions trading system with updated grandfathering, which means that firms are allocated a share of their emissions allowances free of charge, in proportion to their greenhouse gas emissions in a base year that is updated at regular intervals. The conclusion is that a system of this kind does not necessarily encourage higher production and emissions than auctioning all the emission allowances.

A free market cannot normally provide sufficient incentives to make polluting firms limit their greenhouse gas emissions. This is because a polluter rarely considers damage caused to others. For example, it would be naive to assume that the owners of a coal-fired power plant in Europe will take into account the adverse impact the plant may have on the population of Bangladesh through its contribution to the enhanced greenhouse effect. Since greenhouse gas emissions will be very high in a market economy that does not put a price on emissions, and there is general agreement that this is harmful (see for example IPCC 2007), government and international regulation of such emissions is needed.

There are two main categories of environmental policy instruments available to public authorities: those that create economic incentives, and those that are based on direct control and regulation. The first category includes tradable emissions units and environmental taxes, while the second includes emission ceilings for specific firms and requirements to use clean production technology. Economists often support the use of the first category of instruments, since they are generally cost effective. An environmental policy instrument that is cost effective induces the maximum reduction in greenhouse gas emissions given the resources countries are willing to use on emissions abatement.

In a system of tradable emission allowances, there is a ceiling or cap on total greenhouse gas emissions. Firms and other actors in the market are then required to hold emission allowances corresponding to the volume of their emissions. The allowances can be traded in a market. This system allows actors whose abatement costs will be high to buy allowances from other actors whose abatement costs are lower. It is this mechanism that makes an emissions trading scheme cost effective.

The EU Emissions Trading Scheme is an important example of such a system. Emissions trading under this scheme started in 2005. At the moment it applies to about half of the EU countries' CO_2 emissions. Until now, most of the EU emission allowances have been allocated to firms free of charge on the basis of historical emissions (grandfathering). New firms are allocated emission allowances on the basis of expected production levels and specified emission standards. Firms that reduce production levels risk a reduction in the number of allowances allocated free of charge in the future. In practice, this system rewards emissions and is not in line with the polluter-pays principle. Auctioning allowances, on the other hand, does not reward emissions. Another important argument for auctioning emission allowances is that this brings in revenues that can for example be used to reduce other distortionary taxes. So why has the EU chosen to allocate allowances free of charge? One important reason is probably concern that competitively exposed and emission-intensive industries will relocate abroad, causing carbon leakage.

A new study analyses a system of emissions trading with updated grandfathering, which means that firms are allocated emissions allowances free of charge in proportion to their emissions in a base year that is updated at regular intervals. For example, allowances could be allocated free of charge in 2008 on the basis of emissions in 2005. Emissions in 2006 would then be used as the basis for allocating allowances free of charge in 2009, and so on. In the study, the effects of this system are compared with ordinary auctioning of allowances and with a system of grandfathering using a fixed base year. In the latter case, firms cannot influence the quantity of grandfathered allowances they receive in later years. This system has been used to reduce acid rain in the US.

If firms can increase the number of grandfathered allowances they receive in the future by increasing their emissions today, we might expect both emissions and production to increase. In this case, the system would reduce carbon leakage. However, the analysis indicates that updated grandfathering does not result in different levels of production and emissions from auctioning alone, if there is a binding emissions ceiling. Updated grandfathering means that each firm in isolation would benefit from increasing its emissions. However, the overall ceiling on emissions means that the industry as a whole cannot increase its emissions. As a result, bidding in the market drives the carbon price upwards until it is equal to the firms' marginal abatement costs plus the current value of future grandfathered allowances. The production and emission levels therefore remain unchanged.

Moreover, the study shows that allocating allowances by updated grandfathering does not make it more profitable to establish a new firm than if they are allocated by grandfathering using a fixed base year or by auctioning all the allowances. It is worth noting that this is true even though updated grandfathering means that after some time, new firms will receive allowances free of charge. Nor do the results indicate that fewer firms will close down. This is perhaps unexpected, since firms that close down will lose their free allocation of allowances after a certain length of time. These results are driven by the previously mentioned increase in the carbon price. In a system with updated grandfathering, new firms pay a higher initial price for emission allowances (in the period before they receive grandfathered allowances), but after this their costs are lower. Similarly, a firm that closes down receives more valuable allowances, but for a shorter period, than under a system using a fixed base year. It can be shown in both cases that these two effects cancel each other out. However, if the emission ceiling is set too high, so that it has no binding effect in practice, emissions will rise if updated grandfathering is introduced.

The value of grandfathered allowances represents an income transfer to the firms that receive them. How should these transfers be distributed? In this connection, there are two important problems related to grandfathering with a fixed base year. Firstly, it may seem unfair to reward historical pollution by allocating valuable emission allowances, particularly to firms that have closed down. Secondly, the system results in undesirable discrimination between old and new firms. Can updated grandfathering resolve this problem, since new firms also receive grandfathered allowances after the initial period? The analysis concludes that updating the base year will not reduce the differential treatment of old and new firms. It also shows that it is possible to devise an allocation rule that makes the value of the grandfathered allowances allocated to each firm equal in the two regimes.

The results indicate that updated grandfathering is not a particularly appropriate approach if the goal is to limit carbon leakage or prevent discrimination between old and new firms.

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15.5. The Clean Development Mechanism: does afforestation both mitigate climate change and reduce poverty?

Solveig Glomsrød

Norway and other parties with emission commitments under the Kyoto Protocol can earn certified emission reduction credits (CERs) for projects carried out in developing countries. A study of a tree-planting project in Tanzania shows that its effects on both the carbon balance and income distribution vary considerably depending on whether it is farmers, wealthy urban landowners or the government who host the project and receive payment for the CERs generated. Projects hosted by foreign investors do not appear to reduce poverty, enhance growth or result in extra carbon sequestration in soil.

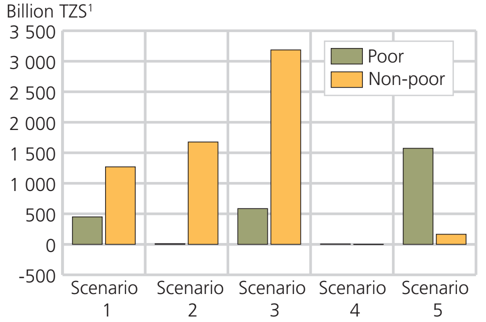
The Kyoto Protocol provides for countries that have undertaken to reduce their emissions to meet part of their commitments by purchasing certified emission reduction credits (CERs) from developing countries that do not have commitments. This is known as the Clean Development Mechanism (CDM) and, in addition to emissions reduction, its purpose is to assist developing countries to achieve sustainable development. Sustainability includes poverty reduction, and an important question is to what extent CDM projects designed to mitigate climate change also reduce poverty. To illustrate this, a recent study (Glomsrød et al. 2008) analyses the economy-wide impacts of a tree-planting CDM project in Tanzania. The study focused on the effects on income distribution and the net impact on the carbon balance when ripple effects on the economy are taken into account using a general equilibrium model that captures the effects of income growth and price changes on supply and demand in various markets.

Afforestation projects can be used in climate change mitigation because trees take up carbon from the atmosphere during growth. Afforestation projects in countries that do not have Kyoto emission commitments can therefore be used by countries with emission-reduction commitments to earn CERs. When a project is carried out, payment for CERs flows from abroad as the plantation accumulates carbon. In this study, the carbon price was set at USD 30 per tonne carbon (C), corresponding to USD 8 per tonne carbon dioxide (CO_2).

The project host and recipient of payment for the CERs could be groups of farmers, urban landowners or the government of the host country, or foreign investors. This analysis is a sensitivity study of five different scenarios, in which different actors host the project. The effects of the project on Tanzania's gross domestic product (GDP) and on the income of three groups of urban households and three groups of rural households are calculated for each scenario.

Even though the CDM project itself is identical in all scenarios, the growth impulses from the project to the rest of the economy vary because the hosts use the income from the project in different ways. For example, poor households use more of the extra income on food, while wealthier households consume a larger proportion of imported goods.

Figure 15.1 **Income growth for poor and non-poor households**



[1] Tanzanian shilling.

The effect of the growth impulses from the project on agricultural productivity and capacity to sequester carbon in soil vary from one scenario to another. The study includes calculations of the increase in carbon sequestration in soil with increasingly intensive farming. As the yield per unit area rises, a larger quantity of carbon from roots and other plant residues is available for uptake in soil. This happens without any payment to farmers for carbon sequestration. Their decision to change farming practices is based on shifts in demand and prices.

In scenario 1, we assume that all farmers participate in tree-planting projects and receive payment in proportion to their share of the land. In scenario 2, the project is hosted by wealthy urban landowners, while in scenario 3 it is under government ownership. In scenario 4, foreign investors own the project, while in scenario 5, in contrast, the project is run as a community project by the poorest segments of the rural population. In scenario 3, the profits from the plantation are used to increase the level of investment. In all other scenarios, the level of investment is kept constant.

Figure 15.1 shows income growth for poor and non-poor households for the country as a whole. Poor households include all those under the basic need poverty line, including those who are also under the food poverty line.

Scenario 4, in which foreign investors take the profits out of the country, results in no income growth either for the poor or for the non-poor. The costs of establishing plantations are so low that they have no effect on Tanzania's economy. Both scenario 1, where farmers host the project, and scenario 3, with the government as host, result in a small growth in income for the poorest households. However, their income growth is much smaller than the value of the direct carbon payments, and the non-poor benefit considerably more from the project. This shows that the flow of carbon payments is not in itself a good indicator of poverty reduction. In scenario 3, where the government hosts the project and invests the profits, the total growth in income is about three times larger than the value of the carbon payments. The inflow of carbon payments to the economy also influences the exchange rate, and imported investment goods become cheaper. This contributes to the higher growth in scenario 3.

The poor benefit most if they run the project on a community basis and thus receive the carbon payments (scenario 5). However, growth in their income does little to stimulate the rest of the economy, and total income increases considerably less than if the government owns the project and invests the profits.

Table 15.2 **Carbon sequestration in soil. 2001–2021. Million tonnes**

	Scenario				
	1	2	3	4	5
Total	25.9	22.7	31.1	14.2	26.6
Plantation	14.1	14.1	14.1	14.1	14.1
Agricultural soil	11.8	8.6	17.0	0.1	12.5
Ratio of soil to plantation sequestration	0.84	0.61	1.20	0	0.88

The study also shows that different ways of organising the CDM project have a major impact on its overall effect on the carbon balance. Table 15.2 shows the effect of the different scenarios on carbon sequestration in soil. It can be seen that when the project is under Tanzanian ownership, additional carbon sequestration in agricultural soil is 61–120 per cent of that achieved by the tree-planting project itself, without any form of carbon payment to the agricultural sector. A project under foreign ownership has no such additional effect, because the profits are transferred out of the country and do not stimulate demand that results in greater productivity and carbon sequestration in agricultural soil.

On the basis of this study of a CDM tree-planting project, it can be concluded that the value of carbon payments is a poor indicator of the capacity of a project to generate growth measured in terms of GDP. Calculations show that some scenarios result in growth in GDP that is three times as high as the value of the carbon payments, while others do not stimulate economic growth at all. Furthermore, it appears that if the poor are to receive more of the income from such projects, they must also own and run the projects. Government-run projects that use carbon payments to increase investments have more effect on rural development, but do not benefit the poorest groups of the population to any great extent. The extent to which agriculture is stimulated via the market is very important for the effect of the project on income growth and income distribution, and also for its net carbon effect. A project under foreign ownership does not make any contribution to economic growth or carbon sequestration beyond what takes place in the plantation itself.

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15.6. Where should cuts be made in greenhouse gas emissions?

Annegrete Bruvoll

Most countries throughout the world agree that greenhouse gas emissions must be reduced. However, it is not easy to agree on which countries should reduce their emissions, by how much, and who should pay. The developing countries feel it is unreasonable to expect them to accept large abatement costs that will slow their economic growth. But cost effectiveness and distribution of costs are two different issues – it is possible to cut emissions mainly in developing countries but ensure that the developed countries cover most of the costs.

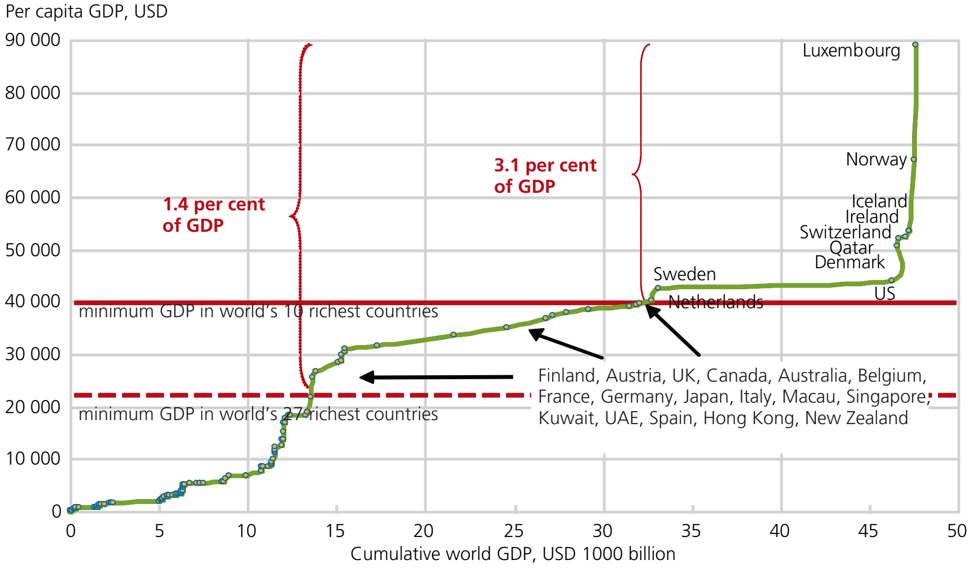
It has proved difficult to persuade the developing countries to join binding agreements on climate change. Poor countries have much more immediate problems to deal with than long-term global warming, although they are expected to be hardest hit by climate change in the long term. The developing countries also consider that it is largely up to the developed countries to deal with the problem, since the accumulated greenhouse gas concentration so far is a result of growth in the rich part of the world.

As a result, not much progress has been made towards a truly global agreement. The current Kyoto Protocol only applies to about one third of global emissions, and the emission targets for these sources of emissions are not strict enough to have much influence on global warming.

On the other hand, it is not rational to devote large amounts of funding to reducing emissions from rich countries, when the effect on emissions is generally much smaller for a given sum than in developing countries. The principles of global cost effectiveness are considered more closely in Bruvoll (2008). This means cutting emissions in the parts of the world where the costs of doing so are lowest. Various studies have attempted to rank emissions according to the costs of reduction. Although there are some very low-cost options for reducing emissions in rich countries, most of them are in developing countries. The technologies in use in these countries are less effective, and there is greater potential both energy efficiency measures and for emissions abatement. In Norway, where an active energy and environmental policy has been followed for several decades (the CO_2 tax has been in use since 1991, for instance), most low-cost large-scale measures to reduce emissions have already been implemented. During the shift from an unregulated economy to one with more extensive environmental regulation, there will be many low-cost abatement options, which will gradually become more limited. By carrying out the cheapest measures globally, it is possible to achieve far more for the same level of investment than by focusing too strongly on domestic measures.

According to the Stern Review, the annual costs of limiting global warming to 3°C will be around one per cent of global GDP. This estimate is based on the assumption that the measures implemented are cost effective, in other words that the lowest-cost measures are carried out. One way of covering these costs is for each country to contribute one per cent of its GDP.

Figure 15.2. **Per capita GDP in USD and cumulative total world GDP in USD 1000 billion. Reductions in GDP if all climate-related costs (one per cent of world GDP) are split between the richest countries**



Sources: World Bank (2006 figures) and Statistics Norway.

In Figure 15.2, countries are ranked by income (per capita GDP), with the richest countries furthest to the right. The cumulative total GDP is shown along the horizontal axis, and this shows that total world GDP is about USD 48 000 billion. Average per capita GDP for the world as a whole is about USD 7 500, and the average for the OECD countries is about USD 22 000. The GDP of the world's 10 richest countries, in other words those where per capita GDP is highest, corresponds to 32 per cent of total world GDP. Per capita GDP in all these countries is more than USD 40 0000.

The next step is to consider a situation where the 10 richest countries fund all the measures needed to limit global warming to 3°C. If they all pay the same proportion of their GDP to make up the equivalent of one per cent of world GDP, these 10 countries would have to contribute 3.1 per cent of their GDP (and all other countries would pay nothing). Another option is to include all countries that are richer than the OECD average (per capita GDP more than USD 22 000), which means the 27 richest countries in the world. These countries would have to contribute 1.4 per cent of their GDP to climate-related measures.

These figures show that there is a difference of less than ½ per cent of GDP in the burden on these 27 countries if they accept the entire burden, rather than all countries contributing the same proportion (1 per cent) of GDP. The IEA (2006) estimates that average economic growth in the OECD countries in the period up to 2030 will be 2.2 per cent per year. In other words, there is a prospect of net economic growth in the richest group of countries even if they accept the entire global economic burden for reducing greenhouse gas emissions.

These calculations are valid in the short term. Economic growth is projected to be much higher in developing than in developed countries in the decades ahead. Annual growth in non-OECD countries is estimated at 3.9 per cent. The developed countries will therefore account for a steadily decreasing proportion of the world economy, so that the developing countries would have to pay considerably larger sums in a few decades time to maintain their contributions at 1 per cent of world GDP. On the other hand, it will be reasonable to expect developing countries to pay more as more and more of them are lifted out of poverty.

These examples illustrate the scale of income disparities in the world, and why the developing countries are so insistent that developed countries must accept most of the costs of reducing emissions. The poor countries have moral, economic and strategic reasons for avoiding binding agreements. The estimates used here are uncertain, the situation will change over time, and the costs will be heavily dependent on the how much global warming the world community ultimately decides to accept. Nevertheless, the examples illustrate that initially, it would be quite possible for a limited number of the richest countries in the world to fund most of the costs of reducing global emissions. The international negotiations have also shown that it is difficult to persuade large countries with high levels of emissions, such as the US and Australia, to join binding agreements. Nevertheless, it may be easier to reach agreement in negotiations between a group of 10-20 countries than among 200 countries.

Norway's emissions are so small – only 0.1 per cent of global emissions – that nothing the country does will have any noticeable effect on global warming. On the other hand, the country is so rich, accounting for almost 1 per cent of global GDP, that it is possible to make a real difference by using a proportion of this on cost-effective measures in other countries. To maximise the emission reductions achieved for a given level of investment, emission cuts should as far as possible be made abroad rather than in Norway. How much funding should be provided is a political question, and basically weighing up whether private and public consumption or future pensions should be reduced.

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15.7. Norway's complicated climate and energy policy

Annegrete Bruvoll and Hanne Marit Dalen

Standard economic theory offers clear advice on how to achieve cost efficiency. Only one instrument should be used per goal, irrespective of whether the goals are related to greenhouse gas emissions, local environmental damage or distributional effects across groups in society. However, in climate and energy policy, there are many more instruments in use than there are goals, and the political approach taken in practice differs considerably from that recommended by economic theory to achieve cost efficiency. Industrial and district policy prove to play an important role in the design of climate and energy policy, and result in a high degree of differentiation in instruments depending on which polluter is targeted.

Statistics Norway is carrying out a project called "Multiple Instruments", funded by the Research Council of Norway, which is looking at how closely the current use of climate and energy policy instruments is in line with recommendations derived from economic theory, the theoretical consequences of deviations from such recommendations, and the empirical importance of these consequences.

In a theoretical review of various systems of taxes on emissions and subsidies for alternative energy systems, Bye and Bruvoll (2008) show that emissions trading and green and white certificates all function as a combination of taxes and subsidies. Such complex systems obscure cost efficiency and distributional effects, because the weighting of taxation and subsidy elements in each instrument and in the overall set of instruments is unclear.

Bruvoll and Dalen (2008) review the range of instruments used in Norway's climate and energy policy, especially the CO_2 tax. This currently varies from zero to NOK 354 per tonne CO_2, depending on the source of the emissions. Figure 15.3 shows average CO_2 tax rates for different sectors and the shares of Norway's total emissions to which they apply. The sectors near the left-hand side of the figure are mainly those with high process emissions, which are exempt from the tax, and other sectors that use energy commodities that are not included in the taxation system. These sectors also use some transport oils and other energy commodities that are taxed, but the average tax level is low. Sectors that pay an average tax of around NOK 200 per tonne CO_2 include domestic shipping and land transport. These use substantial amounts of autodiesel and marine transport oils, which are taxed at about this rate. The average tax rate for households is almost NOK 300 per tonne CO_2. The main source of household emissions is petrol, but diesel, fuel oils and kerosene account for about one third of household emissions. The average tax paid by households is between the tax rates for these energy sources. The average CO_2 tax rate is highest for the extraction of crude oil and natural gas.

One consequence of this differentiated system is that the costs of emission abatement are higher than they would be if all sectors were treated equally. Instead of introducing emission abatement where costs are lowest, they are carried out at varying costs. From 2006, the Norwegian emissions trading scheme was expanded and linked to the EU scheme (EU ETS). In a system with freely transferable allowances, the marginal cost for the sectors that are included (including those marked A, B, C and D in Figure 15.3) will be the same as the price of emission allowances. This makes climate policy more effective – the prices of emission abatement become cost-effective for more and more sectors.

Differentiation of the CO_2 tax has major distributional effects. Comparing the existing system with a cost-effective system where all emissions are priced at the same level, corresponding to a price of NOK 200 per tonne CO_2 for emission allowances, shows that households pay an excess amount of about NOK 0.5 billion through the CO_2 tax on petrol. The oil and gas extraction sector pays an excess amount of about NOK 1.5 billion. Altogether, these sectors together with various other sectors whose petrol consumption is relatively high pay NOK 2.1 billion more in CO_2 tax than they should in a cost-effective system based on the current carbon price in the EU ETS market.

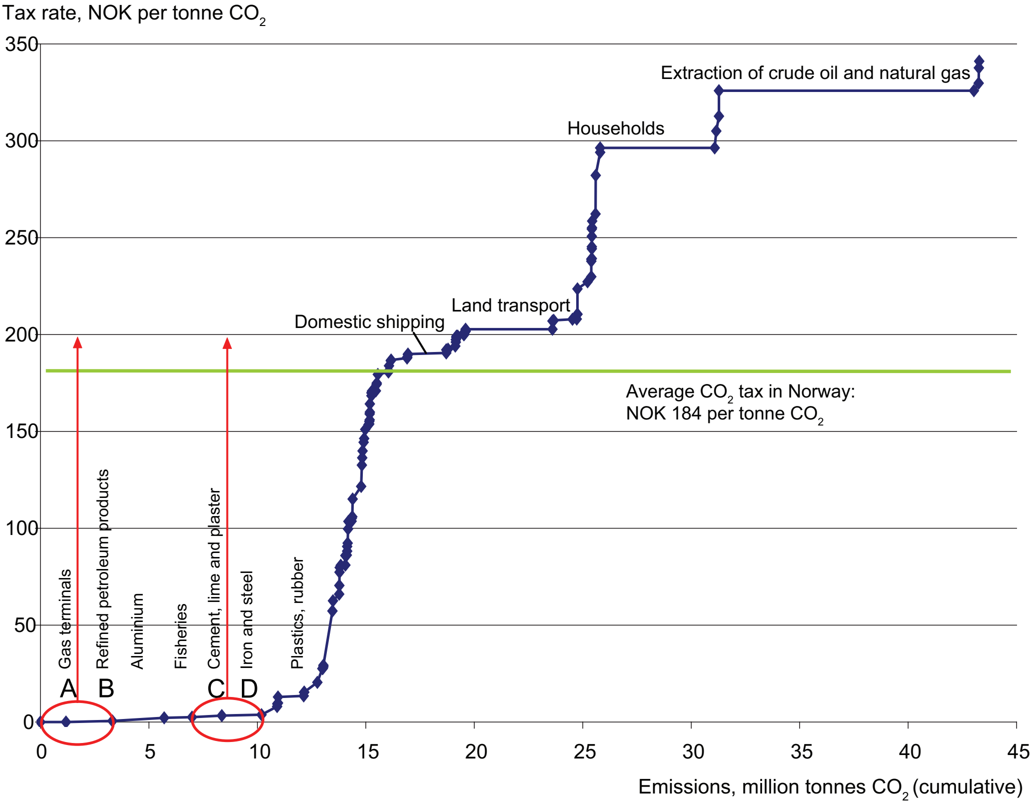
In contrast, the other polluters in the process industry, together with the transport sector, gas terminals, oil refineries, and the fisheries sector, pay NOK 2.8 billion less than they should on the basis of a price of NOK 200 per tonne CO_2. The polluter-pays principle is not being applied to these sectors. They receive indirect support in the form of tax exemptions, a reduced CO_2 tax rate and allocation of emission allowances free of charge.

The review of policy instruments also shows that in practice, Norway's climate and energy policy otherwise is designed to bring in tax revenues and to support specific sectors and regions. It is for example difficult to find environmental grounds for the electricity tax and the basic tax on fuel oil. The extensive exemptions from both environmental taxes and fiscal charges are made for regional policy reasons. In addition, the efficiency of the policy instruments used is weakened by the fact that other sectors are regulated more strictly than the optimal level in economic terms. Subsidies for alternative energy sources are largely designed to achieve the same goals as environmental taxes, but are less effective.

According to the polluter-pays principle, emissions should be paid for through taxes or by buying emission allowances. Under a cost-effective policy, all greenhouse gas emissions should be taxed equally, and fiscal electricity and fuel oil charges should apply only to final use and should also be equal.

Competition rules within the European Economic Area may be one reason why climate policy is indirectly used to support certain industries. However, there are many openings within EEA legislation that make it possible to provide support for maintaining settlement patterns and developing infrastructure. Direct transfers of this kind are much more precisely targeted than for example indirect subsidies to firms with large CO_2 emissions or to households in North Norway, whose electricity consumption is highest. Price support through tax reductions and exemptions obscures priorities and the extent of the support, whereas direct transfers make the political priorities clear. Reorganisation of Norway's policy in this way would make it more efficient and free more funding for distribution. This would make it possible to use funding and other resources for other purposes. The

Figure 15.3. **CO_2 tax: average rate and rate by sector. NOK per tonne CO_2, 2006**



size of this potential is an empirical question that will be further studied as part of the project.

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15.8. Differentiation of R&D subsidies when carbon emissions are restricted

Brita Bye and Karl Jacobsen

Technological developments will play an important role in reducing future greenhouse gas emissions. Stimulating research and development (R&D) may be a way of spurring technological developments. This ongoing study analyses whether government support for environmental technology should be different from support for general R&D. The results indicate that subsidising general technological developments provides greater economic welfare gains than subsidising environmental technology developments. The difference in welfare gains between the two types of subsidy is reduced if the carbon tax is increased.

The environmental damage caused by carbon emissions is not normally taken into account in market prices for emission-intensive goods and services. This is a market failure, and according to economic theory, market failures can be corrected using political instruments. Examples of instruments to correct market failure related to environmental damage caused by emissions are emission taxes or carbon pricing. These tools enable us to present operators with socially correct prices, i.e. prices as they would be if environmental damage were to be priced in.

Market failure can also affect the R&D market. One source of market failure in the R&D market is the positive effect R&D activities have on other companies from the dissemination and accumulation of knowledge. The additional gain to society of knowledge accumulation from R&D activities is not taken into account by R&D firms. As a result, the level of research conducted by R&D firms is too low in relation to what is socially desirable. This market failing can be corrected using subsidies, raising the level of research to the desired level, i.e. the level that would result if R&D firms took account of the additional gain of knowledge accumulation.

Thus, according to economic theory, emission taxes or carbon pricing should be used to correct market failure related to pollutants, while R&D subsidies should be used to correct market failure in the R&D market. The optimal support for the various R&D markets will depend on the magnitude of the market failure in these markets. If there is a difference in the scale of market failure between general R&D and environmental technology R&D, government support to these R&D markets should also differ.

However, increased pollution costs, in the form of higher carbon taxes, will affect market failure in the R&D market as the level of accumulated knowledge in the economy, which determines the degree of market failure in R&D markets, changes with pollution costs. One example of this is the increase in demand for environmental technology when the carbon tax rises. This in turn affects market failure in the R&D market for environmental technology. This study examines the impact on economic welfare of different systems for subsidising general and environment-related R&D combined with different levels of carbon taxation. In our model, economic welfare is defined by levels of consumption.

The model is a macroeconomic model for the Norwegian economy showing two R&D sectors that contribute to economic growth. One of the sectors generates general knowledge that benefits more or less the whole economy in the form of increased productivity. The other develops climate-friendly technology, exemplified by technology for capture and storage of CO_2 from gas power plants. The productivity effect of increased knowledge capital is assumed to be positive, but declining. In our analysis, pollution costs are represented by a constant carbon tax.

A higher level of carbon taxation leads to lower production in emission-intensive industries. The demand for labour and other resources is reduced, and prices for these factors fall. As a result, production costs for the relatively more labour-intensive R&D sectors are reduced and R&D production rises. The degree of market failure in R&D markets changes, in turn changing the optimal subsidies for R&D. In addition, optimal subsidies change relative to one another. Preliminary results from simulations on the numerical general equilibrium model indicate that government subsidies for the two types of R&D should not be the same. R&D subsidies should be differentiated in favour of general R&D. A high carbon tax reduces the gain from differentiating subsidies in favour of general R&D, showing that the level of carbon taxation affects market failure related to knowledge accumulation differently in the two R&D markets.

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15.9. Which petroleum sector tax rate provides the highest revenues for Norway?

Lars Lindholt

In this study, we discuss which tax rate maximises government petroleum revenues from the Norwegian continental shelf. A robust conclusion seems to be that a reduction in the current tax level will not boost production and investment to the extent that government revenues will increase. This result holds even if the price of oil should fall to USD 20 per barrel.

Norway is often described as a mature oil province, with falling production and fewer and smaller discoveries. Oil prices have risen from USD 28 per barrel in 2003 to about USD 72 in 2007 and have continued to rise in 2008. As late as 2003, some segments of the petroleum sector argued for a reduction in the Norwegian petroleum revenue tax from 50 to 25 per cent, which is charged in addition to corporate tax of 28 per cent. This will result in a tax reduction from 78 to 53 per cent. The return on investment was claimed to be too low, particularly in smaller fields.

Criticism of the Norwegian tax system has abated in pace with rising oil prices. Nonetheless, a number of studies assert that many oil provinces are experiencing falling production and a reduction in exploration because tax systems to stimulate activity have not been introduced. In this study (Lindholt 2008), we discuss which tax rate maximises the government's discounted petroleum revenues in Norway.

A partial equilibrium model for the global oil market, FRISBEE, has been used in the study. Oil companies make their investment and production decisions based on profitability assessments and detailed knowledge about global oil fields. Producers can either invest in new fields or in increased production in existing fields. Since investment is primarily focused on the most profitable reserves, activities are spread geographically. Oil companies gradually focus their investment on less profitable reserves, leading to higher costs as the reserves are developed. On the other hand, new discoveries and technological advances result in lower costs.

We focus on Norway and study how different tax rates affect company earnings and thereby their future investment and production on the Norwegian shelf in the period to 2030. On the basis of these scenarios, we derive the tax rate that provides the highest discounted government revenues over the period. The calculations are based on oil prices of USD 20, USD 40, USD 60 and USD 80 per barrel.

The results show that a tax reduction does not in any scenario lead to an increase in production that is large enough (and early enough) to provide higher tax revenues. Similarly, some increase in tax does not reduce production to the extent that tax revenues decrease. Under our assumptions, increasing the tax rate to 83-87 per cent is optimal over a range of oil prices, irrespective of how the government assesses revenues over time. However, a tax increase above this level will reduce production after a few years, resulting in a decline in discounted revenues.

When oil prices are high, a change in tax level has a relatively small and short-term effect on production and investment in new fields and in increased production in existing fields. A change in net oil prices after tax has little effect on investment volumes because when the level of activity is high, the additional costs of a change in investment are very high. When oil prices are low, there is more scope for a change in investment as the additional costs of this change are lower.

Even though higher taxes have a more permanent effect on investment when oil prices are low, it is important to remember that investment is scaled down from the first year and to a greater extent than production. This reduction in investment results in lower tax deductions due to lower rates for depreciation, uplift and interest expenses on invested capital. As a result, the tax base increases and offsets the negative effects of higher taxes on government revenues. This is why the optimal tax level is actually marginally higher when oil prices are low.

Even though criticism of the tax level has abated in pace with the rise in oil prices, we thus show that the optimal approach is in fact to raise the tax level, even if oil prices should fall to USD 20 per barrel. In addition, our results show that the optimal tax level is marginally higher when the government sets a high discount rate, i.e. when greater emphasis is placed on revenues in the near future than revenues further ahead. The reason for this is that higher taxes result in a somewhat higher tax level at the beginning of the period.

In order to avoid premature conclusions about the optimal tax level on the Norwegian continental shelf, we have conducted various sensitivity calculations, which all point towards a lower tax rate. We increase capital costs and reduce the volume of new discoveries. In addition, we expose oil companies to credit constraints, allow taxes to have a sharply negative effect on the discovery rate and increase the profitability of relocating production to other regions if Norway raises taxes. We also take into account that higher taxes reduce Norwegian oil companies' profits and thus total revenues from the continental shelf. According to these sensitivity calculations, it is less profitable for the government to increase taxes, although the rate should nonetheless not be set below the current 78 per cent.

Only in a scenario where capital costs double and assumptions regarding new discoveries are pessimistic, and where we also take into account Norwegian oil companies' profits, is the optimal tax rate 75-76 per cent, if the authorities also place some emphasis on revenues further ahead. A robust conclusion therefore seems to be that reducing the current tax level on the Norwegian continental shelf will not boost production and investment to the extent that government revenues will increase.

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15.10. Household electricity tariffs

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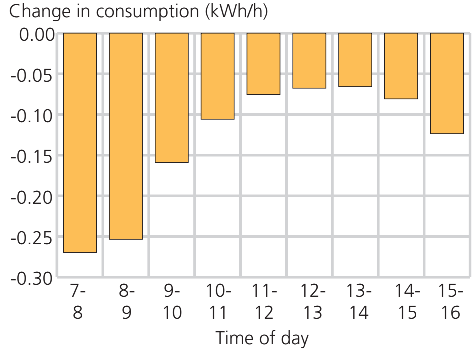
Recently there has been increased interest in electricity pricing methods that give more accurate signals to customers about the costs of their consumption to network companies and power suppliers. Some grid and production costs are due to very short-term peak demand. With a price system where customers do not pay only for their total consumption over long periods, but also for the highest maximum consumption in a period, more accurate price signals can be provided. So-called demand tariffs for these consumption peaks have so far been confined to manufacturing and the business sector. It may be of interest to offer these tariffs to households if the result is a reduction in household consumption peaks. We analyse households' response to a demand tariff using data from the grid company Istad Nett AS in Molde, which has offered this tariff to household customers since 2000. We find that customers reduce their consumption in all the peak demand hours, with a maximum reduction of 9 per cent. Consumption reductions might have been even higher if more information had been provided to consumers about their consumption and the costs involved in using electricity.

Traditionally, households have only paid for energy consumption, i.e. the total amount of electricity used in the course of for example one year, irrespective of time of use. However, a considerable share of the grid and production costs are not only determined by energy consumption, but also by maximum demand, or peak load in specific hours, as considerable investment is necessary in order to produce and transmit sufficient electricity in episodes of peak demand. Since there must always be sufficient grid and production capacity to meet the demand for electricity, the system must be dimensioned for the maximum consumption that may arise in a single hour during a cold period in winter, even if this only occurs occasionally. In order to avoid investing in costly capacity, the idea is to reduce consumption peaks by smoothing consumption. More accurate price signals to customers may be provided by introducing a so-called demand tariff for households. In this analysis, we study the potential effect of such a tariff on electricity consumption.

With a demand tariff, users pay for their peak consumption, i.e. the highest consumption per hour in a specified period, for example a month or a year. In other words, a price is paid for the maximum number of kilowatt hours used per hour (kWh/h). As this price may be very high, hundreds of kroner per kWh/h, there is a potentially strong incentive to reduce the highest peaks, which in Norway typically occur in periods of extremely low temperatures. As a result, electricity tariffs will to a greater extent reflect the actual cost structure. Demand tariffs have so far primarily been confined to business customers with higher consumption and greater opportunity to monitor and influence their electricity consumption since they have meters that are able to register maximum consumption. So far, demand tariffs have not been applied to household price systems in order to avoid complicated tariffs and because households do not normally have the necessary metering technology.

Figure 15.4. **Average reduction in consumption per consumer for hours demand tariff was in effect**



Source: Stokke et al. (2008)

A number of developments have led to renewed interest in demand tariffs as a method of regulating demand to bring it into line with costs. Cost awareness has increased in all production and service segments as a result of intensified competition. There is greater focus on the necessity of a price response on the demand side as a component of a well functioning electricity market. Without such a response, demand will in reality be completely inelastic. This may lead to extremely high prices during shortages and potentially greater problems related to market power in concentrated markets. It is also important to control consumption in order to reduce greenhouse gas emissions, and reduced consumption in Norway provides opportunities for exporting hydropower, which can replace fossil-fuelled power and CO_2 emissions in other countries. Last but not least, there has been a dramatic reduction in costs related to automatic meter technology and consumption control. Recent years' developments in metering technology have made it possible to apply a more accurately cost-based structure to both grid tariffs and power supply contracts within an acceptable administrative cost for customer and supplier.

Istad Nett AS introduced a demand tariff for its household customers in 2000. The demand tariff is charged in the hour with the highest consumption each month from December to February on weekdays between 07.00 and 16.00. This tariff is optional for customers using hourly metering technology. The advantage for the customer is a lower electricity bill if consumption peaks can be reduced.

We have analysed household data using Istad Nett's demand tariff in order to examine to what extent customers have attempted to avoid peaks in their consumption patterns. We have used a panel data regression model, which captures the average reduction in electricity consumption for each hour the tariff was in effect. By controlling for other variables that influence electricity use, such as spot price fluctuations, temperature, wind and daylight, the model isolates the effect of the tariff. We have used hourly data from about 450 consumers in 2006. Figure 15.4 shows the estimated average reductions in electricity consumption for each hour of the day.

The average reduction in consumption was highest from 07:00 to 08:00, at slightly more than 0.25 kWh/h, or approximately 9 per cent of average household demand in that hour. The reduction was lower in the middle of the day, but rose again in the afternoon, suggesting that it is easiest for consumers to reduce consumption when they are at home and consumption is highest, i.e. in the early morning and late afternoon.

When interpreting the results, it should be taken into account that the consumers in the survey chose this tariff voluntarily and that they therefore probably responded more strongly than a random consumer. On the other hand, it must also be taken into account that the consumers did not receive any information about their consumption patterns. In addition, the complicated structure of the demand tariff may have made it more difficult for the consumers to keep track of the financial consequences of their consumption peaks. For example, the bill for maximum consumption in the winter months was split up and spread over the year, which may have induced them to perceive price signals as weaker than they actually were. It is therefore also likely that reductions could be considerably higher if the actual price at a given time had been communicated to the consumer, for example by means of a small display, alarm, alarm lamp, etc.

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15.11. Macroeconomic modelling as a tool for energy and environmental analysis

Brita Bye

Norway has a long tradition of analysing energy, environmental and economic issues within a macroeconomic model framework. The development of energy and environmental statistics in the 1980s made it possible to develop Statistics Norway's macroeconomic equilibrium models further to include relatively detailed descriptions of energy production and use, which were in turn linked to emissions to air. These models have been used to make consistent projections of economic and environmental conditions and a number of environmental policy analyses over the past 20 years.

Norway has a long tradition of developing and using disaggregated multi-sectoral general equilibrium models, from as far back as the end of the 1950s when Leif Johansen developed the MSG model (Johansen 1960). This work has largely been carried out by Statistics Norway's research department. As a result of the establishment of energy and environmental statistics in the 1980s, energy and environmental modules were developed that were integrated into the core economic model. As a result, consistent analyses could be made of economic developments and energy and environmental conditions. The model system is also used by the Ministry of Finance in its long-term projections of the Norwegian economy. The Ministry's report entitled "Macroeconomic perspectives" (Ministry of Finance 2004) is an example.

The models have been used for a range of analyses of energy and environmental economic issues and policy measures over the past twenty years, see Alfsen et al. (1996) for early analyses and Bye (2008) for more recent analyses. In the past 15 years, the models have been particularly developed for use in analysing cost-efficient instruments such as carbon taxation and carbon quota systems to deal with the global climate change issue. Developing such integrated models and using them for projections and policy analyses increases economists' understanding of environmental policy and raises awareness in the environmental policy debate in general about the relationships between environmental policy and economics.

The latest version of Statistics Norway's general equilibrium model, MSG-6, was specially developed for energy and environmental policy analysis. The model specifies 60 goods, 40 industries and 19 consumer goods (goods and services) and provides a detailed description of energy and environmental policy instruments, other direct and indirect taxes, subsidies, transfers and public spending. Norway is modelled as a small, open economy with exogenous world market prices and interest rates. The representative consumer adapts his supply of labour and the ratio of saving to consumption to maximise welfare, given balanced developments in foreign assets in the long term. The model provides a detailed description of Norway's energy production, including extraction, production and export of oil and gas from the North Sea and the Barents Sea.

Emissions to air of 12 different components in the emissions module are linked to economic activity, such as the use of input factors, production and consumption at a detailed level. The MSG-6 model specifies the six greenhouse gases included in the Kyoto Protocol and six other components (sulphur dioxide SO_2, nitrogen oxides NO_X, carbon monoxide CO, volatile organic components NMVOC, ammonia NH_3 and particles ($PM_{2.5}$ and PM_{10})). The economic model is calibrated to data from the national accounts (NR). Quantifying of the various parameters in the economic model is based on sources such as NR and microdata about households and firms. The emissions module is calibrated to energy data from two different sources; NR (value terms at constant prices) and the energy accounts (physical units). These two data sources are linked together. In addition, emission data from environmental statistics is linked to energy data from NR.

In order to ensure that the integrated MSG-6 model provides an accurate description of the relationship between economic variables, energy use and production, and emissions to air, it is important that energy and emissions data in the different sets of statistics are based on the same sources and aggregation levels. If this is not the case, the estimated emission coefficients (based on both NR and the energy accounts) included in the emissions module in the MSG-6 model may deviate considerably from the actual emission coefficients taken from the environmental statistics. Projected emissions based on the MSG-6 model may then be misleading. The same will apply to emission effects of policy analyses conducted using the MSG-6 model.

In recent years, the integrated MSG-6 model has been used in particular to analyse the effects on economic efficiency of various climate policy instruments. Bye and Nyborg (2003) analysed effects on economic efficiency if Norway replaced its differentiated system for CO_2 taxes with a system with a uniform CO_2 tax, auctioned emission allowances or emission allowances allocated free of charge for all emission sources. The study shows that auctioning emission allowances for all emission sources results in economic efficiency gains, while the differentiated system is better than allocating all allowances free of charge because the latter results in a loss of public revenues that must be compensated by other taxes and thereby results in an economic efficiency loss. A number of other analyses have also been conducted, such as analyses of “green” tax reforms in which revenues from a higher CO_2 tax are used to reduce distortionary taxes, such as employers’ social security contributions, analyses of cross-border carbon leakage resulting from domestic carbon policy, and the effects of various emission trading systems and climate policy objectives.

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