Natural Resources and the Environment 2007. Norway

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Preface

Statistics Norway compiles statistics on important natural resources and environmental issues, and develops methods and models for analysing trends in the extraction and use of natural resources and changes in the state of the environment, focusing particularly on relationships between these factors and other socio-economic developments. The annual publication *Natural Resources and the Environment* gives an overview of this work.

An important objective is to ensure that this publication presents the environmental situation so that it can be readily understood while at the same time including considerable detail. Natural Resources and the Environment 2007 starts with a presentation of updated national indicators for sustainable development. This is followed by detailed descriptions of Norway's natural resources and various environmental problems, including both statistics and analyses. A separate section presents selected research projects.

Statistics Norway would like to thank the people and institutions who have supplied data for *Natural Resources and the Environment 2007*.

The publication was produced by the Division for Environmental Statistics, Department of Economic Statistics, with contributions from the Unit for Energy and Environmental Economics, the Unit for Petroleum and Environmental Economics and the Unit for Economic Growth and Efficiency, Research Department, and the Division for Primary Industry Statistics, Department of Industry Statistics. The 2007 edition was edited by Frode Brunvoll and Henning Høie. Alison Coulthard translated the Norwegian version into English.

Natural Resources and the Environment 2007 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 11 March 2008

Øystein Olsen

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1. Introduction

The state of the environment depends on a complex variety of biological and physical processes. Human pressures such as various types of pollution and the use of natural resources are having substantial adverse impacts on the environment in general and on our own surroundings. Even though technological advances have improved our ability to limit many of the negative effects of economic activity, economic growth and rising consumption are putting increasing pressure on natural resources and the environment. The management and use of the environment and natural resources occupies an important place in the public debate and frequently makes the headlines in the media.

Norway has established a set of indicators for sustainable development, which is intended as a tool for monitoring whether development is sustainable. Analyses of sustainability can result in a political response and in action being taken. A description of sustainability also includes important economic and social factors, demonstrating how important it is to consider natural resource and environmental issues in conjunction with economic and social developments.

An 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.

1.1. Structure and content of the report

This book starts with a presentation of Norway's national core set of indicators for sustainable development, which include indicators or key figures (see box 1.1) for the environment, the economy and social conditions. Part 2 describes the supply and use of natural resources, while Part 3 focuses on pollution and environmental problems. Part 4 presents Statistics Norway's environmental accounts, describing links between the economy and the environment, and describes environmental protection expenditure in industry in Norway. Part 5 presents results from selected environmental and resource-related projects in the Research Department of 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 and 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.

1.2. Indicators and priority areas of environmental policy

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 descriptions of phenomena and problems. Because they are simplified, they may illustrate some aspects of a phenomenon clearly, whereas others are not well described, and the indicators are not independent of each other. Often, several indicators are therefore used to describe a phenomenon. It is important that the indicators are 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 generally recognised way of structuring environmental indicators is the PSR model (Pressure-State-Response), which was developed by the OECD (e.g. OECD 1994, 1998, 2001a, 2005 and 2007). This has been further developed as the DPSIR framework, which includes the driving forces behind environmental pressures and the impacts of environmental change. This is used for example by the European Environment Agency (EEA).

- *Driving forces* These include population growth, economic activity, etc., which lead to
- *environmental Pressures* such as emissions to air and water and extraction of natural resources. These in turn result in changes in
- the *State of the environment* for example changes in water quality or air quality, which cause
- *environmental Impacts* such as fish mortality, adverse effects on human health, reduction in crop yields or species extinction. At some point, society can react by making a
- *Response* to environmental problems, e.g. a CO_2 tax, protection of areas, treatment of emissions. The response in turn results in changes in economic driving forces, environmental pressures and various aspects of the state of the environment.

The 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 and inventories are also important in efforts to link environmental statistics to economic models, analyses and projections.

In addition to the five OECD reports mentioned above, important international reports on environmental indicators and reports on environmental indicators for important sectors include the following: *EEA Signals 2004* (EEA 2004), *Transport and environment: on the way to a new common transport policy - TERM 2006* (EEA 2007), *Environmental pressure indicators for the EU (Eurostat 2001), A selection of environmental pressure indicators for the EU and acceding countries* (Eurostat 2004) and *Environmental indicators for agriculture* (OECD 2001b).

A set of indicators for transport was presented in the report *Samferdsel og miljø - Utvalgte indikatorer for samferdselssektoren* (Transport and environment - Selected indicators for the transport and communication sector) (Brunvoll et al. 2005).

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

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

A set of priority areas has been established in Norwegian environmental policy:

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 these. 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 of 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 2007 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

In the 20 years since the World Commission on Environment and Development published *Our Common Future*, Norway's greenhouse gas emissions have risen, we are slightly further from achieving the target for aid to poor countries, and biodiversity is still under threat from human activities. On the other hand, the acidification load has been reduced, and people are living longer and are better educated. We have little exact information on the impacts of hazardous substances. There are still many challenges to be dealt with.

The World Commission on Environment and Development presented its report *Our Common Future* in 1987. The report defines 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." To achieve sustainable development requires satisfactory progress in addressing all three pillars of sustainable development: economic, environmental and social.

The Ministry of Finance is responsible for coordinating the sustainable development effort in Norway. A new national strategy for sustainable development was drawn up in 2007 and presented in the 2008 National Budget. A set of indicators for sustainable development in Norway has been established as a tool for monitoring whether development is sustainable. Statistics Norway is responsible for updating the indicators. This chapter presents the indicator set that was in use in 2007.

Certain adjustments were made to the indicator set when it was presented in the National Budget 2008.

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

	Indicator	Policy area
1	Norwegian official development assistance as percentage of gross national income	International cooperation for sustainable development and combating poverty
2*	Imports from LDCs and other countries in Africa	
3	Norwegian emissions of greenhouse gases compared with the Kyoto target	Climate, ozone and long-range air pollution
4*	Percentage of Norway's land area where critical loads for acidification have been exceeded	
5	Bird population index - Population trends of nesting wild birds	Biodiversity and cultural heritage
6	Inland water bodies classified as "clearly not at risk"	
7	Coastal waters classified as "clearly not at risk"	
8	Standards of maintenance of protected buildings	
9	Energy use per unit GDP	Natural resources
10*	Spawning stock biomass and precautionary (Bpa) reference point for North-East Arctic cod	
11	Irreversible losses of biologically productive areas	
12	Potential exposure to hazardous substances	Hazardous chemicals
13	Net national income per capita, by sources of income	Sustainable economic and social development
14*	Non-petroleum saving	
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 percentage of population	
18	Life expectancy at birth	

* Indicator changed or replaced in the National Budget 2008, which was published after editing of this publication was completed.
Source: Report No. 1 (2007-2008) to the Storting.

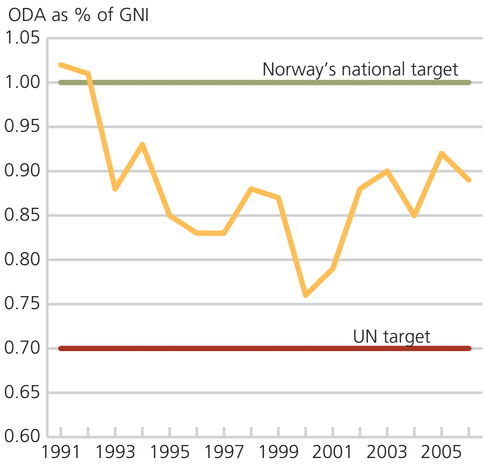
2.1. The set of indicators

International cooperation for sustainable development and combating poverty

Indicator 1. Norwegian official development assistance as percentage of gross national income

Norway is one of the world's richest countries. The quality of life in Norway and the other Nordic countries is higher than almost anywhere else in the world, as reflected by the Human Development Index published by the UN. However, in today's globalised world, there are strong arguments that the quality of a society should not be judged independently of the contribution it makes to solving global environmental and poverty problems (Barstad 2006).

Figure 2.1. Norwegian official development assistance as percentage of gross national income



Source: Norad and Statistics Norway.

- 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".
- In 2006, Norway contributed 0.89 per cent of GNI as official development assistance. Thus, Norway has not quite achieved its target, but ODA as a proportion of GNI is higher than in most other OECD countries. Norway's net development assistance rose from NOK 17.95 billion in 2005 to NOK 18.95 billion in 2006. In the same period, GNI rose from NOK 1 943 billion to NOK 2 134 billion. This means that GNI grew more strongly than development assistance.

Norad describes the goals of Norwegian development cooperation as follows:

- To combat poverty and contribute towards lasting improvements in living standards and quality of life, thus enhancing social and economic development and justice at national, regional and global level. Employment, health and education are of key importance.
- To promote peace, democracy and human rights.
- To promote responsible management and use of the global environment and biodiversity.
- To prevent and alleviate suffering caused by conflicts and natural disasters.
- To promote equal rights and opportunities for women and men in all areas of society.

The Center for Global Development has developed the Commitment to Development Index, which rates rich countries on the extent to which their policies help the poor countries of the world. It ranks 21 of the richest countries in the world and assesses their policies vis-à-vis poor countries in seven policy areas: aid, security, trade, environment, investment, migration and technology. In 2006, Norway was ranked fourth of the 21 countries by overall score (Center for Global Development 2007). It was ranked third as regards aid. It was pointed out that Norway gives a large amount of foreign aid as a share of its income (GNI), that the proportion of tied or partially tied aid is small, and that there is a large amount of private charitable giving. On the other hand, there tend to be many small aid projects, and this may overstretch the authorities in poor countries.

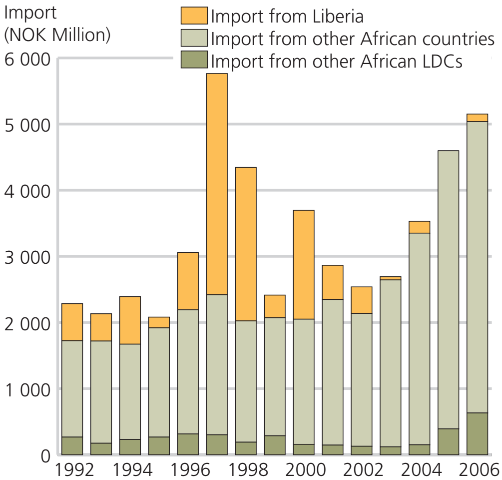
The methodology and the weighting of different factors in such an index can be criticised, but regardless of this, the index is valuable because it may inspire debate and draw attention to important policy areas.

Global poverty reduction: trade with LDCs

Indicator 2. Imports from LDCs and other countries in Africa

If we are to succeed in advancing global sustainable development, the most important tasks will be to resolve environmental problems and reduce poverty. The overriding objective of the UN Millennium Development Goals, adopted in 2000, is the reduction of global poverty. Calculations by the World Bank show that economic growth is vital for poverty reduction. One of the most important means of promoting economic development in developing countries is to give them the opportunity to sell their goods and services to developed countries on equal terms with other countries. Other important measures are economic and technical assistance to improve education systems and health services.

Figure 2.2. Imports from LDCs[1,2] and other countries in Africa



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

- Both total imports to Norway from developing countries and imports from least developed countries (LDCs) as defined by Norad rose from 2005 to 2006. Imports from China totalled NOK 23.5 billion, or about 45 per cent of total imports from developing countries as defined by the OECD (DAC List of ODA Recipients).

- Imports from Africa make up only a small percentage of total imports to Norway, accounting for 2 per cent of the total in the mid-1990s. Since then, imports from Africa have fallen to about 1 per cent of total Norwegian imports. Imports from LDCs in Africa have been very modest and fairly stable throughout the period under consideration, and accounted for only 0.18 per cent of Norway's total imports in 2006. In 2006, imports from African LDCs were dominated by the import of crude oil from Equatorial Guinea, valued at close to NOK 200 million, which accounted for 47 per cent of the total.

Liberia is classified as an LDC. Norwegian imports from African LDCs have 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. In 2005, imports from Liberia were very modest, but rose considerably in 2006, to NOK 116 million.

In 2006, Norway's imports from LDCs totalled NOK 1 293 million, or 0.3 per cent of its total imports. Of this, NOK 748 million, or 58 per cent, came from African LDCs (34 countries). Imports from LDCs outside Africa (16 countries) are dominated by imports of clothing and accessories from Bangladesh. In 2005, these totalled NOK 464 million (of which NOK 400 million was clothing and accessories), corresponding to 62 per cent of the value of imports from all African LDCs, and 36 per cent of all imports to Norway from LDCs.

In the Commitment to Development Index (see indicator number 1, Norwegian official development assistance), Norway is ranked next to last as regards trade. This is because it has high tariffs on agricultural products and high agricultural subsidies. On the other hand, trade barriers against textiles and apparel are low, and Norway ranks first in this respect.

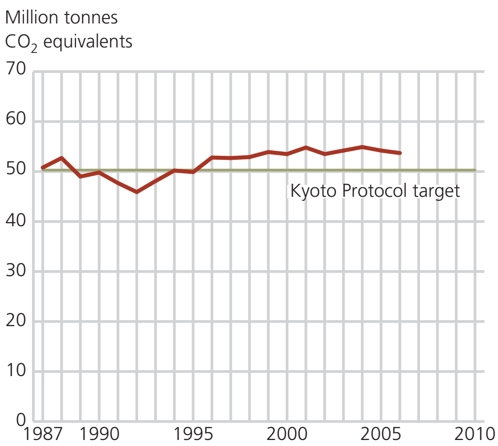
Climate, ozone and long-range air pollution

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

Global warming will put the ability of the world community to achieve sustainable development to the test. Climate change will have far-reaching effects on the environment, resources and the economy, and will pose major challenges for society. The report *Impacts of a Warming Arctic* (ACIA 2004) drew attention to the fact that in the past few decades, the temperature increase in the Arctic has been nearly twice as fast as in the rest of the world. Satellite data show that the average extent of the sea ice in the Arctic has been declining by 2.7 per cent per decade since 1978 (IPCC 2007).

One of the key conclusions of the IPCC Fourth Assessment Report from 2007 is that developing countries will be hardest hit by climate change. They are also least able to adapt to such change.

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.

- In 2006, Norwegian greenhouse gas emissions decreased by 0.8 per cent from 2005. Nevertheless, the overall rise since 1990, the base year for the Kyoto Protocol, is about 8 per cent (4.0 million tonnes CO_2 equivalents). Most of the rise was in the period up to 1999; since then, emissions have been relatively stable. The most important sources of emissions are the oil and gas industry, manufacturing and road traffic.

- In the last two years, emissions have declined to just below the 1999 level. However, a new upward trend in emissions is expected when construction of the Kårstø gas-fired power plant and the Hammerfest LNG plant is completed and they are fully operational. The rise in emissions from road traffic continued in 2006 with the general growth in traffic, but was moderated by a changeover to diesel vehicles. Emissions from road traffic rose by 30 per cent in the period 1990-2006.

In 2006, Norway's aggregate greenhouse gas emissions totalled 53.7 million tonnes CO_2 equivalents. By way of comparison, Norway's assigned amount under the Kyoto Protocol will probably be about 50.3 million tonnes per year for the period 2008-2012. If Norway's emissions exceed its assigned amount, it must introduce national emission reduction measures and in addition make use of the Kyoto mechanisms to acquire further emission units. The mechanisms include emissions trading with other developed countries and funding approved projects to reduce emissions in developing countries (the Clean Development Mechanism).

The Government's projections indicate that Norway's emissions will rise from 53.7 million tonnes CO_2 equivalents in 2006 to 59.2 million tonnes in 2010. If emissions are stable at the 2010 level throughout the Kyoto period, Norway will need to buy emission units corresponding to roughly 45 million tonnes for the whole period 2008-2012. However, it may be necessary to purchase an even larger volume, since the projected figures for 2010 do not include emissions of up to 2 million tonnes CO_2 from the gas-fired power plants at Kårstø and Mongstad. Carbon capture facilities are not expected to be installed at the two power plants before 2011-12 and 2014 respectively.

In June 2007, the Government presented its white paper on Norwegian climate policy (Report No. 34 (2006-2007) to the Storting. This set out the following targets:

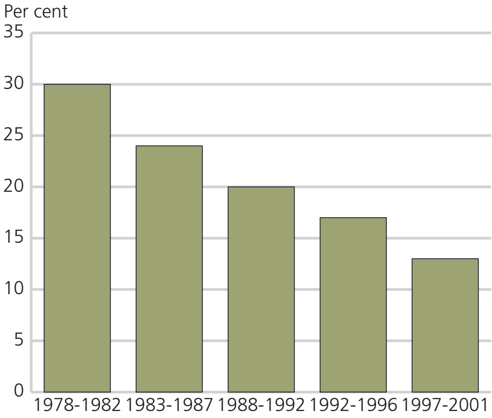
- Norway will undertake to reduce global greenhouse gas emissions by the equivalent of 30% of its own 1990 emissions by 2020.
- Norway will be carbon neutral by 2050.
- During the first commitment period under the Kyoto Protocol (2008-2012), the Government will strengthen Norway's Kyoto commitment by 10 percentage points, corresponding to nine per cent below the 1990 level, and ensure that a substantial proportion of Norway's emissions reductions are achieved through domestic action.

Long-range air pollution: acidification

Indicator 4. Percentage of Norway's land area where critical loads for acidification have been exceeded

Acid rain is still a serious environmental problem in Norway, even though reductions in emissions have reduced the extent of acidification. Acid rain is caused by emissions of sulphur and nitrogen compounds to air. These compounds can be transported over long distances, and emissions from other countries in Europe account for about 90 per cent of acid deposition in Norway. The southern half of the country is particularly seriously affected by acid rain, because inputs of acidifying compounds are highest here, soils are thin and the bedrock consists of acidic rock types such as gneiss and granite, so that critical loads for acidification are low. Parts of eastern Finnmark also show the impacts of acid rain.

Figure 2.4. Percentage of Norway's land area where critical loads for acidification have been exceeded



Source: Norwegian Institute for Water Research (2004).

- At the beginning of the 1980s, critical loads were exceeded across 30 per cent of the total area of Norway. Since then, the pollution load has been reduced, and in 2000, this figure was down to 13 per cent of Norway's total area. If all countries meet their commitments under the Gothenburg Protocol, it will drop further to about 7 per cent. Thus, there is still expected to be some fish mortality and damage to fish stocks. Fish mortality and damage to fish stocks will therefore continue unless preventive measures such as liming are also kept up.
- No newer data are available for this indicator at present, but developments are being followed as part of the monitoring programmes for long-range air pollution. In its annual report for 2004 on monitoring of long-range transport of pollutants, the Norwegian Institute for Air Research (2005) noted that the concentration of sulphur in air had never been lower since measurements started in 1973. According to the report for 2005 (Norwegian Institute for Air Research 2006), concentrations of strong acid, sulphate, nitrate and ammonium in precipitation in 2005 were somewhat higher than in 2004, but the same as or lower than in 2003.

The Norwegian Pollution Control Authority's report summarising the results of all the monitoring programmes for long-range air pollution (Norwegian Pollution Control Authority 2006) confirms the impression of the past few years that concentrations of acidifying substances are beginning to level off. Although concentrations of these substances in fresh water are lower than they have ever been since the monitoring programmes were started in 1980, there is less improvement from one year to the next than before.

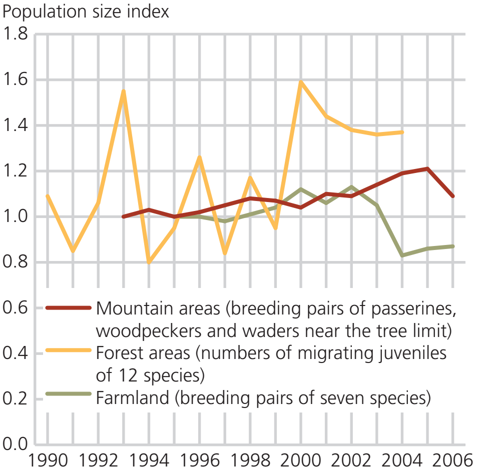
In 2006, Norwegian NO_x emissions totalled 195 000 tonnes, 1 per cent lower than in 2005. Emissions have been reduced by 8.5 per cent since 1990, but must be reduced by a further 20 per cent or 39 000 tonnes by 2010 if Norway is to meet its commitment of limiting emissions to 156 000 tonnes, as set out in the Gothenburg Protocol. Emissions of ammonia declined weakly from 2005 to 2006, to 22 600 tonnes. This is just under the Gothenburg target, which is 23 000 tonnes. The figures for SO_2 emissions in 2006 are not yet available. In 2005, SO_2 emissions totalled 23 800 tonnes. Under the Gothenburg Protocol, Norway's SO_2 emissions are to be below the ceiling of 22 000 tonnes in 2010. This will require a reduction of 8 per cent from the 2005 level.

Biodiversity and cultural heritage

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

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.

Figure 2.5. Bird population index - Population trends of nesting wild birds



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

- In mountain areas, populations of nesting birds have increased. This trend is expected, given a warmer climate and a denser mountain forest. The figures for forest birds show large variations from year to year and no clear trend. The variations may reflect real fluctuations in populations, but could also be a result of the data collection method. Population trends are also uncertain in agricultural areas.

- The three data series shown are all based on incomplete data and are not representative of the country as a whole. This indicator needs further development to obtain better and more representative data. A monitoring system that is intended to provide representative data from the whole country is being developed.

Biodiversity: freshwater and coastal ecosystems

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

The indicators for aquatic ecosystems are related to the EU Water Framework Directive, which is intended to protect Europe's inland and coastal waters. The directive sets the goal that "good water status" is to be achieved in all inland and coastal waters. This goal is to be achieved at the latest after the entry into force of the directive. According to the directive, inland water bodies and coastal waters are to be classified by ecological status in five categories: high, good, moderate, poor and bad. Each member country must develop classification methods and monitoring systems.

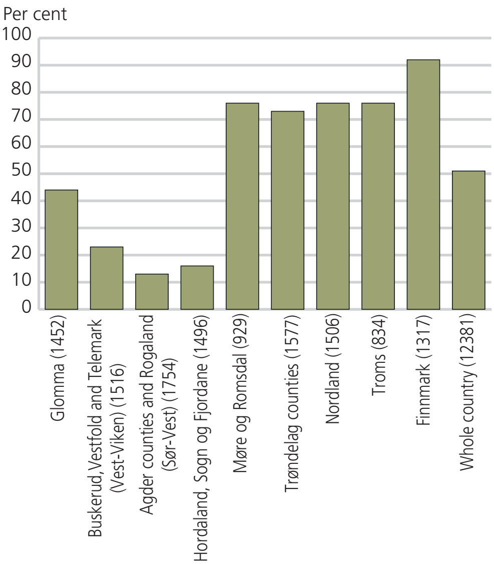
The previous survey of ecological status in water bodies in Norway was based on four regions. Since then, new regulations on a framework for water resource management have entered into force (1 January 2007), which divide Norway into nine river basin districts. The river basin districts are in turn divided into 247 catchments draining to Norwegian sea areas and 15 catchments draining to Finland and Sweden. In September 2007, an updated overview of ecological status in Norway's inland water bodies, coastal waters and groundwater bodies was presented. This was only a preliminary survey, so that the results are uncertain and only give a general picture of the situation in the roughly 15 000 water bodies that have been investigated in Norway. There is not yet sufficient information to make a complete evaluation of ecological status. A more comprehensive survey of selected river basins and coastal areas is now in progress. The aim is to make a thorough evaluation of all Norwegian inland water bodies and coastal waters by the end of 2009.

For the moment, an assessment of the risk that water bodies will fail to meet the directive's environmental objectives has been carried out. This uses three categories, since the information available does not yet make it possible to use the five categories specified in the directive. The three categories are:

- "not at risk" (for water bodies where it is reasonably certain that good ecological status has already been achieved)
- "insufficient data" (current status and probable trends are uncertain)
- "at risk" (for water bodies where it is reasonably certain that steps will have to be taken to achieve good ecological status, and heavily modified water bodies).

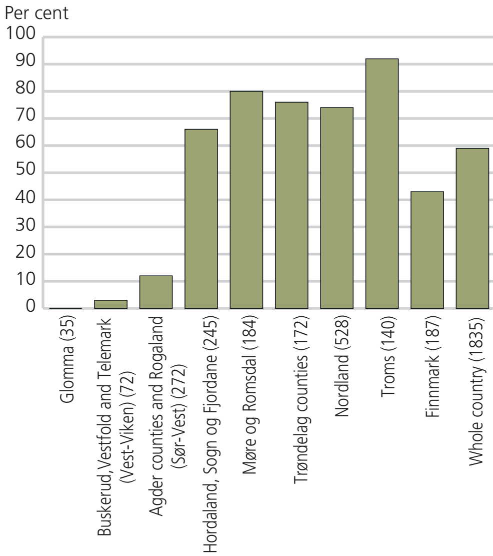
It should be noted that the results are given as percentages of the number of water bodies, which is the system being used in the EU for these indicators. If the area of different water bodies is taken into account, the picture will be different.

Figure 2.6. Percentage of Norwegian water bodies[1] classified as «not at risk» of failing to meet the objectives of the Water Framework Directive. Inland water bodies, by river basin district



[1] A 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.
Source: Directorate for Nature Management and Norwegian Pollution Control Authority.

Figure 2.7. Percentage of Norwegian water bodies[1] classified as «not at risk» of failing to meet the objectives of the Water Framework Directive. Coastal waters, by river basin district



[1] A 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.
Source: Directorate for Nature Management and Norwegian Pollution Control Authority.

- More than half of the inland water bodies that have been assessed have been placed in the category "not at risk". The proportion of water bodies in this category is lowest in the southern part of the country (the first four river basin districts from the left in figure 2.6). Conditions are better further north.
- For the country as a whole, 27 per cent of inland water bodies are in the category "at risk". This corresponds to 3 306 water bodies. Of these, 64 per cent (2 125 water bodies) have been classified as "heavily modified water bodies". These are rivers and lakes that have been physically modified in such a way that the goal of good ecological status cannot be achieved without significantly affecting the way they are being used. Specially adapted environmental objectives are to be set for these water bodies, which include rivers regulated for hydropower production.
- 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 next two districts in the south of the country.
- For the country as a whole, 17 per cent of coastal waters are in the category "at risk". This corresponds to 382 water bodies. Of these, 58 per cent (220 water bodies) have been classified as "heavily modified water bodies", which include areas where there are port facilities.

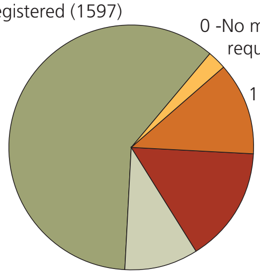
Cultural heritage

Indicator 8: 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 2.8. Registration of standards of maintenance for protected buildings in private ownership, status May 2007. Number of buildings



Source: Directorate for Cultural Heritage.

- By May 2007, about 40 per cent of all protected buildings had been registered and assigned to one of the categories in the figure. The Directorate for Cultural Heritage aims to compile information on standards of maintenance for all protected buildings by the end of 2008.

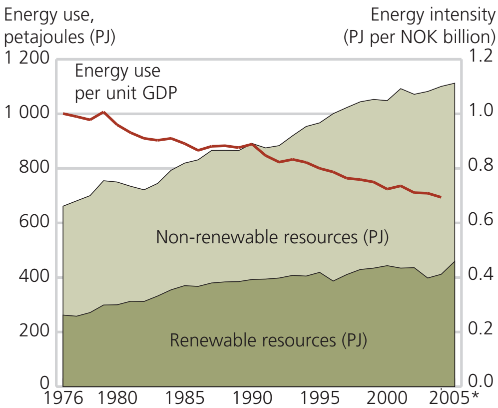
- Of the buildings that have been assessed, more than 60 per cent need moderate or extensive repairs to achieve a standard where only normal maintenance is required.

Natural resources: efficiency in resource use

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. Efficient use of energy is therefore particularly important in the context of sustainability. Energy use can also be used as a rough indication of consumption of materials, and more efficient use of other materials often results in more efficient energy use as well.

Figure 2.9. Energy use per unit GDP[1] and total energy use (PJ) for renewable and non-renewable energy sources



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

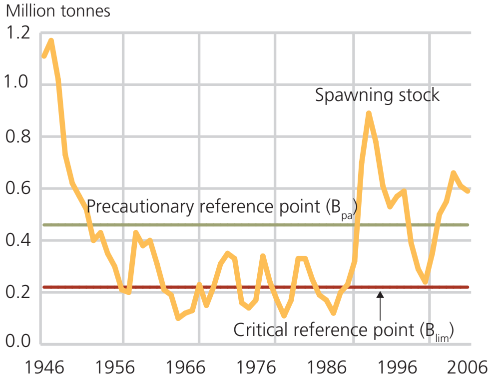
- Except for brief periods around 1980 and 1990, GDP has grown more strongly than domestic energy use, although energy use has also increased substantially. Thus, energy intensity has decreased. International statistics show a similar trend in other OECD countries. A reduction in energy intensity is not necessarily a result of greater energy efficiency in the form of energy savings, since energy efficiency also depends on other factors, including the country's industrial structure. Structural changes are an important factor behind the observed reduction in energy intensity, together with market conditions, greater productivity and technological progress (Bøeng and Spilde 2006). A changeover from traditional industrial production to the production of services can result in lower energy use and higher earnings, but not necessarily in more sustainable production and consumption in a global perspective, if industrial production is moved to low-cost countries.
- From 1976 to 2005, energy use increased by 68 per cent. For the period as a whole, renewable energy use has risen slightly more than non-renewable energy use. However, GDP grew by 147 per cent in the same period, so that energy use has become considerably more efficient relative to value added in this period. In general terms, energy efficiency has improved.

Natural resources: management of renewable resources

Indicator 10: Spawning stock biomass and precautionary (Bpa) reference point for Northeast Arctic cod

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 2.10. Spawning stock biomass and critical (B_{lim}) and precautionary (B_{pa}) reference points for North-East Arctic cod



Source: Institute of Marine Research and ICES.

- The stock of Northeast Arctic cod - the largest cod stock in the world - is managed jointly by Norway and Russia. The TACs (total allowable catch) are now set according to new rules. The spawning stock of Northeast Arctic cod was about 590 000 tonnes in 2006, which is slightly above the precautionary level. 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) is still higher than intended, and the total stock (fish aged 3 years and over) is low (34 per cent below the long-term average for 1946-2005). Illegal fishing is still a considerable problem.

According to the summary of the latest annual report from the Institute of Marine Research, *Marine Resources and Environment 2007* (Skogen et al. 2007), the herring, mackerel and blue whiting stocks, which to some extent use the Norwegian Sea as a feeding ground, are all in good condition. Most fish stocks in the Barents Sea are in good condition, although the capelin stock is still low. In the North Sea, there has been poor recruitment to the sandeel, Norway pout, cod and herring stocks. This is mainly a result of changes in physical and biological conditions, although the cod and sandeel stocks have also been overfished.

Natural resources: management of land resources

Indicator 11: Irreversible losses of biologically productive areas

The committee appointed to develop the set of indicators identified productive areas as a critical resource (Official Norwegian Report 2005:5), but found that the data available was insufficient to provide a satisfactory indicator of irreversible losses of biologically productive areas. The 2006 National Budget included a proposal for Statistics Norway and the Norwegian Forest and Landscape Institute to cooperate on the development of this indicator, using studies currently in progress as a basis. However, as of October 2007, the necessary data for this indicator was still not available.

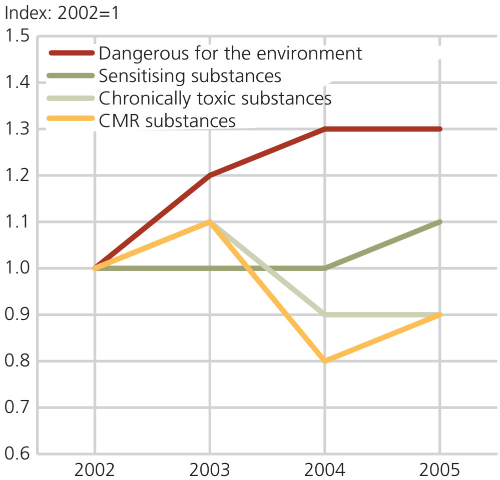
Hazardous chemicals

Indicator 12: Potential 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). More than 100 000 new substances have been synthesised, in addition to all those that occur naturally (EEA 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. It is therefore an important task for society to ensure that chemicals are used and handled safely, so that human health and the environment are protected.

Official Norwegian Report 2005:5, which contained the original set of indicators for sustainable development, emphasised the need for further development of an indicator for chemicals. In the white paper on Norway's chemicals policy (Report No. 14 (2006-2007) to the Storting) the Government pointed to the need to develop an indicator that better reflects progress towards the target of minimising the risk that releases and use of chemicals will cause injury to health or environmental damage.

Figure 2.11. Potential exposure to hazardous substances[1]. 2002-2005. Index, 2002=1



[1] CMR= Carcinogenic, mutagenic or reprotoxic.
Source: Statistics Norway.

- Statistics Norway has developed a new indicator for this purpose, in cooperation with the Norwegian Pollution Control Authority and the Product Register. The indicator shows the degree of potential exposure to hazardous substances, as measured by the quantity of hazardous substances released to the environment in a particular year, and that people can therefore be exposed to and harmed by. According to the calculations, releases of substances that are most hazardous to health (carcinogenic, mutagenic and reprotoxic substances, and chronically toxic substances) have decreased somewhat since 2002. Sensitising substances and substances that are dangerous for the environment have shown the opposite trend. The results must be interpreted with care at present, since the model is still being improved and adjusted.

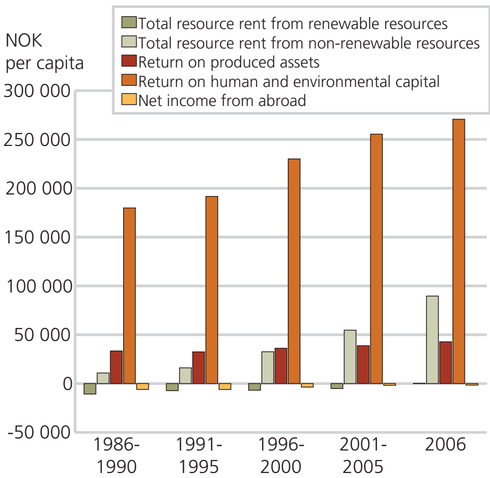
Sustainable economic and social development: sources of income

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, real capital and net foreign assets. 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, net income from abroad 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 per capita, by sources of income



Source: Statistics Norway.

- The indicator shows that human capital and environmental capital are of the utmost importance for our economic welfare, and their importance has been increasing since 1986. Human capital should be understood as the entire contribution from the labour force: this includes actual labour provided, i.e. hours actually worked, and the educational level of the workforce, i.e. the quality of the labour provided (Løkkevik and Greaker 2005). Environmental capital includes, in principle, all non-market-based functions of the environment, such as the provision of clean water and air, recipient functions and biodiversity.
- The exploitation of non-renewable resources, mainly oil and gas, has become increasingly important since 1985, and the resource rent from this sector is now larger than the return on produced assets.

The resource rent from the primary industries agriculture, forestry and fisheries has been negative, mainly as a result of subsidies to agriculture. However, the size of the deficit has decreased during the period, and in 2006 the resource rent was positive. This is mainly due to a strong rise in the resource rent from hydropower.

Methodology and results of national wealth calculations were documented in Greaker et al. 2005.

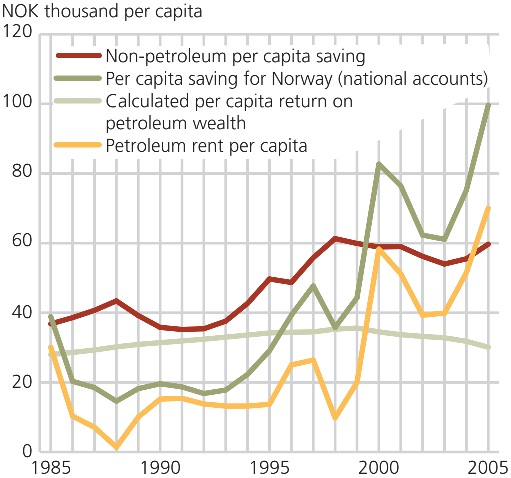
Sustainable consumption

Indicator 14: Non-petroleum saving

Are we consuming too much? Or to be more precise: has the Norwegian population consumed more during one year than we had reason to believe could be sustained over time? If the answer is yes, the level of consumption can in a sense be defined as unsustainable. The indicator "Non-petroleum saving" is intended to answer this question.

Non-petroleum saving is calculated as Norway's disposable income minus consumption and the resource rent from petroleum activities, plus the calculated return on the remaining petroleum wealth. It should be noted that this indicator deals only with the ability to save in financial terms, and does not take into account whether natural resources are being used sustainably, or any environmental degradation caused by economic activity.

Figure 2.13. Non-petroleum saving. NOK 1 000 per capita at constant prices (2005 NOK)



Source: Ministry of Finance and Statistics Norway.

- Non-petroleum saving has been positive in the whole period under consideration. In economic terms, consumption in Norway seems therefore to have remained at a sustainable level. Per capita non-petroleum saving is estimated at close to NOK 60 000 in 2005.
- Figures for the return on our remaining petroleum wealth are based on expectations and are therefore uncertain. However, it should be noted that saving would have been positive throughout the period even if this return had been disregarded, i.e. if non-petroleum saving had been defined simply as saving minus the resource rent from petroleum activities.

According to the 2008 National Budget, which was published after the editing of this publication was completed, this indicator is to be removed from the indicator set. An indicator of trends in income distribution is being introduced instead.

Sustainable public finances

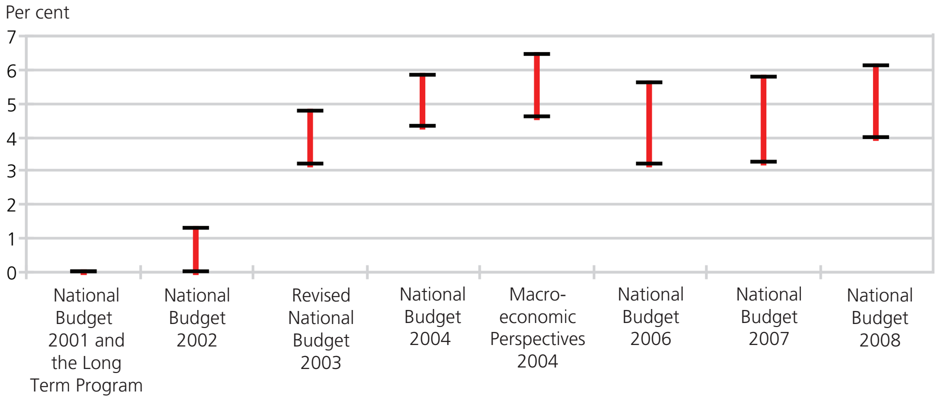
Indicator 15: Generational accounts: Need to tighten public sector finances as a share of GDP

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 current value of public sector revenues must correspond to the current value of public sector expenditure.

- 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.

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.

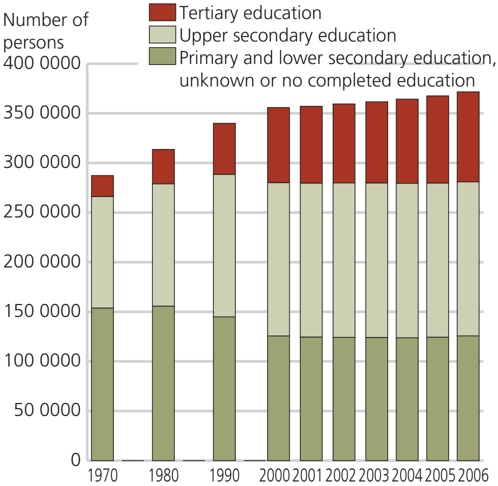
Level of education

Indicator 16: Population by highest level of educational attainment

The level of education in the population may be regarded as 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.”

The variable "highest level of educational attainment" is used internationally as a measure of human capital, and as an indicator in surveys of living conditions.

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



Source: Statistics Norway.

- 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 the period 1983-2006, the number of people with a doctorate has roughly quadrupled (from 3 655 to15 895 persons).
- At the other end of the scale, the share of people with only primary and lower secondary education has decreased by over 20 percentage points since 1970.

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 is almost twice as high as the proportion of women. As of 1 October 2006, just under 8 per cent of men had completed a long programme (more than four years), as compared with just over 4 per cent of women. 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.

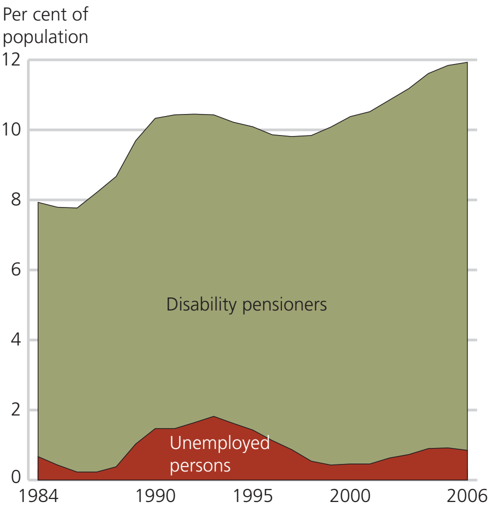
Exclusion from the labour market

Indicator 17: Long-term unemployed persons and disability pensioners as 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. This situation may affect the productive capacity of the economy and, in the long term, social stability and thus the sustainability of society.

Figure 2.16. Long-term unemployed persons and disability pensioners as 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 (continuous period of unemployment more than 26 weeks).
- There was a temporary decrease in exclusion from the labour market until 1998, but since then the percentage has increased again and reached just under 12 per cent in 2006. Most people excluded from the labour market are disability pensioners, and they also accounted for most of the rise in total numbers. In 2006, 25 000 people were registered as long-term unemployed and 328 000 as disability pensioners. Far more women (189 000) than men (139 000) were registered as disability pensioners in 2006. In contrast, more men (15 000) than women (10 000) are registered as long-term unemployed.

In the age group age group 18-66 years, the number of long-term unemployed decreased by about 2 000 from 2005 to 2006. According to the Labour Force Survey, the number of unemployed people was on average 28 000 lower in the first quarter of 2007 than in the first quarter of 2006. There were also fewer temporary employees. Thus, developments in the labour market are positive. Unemployed people accounted for 2.7 per cent of the labour force.

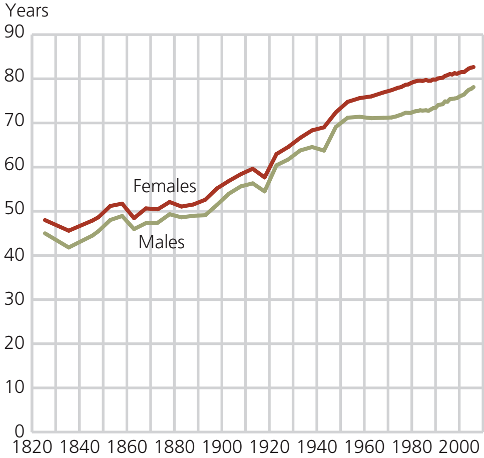
From 2005 to 2006, the number of disability pensioners rose by about 8 000. The number of young people receiving disability pensions also rose. In 2006, more than 3 000 people in the age group 20-24 years were disability pensioners. Of these, 55 per cent were young men and 45 per cent young women. In the population as a whole, women make up a larger proportion of disability pensioners than men.

Health and welfare

Indicator 18: Life expectancy at birth

Life expectancy is a demographic indicator that captures various factors related to health and social welfare. Changes in the indicator can indirectly give information on factors such as 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. 1825-2006



Source: Statistics Norway (2007) and Brunborg (2004).

- Life expectancy in Norway has been increasing for nearly two hundred years and there is every indication that this trend will continue. 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 4.5 years in 2006. Male life expectancy at birth is now 78.1 years, and female life expectancy is 82.7 years. An important cause of this is declining infant and child mortality, but lower mortality in older age groups has also contributed to the increasing life expectancy.
- According to new population forecasts, life expectancy at birth will increase by about 8 years from 2004 to 2060, to 86.0 years for men and 90.1 years for women (Keilman and Pham 2005).

As the population ages, society has to use more resources on health and welfare schemes. Costs for the health sector alone make up a good 10 per cent of Norway's GDP. Absence due to illness, exclusion from the labour market and the need for health care all influence productivity. Life expectancy gives an indication of how long a person can expect to live, but does not give any information on whether they can expect to be in good health. Various indicators have been developed to address this. The indicator Healthy Life Years is based on the number of remaining years that a person of a certain age is still expected to live without disability. Healthy life expectancy at birth is nearly 18 years shorter than life expectancy for women and 11 years shorter for men.

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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
Finland: http://www.miljo.fi/default.asp?contentid=60941&lan=sv
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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 consumption. 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 2006, extraction of energy commodities in Norway was nine times higher than domestic consumption. Most of this is accounted for by extraction of oil and gas, which made up 94 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 nine years' time and the gas reserves in 25 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, 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 3.3 per cent of world oil production in 2006; the corresponding figures for natural gas are 1.6 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 2006 only 35 per cent of Norway's total oil and gas resources (which include all estimated volumes of oil and gas), had been recovered, or 51 and 19 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 25 per cent of gross domestic product (GDP) and 50 per cent of Norway's export revenues in 2006, about the same as 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 electricity production from this source corresponded to only about 5 per cent of petroleum extraction in 2006, expressed as energy content. However, hydropower is a renewable energy source, unlike petroleum resources, which are depleted as they are extracted. In 2006, Norway produced 122 TWh of electricity, as against 138 TWh the year before. This meant that in 2006 there was an import surplus of just under 1 TWh, whereas in 2005

Norway was a net exporter with an export surplus of 12.0 TWh. Mean annual production capability when water inflow to the reservoirs is normal is 120 TWh. In 2006 and 2007, the degree of filling of the reservoirs has varied widely relative to the median level for the period 1990-2005, from 26 percentage points below the median in early September 2006, to 6 percentage points above in early October 2007.

Domestic consumption of energy commodities, excluding the energy sectors, was about the same in 2006 as in 2005. Since 1976, it has risen by an average of 1.2 per cent per year, while the average rate of general economic growth, as measured by GDP for mainland Norway, has been 2.5 per cent per year (see Chapter 14 on the relationship between environmental pressures and economy).

Energy production and use has major environmental impacts. In 2005, the energy sectors accounted for about 32 per cent of total Norwegian greenhouse gas emissions (26 per cent from oil and gas extraction), and other combustion of fossil energy commodities accounted for 41 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

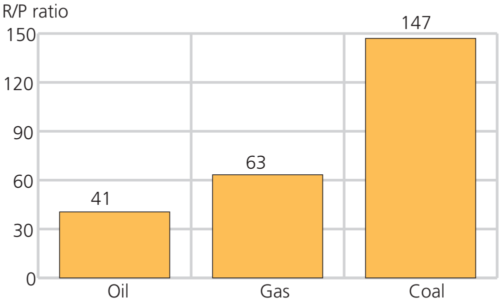
- Reserves are defined as resources that are fairly certainly recoverable given the current economic and technological framework. There is always some uncertainty associated with estimates of reserves, and there is reason to believe that the quality of the data varies widely from country to country. Moreover, assumptions about prices and technology may change over time.
- According to BP (2007), 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, 27 per cent of the world total. Russia, China, India and Australia also have large coal reserves, and together with the US, these countries have three quarters of the world's total reserves. The Middle East has 62 per cent of the world's oil reserves, and about one third of this is in Saudi Arabia. The Middle East also has 40 per cent of the world's gas reserves, while only about 5 and 4 per cent respectively of the total oil and gas reserves are in North America (table 3.1).
- The estimate of gas reserves is higher than that for the beginning of 2006 in BP's annual *Statistical Review of World Energy*, while the estimates for oil reserves do not appear to have been updated to any great extent, and the estimate for coal reserves is unchanged for the third year running.

Table 3.1. World reserves of fossil energy commodities as of 1 January 2007

	Oil		Gas		Coal	
	Billion tonnes	Per cent	Billion tonnes o.e.	Per cent	Billion tonnes	Per cent
World	**164.5**	**100**	**163.3**	**100**	**909.1**	**100**
North America[1]	7.8	4.7	7.2	4.4	254.4	28.0
Latin America	14.8	9.0	6.2	3.8	19.9	2.2
Europe incl. former Soviet Union	19.7	12.0	57.7	35.5	287.1	31.6
Middle East	101.2	61.5	66.1	40.5	0.4	0.0
Africa	15.2	9.4	12.8	7.8	50.3	5.5
Asia and Oceania	5.4	3.3	13.3	8.2	296.9	32.7
OPEC	123.6	75.1	..	..	..	..
OECD	10.4	6.3	14.3	8.8	373.2	41.1
Norway	1.1	0.7	2.6	1.6	..	..

[1] Including Mexico.
Source: BP 2007.

Figure 3.1. R/P ratio[1] for world reserves of fossil energy commodities as of 1 January 2007

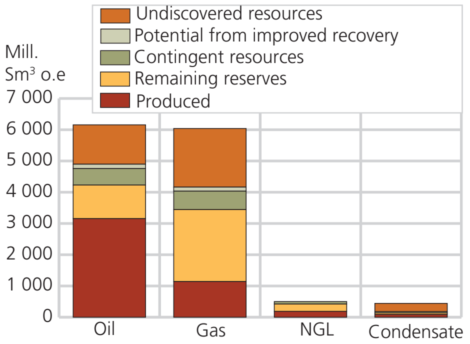


[1] The R/P ratio, or the ratio between reserves and the current annual rate of production, indicates how many years it will take before the reserves are exhausted.
Source: BP 2007.

Norwegian petroleum reserves

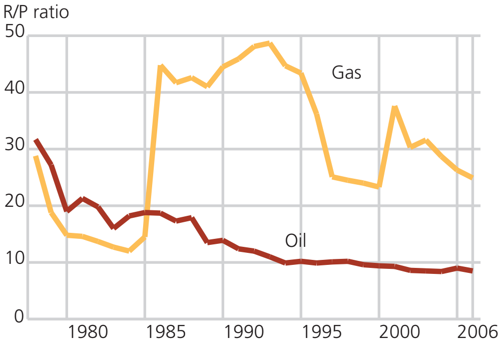
- The Norwegian Petroleum Directorate draws up annual resource accounts for oil and gas. In these, the term *resources* means, in addition to oil and gas that has already been produced, all estimated petroleum deposits – those that are marketable now, those that are not marketable given current technology, and 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 3.2. Norway's oil and gas resources, 31 December 2006. Million Sm³ o.e.



Source: OED/OD (2007).

Figure 3.3. R/P ratio[1,2] for Norwegian oil and gas reserves. 1978-2006



[1] The R/P ratio, or the ratio between reserves and the current annual rate of production, indicates how many years it will take before the reserves are exhausted.
[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.

- As of 31 December 2006, Norway's total oil and gas reserves were estimated at 13.1 billion Sm³ oil equivalents (o.e.) (OED/OD 2007). Of this, 4 573 million Sm³ o.e., or 35 per cent, had already been produced. Thus, there are remaining resources of 8 568 million Sm³ o.e., of which 3 659 million Sm³ o.e., or 28 per cent of the total, is classified as reserves (figure 3.2). Thus, half of the oil resources but only 19 per cent of the gas resources have been extracted. Oil and gas made up 47 and 46 per cent respectively of the total resources expressed in Sm³ o.e., while NGL (natural gas liquids) and natural gas condensate made up 4 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 2006 the R/P ratios for Norway's reserves were 8.5 years (oil) and 24.9 years (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. 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 (2006)[2]	39.9 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	..	..	..	..

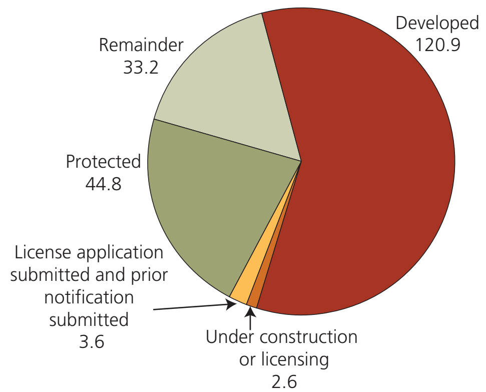
[1] The theoretical energy content of a particular energy commodity may vary. The figures therefore indicate mean values.
[2] Sm³ = standard cubic metre (at 15 °C and 1 atmospheric pressure).
Source: Energy statistics, Statistics Norway, Norwegian Petroleum Industry Association, Norwegian Association 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	1053	292.5	24.9	186.4	29.29	26.33	1

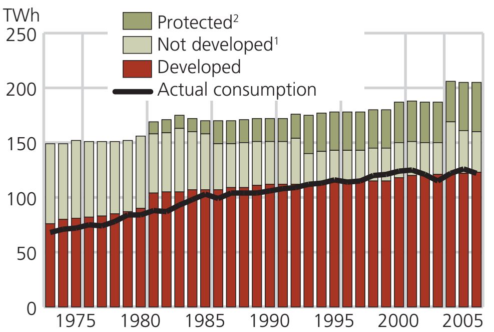
1 Mtoe = 1 million tonnes (crude) oil equivalents
1 Mbarrels = 1 million barrels crude oil (1 barrel = 0.159 m³)
1 MSm³ o.e. oil = 1 million Sm³ oil
1 MSm³ o.e. gas = 1 billion Sm³ natural gas
1 quad = 10^{15} Btu (British thermal units)
Source: Energy statistics, Statistics Norway and Norwegian Petroleum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

Figure 3.4. Norway's hydropower resources as of 1 January 2007[1]. TWh per year



[1] 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 electricity consumption. 1973-2006[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.

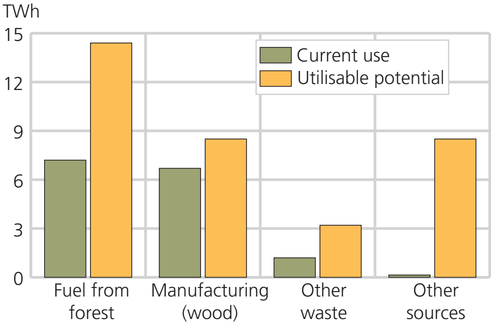
Norwegian hydropower resources

- As of 1 January 2007, Norway's hydropower potential totalled 205.1 TWh per year. Of this, 59 per cent, or 120.9 TWh, had been developed. This leaves 84 TWh that has not been developed, 44.8 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 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 19 per cent for the world as a whole (World Energy Council 2007).
- 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. 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}

Figure 3.6. Bioenergy in Norway. Current use and utilisable potential. TWh



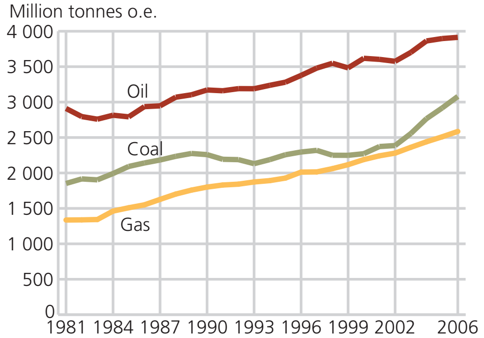
Source: Eid Hohle 2005.

Bioenergy resources in Norway

- Annual consumption of bioenergy resources (wood, wood waste, black liquor, pellets, briquettes) in Norway is about 15 TWh, and the utilisable potential is calculated to be about 35 TWh (Eid Hohle 2005). The utilisable potential indicates how much can be utilised when ecological, technical and economic constraints are taken into account. Technological developments and price trends for energy commodities may therefore influence the size of the utilisable potential.
- A survey of fuelwood use (Statistics Norway 2007) shows that total fuelwood consumption in 2006 was 1.6 million tonnes, which corresponds to a theoretical energy content of about 7.3 TWh. About 10 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 31 per cent of the wood used in holiday homes, as compared with 38 per cent in year-round residences. The proportion of clean-burning stoves has risen by 20 percentage points since 2002. The overall efficiency of fuelwood stoves was about 50 per cent.
- Bioenergy sources that are barely used today offer a total potential of 8.5 TWh. These include energy crops (fast-growing trees and grasses), straw, landfill gas and biogas from manure.

3.2. Extraction and production

Figure 3.7. World production of coal, crude oil and natural gas. 1981-2006. Million tonnes o.e.



Source: BP 2007.

World production of fossil energy commodities

- In 2006, total global extraction of fossil energy commodities increased by 2.8 per cent from the year before to 9.6 billion tonnes o.e. This is a rise of 57 per cent from 1981, corresponding to 1.7 per cent per year. This upward trend has been particularly marked in the last few years - the rise in coal production from 2002 to 2006 was 36 per cent, and the corresponding figures for natural gas and oil were 18 and 9 per cent. Oil accounted for 41 per cent of total global extraction in 2006, while coal and natural gas accounted for 32 and 27 per cent respectively.
- 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 2006 (see table 3.2).
- China is by far the largest coal producer, and also the country where there has been the largest increase in production. From 2002 to 2006, coal production in China rose by 65 per cent. North America and Europe (including the whole of Russia: much of Russia's gas is produced in Siberia) account for almost two thirds of all gas production.
- Saudi Arabia is still the largest oil producer, but may soon be overtaken by Russia, where production has risen by almost 50 per cent since 2000. From 2001 to 2006, Norway's oil production (including condensate and NGL) dropped by one fifth. In 2006, for the first time since 1990, Norway was not among the ten largest producers.

Table 3.2. World production of fossil energy commodities in 2006

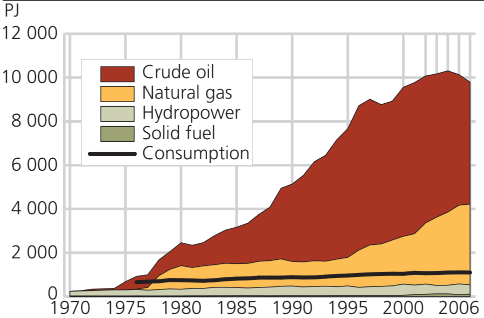
	Oil		Gas		Coal	
	Million tonnes	Per cent	Million tonnes o.e.	Per cent	Million tonnes o.e.	Per cent
Regions						
World	3 914.1	100.0	2 586.4	100.0	3 079.7	100.0
OPEC	1 632.7	41.7	..	..	..	..
OECD	910.5	23.3	978.3	37.8	1 026.2	33.3
North America[1]	646.1	16.5	686.6	26.5	632.8	20.5
Latin America	345.8	8.8	130.0	5.0	51.4	1.7
Europe incl. former Soviet Union	846.7	21.6	965.6	37.3	445.7	14.5
Middle East	1 221.9	31.2	302.3	11.7	0.6	0.0
Africa	473.7	12.1	162.4	6.3	147.8	4.8
Asia and Oceania	379.8	9.7	339.4	13.1	1 801.5	58.5

Major producers

Oil	Million tonnes	Per cent
Saudi Arabia	514.6	13.1
Russia	480.5	12.3
US	311.8	8.0
Iran	209.8	5.4
China	183.7	4.7
Mexico	183.1	4.7
Canada	151.3	3.9
Venezuela	145.1	3.7
United Arab Emirates	138.3	3.5
Kuwait	133.2	3.4
Norway	128.7	3.3
Gas	Mtoe	Per cent
Russia	550.9	21.3
US	479.3	18.5
Canada	168.3	6.5
Iran	94.5	3.7
Norway	78.9	3.0
Algeria	76.0	2.9
UK	72.0	2.8
Indonesia	66.6	2.6
Saudi Arabia	66.3	2.6
Turkmenistan	56.0	2.2
Coal	Mtoe	Per cent
China	1 212.3	39.4
US	595.1	19.3
India	209.7	6.8
Australia	203.1	6.6
South Africa	144.8	4.7
Russia	144.5	4.7
Indonesia	119.9	3.9
Poland	67.0	2.2
Germany	50.3	1.6
Kazakhstan	49.2	1.6

[1] Including Mexico.
Source: BP 2007.

Figure 3.8. Extraction and consumption[1] of energy commodities in Norway. 1970-2006*. PJ

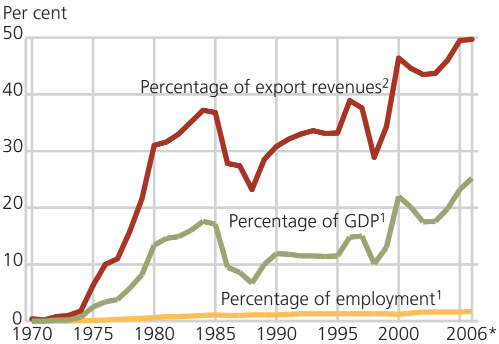


[1] Including the energy sectors, excluding international maritime transport.
Source: Energy statistics, Statistics Norway, Norwegian Petroleum Directorate and Norwegian Water Resources and Energy Directorate.

Total extraction of energy commodities in Norway

- There was a slight decrease in total extraction of energy commodities in Norway from 2005 to 2006. Oil and gas extraction accounted for 95 per cent of the total in 2005. Gas production has reached record levels in recent years, and rose by 2 per cent from 2005. Crude oil production, on the other hand, dropped by 7 per cent. Extraction of solid fuels rose by almost 30 per cent from 2005. A fire in the Svea Nord coal mine in Svalbard in 2005-2006 closed the mine for several months, but since then production has risen sharply again (see the section on Norwegian extraction of coal in Svalbard).
- Hydropower production dropped by 12 per cent from 2005, when high precipitation resulted in very high production.
- In 2006, extraction of primary energy commodities (including hydropower) was nine times higher than domestic consumption.

Figure 3.9. Oil and gas extraction. Percentage of exports, gross domestic product (GDP) and employment. 1970-2006*

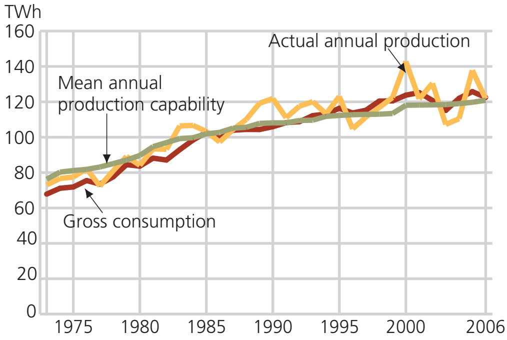


[1] Including services.
[2] Oil and gas only.
Source: National accounts, Statistics Norway.

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). In 2006, oil and gas accounted for about 50 per cent of the value of the country's total exports, the same as the year before. The volume of exports dropped by about 6 per cent, but high prices resulted in an increase of 16 per cent in their value.
- Value added in the petroleum sector corresponded to 25 per cent of GDP, but only about 1.7 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. 1973-2006. TWh

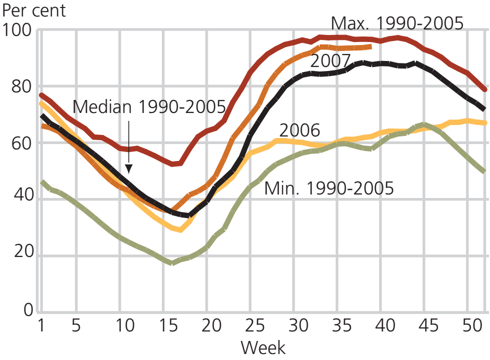


Source: Norwegian Water Resources and Energy Directorate and Energy statistics, Statistics Norway.

Electricity

- According to the Norwegian Water Resources and Energy Directorate, electricity production in Norway totalled 122 TWh in 2006. This is about 12 per cent less than the year before. In addition, about 9 TWh of electricity was generated by gas turbines on the Norwegian continental shelf.
- Hydropower production in 2006 was 0.7 TWh higher than the mean annual production capability (i.e. production in a year with normal precipitation). The mean annual production capability rose by 1.2 TWh from the year before.
- In 2006 there was an import surplus of 0.9 TWh.
- Hydropower accounts for about 98 per cent of mainland electricity production in Norway. The rest is supplied by thermal power and wind power. Several wind farms have been constructed in recent years, and wind power production rose by more than 30 per cent from 2005 to 2006. Nevertheless it only totals just under 700 GWh.

Figure 3.11. Degree of filling of Norway's reservoirs during the year, 2006 and 2007. Minimum, maximum and median values for the period 1990-2005. Per cent

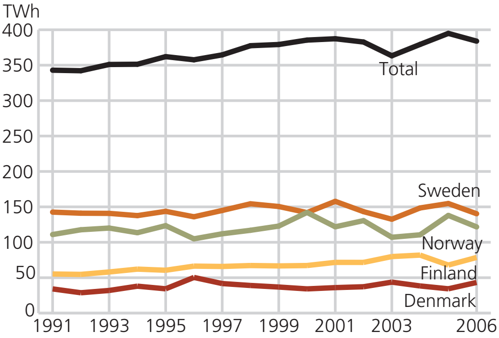


Source: Norwegian Water Resources and Energy Directorate.

Degree of filling of the reservoirs

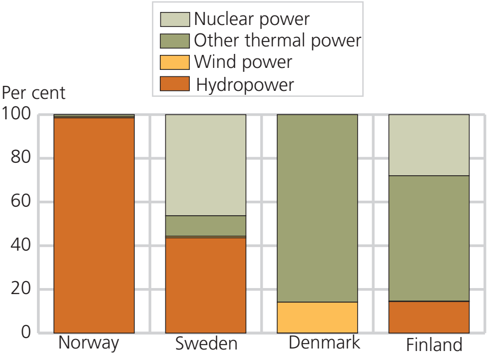
- Water inflow to the reservoirs is of crucial importance for the level of electricity production. Inflow is unevenly distributed over the year, and is normally lowest in winter, when the demand for power is highest. It is therefore necessary to store water in order to be able to produce electricity 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.
- At the beginning of 2007, the total energy capability of Norway's reservoirs was about 84 TWh, or about 70 per cent of annual mean production.
- The degree of filling of the reservoirs was below the median for 1990-2005 for most of 2006. As a result of low inflow in the period June-October, the degree of filling in August-September was 30 per cent below the median, and in early November it was lower than ever registered for this time of year in the period 1990-2005. However, by the beginning of 2007, the degree of filling was only 5 per cent below the median level. The reservoirs contained water corresponding to 8.7 TWh less than a year before (Norwegian Water Resources and Energy Directorate 2007). Until mid-April 2007, the degree of filling remained below the median for 1990-2005: after this, high precipitation raised the degree of filling above the median level, and some of the time considerably above it. In October 2007, the degree of filling was 32 percentage points higher than at the same time in 2006, and 6 percentage points above the median for the period 1990-2005.

Figure 3.12. Electricity production in the Nordic countries. 1991-2006. TWh



Source: Nordel's secretariat (various years).

Figure 3.13. Electricity production in the Nordic countries, by technology. 2006. Percentages



Source: Nordel.

Electricity production in the Nordic countries

- In 2006, total energy production in the Nordic countries excluding Iceland was 383.9 TWh. Sweden is the largest electricity producer in the region, closely followed by Norway (figure 3.12). The technology of electricity production varies widely (figure 3.13). Almost all electricity production in Norway is based on hydropower, while nuclear power is important in Sweden and Finland (46 and 28 per cent, respectively, of the total in 2006), and coal-based power is important in Denmark (54 per cent of the total in 2006). Denmark is the main producer of wind power: in 2006, 6.1 TWh, or 14 per cent of the country's total production, was wind power.
- Iceland produced 9.9 TWh of electricity in 2006, 73 per cent of which was hydropower and 27 per cent geothermal power.
- Energy production in the other Nordic countries influences the electricity balance in Norway. In 2006, Norway was a net importer of electricity, as it was in 2003 and 2004, whereas in 2005 it was a net exporter: imports totalled 9.8 TWh and exports 8.9 TWh. Denmark was a net exporter, while Sweden and Finland were also net importers (Nordel 2007).
- In 2006, Norway's import surplus was 0.9 TWh. There was an import surplus of 1.2 TWh vis-à-vis Denmark, and export surpluses of 0.5 and 0.1 TWh respectively vis-à-vis Sweden and Finland. In addition, Norway imported 0.2 TWh from Russia in 2006. Finland imported considerable quantities of electricity from Russia. Both Sweden and Denmark traded electricity with Germany, and Sweden also traded with Poland.

Figure 3.14. Norwegian net production of coal in Svalbard. 1950-2006. 1 000 tonnes

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

Norwegian extraction of coal in Svalbard

- In April 2006, coal production in the Svea Nord mine in Svalbard was resumed after a prolonged closure after the fire that broke out at the end of July 2005. 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. 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.
- Norway's total coal production for the whole period 1916-2006 was 38.5 million tonnes. At the end of 2006, the reserves of what is defined as marketable coal totalled 59.4 million tonnes, which corresponds to 20 years' production at the 2003 and 2004 rate of extraction.
- In 2006, 52 per cent of the coal sold was used for energy purposes, and more than half of this was exported to Germany. Denmark, Finland, Portugal, France and the US also bought Norwegian coal for energy purposes. Only 1.1 per cent of the total was used in Svalbard. Of total sales, 48 per cent was for industrial purposes, and Germany was the largest customer, purchasing 77 per cent of sales for this purpose. France, Greece and Iceland also bought coal for industrial purposes. 3 per cent of total sales of coal in 2006 were to the Norwegian cement industry.
- In 1916, the newly established Store Norske Spitsbergen Kulkompani took over coal production from the US Arctic Coal Company, which had been operating for 10 years. In 2001, the subsidiary Store Norske Spitsbergen Grubekompani was established, and is now responsible for production. The company made a profit from the first year of ordinary production in 2002, whereas Norwegian coal production had always previously been dependent on government support. However, the stoppage in 2005/2006 resulted in an operating loss in 2006.
- Norway's sovereignty over the archipelago was recognised when the Spitsbergen Treaty was signed in 1920. Before this, the area had been a no man's land under international law, where many nations were engaged in hunting and research. By 1920, the Soviet Union (before that, Russia) had already been mining coal in Svalbard for some years, and in accordance with the Spitsbergen Treaty, this has continued ever since. Since the mining community of Pyramiden was closed down in 1998, Russia has only produced coal in Barentsburg.

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 2005 (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 2003-2005, this rose to 9-10 million tonnes a year, which is equivalent to 22 per cent of Norway's total emissions.
- Gas turbines are also an important source of NO_x emissions, and accounted for almost 35 000 tonnes in 2005, or 18 per cent of Norway's total NO_x emissions. Total NO_x emissions were reduced by 7 per cent from 1990 to 2005, but emissions from the energy sectors rose by 53 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 and 2000-2005*. Percentages

	1990	1995	2000	2001	2002	2003	2004	2005*
Greenhouse gases (expressed as CO_2 equivalents)	23	26	30	31	31	31	31	32
Carbon dioxide (CO_2)	28	31	35	35	36	36	36	37
Methane (CH_4)	9	14	17	19	18	17	18	16
Nitrous oxide (N_2O)	1	1	1	1	1	1	1	1
Acidifying substances (expressed as acid equivalents)	15	18	24	22	22	23	23	24
Sulphur dioxide (SO_2)	12	10	16	16	17	17	15	18
Nitrogen oxides (NO_X)	20	25	32	30	29	31	32	33
Ammonia (NH_3)	0	0	0	0	0	0	0	0
Ecological toxins								
Lead (Pb)	1	3	6	5	2	2	1	2
Cadmium (Cd)	10	7	9	8	6	6	6	8
Mercury (Hg)	8	9	9	6	6	6	5	5
Arsenic (As)	6	3	4	4	5	6	7	6
Chromium (Cr)	3	2	3	3	4	6	6	7
Copper(Cu)	2	1	2	1	1	1	1	1
Total PAH	1	1	1	1	1	1	1	1
Dioxins	11	6	12	13	11	9	8	10
Other pollutants								
Non-methane volatile organic compounds (NMVOCs)	45	60	68	70	66	62	58	51
Carbon monoxide (CO)	1	1	2	2	2	2	2	3
Particulate matter	1	2	2	2	2	2	2	2

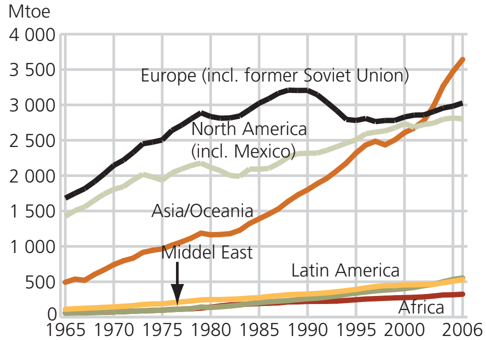
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

- 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 2005, emissions from this source totalled 78 000 tonnes, which is a decrease of 58 per cent from 2001. From 1990 to 2005, there was a reduction in both total NMVOC emissions and emissions from the energy sectors, but since emissions from the energy sector were reduced relatively less, they now account for a larger proportion of emissions.
- In 2005, 18 per cent of Norway's total SO_2 emissions were generated by the energy sectors. Oil refining alone accounted for 7 per cent, mainly in the form of process emissions. From 1990 to 2005, emissions from the energy sectors were reduced by 32 per cent, but since total emissions were more than halved in the same period, the energy sectors accounted for a larger proportion of the total in 2005 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).

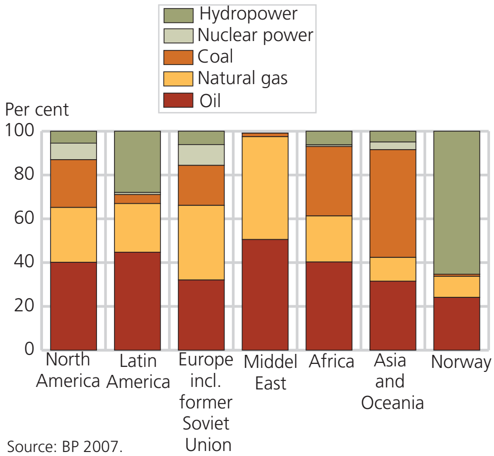
3.4. Energy use

Figure 3.15. World energy use 1965-2006. Mtoe



Source: BP 2007.

Figure 3.16. Energy use by energy carrier (excluding bioenergy) in different regions. 2006. Percentages



Source: BP 2007.

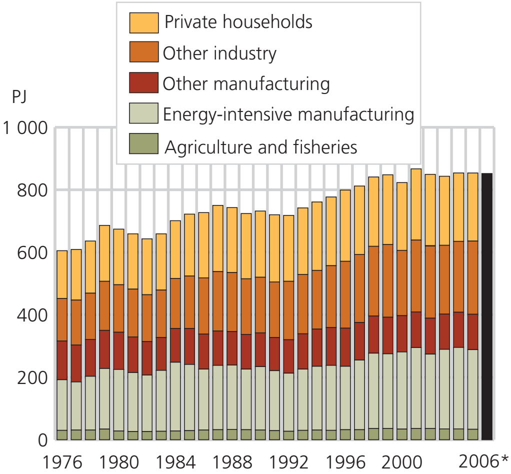
World energy use

- In 2006, global consumption of energy commodities (excluding bioenergy) totalled 10 879 million tonnes o.e., 2.4 per cent more than the year before. In North America, energy use declined somewhat from 2005 to 2006, while it rose by 4-5 per cent in Latin America, the Middle East and Asia/Oceania. In recent years, energy use has been rising particularly rapidly in Asia, where it was 40 per cent higher in 2006 than in 2000. Most of the rise has been in China, where consumption of energy commodities rose by more than 75 per cent in this period. In 2006, China accounted for 16 per cent of total world energy use, as compared with 10 per cent in 2000. The US is the only country where consumption is higher than in China. It accounts for 21 per cent of the total, but consumption has not changed much in the last few years. The EU member states accounted for 16 per cent of energy use. In 2006, oil accounted for 36 per cent of world energy use, followed by coal and natural gas at 28 and 24 per cent respectively. However, the energy commodity that showed the largest rise in consumption from 2005 to 2006 was coal (4.5 per cent); this was largely due to the steep rise in consumption in China.

- The energy mix varies greatly from one country to another: in 2006, Asia/Oceania accounted for 58 per cent of all coal consumption, while 79 per cent of all nuclear power and 67 per cent of natural gas consumption was in Europe (including the former Soviet Union) and North America. Norway is the country where the proportion of hydropower in the energy mix is highest (65 per cent), but it is also important in Brazil, where it accounted for 38 per cent of the total in 2006.

- 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).

Figure 3.17. Domestic energy use[1] by consumer group. 1976-2006*. PJ



[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 2006, Norway's total energy use (including energy commodities used as raw materials, excluding international maritime transport) was 1 099 PJ. This was a slight decrease from the year before. Energy use in the energy sectors totalled 247 PJ. The energy sectors 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, decreased slightly from the year before, and totalled 852 PJ in 2006. Energy use rose by an average of 1.2 per cent per year from 1976 to 2006. In the same period, GDP excluding the oil and gas sector grew by an average of about 2.5 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 1976-2005. Since these groups are dependent on cyclical changes, the rise has been uneven. Energy use by households rose steadily up to 1996, and 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.

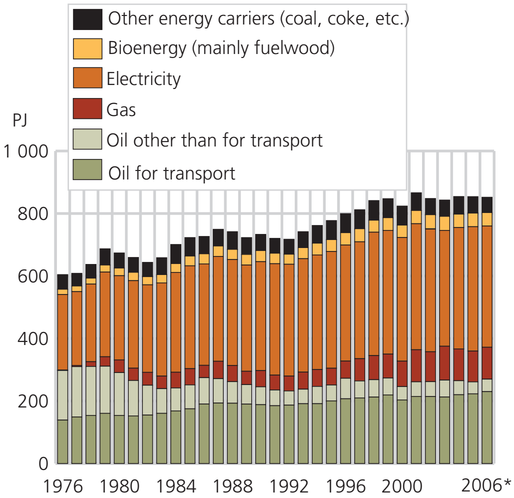
Box 3.3. Environmental pressures caused by the extraction and use of energy

Emissions to air occur during the extraction, transport and use of oil and gas products. These can result in climate change, acidification, the formation of ground-level ozone and local air pollution (see Chapter 9: Air pollution and climate change). Emissions to air from the energy sectors in 2005 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.

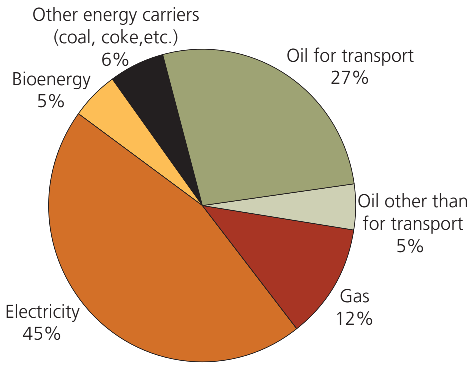
Infrastructure development takes place during the development of new capacity for energy generation, and includes the construction of dams, roads, onshore installations and transmission lines. Hydropower production also results in variable water levels in reservoirs and changes in discharge volumes in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

Figure 3.18. Energy use[1] by energy carrier. 1976-2006*. PJ



[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. 2006*. Percentages[1]

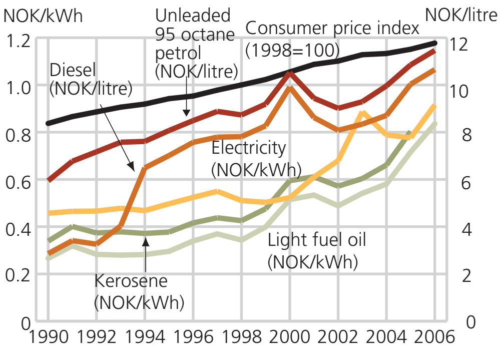


[1] Electricity accounts for a lower proportion of energy use here than in figure 3.16. This is mainly because figure 3.16 does not include the use of bioenergy or energy commodities used as raw materials and reducing agents.
Source: Energy statistics, Statistics Norway.

Consumption by energy commodity

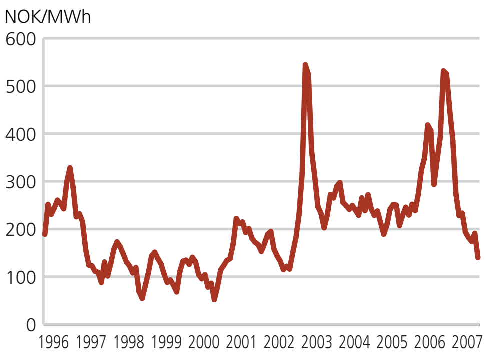
- Total oil consumption, excluding the energy sectors and international maritime transport, dropped by about 9 per cent in the period 1976-2006, despite the fact that a consumption of oil for transport rose by 66 per cent in the same period.
- Transport now accounts for 85 per cent of total oil consumption, 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, when it has been dropping even further.
- Electricity consumption rose from 241 PJ in 1976 to 388 PJ in 2006. This is an increase of 61 per cent. From 2002 to 2003, high electricity prices resulted in a marked drop in consumption, but since then consumption has been rising again. 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. Price trends at end-user level. NOK per kWh and litre, current prices



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

Figure 3.21. Price trends for electricity, Nord Pool system price[1]. 1996-2007. NOK/MWh

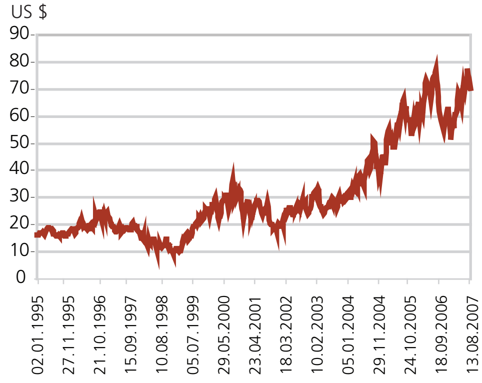


[1] Theoretical market price without any restrictions on transmission.
Source: Nord Pool.

Prices

- The listed price (average price from the Norwegian Petroleum Industry Association) of light fuel oil rose by about 17 per cent from 2005 to 2006. According to the quarterly price statistics, the average electricity price (including transmission charges and taxes) for households reached the record level of NOK 0.915 per kWh. This resulted in lower electricity consumption, some of which was replaced by higher consumption of light fuel oils.
- 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.
- Trade in electricity has been deregulated in Norway, and producers and suppliers trade on the joint Nordic power exchange, Nord Pool. The basic price of much of the electricity traded is thus determined by the market at any time. However, some electricity is also traded in the form of bilateral fixed contracts, standard fixed contracts and standard variable contracts. Figure 3.21 is a graph of the average monthly Nord Pool system price in the period 1996-2007. It shows that there can be very large variations from one month to another. From autumn 2000 to autumn 2006, prices showed a clear rising trend, but have since been dropping because inflow to the reservoirs has been high.

Figure 3.22. Spot price of Brent Blend. 1995-2007. USD



Source: Petroleum Intelligence Weekly.

- The spot price of Brent Blend dropped from about USD 77 per barrel in mid-August 2006 to just over USD 50 per barrel in early January 2007. Since then, the price has been rising, and was more than USD 70 per barrel at the beginning of September. The average spot price of Brent Blend was just over USD 65 per barrel for the first eight months of 2007, which is the same as the annual average for 2006.
- Several factors explain the decline in oil prices in the last few months of 2006. Firstly, autumn and winter were relatively mild in the northern hemisphere, so that demand for fuel oil was not particularly high. The Middle East ceasefire also resulted in less concern that conflicts would spread and influence oil prices in the region.
- The main reason for the price rise in 2007 was colder weather in the northern hemisphere during the first quarter. In addition, OPEC decided to reduce production by 0.5 million barrels per day from February onwards, in addition to the reduction of 1.2 million barrels a day it introduced in November 2006. Furthermore, demand for petrol was high, mainly because of the rise in demand in the summer season in the US, which lasts from April to October.

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Useful websites

Statistics Norway - Electricity, gas and water supply:
http://www.ssb.no/english/subjects/10/08/
Statistics Norway - Energy balance and energy accounts:
http://www.ssb.no/english/subjects/01/03/10/energiregn_en/
Statistics Norway - Extraction of oil and gas:
http://www.ssb.no/english/subjects/10/06/20/
Statistics Norway - Petroleum sales: http://www.ssb.no/english/subjects/10/10/10/petroleumsalg_en/
British Petroleum (World Energy Review): http://www.bp.com/home.do
International Energy Agency: http://www.iea.org/
World Energy Council: http://www.worldenergy.org/
The Energy Farm (Centre for Bioenergy in Norway): http://energigarden.no/
Norwegian Water Resources and Energy Directorate: http://www.nve.no/
Norwegian Petroleum Industry Association: http://www.np.no/
Ministry of Petroleum and Energy: http://www.regjeringen.no/nb/dep/oed.html?id=750
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4. Agriculture

The total size of agricultural areas in use 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 eutrophication of water bodies caused by nutrient enrichment. 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 these factors 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 pressure to convert farmland for development.

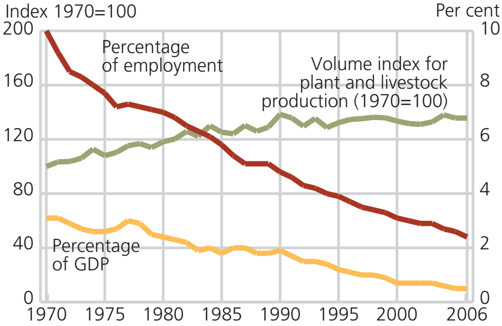
One of the most important objectives of farming is to safeguard the national food supply (Report No. 19 (1999-2000) to the Storting). The food production potential in Norway is primarily restricted by the climatic conditions and the availability of land resources suitable for farming. Consequently, protecting agricultural land resources has high priority.

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 (index 1970=100) and share of employment and GDP. 1970-2006*



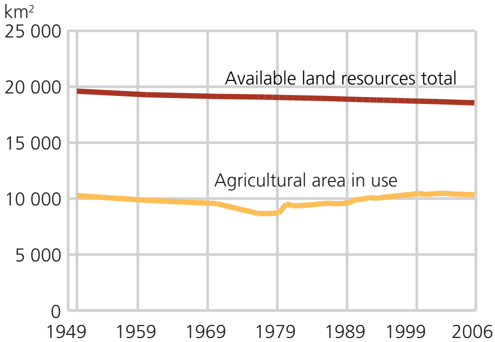
Source: Budget Committee for Agriculture (2007) and Norwegian National Accounts, Statistics Norway.

Agriculture in an economic perspective

- From 1970 to 2006, employment in agriculture fell by 67 per cent (from 150 000 to 50 000 normal full-time equivalents). In comparison, manufacturing employment fell by approximately 29.5 per cent.
- Agriculture's share of GDP fell from 3.1 to 0.5 per cent. In comparison, manufacturing declined from 18.3 to 8.4 per cent.
- Agricultural production has increased by about 36 per cent in the same period. However, production volume has not increased since 1990.

4.2. Land resources

Figure 4.2. Available land resources and agricultural area in use. Norway. 1949-2006*

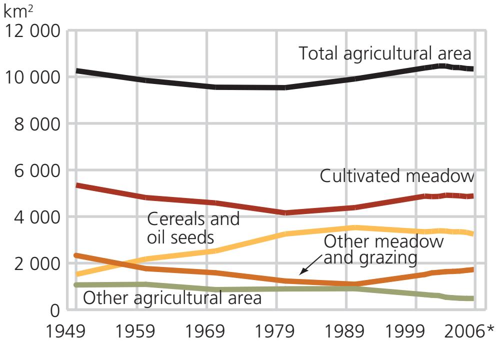


Source: Agricultural statistics, Statistics Norway and Grønlund and Høie (2001).

Available land resources and cultivated areas

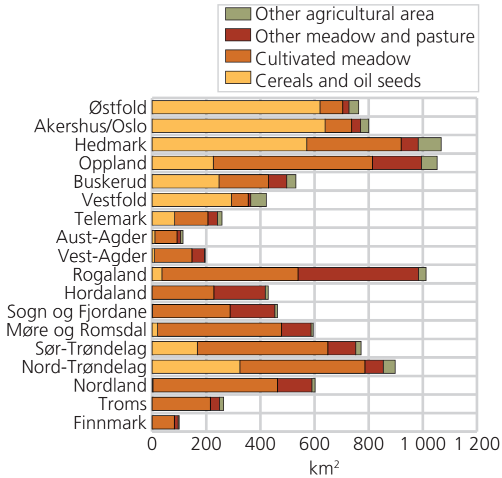
- About 3 per cent of the country is cultivated, as compared with over 10 per cent in the world as a whole.
- Some of the land resources available are not in use for agriculture, either temporarily or on a permanent basis. In 1979 and 1989, this applied to 6-7 per cent of the total agricultural area. Areas that are not being used can be taken into use again later for agricultural purposes, but may also become overgrown by forest or be converted for purposes that prevent future agricultural production.
- The scarcity of land resources means that the current self-sufficiency rate is about 50 per cent. Up to about 1990, the self-sufficiency rate was rather lower than this. The subsequent rise is mainly explained by more use of Norwegian-produced cereals for human consumption (Directorate for Health and Social Affairs 2007).
- Almost the same proportion of land is classified as cultivable, but these areas are generally less valuable than land that is already being cultivated. Most of the cultivable land is in areas with a climate that is most suitable for the production of grass and other fodder crops.
- 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 in the early 1990s, a significant decrease in new cultivation activities has been recorded. In 2006, the municipalities approved new cultivation of about 12 000 decares of land.
- From 1949 to 2006, the available land resources (cultivated and cultivable land) have decreased by over 1 000 km² or 5.3 per cent as a result of the conversion of land for purposes that prevent future agricultural production. The proportion of the available resources actually cultivated was 56 per cent in 2006, as compared with 52 per cent in 1949.

Figure 4.3. Agricultural area in use. 1949-2006*



Source: Agricultural statistics, Statistics Norway.

Figure 4.4. Agricultural area in use, by county. 2006*

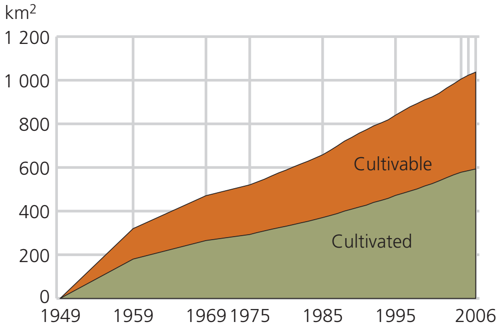


Source: Agricultural statistics, Statistics Norway.

Agricultural area in use

- From 1949 to the mid-1970s, the agricultural area in use decreased from 10 300 km² to 8 700 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, and to stricter requirements with regard to the minimum area for manure spreading.
- In 2001 and 2002, the agricultural area in use was a little under 10 500 km². Since then it has dropped by 1.2 per cent, to 10 340 km² in 2006. In some counties, a considerably larger percentage reduction has been registered: in Aust-Agder, Vest-Agder, Sogn og Fjordane and Finnmark, the agricultural area in use has dropped by 4-5 per cent, and in Hordaland by 9 per cent.
- 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 2006.
- 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 now accounts for 17 per cent of the agricultural area in use.

Figure 4.5. Accumulated conversion of cultivated and cultivable land[1]. 1949-2006*



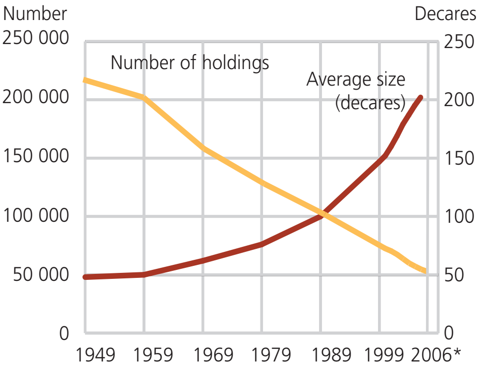
[1] For the period 1949-1975 data is only available for cultivated areas that were converted. The area of cultivable land converted in this period has been estimated on the basis of the ratio between cultivable and cultivated land converted in 1976-1997.
Sources: Statistics Norway, Ministry of Agriculture and Food and Norwegian Agricultural Authority.

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 1 037 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 2006, 8 000 decares of cultivated land were converted for other purposes, including 300 decares for tree-planting.

4.3. Size of holdings and cultural landscape

Figure 4.6. Number of holdings and average size of agricultural area in use (decares). 1949-2006*



Source: Agricultural statistics, Statistics Norway.

Holdings - number and size

- The number of holdings in Norway has been reduced to about a fourth since 1949; 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 1999-2006 was 3.9 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 1989, 23 per cent of the agricultural area in use was rented. In 1999, this share had increased to 31 per cent, and it was estimated at 39 per cent in 2006. In Telemark, Aust-Agder, Vest-Agder and Troms, the proportion of agricultural land rented was more than 50 per cent.

Table 4.1. Numbers of livestock spending at least 8 weeks on outlying rough grazing

	Livestock, total	Cattle, total	Sheep	Goats	Horses over year old[1]
1985	2 800 000	432 600	2 266 900	92 400	8 200
1990	2 419 400	276 700	2 048 400	87 300	7 000
1995	2 581 300	268 700	2 225 100	81 300	6 300
2000	2 316 600	227 400	2 013 600	69 400	6 200
2005	2 379 700	239 000	2 067 000	65 900	7 800
2006	2 279 000	222 400	1 985 800	62 800	8 100

[1] Figures for 2005 and 2006 include all horses.
Source: Norwegian Agricultural Authority.

- Since 1949, the average size of holdings by area of agricultural land in use has more than quadrupled, to 202 decares in 2006.
- 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. In 1949, 22 600 holdings had their own summer farms or a share in a summer farm. By 2006, this had dropped to only 2 000 holdings.
- Grazing livestock play an important role in preventing or 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, see table 4.1. The regional environmental programmes also include other measures to prevent open landscapes from becoming overgrown.

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 among 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.

4.4. Pollution from the agricultural sector

Table 4.2. Emissions to air from agriculture. Greenhouse gases and acidifying substances. 2005*

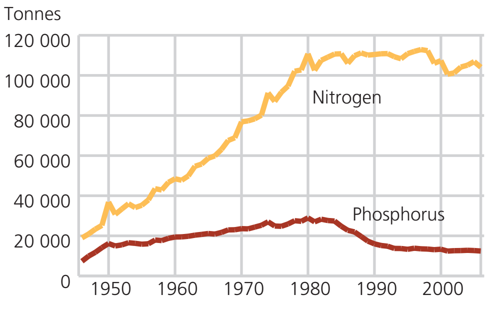
	Emissions from agriculture. 1 000 tonnes	Share of total emissions in Norway. Per cent
Greenhouse gases	4 796[1]	9.1
Carbon dioxide (CO_2)	415	1.0
Nitrous oxide (N_2O)	6.9	45.0
Methane (CH_4)	106.2	48.5
Acidifying substances	1.3[2]	20.0
Ammonia (NH_3)	20.3	88.3
NO_X	3.6	1.8
SO_2	0.1	0.4

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

Emissions to air

- Nitrous oxide (N_2O): important sources 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.
- Methane (CH_4): livestock. Between 80 and 90 per cent is released directly from the gut.
- Ammonia (NH_3): animal manure (about 90 per cent), the use of commercial fertiliser and treatment of straw with ammonia.
- See also Chapter 9. Air pollution and climate change.

Figure 4.7. Sales of nitrogen and phosphorus in commercial fertilisers. 1946-2006

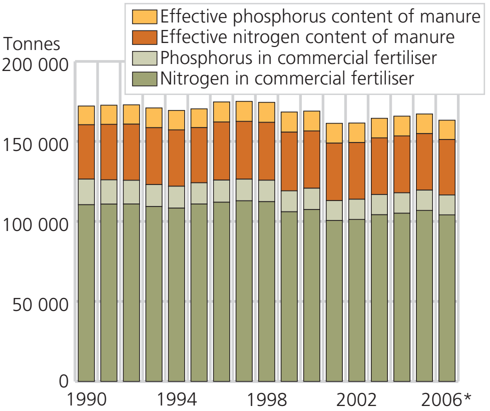


Source: Norwegian Food Safety Authority.

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. In 2001 and 2002, sales of nitrogen fertiliser were 10 per cent lower than in the peak years 1996-1998, but there has been a moderate rise since then.

Figure 4.8. Sales of nitrogen and phosphorus in commercial fertiliser and calculated effective nitrogen and phosphorus content of manure. 1990-2006*



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.
- There are large regional differences in quantities of manure and the area available for manure spreading. The largest quantities of manure are in important livestock counties such as Hedmark, Oppland and the counties from Rogaland to Nordland.
- The last survey of the area used for spreading manure was carried out in 2002. This showed that manure was applied to just under 3.9 million decares, consisting of 62 per cent meadow for mowing (on arable land or permanent), 30 per cent other crops on arable land or ploughed and reseeded meadow and 8 per cent pasture.

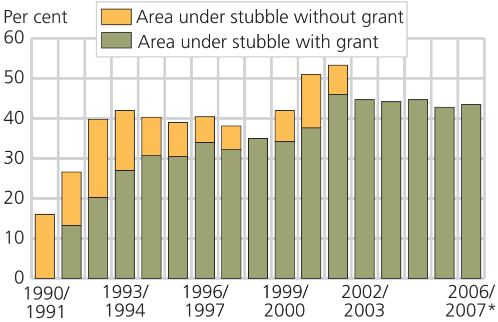
Box 4.2. Pollution from the agricultural sector

Farming results in air and water pollution. Agriculture is a major source of discharges of nutrients to water (nitrogen and phosphorus) (see further details in Chapter 12). In 2005, agriculture accounted for about 47 and 57 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 4.2). 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.

Figure 4.9. Proportion of cereal acreage left under stubble in autum[1]. 1990/1991-2006/2007*

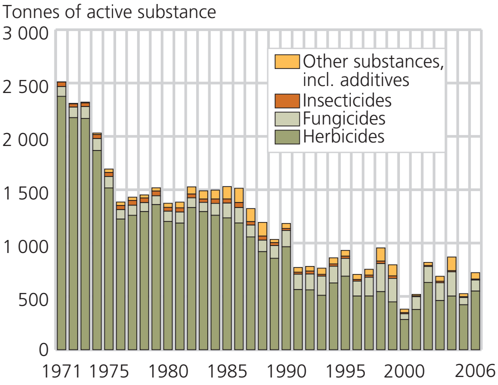


[1] Total area under stubble not recorded in 1998/99 and after 2001/02.
Source: Agricultural statistics, Statistics Norway, Ministry of Agriculture and Food and Norwegian Agricultural Authority.

Soil management

- 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. The area under stubble (i.e. area that is not tilled between harvesting and spring) increased from 16 per cent in 1990/91 to 42 per cent in 1993/94. This level remained stable until 2000, but increased to 53 per cent in 2001/02.
- After 2001/02, information is only available on the area under stubble for which grants are provided. From 2002/03 onwards, this has been equivalent to 43-45 per cent of the total area under cereals and oil seeds. The area under stubble in winter 2006/07 for which support was granted was 1.4 million decares.
- Support is also provided for other forms of amended soil management. In all, 325 000 decares of areas that are lightly harrowed in autumn, directly sown autumn cereals, autumn cereals sown after light harrowing and catch crops received grants in the season 2006/07. Grassed channels are also covered by the grant schemes. From 2005, these schemes have been included in the regional environmental programmes, and the way these are organised varies from county to county.

Figure 4.10. Sales of chemical pesticides. Tonnes active substances. 1971-2006



Source: Norwegian Food Safety Authority.

Use of plant protection products

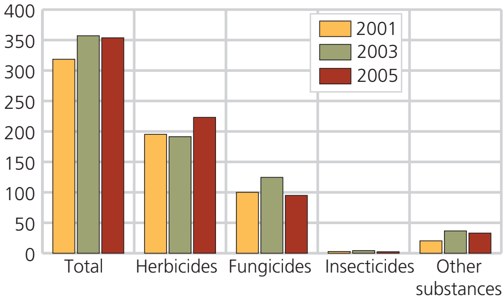
- The sales statistics apply to sales by importers to distributors and do not therefore show actual annual usage. Statistics for recent years are influenced by the fact that there have been changes in the taxation system, which have resulted in some hoarding of pesticides. The introduction of a new system in 1999, which included a tax increase, and a further tax increase in 2000 resulted in a high level of imports at the end of 1998 and 1999. As a result, sales were low in 2000 and 2001. A new change in the tax system entered into force in autumn 2004. This resulted in higher imports of certain products in 2004 and correspondingly lower figures in 2005.
- 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.

Box 4.3. Measures to prevent soil erosion

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

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. This support scheme also applies to some other types of areas such as areas lightly harrowed in autumn, directly sown autumn cereals, autumn cereals sown after light harrowing, catch crops and grassed channels. Support is provided because crop yields are expected to be lower in the following season without autumn tillage. In the long run, however, reducing soil loss will help to maintain soil quality, with a potentially positive impact on future crop yields.

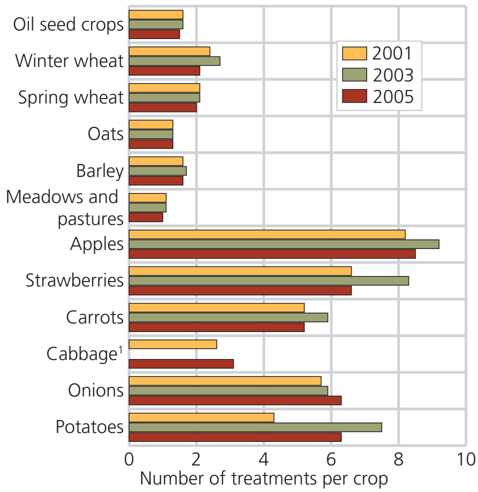
Figure 4.11. Use of pesticides by type of product. 2001, 2003 and 2005. Tonnes active substances



Source: Agricultural statistics, Statistics Norway (Bjørlo 2006).

- 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. Figure 4.12 shows which crops were included.
- Pesticide use in agriculture may vary considerably from one year to another, largely because of weather conditions. To give a reliable picture of consumption patterns and trends over time, surveys must be repeated at regular intervals.
- With the exception of meadow and pasture, the proportion of the area treated with pesticides varied from 81 per cent to almost 100 per cent in 2005. Only 6 per cent of the area of meadow and pasture was treated, largely in connection with ploughing and reseeding.

Figure 4.12. Average number of treatments for crops in surveys. 2001, 2003 and 2005

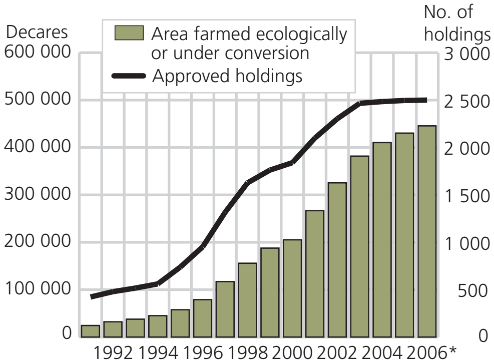


[1] No data available for 2003.
Source: Agricultural statistics, Statistics Norway (Bjørlo 2006).

- Crops are vulnerable to pests to a varying extent. Among the crops in the survey in 2005, the number of treatments varied from an average of 1.1 in meadows and pastures to 8.2 in apple production.
- The results show that pesticides were generally used at the recommended application rates or somewhat below this.
- Preparations used to treat seeds or plants before planting were not included in the survey. In addition, there is some use of pesticides outside the agricultural sector, for example in gardens, on golf courses, along roads and railways and in forestry.

4.5. Ecological farming

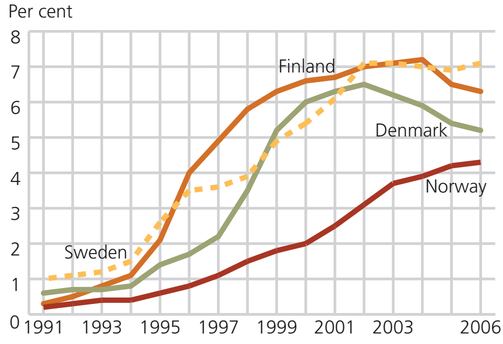
Figure 4.13. Holdings approved for ecological farming and total area farmed ecologically or in the process of conversion. 1991-2006



Source: Debio.

- 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 agricultural area is to be farmed ecologically within 10 years, provided that there is a market for the products. Based on the agricultural area in use in 2006, this corresponds to just over 1 million decares. The area farmed ecologically in Norway is rising, but has not increased much in recent years. In 2006, the area converted to ecological farming and the area in the process of conversion totalled 446 000 decares, which corresponds to 4.3 per cent of the total agricultural area.
- In 2006, meadow and pasture accounted for 75 per cent of the area converted, while cereals accounted for 15 per cent and other crops for 10 per cent.
- The percentage of the agricultural area converted to ecological farming was highest in Buskerud, Telemark and Sør-Trøndelag, at 6.6-6.7 per cent, and lowest in Rogaland, at 0.6 per cent.
- The proportion of ecologically farmed livestock is low. In 2006, the figures were 4.8 per cent for suckler cows, 2.1 per cent for dairy cows, 0.2 per cent for breeding sows, 3.0 per cent for winter-fed sheep and 2.0 per cent for laying hens.

Figure 4.14. Percentage of the total agricultural area farmed ecologically or in the process of conversion in the Nordic countries. 1991-2006



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).

- In 2006, the percentage of land farmed ecologically was lowest in Norway, where it was 4.3 per cent, as compared with 5-7 per cent in the other Nordic countries.
- Ecological farming increased in all the Nordic countries in the 1990s, but in the last two to three years, the area ecologically farmed has remained stable or dropped slightly in Sweden, Denmark and Finland. This may be because of a reduction in the prices obtained for ecological products as a result of lower demand than expected. In addition, environmental grants have been introduced, and their requirements are less strict than those for certification for ecological farming.
- There has been a growing demand for ecological products in 2006-2007. However, production cannot be increased in the short term since conversion from conventional to ecological farming takes 2-3 years.

Box 4.4. Ecological farming

Ecological farming (or organic farming) is a collective term for various farming systems based on some common principles:
- No use of commercial 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.

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

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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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Report No. 19 (1999–2000) to the Storting: *Om norsk landbruk og matproduksjon.* (Norwegian agriculture and food production). Ministry of Agriculture.

5. Forest and uncultivated land

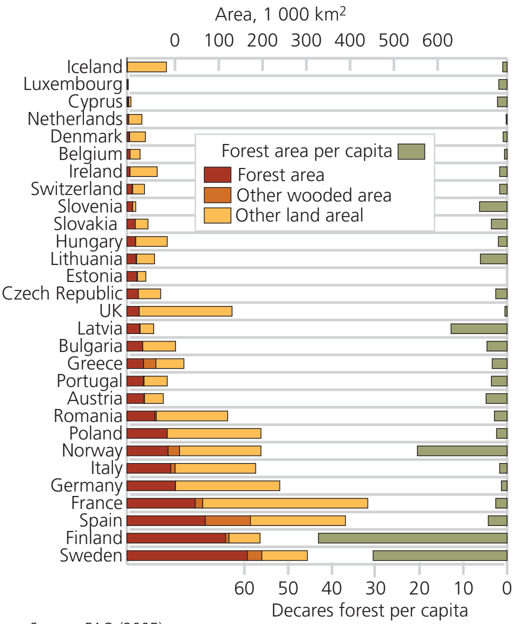
The Norwegian forests contain a wide variety of resources and environmental qualities. In terms of the economy, forests are primarily important as a source of raw materials for the sawmilling and pulp and paper industries. The forest, with its biological diversity, also has considerable intrinsic value as an ecological resource and as an outdoor recreation area for an increasingly urbanised population. This provides a basis for utilising the resources of uncultivated areas for tourism as well.

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 EU and EFTA countries



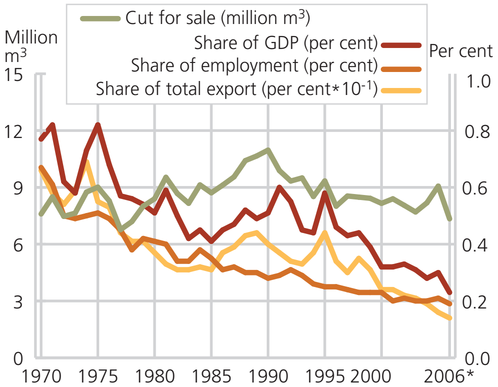
Source: FAO (2005).

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 2006). 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. Forestry

Figure 5.2. Forestry: share of exports, employment and GDP. Annual roundwood removals. 1970-2006*



Source: National accounts and forestry statistics, Statistics Norway.

Roundwood removals and economic importance

- In 2006, forestry's share of total employment was 0.19 per cent. This is equivalent to 3 950 full-time equivalents, down from about 10 000 in 1970. The relative reduction was somewhat lower than for agriculture.
- Forestry's share of Norway's GDP dropped from 0.77 per cent in 1970 to 0.23 per cent in 2006. Forestry's share of GDP has declined less sharply than that of agriculture.
- The gross value of removals of industrial roundwood was NOK 2.3 billion in 2006, and wood and wood processing products worth NOK 13.9 billion were exported from Norway, which is 1.4 per cent of the value of the country's total exports.

Box 5.1. Protection of forests in Norway

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

An estimated 22 000 forest plant and animal species have been recorded in Norway, and about 1 800 of these are rare or endangered (Kålås et al. 2006). Norway has ratified the Convention on Biological Diversity, which was adopted by the UN Conference on Environment and Development in 1992, and is therefore required to take steps to identify and monitor its biological diversity.

As of 1 January 2007, about 1 000 km^2 or 1.3 per cent of the productive forest area in Norway was protected (according to Norwegian Forest and Landscape Institute 2006, the total area of productive forest is 75 346 km^2. Included in this figure are protected forest areas in the national parks (Directorate for Nature Management 2007).

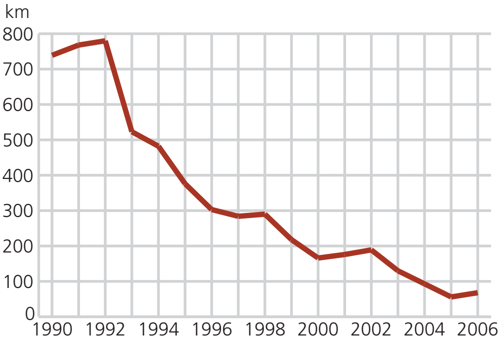
By comparison, about 4 per cent of the total area of productive forest in Sweden and Finland was protected in 2006 (Swedish Forest Agency 2007 and METLA 2006).

In November 2003, the Storting discussed the recent white paper on the Government's environmental policy and the state of the environment in Norway (Report No. 25 (2002-2003) to the Storting). The white paper included plans for a further increase in the protection of forests. This work has been organised according to a three-track strategy: traditional forest protection, forest protection on state-owned land, and voluntary forest protection in collaboration with the Norwegian Forest Owners' Federation.

The most recent white paper on the Government's environmental policy and the state of the environment in Norway (Report No. 26 (2006-2007) to the Storting) states that the government will:

- Enhance progress in voluntary forest protection and carry out a scientific evaluation of such protection in 2008.
- Amend the regulations relating to the construction of forest roads so that areas without infrastructure development are safeguarded in accordance with the Government's policy platform. Prepare for this by evaluating the quality of the data on forest roads and areas without infrastructure development and the forestry industry's need for road construction, and by considering options and consequences with a view to amending the rules on grants in 2007.
- Ensure that planning processes and administrative procedures concerning forest road construction safeguard areas of importance for biodiversity and areas of high conservation value. Promote transparency and participation in administrative procedures relating to forest road construction.
- Work towards active European cooperation on biodiversity and on forests and seek to ensure effective cooperation between the Pan-European Biological and Landscape Diversity Strategy and the Ministerial Conference on the Protection of Forests in Europe.

Figure 5.3. Annual construction of new forest roads for year-round use. 1990-2006



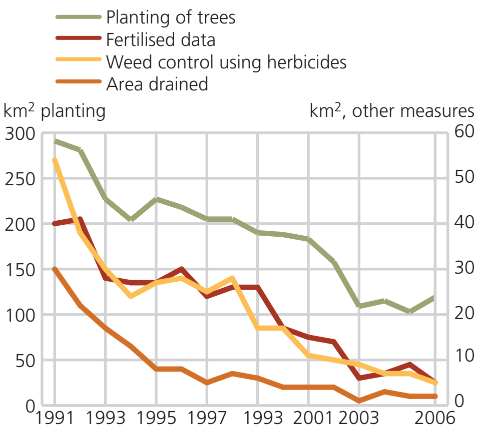
Source: Forestry statistics, Statistics Norway.

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 (SSB/SFT/DN 1994). 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 68 km in 2006.
- A total of NOK 85 million was invested in forest roads in 2006, and NOK 30 million of this was in the form of public grants. This was roughly the same figure as in 2005.

For the size of wilderness-like areas, see Chapter 8 Land and land use.

Figure 5.4. Silviculture measures that have an environmental impact[1, 2]. 1991-2006*



[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 85 million was invested in planting in 2006, and 120 km^2 were planted.
- There may be several reasons for the decline in the use of chemical herbicides: increased focus on environmental considerations in forestry, restrictions on the use of spraying, annulment of grants and reduced profitability in forestry.
- The county of Nord-Trøndelag accounted for more than half of all forest drainage in 2006.

Box 5.2. Forest owners' attitudes to protection of their forests differ between the Nordic countries

A Nordic report (Vatn et al. 2005) analyses the reasons why the protection of forest and wetland biodiversity gives rises to different levels of conflict in Norway, Sweden and Finland. The analysis was based on interviews with forest owners in the three countries, part or all of whose property has been protected. The main finding was that conflicts are closely linked to how the protection process is organised and carried out. In all three countries, the majority of those interviewed were positive to the idea of protecting biodiversity. In Finland and Sweden, the majority of the owners were also positive to protection on their own land provided that they were given full economic compensation, but Norwegian owners were far more negative. There was also considerable dissatisfaction with the protection process in Norway, where it has largely been a «top down» process. Moreover, there was considerable dissatisfaction with the environmental authorities, which have been responsible for the protection process in Norway. In Finland and Sweden, the forest authorities have played a much greater role, and the forest owners appeared to have markedly greater confidence in them. However, it should also be noted that the type of protection has tended to be less strict in Finland and Sweden (for example, some use of time-limited protection). Trials of various forms of voluntary protection are now under way in all three countries.

For more information, see: Vatn, A., E. Framstad and B. Solberg (red.)(2005): Virkemidler for forvaltning av biologisk mangfold. Delrapport 3.Tiltak og virkemidler for vern av biodiversitet i skog og våtmarker. (Instruments for management of biodiversity. 3. Measures and instruments for protecting biodiversity in forests and wetlands) TemaNord 2005:563, Nordic Council of Ministers.

Box 5.3. Environmental inventories in forests - biodiversity

Forestry planning and adequate information about forests and the environment form the main basis of long-term, sustainable forest management. Forestry planning funded by government grants is carried out in accordance with regulations concerning government grants for forestry planning, which include various provisions relating to purpose, requirements for standards and inventory methods, organisation, etc. Registration of biological diversity is now included in forestry planning. Forestry planning aims to obtain localised information to enable forest owners to base their activities on documented facts about forest areas, resources and areas of environmental value. Forestry plans are primarily intended as a tool for owners to generate value-added based on the rational use of forestry resources and sustainable forest management and to function as the basis for annual plans and operations.

It is important that the registration of biodiversity in forests included in forestry planning is conducted according to clearly defined instructions so that the registration can be documented and verified and the results are objective and comparable. This is important in order to ensure that the work of registration maintains a clear and reliable profile, and because the various environmental considerations will always involve consequences for commercial activities.

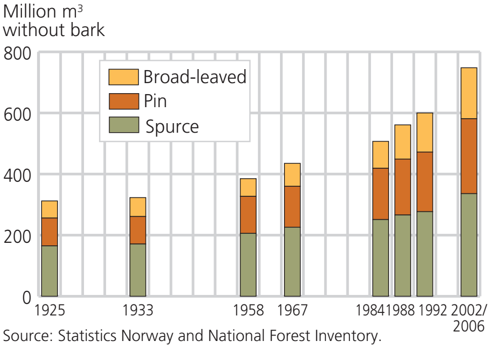
The environmental inventory method used in forestry planning is based on extensive research and documentation of ecological relationships, and clearly indicates how the method was developed and the specific data to be registered. The work has been coordinated by the Norwegian Forest and Landscape Institute. On the basis of the project's scientific results, a registration methodology was developed to capture important environmental qualities in connection with forestry plans drawn up on request from individual forest owners. The project was funded by the Ministry of Agriculture and Food, and government support is provided for forest owners who request forestry plans that include registration of biodiversity. The registration scheme was fully operational from 2001, and registration has been carried out in about 30 km^2 of productive forest. In 2007, NOK 30 million was allocated for forestry planning including environmental inventories.

A booklet is available describing the registration method, and courses have been held for forestry planners and other users. The booklet is available in Norwegian on this institute's website www.skogoglandskap.no).

As work on environmental registration continues, new information can be expected to emerge that will be valuable in connection with the environmental adaptations implemented by the forestry industry in accordance with government policy and the Living Forests Standards. This work is also relevant to the national programme to survey and monitor biological diversity (Ministry of Agriculture and Food 2007).

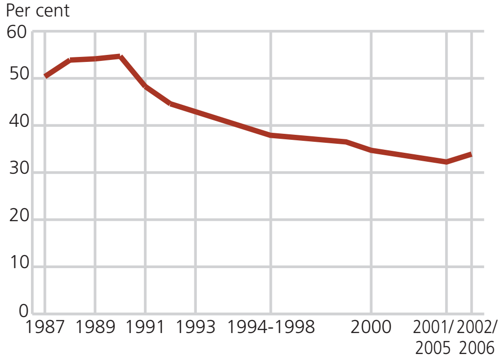
5.3. Increment and uptake of CO_2 by forest

Figure 5.5. Volume of the growing stock. 1925-2002/2006



Source: Statistics Norway and National Forest Inventory.

Figure 5.6. Utilisation rate of the growing stock. 1987-2002/2006



[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.

Forest volume and utilisation rate of the growing stock

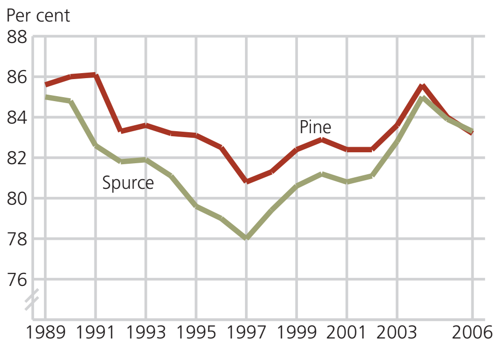
- Since the early 1920s, roundwood removals have been less than the annual increment. In 1925, about 80 per cent of the increment was cut, whereas only about one third was cut in the period 2002–2006. As a result, the volume of the growing stock below the coniferous forest line has more than doubled since 1925.
- In 2006, the gross increment in Norwegian forests was about 25.5 million m³.

Uptake of CO_2

- The increase in the biomass (branches and roots included) of forests in 2005 resulted in an uptake of carbon by forest that corresponded to 24 million tonnes of CO_2 or about 55 per cent of the 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 carbon pools in dead wood and soil have been made. Carbon levels have increased by an amount corresponding to 6 million tonnes of CO_2 or 14 per cent of total anthropogenic emissions in 2005 (Rypdal et al. 2005).

5.4. Forest damage

Figure 5.7. Mean crown condition for spruce and pine. 1989-2006



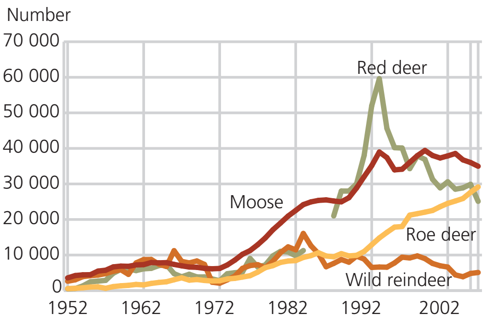
Source: Norwegian Forest and Landscape Institute.

Forest damage in Norway

- Crown density is an indicator of the forest's state of health. Decreasing crown density was the trend from the first survey in 1989 and up to 1997. Since then, crown density of both spruce and pine has improved, with the exception of a small setback for both species in 2005 and 2006.
- Mean crown density was 83.3 per cent for spruce and 83.2 per cent for pine in 2006.
- The crown colour of spruce was greener in 2006 than at any other time since the first survey. Pine and birch, on the other hand, showed significantly poorer crown colour status than the year before.

5.5. Game species

Figure 5.8. Number of moose, red deer, wild reindeer and roe deer killed. 1952-2006

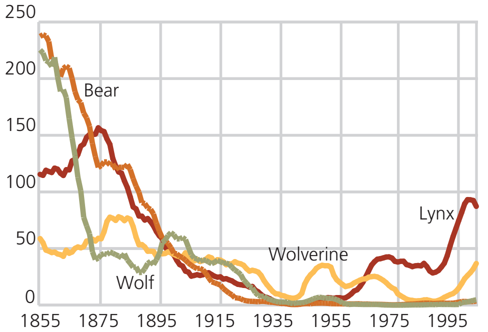


Source: Hunting statistics, Statistics Norway.

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 continued to rise.
- The grazing pressure exerted by large populations of cervids influences the vegetation, and this can affect the landscape and biological diversity.
- The total yield in 2006 was 4 657 tonnes moose meat, 1 672 tonnes venison and 175 tonnes wild reindeer meat.

Figure 5.9. Number[1] of predators killed. 1855-2005



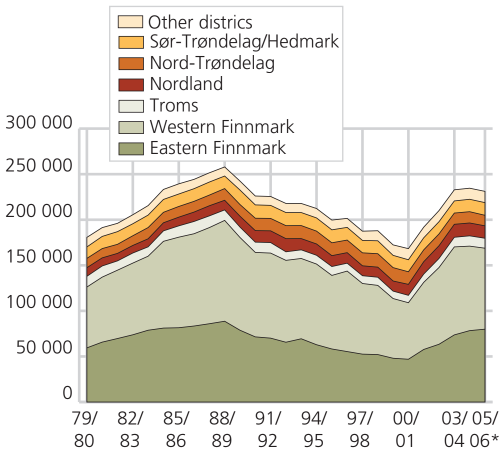
[1] Average number past ten years.
Source: Hunting statistics, Statistics Norway.

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 were protected throughout Norway in 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.

5.6. Reindeer husbandry

Figure 5.10. Trends in the size of the spring herd. 1979/80-2005/06*



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 difficult weather conditions in winter in several years 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.

5.7. 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. 2001-2006*

	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*	15 975	14 610	91

[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.
- In all, 91 per cent of all applications for exemption were granted in 2006. The number of applications was lower than in the two previous years. However, the percentage of exemptions granted increased, so that the number of exemptions was not much lower than the year before.
- 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

Stocks of several important demersal fish species in the North Sea are still very low. The same is true of the Barents Sea capelin stock. The spawning stock of Northeast Arctic cod is considered to be within safe biological limits. However, the fishing mortality is considered to be too high and there is considerable illegal fishing. In 2006, production of farmed salmon increased to 626 000 tonnes.

Most fish stocks in the Barents Sea are in good condition, although the capelin stock is still low. Illegal fishing is a threat to the cod stock, and recruitment to the stock has been poor in recent years. Unusually high temperatures are attracting more southerly species such as blue whiting and pipefish to the area (Skogen et al. 2007).

2006 was a very warm year almost throughout the Norwegian Sea. The major pelagic fish stocks such as herring, mackerel and blue whiting, which to some extent use the Norwegian Sea as a feeding ground, are all in good condition. More than 10 million tonnes of pelagic fish migrate through and feed in the area (Skogen et al. 2007).

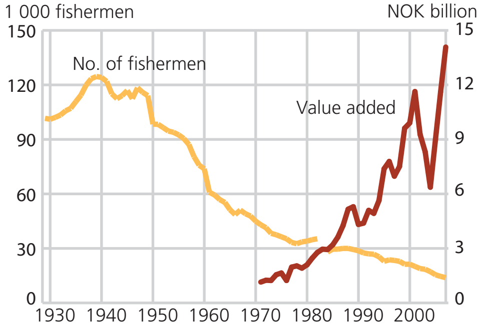
For the last four to five years, recruitment to the sandeel, Norway pout, cod and herring stocks in the North Sea has been poor. This is mainly a result of changes in physical and biological conditions, although the cod and sandeel stocks have also been overfished. According to advice from marine scientists, fishing for cod in the North Sea should have been stopped several years ago. Moreover, illegal landing and discarding of fish makes it difficult to calculate the size of certain stocks, particularly mackerel and cod (Skogen et al. 2007).

The total catches in the world's marine fisheries were 84 million tonnes in 2005, a decrease of about 1.8 million tonnes compared with the year before. The species with the highest total catch was Peruvian anchovy (*Engraulis ringens*). The catch of this species was 10.2 million tonnes, which corresponds to more than four times the total yield of Norwegian fisheries and 12 per cent of the total world catch in marine areas. Total world aquaculture production in 2005 was 48 million tonnes.

In its report *The State of World Fisheries and Aquaculture 2006*, FAO (2007b) estimates that 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.

6.1. Principal economic figures for the fisheries

Figure 6.1. Value added[1] in the fishing, sealing and whaling industry 1970-2006, and number of fishermen 1930-2006

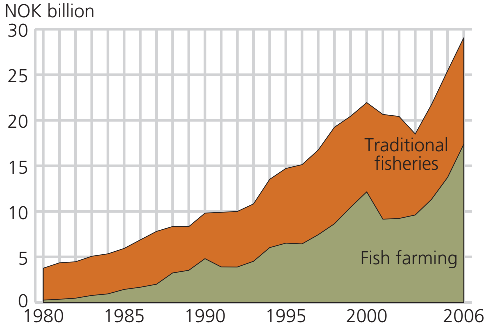


[1] Value added in basic values. Current prices.
Source: Directorate of Fisheries and National Accounts, Statistics Norway.

GDP and employment

- According to the Norwegian national accounts, fishing, sealing, whaling and fish farming contributed NOK 14.0 billion, or 0.65 per cent, to Norway's gross domestic product (GDP) in 2006.
- The fishing industry accounted for 0.65 per cent of total employment in 2006. At the end of 2006, 13 932 fishermen were registered in Norway. The number of fishermen has dropped by 89 per cent since the late 1930s. Since 1990, the reduction has been almost 50 per cent. Farming of salmon and trout employs about 3 000 people.

Figure 6.2. First-hand values in traditional fisheries and fish farming. 1980-2006



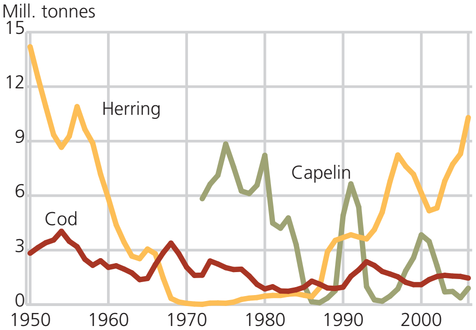
Source: Directorate of Fisheries and Fisheries statistics, Statistics Norway.

Production and prices

- According to preliminary figures from the national accounts, production in fisheries, sealing, whaling and fish farming rose by 0.8 per cent from 2005 to 2006, measured in constant prices.
- The total catch in the traditional Norwegian marine fisheries has dropped since 2002. From 2005 to 2006, there was a drop of 6.2 per cent to 2.2 million tonnes. This was to a large extent due to a reduction in catches of fish for production of fish meal, fish oil and animal feed.
- In 2003, prices were low and the first-hand value of the catch in the traditional fisheries was NOK 8.9 billon. The first-hand value of the catch rose considerably in 2004 and 2005, but then declined slightly again in 2006. In 2006, the total value of the catch was NOK 12 billion (Statistics Norway 2007).
- Fresh salmon is the most important export product for the fish farming industry. From 2000 to 2003, the export price dropped by 33 per cent, while the quantity exported rose by 19 per cent. From 2003 to 2006, the price rose by 50 per cent, and about half of the price rise took place in the last year of this period (Statistics Norway 2007).

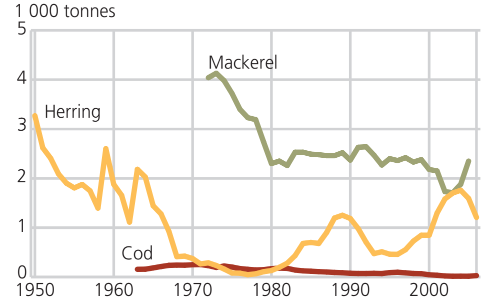
6.2. Trends in stocks

Figure 6.3. Trends for stocks of Northeast Arctic cod[1], Norwegian spring-spawning herring[2] and Barents Sea capelin[3]. 1950-2006



[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.

Figure 6.4. Trends for stocks of cod[1] in the North Sea, North Sea herring[2] and Northeast Atlantic mackerel[2,3]. 1950-2006



[1] Fish aged three years and over [2] Spawning stock.
[3] Southern, western and North Sea mackerel.
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 10 million tonnes in 2006. Thus, the stock is well above the precautionary level of 5 million tonnes.
- The total stock of capelin in the Barents Sea in autumn 2006 was estimated to be below 0.9 million tonnes. The stock is still low, but will probably increase in the years ahead.
- The total stock of Northeast Arctic cod was estimated to be about 1.3 million tonnes in 2006, and the spawning stock was estimated at just under 0.6 million tonnes.

North Sea

- The spawning stock of North Sea herring was estimated to be about 1.2 million tonnes in 2006, a little under the precautionary level. All the year classes after 2001 have been weak.
- The North Sea cod stock is at a historical low, and it is being harvested unsustainably.
- The total spawning stock of mackerel has been decreasing for some time. The estimate for 2005 indicates an increase, but this is very uncertain.

Box 6.1. More about stock trends and fisheries management

- The stock of *Norwegian spring-spawning herring* is now more than 10 million tonnes, which is the same level as in the 1950s, and well above the precautionary level defined by marine scientists. According to the 2007 annual report on marine resources and environment (Skogen et al. 2007), a new herring era is probably beginning. The herring stock is influenced by changes in climate, and growing conditions for the species are good in periods when there is a high inflow of warm Atlantic water to Norwegian coastal waters.

- The decline in the total stock of *Barents Sea capelin* from 2002 to 2003 is due to weak recruitment, increased natural mortality and reduced individual growth. This collapse of the stock is not considered to have been caused by fishing. Predation by cod and herring on capelin and capelin larvae is an important cause of the higher natural mortality. There has been no commercial fishery for capelin in the Barents Sea since 2003. The Norwegian-Russian Fisheries Commission decided, as recommended by the ICES Advisory Committee on Fishery Management, to close the fishery for Barents Sea capelin in winter 2007.

- The spawning stock of *Northeast Arctic cod* - just under 600 000 tonnes in 2006 - is somewhat above the precautionary level, but the fishing mortality is still considered to be too high. One important reason for the increase in spawning biomass after 2000 is earlier maturation. Illegal fishing is a serious problem, and total landings in recent years have been considerably above the TAC (total allowable catch). The TAC for 2007 was 424 000 tonnes. This is considerably higher than the level recommended by the International Council for the Exploration of the Sea (ICES), but 47 000 tonnes lower than in 2006.

- The spawning stock of North Sea herring was substantially depleted in the period 1989-1993, from a level of 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 in reasonably good condition, but is 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.

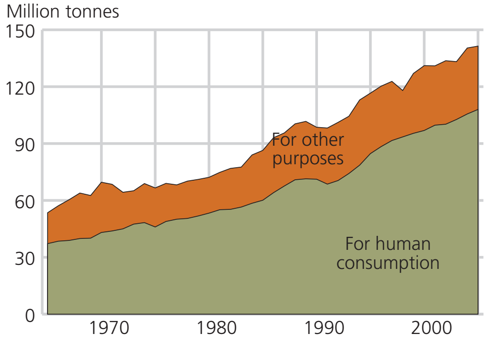
- Several of the stocks of demersal fish in the North Sea have remained low for many years. The *cod stock in the North Sea* has been heavily fished, and the spawning stock is at an all-time low. ICES has recommended a zero catch of cod, but Norway and the EU have nevertheless set quotas. Recruitment to the stock has been poor in recent years. The stock size of whiting is uncertain, but the stock size 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 are considered to be at low levels. Both these species are short-lived, and it is difficult to give reliable long-term prognoses.

- For management purposes, the spawning stocks of *mackerel* from the three spawning grounds (the North Sea, south-west of Ireland and off Spain and Portugal) are now considered as one stock (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. The current catch level is considered to be too high, and if it is maintained, the stock will probably decline.

Source: Marine Resources and Environment 2007 (Skogen et al. 2007) and ICES (www.ices.dk).

6.3. Fisheries

Figure 6.5. World fisheries production[1], by main uses. 1965-2005



[1] 1 Production data does not include marine mammals (seals, whales, etc.) or plants. Aquaculture is included.
Source: FAO 2007a.

Table 6.1. World fisheries production. 2005

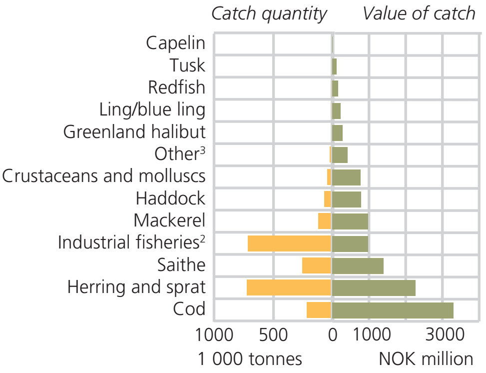
	1 000 tonnes	Per cent
Total production	**141 403**	**100**
Marine fisheries	83 718	59.2
Freshwater fisheries	9 535	6.7
Aquaculture (fish, crustaceans, etc.) in marine waters	20 453	14.5
Aquaculture (fish, crustaceans, etc.) in inland waters	27 697	19.6

Source: FAO 2007a.

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 141 million tonnes in 2005.
- The proportion used for human consumption in 2003 was 76 per cent. Table 6.1 shows production split by type.
- The species with the highest total catch in 2005 was Peruvian anchovy (*Engraulis ringens*) at 10.2 million tonnes: this figure was about 0.5 million tonnes lower than in 2004.

Figure 6.6. Norwegian catches[1] by groups of fish species, molluscs and crustaceans. 2006

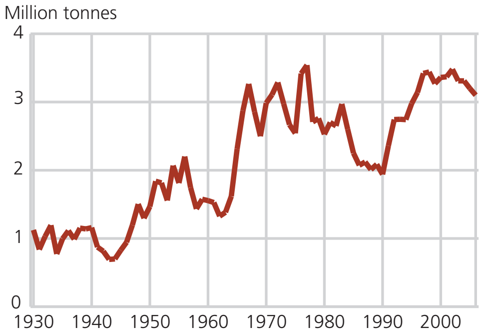


[1] Catches delivered by Norwegian vessels in Norway and abroad.
[2] Includes greater and lesser silver smelt, Norway pout, sandeel, blue whiting and horse mackerel.
[3] Includes the categories hake/pollack/whiting, other flatfish, other demersal fish, miscellaneous deepwater species and other, unspecified fish.
Source: Directorate of Fisheries.

Norwegian catches

- In 2006 the total catch in Norwegian fisheries (including crustaceans, molluscs and seaweed) was 2.4 million tonnes, and the value of the catch was NOK 11.7 billion. The total catch was about 150 000 tonnes lower than in 2005, but the value was about the same.
- Cod and herring were the species with the highest catch value, NOK 3.3 and 2.2 billion, respectively.
- The catch of blue whiting remained high in 2006, at 640 000 tonnes. This is nevertheless 316 000 tonnes less than in 2004 and 96 000 tonnes less than in 2005. The mackerel catch was 122 000 tonnes, slightly higher than in 2005.

Figure 6.7. Total production[1] in Norwegian fisheries. 1930-2006



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

- The total catch in Norwegian fisheries is now two to three times higher than in the 1930s. In the last 10 years, the catches, including seaweed, have varied from 3 million tonnes in 1997 and 1998 to 2.4 million tonnes in 2006.
- 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 2006 was about 3.1 million tonnes.

Box 6.2. World catches and Norwegian catches

Total catches in the world's marine fisheries in 2005 dropped by about 1.8 million tonnes from the year before to about 84 million tonnes. Total catches in freshwater fisheries rose to 9.5 million tonnes.

The catches in the Southeast Pacific dropped by just under 1 million tonnes from 2004. Total landings of *anchoveta* dropped by 0.5 million tonnes, while the catch of *Chilean jack mackerel* decreased by about 100 000 tonnes to about 1.7 million tonnes. These two species made up more than 80 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. Total catches in the Northeast Atlantic have remained stable at about 10-11 million tonnes for a number of years. In 2005, catches in this area totalled 9.6 million tonnes.

According to FAO (2007b), 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.

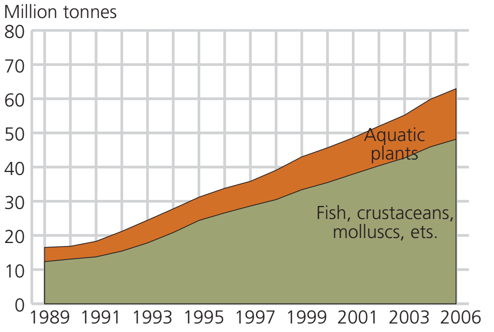
Norway ranks as number 10 among the world's largest fishing nations (excluding farmed production), with a total catch of 2.4 million tonnes in 2005. At the head of the list are China (17.1 million tonnes), Peru (9.4 million tonnes), the US (4.9 million tonnes), Indonesia (4.4 million tonnes), Chile (4.3 million tonnes) and Japan (4.1 million tonnes).

In the Norwegian fisheries, the catch of herring in 2006 was about 40 000 tonnes lower than in 2005, and the value of the catch decreased by NOK 600 million to NOK 2.2 billion. The catch of cod decreased by 5 000 tonnes from 2005, but the value of the catch rose by about NOK 300 million to NOK 3.3 billion. The saithe catch rose by almost 30 000 tonnes to 257 000 tonnes, with a value of NOK 1.4 billion. The mackerel catch rose by about 2 000 tonnes, but its value dropped by NOK 500 million to just under NOK 1 billion. The capelin catch in 2006 was only about 2 000 tonnes, and had a value of NOK 4 million. There was no fishery for Barents Sea capelin in 2006. The shrimp catch was 39 000 tonnes and its value was NOK 612 million. The Norwegian catch of blue whiting was 642 000 tonnes, a decrease of about 100 000 tonnes from 2005. International regulation of the fishery was introduced in 2006, but has not so far made much difference to the catch level. The annual catches have been more than 2 million tonnes since 2003. The fishery for Norway pout was re-opened in September 2006 and for the rest of the year, after being closed in 2005. The catch rose to 14 000 tonnes. In 2006, there was only a limited experimental fishery for sandeels, with a permitted catch of 6 000 tonnes.

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/ og http://www.imr.no/

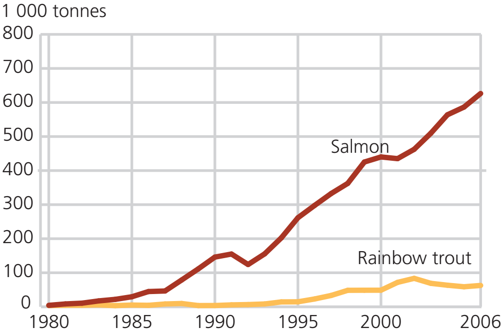
6.4. Aquaculture

Figure 6.8. World aquaculture production. 1989-2005



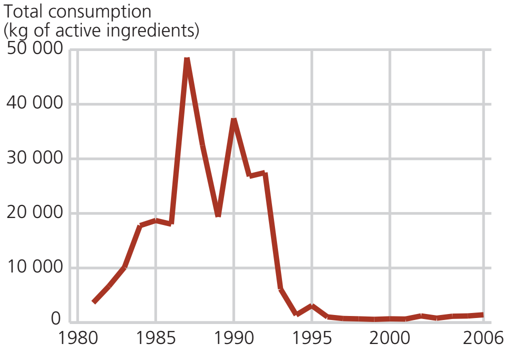
Source: FAO 2007a.

Figure 6.9. Fish farming. Volume of salmon and rainbow trout sold. 1980-2006



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

Figure 6.10. Consumption of medicines[1] (antibiotics) in fish farming. Kg active ingredients. 1982-2006



[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 2005, world aquaculture production totalled 48.1 million tonnes fish, crustaceans, molluscs, etc. corresponding to about 52 per cent of the total catch in marine and inland fisheries for that year.
- Production of aquatic plants totalled 14.8 million tonnes in 2005.
- 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 626 000 tonnes in 2006.
- Production of trout was about 63 000 tonnes in 2006.
- In 2005, Norwegian production of Atlantic salmon accounted for a little under half the total global production of this species (1.24 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 2006 was 1 428 kg, which is an increase of 200 kg from 2005. These figures apply to all species of farmed fish.

Box 6.3. More about aquaculture production

In 2005, world aquaculture production of fish, crustaceans, molluscs, etc. totalled 48 million tonnes, and freshwater production accounted for just under 60 per cent of this (see table 6.1). World aquaculture production (excluding plants) rose by 2.2 million tonnes (5 per cent) in 2005. In addition, 14.8 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 2005.

The species farmed in the largest volume was the Pacific oyster (4.5 million tonnes), followed by a number of species of carp. On a list of 30 farmed species of which over 210 000 tonnes were produced in 2005, Atlantic salmon ranked 12th and mussels 21st. World production of Atlantic salmon in 2005 was 1.2 million tonnes.

Although salmon is the dominant species in Norwegian fish farming in terms of both volume and value, there is also increasing interest in several other species. Mussel farming is gaining ground. According to preliminary figures from the Directorate of Fisheries, production in 2006 was about 3 700 tonnes, which is a reduction of about 1000 tonnes from 2005. There is a very large potential for the production of mussels in Norwegian waters, both from a biological and environmental point of view and in terms of resources. According to FAO, world production of mussels in 2005 was 390 000 tonnes, which is a reduction of 85 000 tonnes from 2004.

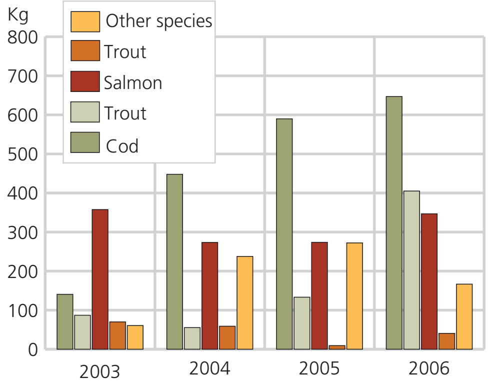
Production of other fish species than salmon and trout for human consumption is still relatively modest in volume. In 2006, 11 000 tonnes of cod and about 4 900 tonnes of other species (Arctic char, halibut, turbot, etc.) were sold in Norway.

According to preliminary figures from the Directorate of Fisheries, total losses from sea-water rearing units in 2006 were 34.6 million fish (about 31 million salmon and 3.6 million trout). This included 963 000 salmon and trout that were reported to have escaped from fish farms. In addition, 288 000 fish of farmed marine species (cod and halibut) were reported to have escaped. Other losses are attributed to mortality, fish discarded at slaughtering plants and unknown causes.

The EU is the most important market for farmed Norwegian fish. In 2006, the EU countries accounted for 72 per cent of all farmed fish exported from Norway, a rise of 3.6 percentage points from the year before. However, access to this market has for many years been influenced by various trade policy instruments used by the EU to limit imports of Norwegian fish, mainly intended to protect Scottish fish farmers. In January 2006, the EU adopted new anti-dumping measures against imports of farmed salmon from Norway. These took the form of minimum prices for different salmon products, and in the first instance apply for a five-year period. In February 2006, the Government decided to bring the anti-dumping measures before the WTO Dispute Settlement Body. Since March 2004, the EU has also imposed an anti-dumping duty of 19.9 per cent on imports of Norwegian rainbow trout. The case Norway has brought before the WTO does not directly concern this anti-dumping duty (Statistics Norway 2007a).

Exports of salmon to Russia almost doubled from 2003 to 2005. However, from 1 January 2006 Russia introduced a general prohibition on imports of Norwegian fresh salmon, claiming that it contained unacceptably high levels of cadmium and lead. The prohibition did not apply to imports of frozen salmon. Exports of fresh Norwegian salmon started up again in the course of 2006, but only from approved facilities. As a result, exports of farmed fish from Norway to Russia dropped from 70 000 tonnes in 2005 to 50 000 tonnes in 2006, and the proportion of farmed fish in exports to Russia dropped from 15 to 10 per cent (Statistics Norway 2007a).

Figure 6.11. Use of antibiotics[1] in fish farming, by species. Kg active ingredients. 2003-2006



[1] Prescription-based statistics. The total quantity (1600 kg) therefore differs somewhat from the sales-based statistics figures (1428 kg).
Source: Norwegian Food Safety Authority and NORM/NORM-VET 2007.

- An analysis of prescription-based statistics carried out by the Norwegian Food Safety Authority showed that cod farming accounted for 650 kg or 40 per cent of the total consumption of antibiotics in fish farming in 2006 (1 600 kg). Consumption of antibiotics in cod farming has risen since 2005, but consumption is strongly correlated with production, and according to the Authority, there is no indication that problems related to bacterial diseases of cod are growing.
- Consumption of antibiotics for salmonids (salmon and trout) is low relative to the production volume.

Box 6.4. Some important diseases and health problems associated with salmonid farming

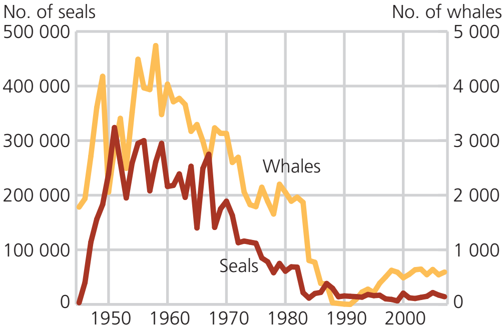
This information on the incidence of disease in salmon farming in 2006 is based on figures in *Annual report on the coastal zone and aquaculture 2007* (Dahl et al. 2007). Serious diseases include the following:

- Furunculosis, caused by the bacterium Aeromonas salmonicida (registered at 1 hatchery and in 2 rivers in 2006).
- Bacterial kidney disease (BKD), caused by the bacterium Renibacterium salmoninarum (not registered in 2006).
- Infectious salmon anaemia (ISA), a virus disease (registered at 4 sites in 2006).
- Infectious pancreatic necrosis (IPN), a virus disease (registered at 207 sites in 2006).
- Pancreas disease (PD), a virus disease (registered at 58 seawater sites in 2006).
- Heart and skeletal muscle inflammation, a virus disease (registered at at least 94 sites in 2006).

Other serious diseases that cause considerable losses include cardiomyopathy syndrome (CMS) and winter ulcers.

6.5. Sealing and whaling

Figure 6.12. Norwegian sealing and whaling[1]. 1945-2007*



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

- In 2006, the total seal catch was 13 390 harp seals (10 086 in the East Ice and 3 304 in the West Ice) and 3 647 hooded seals (in the West Ice). Preliminary figures for 2007 indicate a total catch of 13 981 harp seals (7 828 in the West Ice and 6 153 in the East Ice) and 2 hooded seals. Hunting of hooded seals was prohibited in 2007. The value of the catch in 2006 was NOK 4.5 million.
- The quota for the small whale hunt in 2006 was 1 052 animals, but only 546 were caught. The value of the small whale catch in 2006 was about NOK 21 million. Preliminary figures for 2007 indicate a catch of 592 whales with a value of NOK 24 million. The quota for 2007 was set at 1 052 whales.

Box 6.5. Sealing and whaling

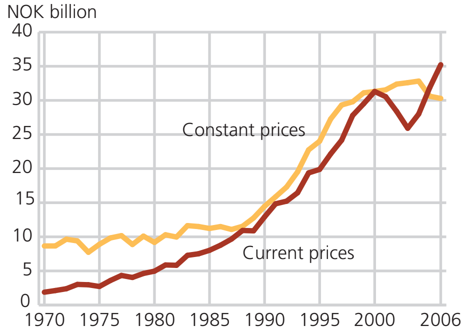
Norwegian *sealing* has essentially been based on two species, harp seals and hooded seals, and has taken place in the Newfoundland area (until 1983), the West Ice (off Jan Mayen) and the East Ice (drift ice areas at the entrance to the White Sea). The most recent estimates for stocks of harp seals are 600 000 year-old and older animals in the West Ice and about 2 million in the East Ice. The stock of hooded seals in the West Ice numbers about 70 000 animals (Skogen et al. 2007). Since the early 1980s, catches of seals have been small, varying between 10 000 and 40 000 animals per season.

Norwegian catches of *small whales* have consisted mainly of minke whales. The traditional commercial hunt was discontinued after the 1987 season, but was resumed in 1993, when 226 whales were taken.

The *Northeast Atlantic minke whale stock* (which includes animals on the whaling grounds in the North Sea, along the Norwegian coast, in the Barents Sea and off Svalbard) is estimated at 80 500 animals. The most recent estimate for the minke whale stock in the *Jan Mayen area*, based on the 1997 survey, is 26 700 animals (Skogen et al. 2007).

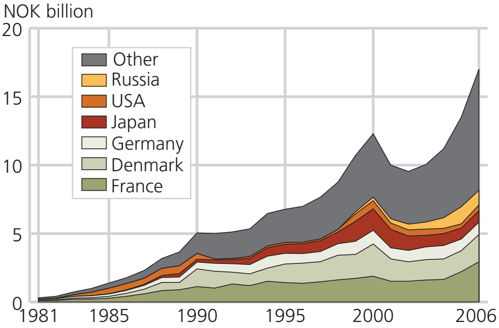
6.6. Exports

Figure 6.13. Value of Norwegian fish exports. Current and fixed prices (2000 NOK). 1970-2006



Source: National accounts, Statistics Norway.

Figure 6.14. Exports of salmon[1], by main importing countries. 1981-2006. Current prices



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

- In 2006, Norway exported about 2 million tonnes of fish and fish products to a value of almost NOK 36 billion. Exports to EU countries accounted for 64 per cent of the export value.
- According to FAO, Norway was in 2005 the world's second largest exporter of fish in terms of value, behind China and ahead of Thailand, the US, Denmark, Canada, Chile, the Netherlands and Vietnam. Norway's fish exports accounted for about 6 per cent of the value of total world fish exports.
- Salmon exports were worth NOK 17 billion in 2006. This was a rise of more than NOK 3 billion from 2005.
- Denmark and France have for a number of years been the most important importers of Norwegian farmed salmon. Exports to Denmark (NOK 2.0 billion) and France (NOK 2.9 billion) increased considerably from 2005 to 2006.
- China is a new, interesting market for salmon, although the value of exports in 2006 was only NOK 147 million. Exports to Russia totalled NOK 1.1 billion.

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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

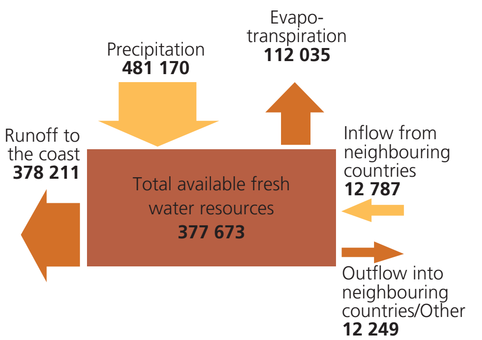
Water is of vital importance to life and health and to society as a whole. Providing good quality water and sufficient water at all times is therefore a primary objective in the supply of water. The authorities require all water works supplying more than 50 persons or 20 households or holiday homes, 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 2005, a total of 1 580 water works (municipal and private) were subject to reporting requirements, and 347 of these recorded unsatisfactory results for pH. Furthermore, 198 water works recorded unsatisfactory results for water colour, and thermo-tolerant intestinal bacteria in the water were found at 105 water works. 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. 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).

About 90 per cent of the population in Norway receive their water supplies from surface sources. These water sources 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 already 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 1971-2000. Whole country. Million m³

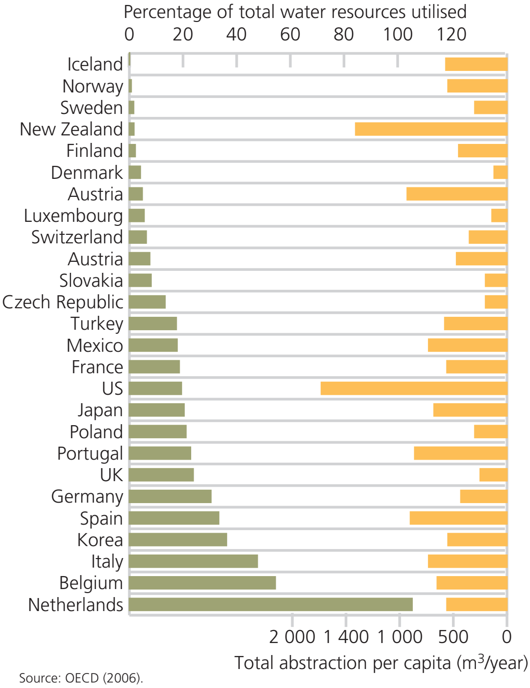


[1] Records of precipitation do not make it possible to calculate inputs with the same accuracy as runoff. As a result, there is a discrepancy between total inputs and total runoff in the figure. Based on normal values for precipitation and evapotranspiration in the period 1961–1990. Source: Norwegian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

Tilgjengelige ferskvannressurser

- Water resources available in Norway in a normal year total about 378 billion m^3.
- 97 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. Percentage of total freshwater resources utilised and abstraction per inhabitant in OECD countries at the turn of the century

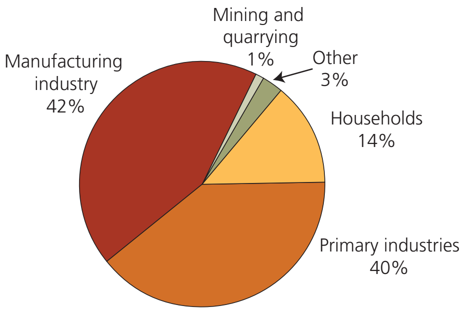


Source: OECD (2006).

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 550 m^3 per year. This is well below the average for the OECD countries (880 m^3). The average in the US 1 730 m^3, and in Denmark 120 m^3.

Figure 7.3. 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.

- A total of about 2.5 billion m³ of freshwater is used annually in Norway. The manufacturing industries use just over 1 billion m³, and the metal industry, the chemical industry, the pulp and paper industry and the food industry account for 95 per cent of this. The primary industries use roughly the same amount of water as the manufacturing industries.
- Households use about 345 million m³ of freshwater. Approximately 90 per cent of this is supplied by public water works. Manufacturing industries and the primary industries (agriculture, forestry and fish farming) largely meet their water needs from their own sources.

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 12.2). 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
  - administrative arrangements based on river basin districts (no river basin is to be split between river basin districts)
  - programmes and measures based on river basins and river basin districts
  - clear assignment of responsibilities and coordination between authorities (cross-sectoral management)
- specified environmental objectives for all water and a stronger focus on ecological conditions
- greater need for investigation and monitoring.

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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.

Norway has adopted regulations on a framework for water resource management, which divide the country into nine river basin districts. One county governor's office has been made responsible for coordinating the implementation of the regulations in each river basin district, in close cooperation with a river basin committee. This consists of representatives of the appropriate regional and local authorities. In addition, a reference group is to be established for each district. These are consultative bodies for the committees, and rights-holders and private and public interest groups will be encouraged to participate.

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, and start-up conferences have been held in each district. All the districts except Finnmark have submitted proposals for which river basins are to be covered by the first set of management plans.

Before an appropriate management regime for a river basin can be determined, its characteristics must be identified. This process has been started, and electronic tools have been developed for handling the information. Guidance documents for the tasks for which the river basin districts are responsible are being drawn up.

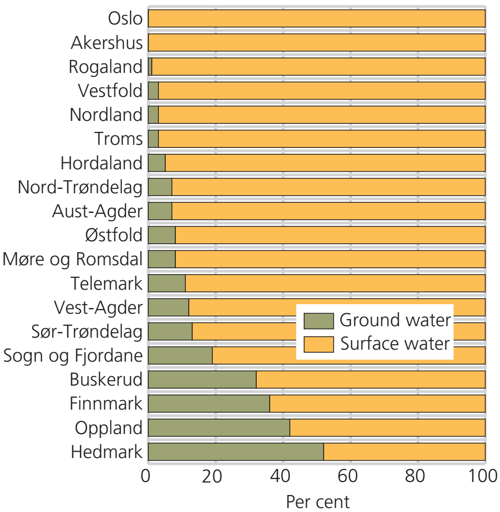
The Ministry of the Environment is responsible for reporting to the EFTA Surveillance Authority on the progress of the various processes and developments in the status of water bodies. The Ministry also represents Norway in cooperation between Norway and the EU member states on implementation of the directive.

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).

7.2. Public water supplies

Figure 7.4. Percentage of population connected to municipal water works, split by types of water source. County. 2005[1]

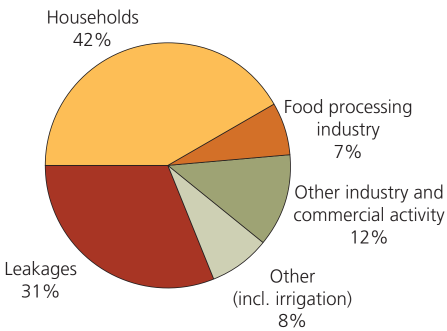


[1] Surface water includes four water works in Sør-Trøndelag and Nordland which supply 485 people using seawater as the water source.
Source: National Institute of Public Health, water works register.

Water sources

- In 2005, about 90 per cent of Norway's population was served by public water supplies from 1 580 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 2005, 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 7.4.).
- 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 2005 had the highest percentage of the population connected to water works using groundwater as their source were Hedmark, Oppland and Finnmark.

Figure 7.5. Percentage of public water supplies used by various sectors[1]. 2005



[1] The figure is based on data for 1 580 water works in 2005.
Source: National Institute of Public Health, water works register.

Production and consumption of water

- Water production at Norwegian water works in 2005 was calculated to be 741 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 205 litres per person per day in 2005.
- There is substantial uncertainty associated with these figures as they are largely based on estimates from the water works.

Box 7.2. Waterborne communicable diseases

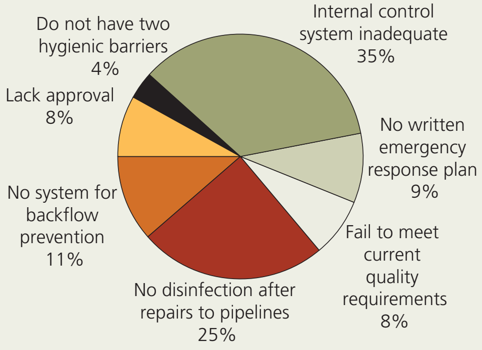
Norwegian drinking water is generally considered to be of high quality. Nevertheless, outbreaks of disease caused by waterborne pathogens are reported every year. In the period 1988-2002, 72 outbreaks of waterborne disease were reported, involving a total of 10 616 registered cases (Nygård et al. 2003). So far, 15 outbreaks of disease have been registered in the period 2003-2007 (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 general 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 or 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.

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Source:

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.

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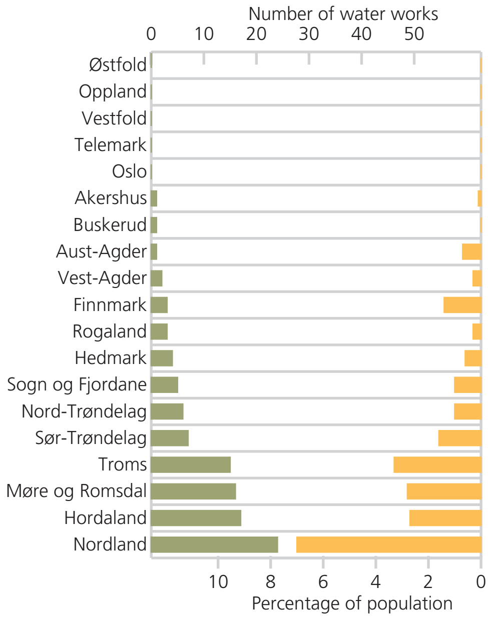
http://www.mattilsynet.no/mattilsynet/multimedia/archive/00029/Sluttrapport_-_Matti_29907a.pdf

Nygård, K., B. Gondrosen and V. Lund: Sykdomsutbrudd forårsaket av drikkevanni Norge (Outbreaks of disease in Norway caused by drinking water). Tidsskr 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.

Figure 7.6. Number of water works where *E. coli* was registered, and percentage of the population who had to boil drinking water. By county. 2005[1]

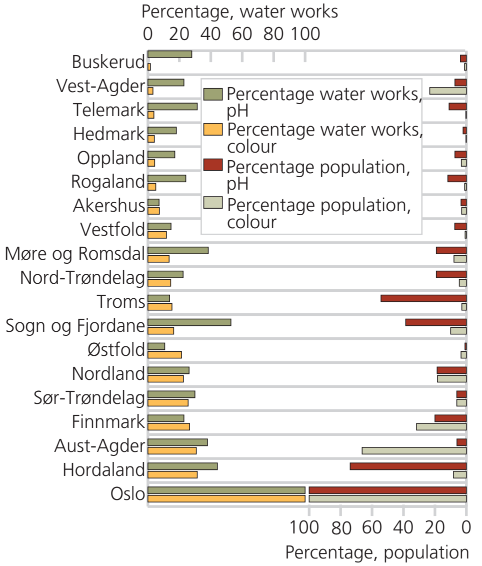


[1] Based on information from 1 308 water works that took samples to test for the presence of *E. coli*.
Source: National Institute of Public Health, water works register.

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 2005, the highest percentages of unsatisfactory samples were recorded in the counties of Nordland, Hordaland and Møre og Romsdal.
- According to figures from selected water works that supply 4.2 million people in Norway, 1 per cent of the population is supplied with drinking water that does not satisfy water quality with regard to *Escherichia coli*. The *E. coli* bacteria is a common indicator of the presence of faecal contamination in water.

Figure 7.7. Percentage of public water works that do not satisfy the requirements with respect to pH and colour, and percentage of population affected. By county. 2005[1]



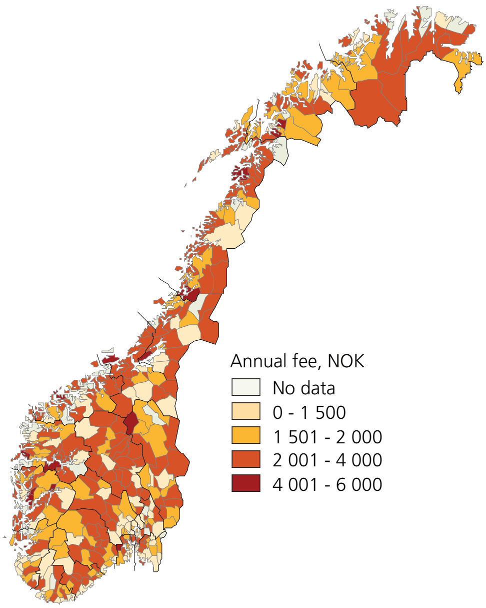
[1] The figure is based on information from 1 251 water works that conducted pH tests and 1 260 that conducted colour tests. In Oslo, the information refers to one water works comprising several treatment plants. The main treatment plant is currently not satisfactory, but a new plant is under construction.
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.
- Acidic water 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.
- A pH level that is too low is mainly due to acid rain and runoff from acidic rock such as granite and gneiss. The problem of coloured water is mainly due to humus and organic material deposited in water sources during rainfall and minor flooding.

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 7.8. Annual fees for water supply, by municipality. 2007



Source: KOSTRA, Statistics Norway.

Water supply fees

- The average water supply fee for the county as a whole rose by 3.9 per cent from 2006 to 2007.
- The fees vary significantly between municipalities, from NOK 499 to NOK 5 488.
- The reasons for the large variations in water supply fees have not been systematically surveyed, but in general, local conditions such as 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.

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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8. Land and land use

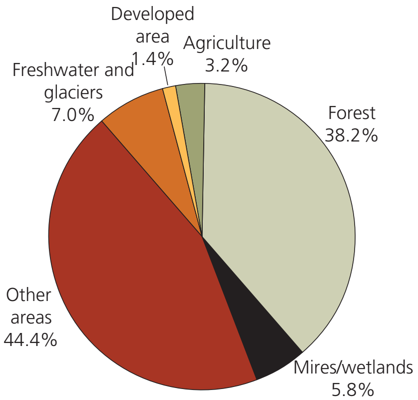
With a land area of 304 280 km^2 and a population of barely 4.7 million, Norway has the second lowest population density in Europe after Iceland, with 15 inhabitants per km^2. Because of Norway's climate, geology and topography, a large proportion of the country has not been developed for settlement 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. 2007



[1] Land cover is the physical coverage of land, e.g. forest, cultivated land, buildings, roads.
Source: Norwegian Mapping Authority (2007) and Statistics Norway.

The most common types of land use

- Developed land contains almost 3.8 million buildings, 4 100 km of rail track (Norwegian Mapping Authority 2007 and Norwegian National Rail Administration 2006). There are also 93 000 km of public roads and about 76 000 km of private roads (Directorate of Public Roads 2006). Roads cover about 120 km^2 (Statistics Norway 2005).
- Agricultural area in use covers about 10 200 km^2 and productive forest about 75 000 km^2 (Norwegian Forest and Landscape Institute 2007).
- The remaining land area comprises other cultivated land, non-developed coastal areas, scrub and heaths, marginal forest, and mountains. About 2 600 km^2 of the mainland is under permanent ice and snow (Wold 1992).

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 baseline. The mainland covers 323 802 km^2 in total (304 280 km^2 land and 19 522 km^2 fresh water). 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 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 1929 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 2007, http://www.ssb.no/english/yearbook/).

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.

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

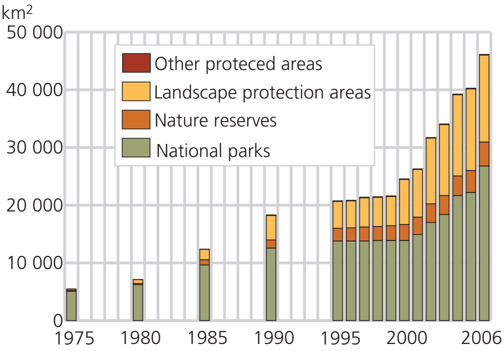
Protecting areas of recreational value is an expressed national target. Several specific indicators have been drawn up as operational tools to monitor developments in relation to the national targets for the priority area outdoor recreation in environmental policy.

Access to the 100-metre belt along the coast is one such indicator. The mainland coastline is 83 300 km long, including islands, fjords and bays. This is equivalent to 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 2007). 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 39.4 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.

Read more in: *Bygging i strandsonen (1985–2007). Skrumper langsomt inn* (Development in the shore zone (1985–2007). Slowly shrinking). Today's statistics, 21 June 2007. http://www.ssb.no/english/subjects/01/01/20/strandsone_en/, Statistics Norway.

8.2. Protection and development

Figure 8.2. Areas protected under the Nature Conservation Act. Whole country. 31 December 1975-2006. km²



Source: Directorate for Nature Management (2006).

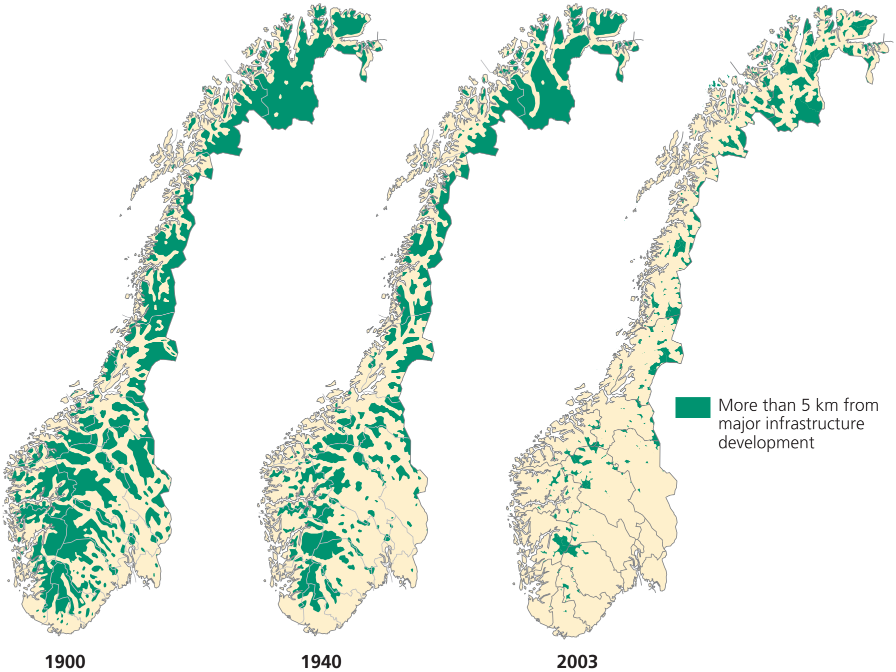
Areas protected under the Nature Conservation Act

- The total area protected under the Nature Conservation Act has expanded considerably since 1975. As of 1 January 2007, protected areas included 29 national parks, 1 790 nature reserves, 174 protected landscapes and 118 other types of protected area.
- The total area protected rose from 40 347 km² in 2006 to 46 168 km² in 2007, or about 14 per cent of Norway's total area. Most of the rise is explained by the establishment of new national parks and the expansion of already existing national parks. In addition, some areas are protected under other legislation.
- As of 1 January 2007, about 1 000 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 2007).
- In 139 municipalities, less than 1 per cent of the land area is protected under the Nature Conservation Act, while in 49 municipalities, more than 25 per cent of the total area is protected. Most of the municipalities with a high proportion of protected areas include large areas of mountain, glacier or other marginal areas.

Wilderness-like areas

- The size of wilderness-like areas is an indicator of pressure on biological diversity. In wilderness-like areas, pressure from human activity is low, and there is little disturbance of the original biological diversity.
- Wilderness-like areas have been dramatically reduced from about 48 per cent of Norway's land area in 1900 to between 11 and 12 per cent today.

Figure 8.3. Wilderness-like areas[1]. 1900, 1940 and 2003



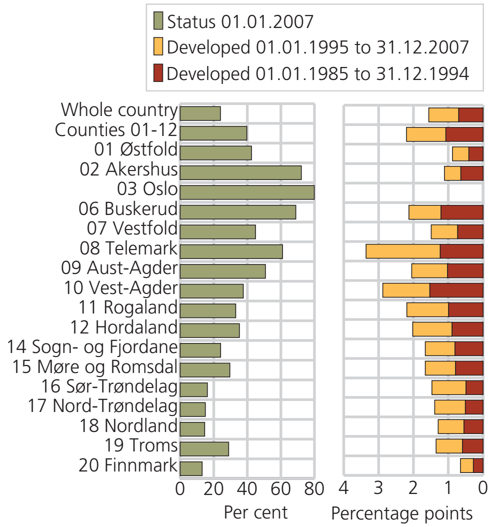
[1] Wilderness-like areas are defined as lying at least 5 km from the nearest major infrastructure development, defined as public roads and railways (except tunnels): forest roads: farm tracks, access roads and roads to summer farms exceeding 50 m in length: ancient tracks improved for use by tractors and off-road vehicles: tracks approved for motor vehicles when the ground is not snow-covered (Finnmark): power lines carrying 33 kV or more: reservoirs (entire extent of water at highest regulated water level), regulated rivers and streams: power plants, penstocks, canals, levees, embankments and flood protection works.

Source: Brun, M. NOU-1986 / Directorate for Nature Management 2004 / Geodatasenteret AS 2004. Editing and graphic production: Geodatasenteret AS 2004.

Access to the coast

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 offer very valuable opportunities 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 8.4. Proportion of the coastline less than 100 m from the nearest building[1] in 2007. Changes from 1985 to 2007



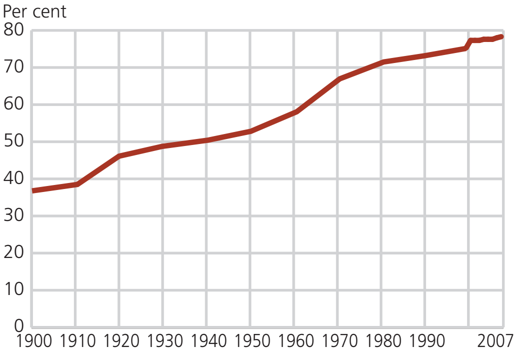
[1] Large numbers of buildings were registered in the GAB register (the official Norwegian register for property, addresses and buildings) in 1993-1994, and figures for changes before 1995 are therefore uncertain. Figures for changes in Oslo are not included.
Source: Statistics Norway 2007c.

- 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 1.6 per cent, or 1 300 km, of the shoreline from 1985 to 2007.
- The greatest changes have taken place in the southern parts of the country, where the largest proportion of the coastline was already developed.

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 4/5 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 8.5. Percentage of population resident in urban settlements/densely populated areas. 1900-2007



Source: Statistics Norway 2007a.

Population trends and area of urban settlements

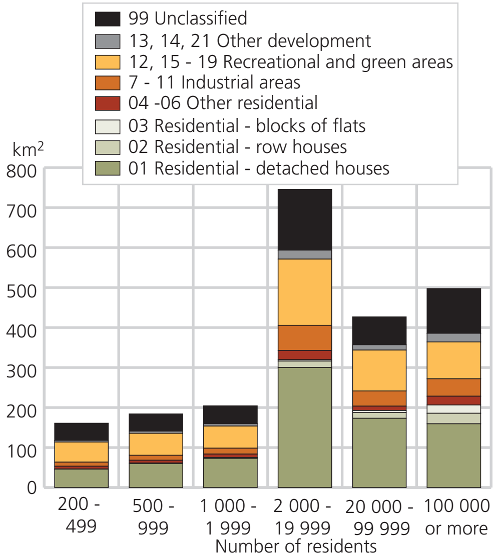
- In 2006, the number of people living in urban settlements rose by 47 500. A total of 78 per cent of the Norwegian population now lives in urban settlements. The total area of urban settlements in Norway is 2 294 km^2. The area of urban settlements increased by 31 km^2 from 2006 to 2007.
- As of 1 January 2007, the average population density in Norwegian urban settlements was 1 593 inhabitants per km^2. The corresponding figure for 2000 was 1 588 inhabitants per km^2.
- In the four largest urban settlements, Oslo, Bergen, Stavanger/Sandnes and Trondheim, the population increased by about 19 000 persons, or about 2 per cent, in 2006.
- As of 1 January 2007, 707 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 25 per cent of the total area of urban settlements.

Table 8.1. Urban settlements[1], residents and area, by size of population. 1 January 2007. Change from 2006 to 2007

	2007			Change from 2006 to 2007		
	Number of areas	Population	Total area in km^2	Number of areas	Population	Area, km^2
Total	**917**	**3 655 391**	**2 294.08**	**12**	**47 578**	**30.98**
200 - 499	340	116 587	167.01	10	1 675	4.21
500 - 999	220	153 005	190.12	-1	-1 612	1.63
1 000 - 1 999	147	207 397	210.66	1	-374	0.74
2 000 - 19 999	191	1 031 895	773.67	2	11 105	12.28
20 000 - 99 999	15	752 541	442.06	0	13 341	7.98
100 000 or more	4	1 393 966	510.56	0	23 443	4.14

[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.
Source: Statistics Norway 2007a.

Figure 8.6. Land use in urban settlements, by size of population. km². 2005



Source: Land use statistics, Statistics Norway (2005).

Land use and physically developed area in urban settlements

- Urban settlements make up less than 1 per cent of Norway's total area, but about one fourth of the physically developed area. Infrastructure, buildings and roads make up about 30 per cent of the total area of urban settlements.
- Buildings in urban areas cover about 220 km², and buildings outside urban areas about 200 km².
- Roads account for about 2/3 of the physically developed area in urban settlements. Outside urban settlements, this share is 88 per cent (forest roads included).
- Detached houses account for over one third of the total area of urban settlements.
- Housing density and land use efficiency are lower in small urban settlements, which are therefore less compact than large urban settlements.

Box 8.4. Delimitation of urban settlements and background data

An urban settlement has been defined by Statistics Norway in simple terms as an area that has at least 200 residents and where the distance between buildings does not normally exceed 50 metres. Urban settlement boundaries are thus dynamic, changing with building developments and changes in the population.

In addition to the increasing expansion of the major urban settlements, general population growth has resulted in some small areas of scattered settlement developing into urban settlements. At the same time, in areas where the industrial structure is weak, a declining population has meant that some urban settlements are no longer classified as such.

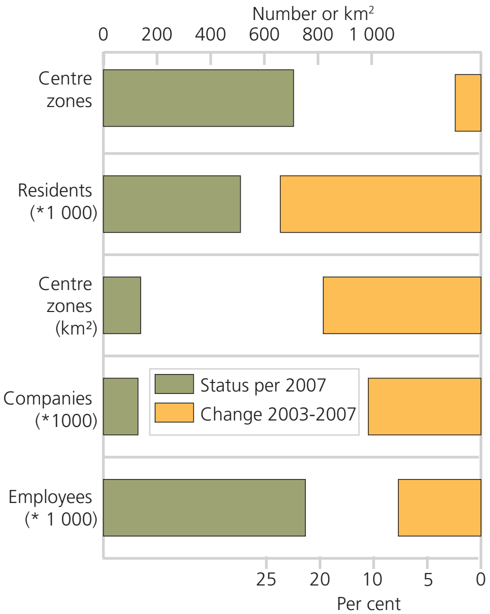
Changes in methods of operation in the primary industries and the evolution and concentration of the manufacturing industries and service sectors have resulted in major changes in settlement patterns over the last 100 years. Urban settlements vary widely in size, both measured by area and by population, but most of Norway's urban settlements are small.

From 1999 onwards, urban settlement statistics have been based on correlation between the National Population Register and the GAB register, the official Norwegian register for property, addresses and buildings. With the help of numerical addresses, address or building coordinates and a geographical information system (GIS), buildings and the associated population are grouped together into urban settlements. The quality of the statistics will always depend on the completeness and accuracy of the register data.

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 8.7. Number of centre zones, centre zone area, residents, employees in wholesale and retail trade and companies in centre zones. 2007. Change from 2003 to 2007. Per cent



Source: Statistics Norway 2007d.

- Centre zones (see box 8.6) only figured in 227 of Norway's 432 municipalities as of 1 January 2007, and tend not to be formed in the smallest municipalities (Statistics Norway 2007c).
- As of 1 January 2007, there were 709 centre zones in Norway, with a total population of about 511 000. Even though the number of centre zones has varied since 2000, there has been 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 2007, the number of employees in centre zones was 753 000.
- About 10 per cent of the population lives in centre zones, a weak rise from earlier years. The population density in these zones is 3 700 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.

Box 8.5. Land use calculation, data sources and uncertainty

Land use statistics for urban settlements are calculated on the basis of building and property figures in the GAB register, the official Norwegian register for property, addresses and buildings, information on commercial activity in the form of a business code from the Register of Business Enterprises, and area calculated from the outline of buildings in cartographical series (mainly on a scale of 1:1 000). Land use is quantified at two geographical levels: physically developed areas and aggregated land use areas (functional areas). Land use in terms of physical development means roads, railways, buildings, etc. Aggregated land use areas refer to functional use (residential (gardens and smaller roads included), transport, industry, commercial, etc.). Methods and uncertainty are described in technical documentation reports (Bloch 2002a-e).

Box 8.6. 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/tettstedskart.

Box 8.7. 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.

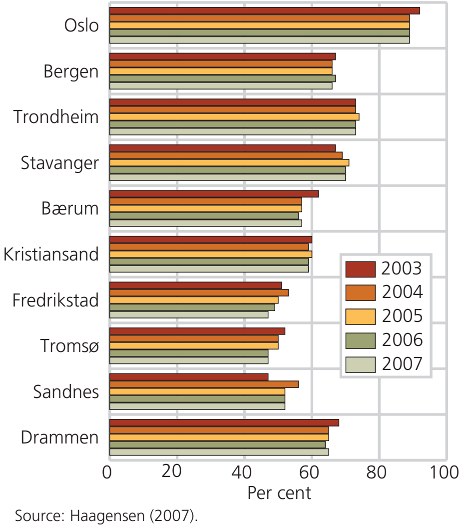
These indicators were described in more detail in *Tilgang til friluftsområder. Metode og resultater 2004*. (Access to outdoor recreational areas - method and results 2004) (Engelien et al. 2005).

Proximity to schools and local shops in urban settlements in the 10 largest municipalities

Schools and local shops have key functions, and a large proportion of the population need to go to them a number of times a week. Proximity between people's homes and local schools and shops makes it possible to reduce travel by car and its environmental impacts. It is therefore important to maintain statistics of the distances between people's homes and schools and local shops.

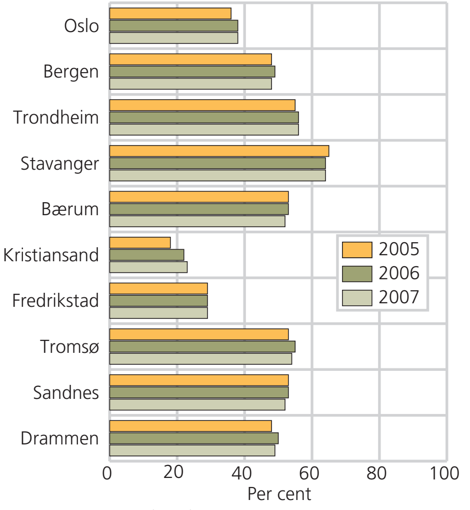
- In Oslo, more than 80 per cent of the population have a food store within 500 metres of their homes. The proportion is lowest in Fredrikstad, at barely 50 per cent.
- There has been an overall reduction in the proportion of the population with easy access to a food store in the 10 largest municipalities. The only municipalities where the proportion has risen are Stavanger and Sandnes. This may mean that local shops are being closed, with a resulting increase in transport by car.
- In six of the 10 municipalities, about 50 per cent of the pupils live less than 500 metres from the nearest school.
- The proportion is highest in Stavanger and lowest in Kristiansand, where it was only just over 20 per cent in 2007.
- There is no clear relationship between the population of the municipality and the number of children of school age who live less than 500 metres from a school.

Figure 8.8. Proportion of the population whose homes are within 500 metres of the nearest food store in urban settlements. The 10 largest municipalities. 2003-2007. Per cent



Source: Haagensen (2007).

Figure 8.9. Proportion of schoolchildren who live less than 500 metres away from the nearest school in urban settlements. The 10 largest municipalities. 2005-2007. Per cent

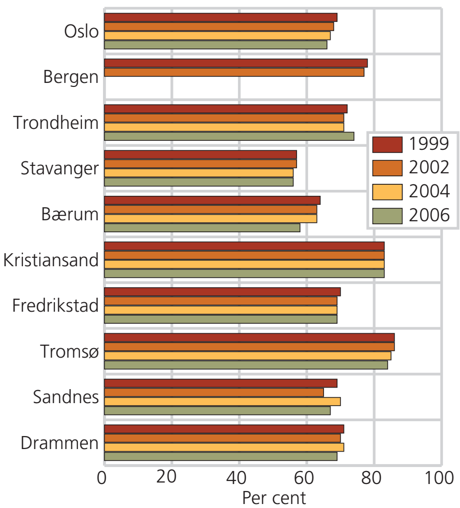


Source: Haagensen (2007).

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 (2001-2002) to the Storting. The goal of high-density urban development means that there is high 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 when towns are developed and building density is increased, for example in Report No. 26 (2006-2007) to the Storting.

Figure 8.10. Residents with safe access to play and recreational areas in urban settlements. The 10 largest municipalities. Per cent



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.

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 5.7 Management of uncultivated areas.

Table 8.2. Percentage of municipalities with an adopted plan with special focus on biodiversity, outdoor recreation and protection of the cultural heritage. Average age of plans in the reporting year

	Biodiversity		Outdoor recreation		Cultural heritage	
	Percentage of municipalities with plan	Age. Years	Percentage of municipalities with plan	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	43	3.3	54	2.9	27	4.6
By population in municipalities, 2006						
Over 300 000	100	4.0	100	0.0	0	..
50 000-300 000	75	2.9	67	1.6	67	1.4
30 000-50 000	83	3.5	67	3.6	58	6.7
20 000-30 000	68	5.2	82	5.3	59	6.0
10 000-20 000	48	2.9	59	2.9	38	4.5
5 000-10 000	43	3.5	63	2.9	21	4.1
2 000-5 000	32	2.8	45	2.1	24	4.4
Under 2 000	40	3.2	47	3.2	14	6.1

Source: Statistics Norway 2007b.

Administration of plans in areas of particular environmental value

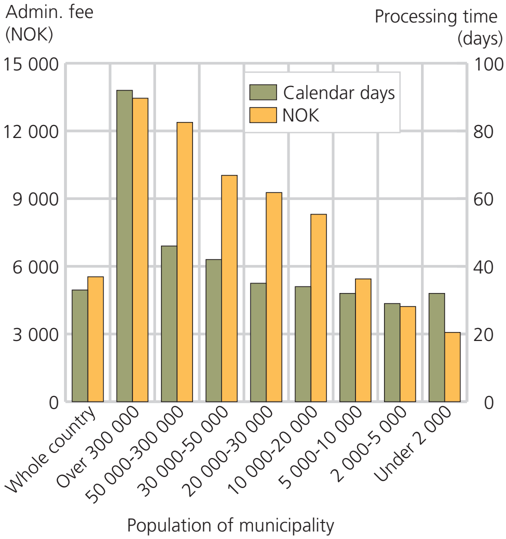
- Plans may be binding or in the form of guidelines indicating which projects can be implemented. Reports on projects in areas of particular environmental value (defined as agricultural areas, areas of natural environment and outdoor recreation areas, the 100-metre belt along the coast and special areas set aside for the protection of the cultural heritage) show that most applications are in accordance with plans and are approved (see table 8.3).
- 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.

Table 8.3. Building project applications in areas of particular environmental value. 2001-2006*

Type of area	Year	No. of cases processed[3,4]	Applications consistent with plan, approved	Applications that include exemptions, approved	Rejected applications	Percentage of applications for exemptions approved
New buildings in agricultural areas, areas of natural environment and outdoor recreation areas[1]	2001	15 853	11 097	3 646	1 268	74
	2002	17 167	12 704	3 433	1 030	77
	2003	7 801	4 864	2 266	671	77
	2004	7 175	4 969	1 838	368	83
	2005	4 375	2 188	1 750	438	80
	2006*	3 301	1 643	1 311	348	79
New buildings in areas along rivers and lakes where building is prohibited[1,2]	2001	..	..	269	67	80
	2002	..	..	328	82	80
	2002	..	..	328	82	80
	2003	..	..	239	86	74
	2004	..	..	202	93	68
	2005	398	68	256	74	78
	2006*	288	78	161	48	77
New buildings in the coastal zone where building is prohibited[1,2]	2001	..	..	1 096	540	67
	2002	..	..	1 083	487	69
	2003	..	..	867	308	74
	2004	..	..	864	303	74
	2005	3 173	1 744	1 024	405	72
	2006*	2 417	1 280	790	347	69
Projects in areas set aside for protection of the cultural heritage	2001	799	631	96	80	55
	2002	568	403	91	74	55
	2003	866	628	91	147	38
	2004	636	430	118	88	57
	2005	948	627	184	137	57
	2006*	870	533	150	186	45

[1] For 2001 and 2002, the numbers are for all projects: from 2003 for new buildings only
[2] For 2001-2004, the figures are for applications for exemptions only
[3] The number applies to municipalities that reported for the years 2001-2003 (about 80 per cent of all municipalities). From 2004 the figures apply to the whole country.
[4] From 2005, agriculture is not included
Source: Statistics Norway 2007b.

Figure 8.11. Administrative municipal fee for building of single-family dwelling and average case processing time for undertakings for which application is required, by size of population. 2006



Source: Statistics Norway 2007b, KOSTRA.

Fees and case processing time in municipal land use management

- In 2006, net expenses for land use planning made up just over 0.5 per cent of total net municipal operating expenses and about 1 per cent of gross expenses. Fees have been rising much faster than prices generally in recent years, so that the municipalities are covering an increasing proportion of their expenses through the fees they collect.
- 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. There may be more objections, resulting in an increase in the administrative load.
- 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. However, this has not been further analysed.

Box 8.8. 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 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 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.

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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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Part 3
Pollution and environmental problems

9. Air pollution and climate change

Preliminary calculations show that in 2006, greenhouse gas emissions in Norway were 8 per cent higher than in 1990, but that they have declined by a little over 1 per cent per year since 2004. The increase 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.

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 hazardous chemicals. 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).

Preliminary and final figures
In 2007, national emission figures for 2006 were published. These were preliminary figures based on the previous year's calculations, in addition to emission figures reported by large enterprises and the activity data available now. Experience shows that these emission figures are good estimates for most pollutants at national level.

The 2005 figures are also considered to be preliminary figures. This is because auditing of the energy accounts, which are a very important source of data for the emission inventory, takes about eighteen months to complete. However, we would normally only expect minor adjustments between the preliminary figures for 2005, which were published in 2007, and the final figures, published in 2008. Because of the requirement to recalculate the figures to take account of new information, even the final figures may be changed. They are then republished, but the adjustments are usually smaller than for the preliminary figures.

Emission figures are presented in a series of tables, for example showing emissions by source or by sector. Most of the figures in this chapter are based on aggregated figures for emissions by source. Time series for the national emission figures and emissions split by source, sector, county and municipality are also available on Statistics Norway's website at: http://www.ssb.no/english/subjects/01/04/10/.

For documentation of the emission inventory, see Aasestad, K.: *The Norwegian Emission Inventory 2007. Documentation of methodologies for estimating emissions of greenhouse gases and long-range transboundary air pollutants.* Reports 2007/38, Statistics Norway.

Box 9.2. Environmental problems caused by air pollution

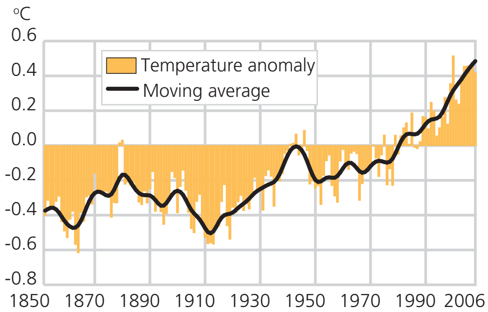
Climate change	Anthropogenic emissions of greenhouse gases, sulphur dioxide (SO_2) and particulate matter can alter the natural chemical composition of the atmosphere. Greenhouse gases cause warming of the atmosphere, whereas SO_2 and particulate matter mainly have a cooling effect. It is difficult to 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. Acid rain 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. Acid rain increases leaching of nutrients and metals from soils and can cause corrosion damage to buildings. 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.
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 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

The natural greenhouse effect results in a global mean temperature of 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 2005a). 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 result in climate change. This phenomenon is called the anthropogenic or enhanced greenhouse effect. Norway's total greenhouse gas emissions are shown in figure 9.3. If emissions of greenhouse gases continue to rise, there will also be a growing risk of serious, far-reaching impacts, such as floods, droughts 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 boxes 9.5 and 9.6).

Figure 9.1. Global mean temperature[1]. 1850-2006



[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

- 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 2006, the global mean temperature was 0.42 °C above the normal value the period 1961-1990.

- For Norway as a whole, 2006 was one of the warmest years ever registered, together with 1934 and 1990. The mean temperature was 1.8 °C above normal. The annual mean temperature in parts of Svalbard was 5 °C above normal and clearly the highest ever registered.

National target - Climate change

1. Norway will comply with its commitment under the Kyoto Protocol, which is that its greenhouse gas emissions in the period 2008-2012 must not be more than 1 per cent higher than in 1990.

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

Table 9.1. Emissions of CO_2 by countries, 2003 and changes from 1990

	CO_2 emissions 2003. Million tonnes	Per cent of total	Change from 1990. Per cent
US	5 842	22.8	16.6
China	4 151	16.2	72.8
Russia[1]	1 509	5.9	-36.1
India	1 276	5.0	87.9
Japan	1 259	4.9	12.2
Germany	865	3.4	-14.7
Canada	586	2.3	27.5
UK	557	2.2	-5.3
Italy	487	1.9	13.2
South Korea	457	1.8	89.1
Mexico	417	1.6	10.9
France	408	1.6	2.8
Iran	382	1.5	74.8
Australia	372	1.4	32.3
South Africa	365	1.4	27.6
Spain	332	1.3	45.3
Ukraine	313	1.2	-57.6
Poland	308	1.2	-35.3
Saudi Arabia	303	1.2	53.2
Brazil	299	1.2	47.3
Indonesia	296	1.2	97.7
Thailand	246	1.0	156.9
Norway	43	0.2	25.6

[1] 1999.
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 39 per cent of total global CO_2 emissions in 2003.
- Since 1990, emissions have dropped considerably in countries such as Russia, 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. Calculations published in June 2007 by the Netherlands Environmental Assessment Agency, based on data from the BP Statistical Review of World Energy 2007, show that China overtook the US in 2006 as the world's largest CO_2 emitter. CO_2 emissions in China totalled 6 200 million tonnes, as compared with 5 800 million tonnes in the US. 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.
- Among the major emitters, per capita CO_2 emissions in 2003 were highest in the US at 20.0 tonnes, followed by Australia and Canada at 18.8 and 18.5 tonnes respectively. The corresponding figures for China and India were only 3.2 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 9.4 tonnes CO_2.

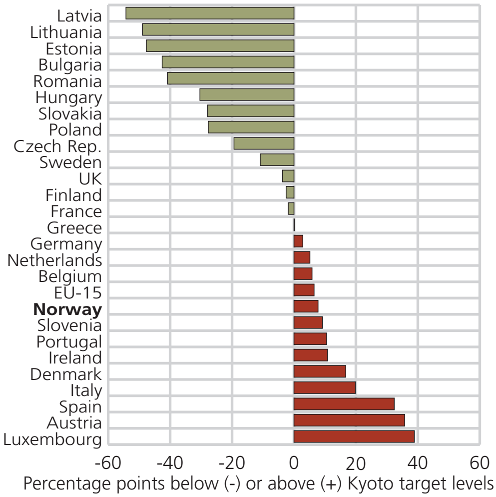
Climate policy targets

- Norway will undertake to reduce global greenhouse gas emissions by the equivalent of 30 per cent of its own 1990 emissions by 2020.
- Norway will be carbon neutral by 2050.
- During the first commitment period under the Kyoto Protocol (2008-2012), the Government will strengthen Norway's Kyoto commitment by 10 percentage points, corresponding to nine per cent below the 1990 level, and ensure that a substantial proportion of Norway's emissions reductions are achieved through domestic action.

Source: Report No. 34 (2006-2007) to the Storting: *Norwegian climate policy.*

Early in 2008, the three-party coalition Government and three of the opposition parties reached an agreement on climate policy which further strengthens some of Norway's climate policy targets. For example, they agreed that Norway will seek to become carbon neutral by 2030 rather than 2050 if other developed countries make similar commitments.

Figure 9.2. "Distance-to-target" for greenhouse gas[1] emissions in 2005 (deviation of actual emissions from Kyoto targets). Percentage points below (-) or above (+) Kyoto target levels[2]



[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 (2007) and emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

- Aggregate greenhouse gas emissions from the 15 "old" EU states decreased by 0.8 per cent from 2004 to 2005 (EEA 2007). The EU member states must reduce their overall emissions by 8 per cent by 2008-2012 compared with the 1990 level 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. In 2005, its emissions totalled 1 002 million tonnes CO_2 equivalents, a reduction of 18.7 per cent since the base year. Under the EU burden-sharing agreement, 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 52 per cent in the period 1990-2005. This is the greatest rise in any EU state, and far above its target of 15 per cent under the burden-sharing agreement.

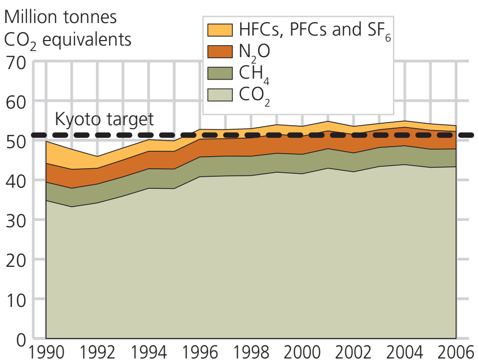
- Emissions from the former Eastern bloc countries in the EU have dropped considerably in the period 1990-2005. There has been a weak rise in emissions in Slovenia, but emissions have dropped by 26-58 per cent in the other nine countries in this group.

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 og 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.

Figure 9.3. Total emissions of greenhouse gases in Norway. 1990-2006*. Million tonnes CO_2 equivalents



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

Aggregate greenhouse gas emissions in Norway

- Greenhouse gas emissions in Norway declined by 0.8 per cent from 2005 to 2006. The overall rise since 1990, the base year for the Kyoto Protocol, is about 8 per cent. Emissions totalled 53.7 million tonnes CO_2 equivalents in 2006.
- There were several reasons for the decrease in emissions in 2006, but the most important was probably lower emissions from manufacturing and from the oil and gas industry. This was explained by a lower level of activity combined with environmental measures. Overall gross production of oil and gas declined, while consumption of fuel oils and other fossil fuels in manufacturing, other industries and households rose considerably in 2006.
- The increase in emissions from 1990 to 2005 is mainly due to the growth in emissions from oil- and gas-related activities, which rose by 70 per cent in the same period. There was also a 30 per cent increase in emissions from road traffic, which is related to a rise in the level of economic activity.
- In 2006, CO_2 accounted for 81 per cent of greenhouse gas emissions. The rise in emissions has also been greater for CO_2 than for other greenhouse gases. Emissions of fluorinated gases have dropped by 73 per cent since 1990.
- It is estimated that emissions will continue to rise and reach 59.2 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 (2006-2007) to the Storting).

Box 9.4. Greenhouse gases and global warming potential

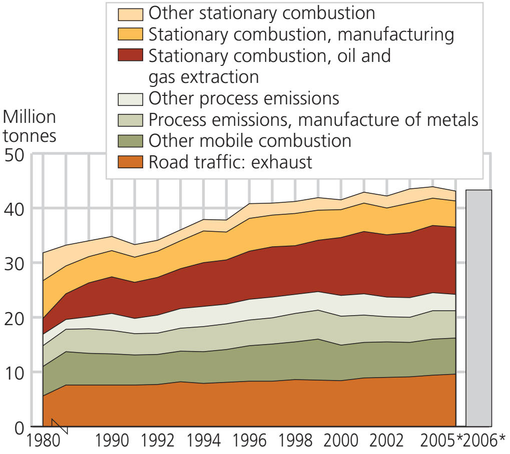
The three most important greenhouse gases are carbon dioxide (CO_2), methane (CH_4) and nitrous oxide (N_2O). Anthropogenic emissions of CO_2 are mainly associated with the combustion of fossil fuels, but are also generated by various chemical processes in manufacturing industries. Methane is formed 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 (HFCs)	
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 (PFCs)	
CF_4 (PFC-14)	6 500
C_2F_6 (PFC-116)	9 200
C_3F_8 (PFC-218)	7 000
Sulphur hexafluoride (SF_6)	23 900

The Kyoto Protocol applies to the greenhouse gases CO_2, CH_4, N_2O, sulphur hexafluoride (SF_6), hydrofluorocarbons (HFCs) and perfluorocarbons (PFCs).

Figure 9.4. Emissions of CO_2 by source. 1980-2006*



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

Carbon dioxide (CO_2)

- In 2006, CO_2 emissions totalled 43.3 million tonnes: this is an increase of 0.4 per cent from the year before. The overall rise since 1990 is about 25 per cent.
- The most important sources of CO_2 emissions are oil and gas extraction and road traffic, which accounted for 28 and 22 per cent respectively of the total in 2005. Process emissions from metal production accounted for 11.5 per cent of emissions.

Box 9.5. The Kyoto Protocol and the Kyoto mechanisms

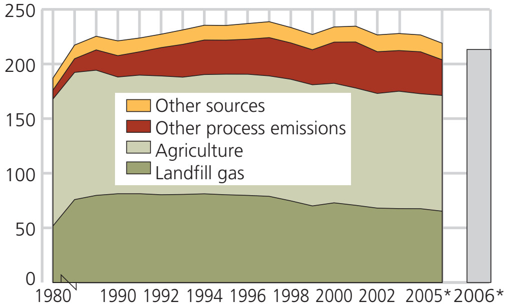
By May 2007, 171 countries and the EU had ratified the Kyoto Protocol. However, the US and Australia had not done so[1]. Once it had been ratified by the required number of countries, the Protocol entered into force on 16 February 2005. Thirty-seven developed country parties have been allocated assigned amounts of emissions for the period 2008-2012. The assigned amount is defined as a percentage of the country's greenhouse gas emissions in a base year (most often 1990), and varies from 92 to 110 per cent of emissions in the base year. In 2007, final figures for the assigned amounts were calculated. 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 make use of the Kyoto mechanisms to acquire further emission units. The mechanisms include emissions trading with other developed countries and funding approved projects to reduce emissions in developing countries (the Clean Development Mechanism). 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
Countries that have undertaken commitments under the Protocol may trade emission units among themselves. A country that can reduce emissions to below the target set out in the Protocol at relatively low cost may sell units 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, this is a more cost-effective solution than requiring all countries to carry out emission reductions within their own borders. 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.

[1] Australia has later ratified the protocol.

Figure 9.5. Emissions of CH_4 by source. 1980-2006*



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

Methane (CH_4)

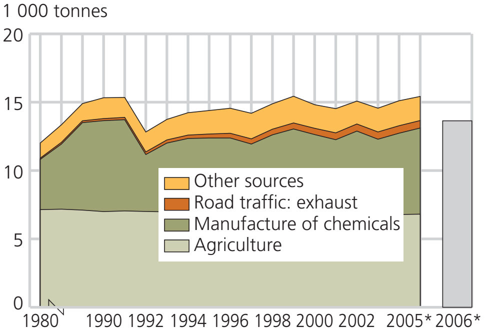
- In 2006, CH_4 accounted for 8 per cent of Norway's aggregate greenhouse gas emissions.
- CH_4 emissions totalled 214 500 tonnes, 2 per cent less than the year before. There has been a 3 per cent decrease in emissions since 1990.
- The most important sources of CH_4 emissions are agriculture (livestock and manure) and landfills, which in 2005 accounted for 48 and 30 per cent of Norwegian emissions, respectively.
- The model used to calculate emissions of methane from landfills was improved in the period 2004-2006. As a result, the estimated level of emissions from this source has been cut by more than 50 per cent (Norwegian Pollution Control Authority 2005 and Skullerud 2006).

Box 9.6. 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. Based on the most recent calculations of emissions in 1990, this corresponds to 251 million tonnes CO_2 equivalents for the whole Kyoto period (49.8 million tonnes * 1.01 * 5). In 2006, Norway's aggregate greenhouse gas emissions were 53.7 million tonnes CO_2 equivalents. The Government's projections indicate that Norway's emissions will rise from 53.7 million tonnes CO_2 equivalents in 2006 to 59.2 million in 2010. If emissions are stable at the 2010 level throughout the Kyoto period, Norway will need to buy emission units corresponding to roughly 45 million tonnes for the whole period 2008-2012. The projected figures for 2010 do not include emissions totalling 2 million tonnes CO_2 from the gas-fired power plants at Kårstø and Mongstad. Carbon capture facilities are not expected to be installed at the two power plants before 2011–12 and 2014 respectively.

Measures for reducing greenhouse gas emissions in Norway have been presented in the report from the Low Emission Commission (Official Norwegian Report 2006:18), the most recent white paper on Norwegian climate policy (Report No. 34 (2006-2007) to the Storting) and a mitigation analysis from the Norwegian Pollution Control Authority (2007). The total emission reduction potential of the technical measures presented in the mitigation analysis is estimated at 19.9 million tonnes CO_2 equivalents in 2020 relative to projected emissions if no new measures are introduced (58.7 million tonnes). This means that if the full potential is realised, emissions in 2020 would be 22 per cent below the 1990 level.

Figure 9.6. Emissions of N_2O by source. 1980-2006*

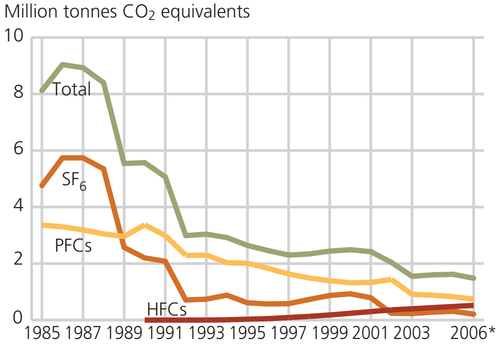


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Nitrous oxide (N_2O)

- In 2006, N_2O accounted for 8 per cent of Norway's aggregate greenhouse gas emissions.
- N_2O emissions totalled 14 100 tonnes, which is a drop of about 8 per cent from 2005.
- The most important sources of N_2O emissions are agriculture and the manufacture of chemicals (mainly commercial fertiliser), which accounted for 44 and 41 per cent respectively in 2005. The marked drop in emissions from 1991 to 1992 reflects a cut in emissions from fertiliser manufacturing as a result of technological improvements.

Figure 9.7. Total emissions of other greenhouse gases (HFCs, PFCs and SF_6). 1985-2006*



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 2006, emissions of sulphur hexafluoride (SF_6) totalled 9 tonnes, equivalent to 200 000 tonnes CO_2 equivalents, which is a drop of 32 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.
- Emissions of perfluorocarbons (PFCs) dropped by 10 per cent from 2005 to 2006, and now equal about 700 000 tonnes CO_2 equivalents. Emissions of hydrofluorocarbons (HFCs) increased by 8 per cent in the same period, and totalled 520 000 tonnes CO_2 equivalents in 2006.
- Measured in CO_2 equivalents, these pollutants together accounted for almost 3 per cent of Norway's aggregate greenhouse gas emissions in 2006.

Box 9.7. 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.

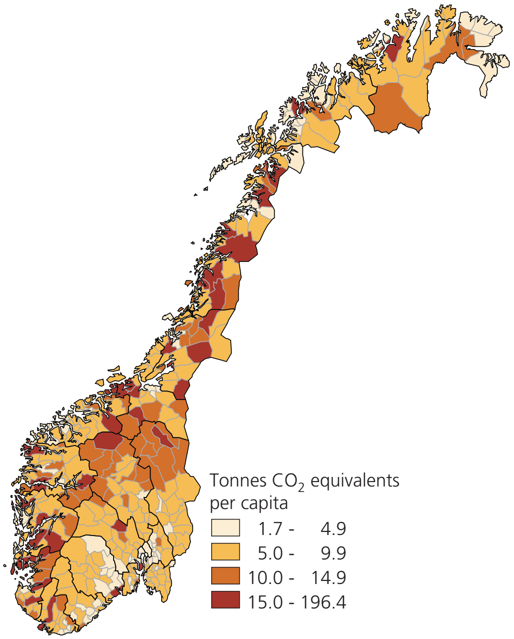
Greenhouse gases. Shares of total emissions and calculated uncertainty in emission figures. 1990 and 2004

1990			2004		
	Share of total emissions (CO_2 eq.)	Uncertainty (per cent)		Share of total emissions (CO_2 eq.)	Uncertainty (per cent)
Total	1	±7	Total	1	±6
CO_2	0.69	±3	CO_2	0.80	±3
CH_4	0.10	±15	CH_4	0.09	±14
N_2O	0.10	±57	N_2O	0.09	±59
HFCs	0.00	±49	HFCs	0.01	±51
PFCs	0.07	±21	PFCs	0.02	±20
SF_6	0.04	±2	SF_6	0.005	±15

The uncertainty in the input data for the emission inventory was assessed on the basis of available data and expert assessments. Finally, level and trend uncertainties were estimated using Monte Carlo simulation. The analyses were made both excluding and including the LULUCF sector (land use, land-use change and forestry).

For documentation, see Aasestad, K.: The Norwegian Emission Inventory 2007. *Documentation of methodologies for estimating emissions of greenhouse gases and long-range transboundary air pollutants*. Reports 2007/38, Statistics Norway.

Figure 9.8. Per capita emissions of CO_2 equivalents by municipality. 2005

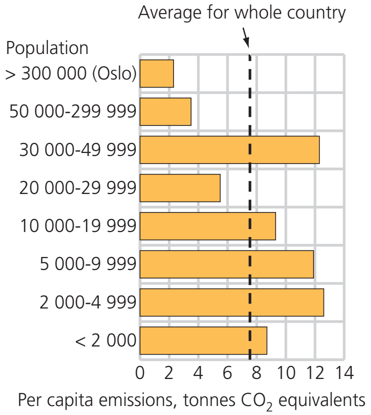


Map data: Norwegian Mapping Authority.
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Greenhouse gas emissions at local level

- CO_2 is the most important greenhouse gas in all counties.
- Manufacturing, road traffic, agriculture and landfills are the largest sources of greenhouse gas emissions in most municipalities.
- About 68 per cent of Norway's CO_2 emissions can be allocated to household and industrial activities in the municipalities. The rest, 32 per cent in 2005, are generated at sea and in Norwegian airspace, mainly by the oil and gas industry, shipping and air traffic.

Figure 9.9. Average per capita greenhouse gas emissions in Norway, from municipalities grouped by population size. 2005. 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 2.3 tonnes in 2005. The corresponding figure for the 12 other municipalities with populations of over 50 000 was 3.5 tonnes, while it was 12.3 tonnes in municipalities with a population of 30 000-50 000. The average for the country as a whole in 2005 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 municipalities. 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.

Box 9.8. 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 (NOx) from the combustion of fossil fuels. In addition, ammonia and ammonium ions (NHx) 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. As a result, acidification is still occurring, causing serious damage to biological communities.

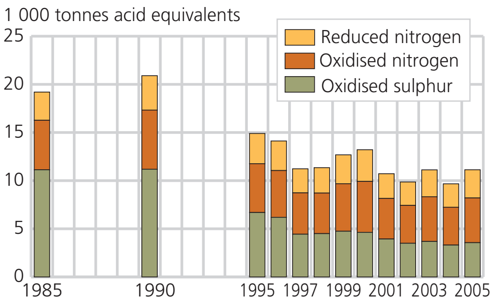
National targets - Long-range air pollutants

1. Annual emissions of sulphur dioxide (SO_2) will not exceed 22 000 tonnes from 2010 onwards.
2. Annual emissions of nitrogen oxides (NO_x) will not exceed 156 000 tonnes from 2010 onwards, and annual emissions in the period up to 2010 will not exceed the 1987 level (218 000 tonnes).
3. Annual emissions of volatile organic compounds (VOCs) will not exceed 195 000 tonnes from 2010 onwards. In the period up to 2010, annual emissions will not exceed the 1988 level (252 000 tonnes), and annual emissions from the entire mainland and the Economic Zone of Norway south of 62° N will not exceed 70 per cent of the 1989 level (191 000 tonnes).
4. Emissions of ammonia (NH_3) will not exceed 23 000 tonnes from 2010 onwards.

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

9.2. Acidification

Figure 9.10. Deposition of acidifying substances in Norway. 1985-2005



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, critical loads are still being exceeded in large parts of the southern half of Norway.
- Emissions from Norway are largely deposited in Norway or over the sea (EMEP/MSC-W 2006). 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 under the Gothenburg Protocol for SO_2 and NO_x. 1 000 tonnes

	SO_2			NO_X		
	Emissions		Target	Emissions		Target
Country:	1990	2005	2010	1990	2005	2010
UK	3 687	706[1]	625	2 966	1 627[1]	1 181
Germany	5 350	560	550	2 861	1 443	1 081
Russia[2]	6 113	1 858[1]	2 470	3 600	3 093[1]	2 500
Sweden	109	40	67	314	205	148
Denmark	178	22	50	274	186	127
Norway	52	24	22	213	197	156

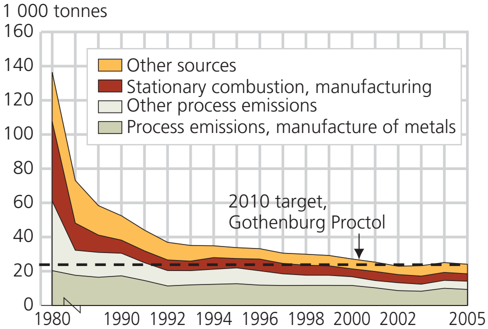
[1] Emissions in 2004.
[2] Figures according to "Expert Emissions used in EMEP models". The figures apply to the European part, within the EMEP area.
Source: EMEP (2007).

Box 9.9. 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 9.11. Emissions of SO_2 by source. 1980-2005*

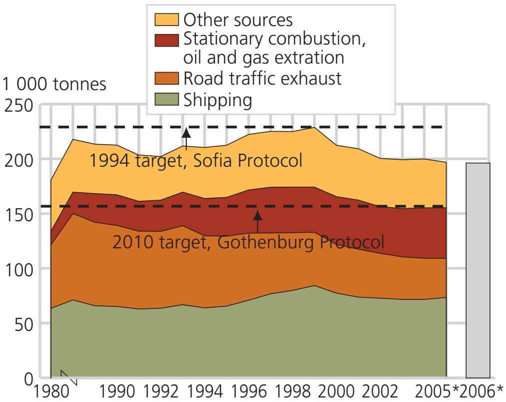


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Sulphur dioxide (SO_2)

- Sulphur emissions decreased steadily from the mid-1980s, but rose again in 2003 and 2004. In 2005, SO_2 emissions totalled 24 080 tonnes, a drop of 3.9 per cent from 2004. Since 1990, emissions have been cut by more than half through measures to reduce industrial emissions, a changeover from fossil fuels to electricity, and reduction of the sulphur content of oil products and raw materials.
- The recent fluctuations in sulphur emissions are explained by variations in emissions from the manufacture of iron, steel and ferro alloys, carbide production and shipping. Domestic shipping and fishing vessels accounted for almost 16 per cent of total emissions in 2005.
- The Gothenburg Protocol entered into force in 2005. Under this agreement, Norway has undertaken to reduce its annual SO_2 emissions to 22 000 tonnes by 2010. This means that emissions must be reduced by almost 9 per cent from the 2005 level.

Figure 9.12. Emissions of NO_x by source. 1980-2006*

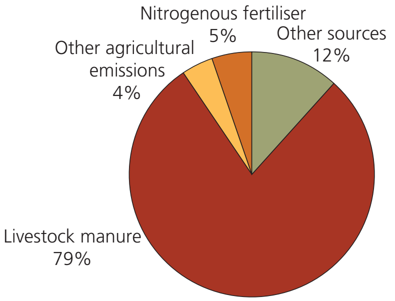


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Nitrogen oxides (NO_x)

- In 2006, NO_x emissions totalled 194 500 tonnes, a drop of 1.2 per cent from the year before. Since 1990, emissions have been reduced by 8.5 per cent.
- The largest sources of NO_x emissions are shipping and fisheries (37 per cent), stationary combustion in the oil and gas industry (23 per cent) and road traffic (18 per cent). The only reduction since 1990 has been in emissions from road traffic. This is explained by lower emissions from petrol vehicles as a result of limits on exhaust emissions. Emissions from diesel vehicles have risen in recent years despite the limits on exhaust emissions, because the number of diesel vehicles has risen.
- 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 20 per cent by 2010.

Figure 9.13. Emissions of ammonia by source. 2005*. Per cent

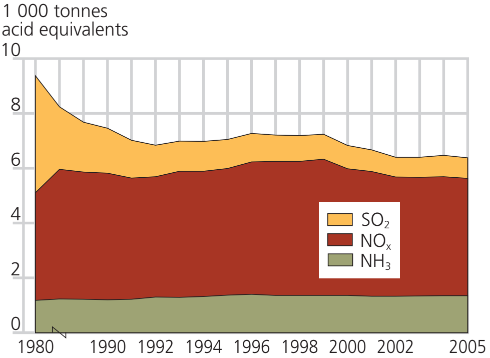


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Ammonia (NH_3)

- In 2006, NH_3 emissions were 1.8 per cent lower than the year before, and totalled 22 600 tonnes. This is just below the emission ceiling of 23 000 tonnes under the Gothenburg Protocol.
- Agriculture generated 88 per cent of Norwegian emissions of ammonia in 2005. 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 (2 per cent).

Figure 9.14. Emissions of acidifying substances in Norway. Acid equivalents. 1980-2005*



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

Aggregate emissions of acidifying substances

- In 2005, Norway's aggregate emissions of acidifying substances, expressed as acid equivalents, amounted to 6 390 tonnes. NO_X accounts for 67 per cent of the total.
- Emissions expressed as acid equivalents showed only a slight decrease from 2004 to 2005.
- The dispersal potential of SO_2 and NO_X emissions is greater than that of NH_3 emissions.

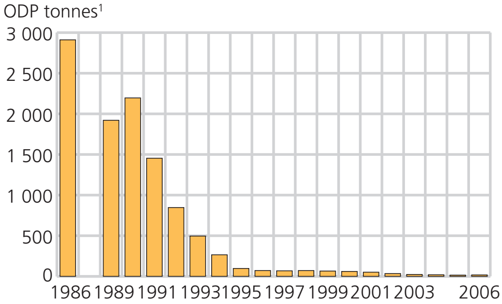
National targets - Depletion of the ozone layer

1. Consumption of halons, all types of chlorofluorocarbons (CFCs), tetrachloromethane, methyl chloroform and hydrobromofluorocarbons (HBFCs) will be eliminated.
2. Consumption of methyl bromide will be phased out by 2005.
3. Consumption of hydrochlorofluorocarbons (HCFCs) will be stabilised in 1995 and phased out by 2015.

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

9.3. Depletion of the ozone layer

Figure 9.15. Imports of ozone-depleting substances to Norway. 1986-2006



[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 17 ODP tonnes of ozone-depleting substances in 2006. This is 10 per cent more than in 2005.
- 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 was reduced by an average of 0.16 per cent per year in the period 1979-2005 (Norwegian Institute for Air Research 2006).

Box 9.10. 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 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 9.11. 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/m^3 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. According to the Norwegian Institute for Air Research, levels of ground-level ozone were unusually high in 2006 throughout Norway. 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/m^3, 1-hour average), was exceeded at six of the eight operative measuring stations, on four different days. The EU information threshold is 180 µg/m^3, and was exceeded at two measuring stations on two different dates. The EU (and Norwegian) target value for the protection of human health (a maximum daily 8-hour mean of 120 µg/m^3) was exceeded on 36 different dates in 2006. In 2005, it was only exceeded on 16 different dates. Ground-level ozone concentrations have not been so high since 1994. This is explained by a combination of unusual meteorological conditions and agricultural fires in Eastern Europe (NILU 2007).

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
NMVOCs	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 26 per cent in the period 1990-2006.

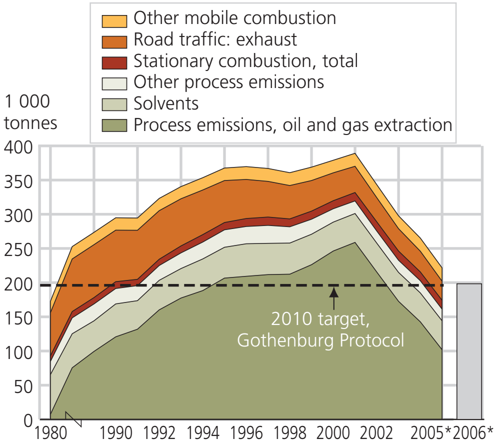
Box 9.12. Ozone precursors, sources and harmful effects

Substance	Important sources[1]	Effects
Non-methane volatile organic compounds (NMVOCs)	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.

9.4. Formation of ground-level ozone

Figure 9.16. Emissions of NMVOCs by source. 1980-2006*



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

NMVOCs

- In 2006, Norway's NMVOC emissions totalled 196 000 tonnes: this is a reduction of 11 per cent from 2005 and only half the level in 2001, when emissions reached the highest level since 1980.
- This reduction is mainly a result of measures to reduce emissions during loading and storage of crude oil offshore. Emissions in 2006 were also reduced by recovery of oil vapour at onshore loading facilities, lower sales of petrol and an increase in the number of cars fitted with catalytic converters.
- Under the Gothenburg Protocol, Norway has undertaken to meet an emission ceiling of 195 000 tonnes NMVOCs in 2010. To achieve this, emissions must be reduced by a further 1 per cent in the period up to 2010. The target appears to be within reach.

Target value for ground-level ozone

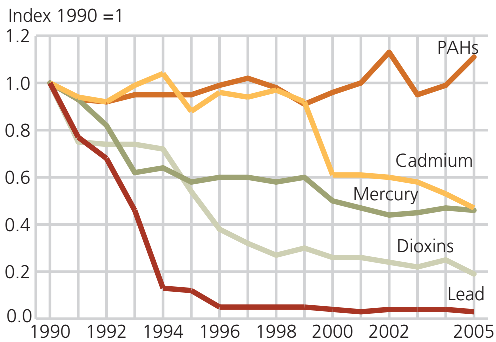
1. Target value for the protection of human health: By 2010, the maximum daily 8-hour mean concentration will not exceed 120 µg/m^3 on more than 25 days per calendar year, averaged over three years.

Source: Pollution Regulations.

9.5. Ecological toxins

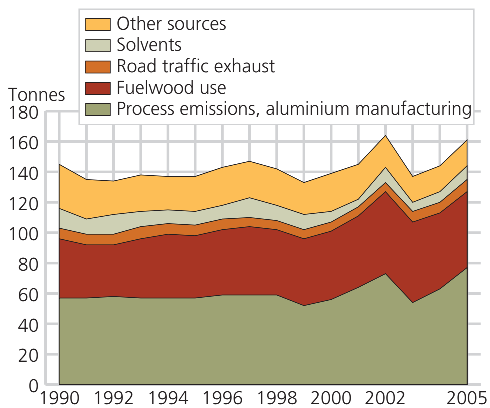
Norway has taken on international commitments to reduce emissions to air of selected hazardous substances in relation to 1990 levels. Under the Protocol on Heavy Metals, Norway has undertaken to reduce its emissions of lead, cadmium and mercury, and under the Protocol on Persistent Organic Pollutants (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 9.17. Changes in emissions of lead, cadmium, mercury, total PAH and dioxins in Norway. Index 1990=1. 1990-2005*



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

Figure 9.18. Emissions of total PAH to air by source. 1990-2005*



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. Other important reasons for reductions in emissions of these substances, especially after 1995, are the installation of equipment to control emissions and improvements in its operation, and the closure of plants in the chemical and metallurgical industry.
- However, releases of certain substances have risen to some extent in the last few years. Two of the reasons for this are a rise in metal production and fuelwood use.

PAHs

- In 2005, Norway's emissions of "total PAH" were 160 tonnes, 12 per cent more than the year before. PAH-4, which is the component regulated by the POPs Protocol under the LRTAP Convention, accounted for 17 tonnes of this, which is an increase of 13 per cent from 2004.
- The largest sources of PAH emissions are fuelwood use in households and process emissions from aluminium production. These two sources accounted for 31 and 48 per cent respectively of the total in 2005. Process emissions accounted for 69 per cent of total PAH-4 emissions.

- The rise in PAH emissions in the last few years is a result of higher emissions from aluminium production: emissions from this source in 2005 were 34 per cent higher than in 1990, and this level was the highest for the whole period 1990-2005. Emissions from fuelwood use in 2004 and 2005 were somewhat lower than in the peak years 2002 and 2003, but were nevertheless 28 per cent above the 1990 level in 2005. Emissions of "total PAH" in 2005 were 11 per cent higher than in 1990 and 17 per cent higher than in 1995. 2002 is the only year in the period 1990-2005 when emissions were higher than this.

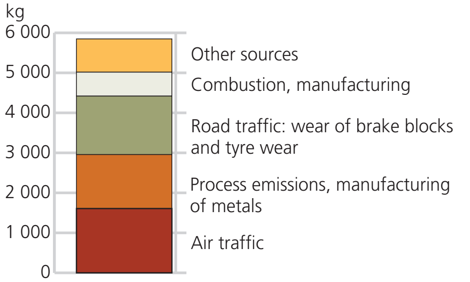
National targets for releases of hazardous substances

1. Releases of certain ecological toxins (see the priority list) will be eliminated or substantially reduced by 2005 or 2010.
2. Releases and use of substances that pose a serious threat to health or the environment will be continuously reduced with a view to eliminating them within one generation (by the year 2020).
3. The risk that releases and use of chemicals will cause injury to health or environmental damage will be minimised.

See Chapter 13. Hazardous substances.

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

Figure 9.19. Emissions of lead to air by source. 2005*



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

Lead (Pb)

- Lead emissions in 2005 were 97 per cent lower than in 1990 and 73 per cent lower than in 1995. This is mainly a result of the changeover to unleaded petrol: emissions from road traffic accounted for 94 per cent of the total in 1990, but had been reduced by 99 per cent in 2005, and accounted for only 3 per cent of the total. There has also been a drop in emissions from manufacturing as a result of lower activity and the closure of some plants. Emissions in 2005 totalled 5.8 tonnes, 29 per cent less than the year before. There was a drop in emissions from air traffic (light aircraft) and metal production, which together with wear of brake blocks are the most important sources of lead emissions today. In 2005, these three sources accounted for 27, 23 and 25 per cent respectively of total emissions.

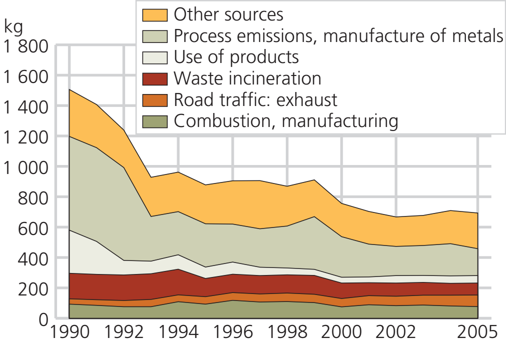
Box 9.13. Ecological toxins, sources and harmful effects

Substance	Important sources[1]	Effects
Arsenic (As)	Chemical industry, pulp and paper industry, metal production and road traffic	Inorganic arsenic compounds (arsenates) are 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	Metal production, pulp and paper industry, fuelwood use, shipping and waste incineration	Become concentrated in organisms and food chains. Carcinogenic.
Cadmium (Cd)	Pulp and paper industry, mineral production, 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 process industry	Liable to bioaccumulate. Some copper compounds are acutely toxic or irritant in mammals.
Chromium (Cr)	Ferro-alloy industry and combustion in industry	Liable to bioaccumulate. Hexavalent compounds (Cr^{6+}) are carcinogenic and sensitising. May cause kidney and liver damage.
Mercury (Hg)	Pulp and paper industry, mineral production, metal production, fuelwood use	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 ($PM_{2,5}$ and PM_{10})[2]	Road traffic and fuelwood use	Increase the risk of respiratory complaints.

[1] The table indicates important anthropogenic sources.

[2] $PM_{2.5}$; particles measuring less than 2.5 µm in diameter. PM_{10}; particles measuring less than 10 µm in diameter.

Figure 9.20. Emissions of mercury to air by source. 1990-2005*

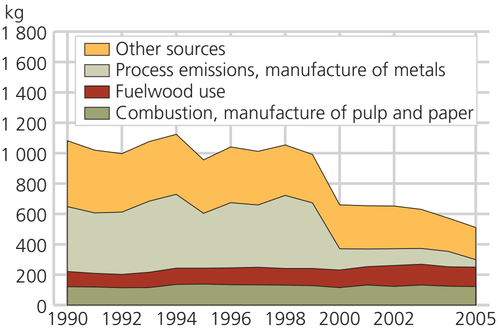


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Mercury (Hg)

- In 2005, mercury emissions to air totalled just under 700 kg, 2 per cent less than in 2004.
- Industrial processes accounted for 35 per cent of the total in 2005. Emissions from mineral production rose sharply from 2004, but this rise was counteracted by an even larger reduction in emissions from metal production, so that overall emissions from industrial processes declined by 2 per cent. Despite the reduction in emissions from metal production, this source alone accounts for one fourth of the total, the same as mobile combustion. Road traffic and shipping accounted for 11 and 10 per cent respectively of total emissions in 2005.
- Just under one third of mercury emissions in 2005 were generated by stationary combustion, largely by waste incineration and manufacturing, which each accounted for 11 per cent of total emissions.
- From 1990 to 2005, overall emissions have been reduced by 54 per cent. Emissions from industrial processes (particularly the manufacture of ferroalloys) have been reduced by two thirds and emissions from product use (for example mercury thermometers) by 83 per cent. Total emissions of mercury in 2005 were 21 per cent lower than in 1995.
- There has also been a substantial reduction in emissions from stationary combustion, which were 41 per cent lower in 2005 than in 1990. However, emissions from mobile combustion have risen, mainly because of the increase in the use of diesel vehicles. Petrol vehicles do not generate mercury emissions.

Figure 9.21. Emissions of cadmium to air by source. 1990-2005*

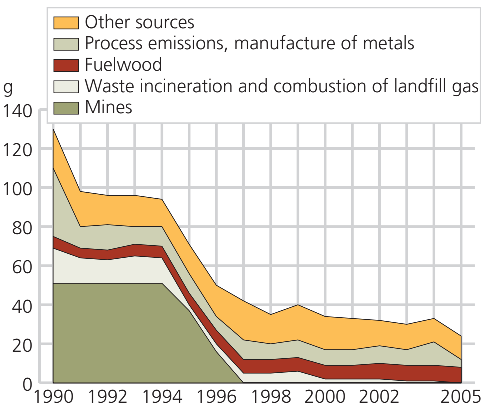


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Cadmium (Cd)

- In 2005, cadmium emissions totalled about 500 kg, 11 per cent lower than the year before.
- Stationary combustion in households and the pulp and paper industry each accounted for about one fourth of total emissions in 2005, the main sources being combustion of wood, wood waste and black liquor.
- Emissions have been reduced by 53 per cent from 1990 to 2005. This is mainly explained by a reduction of almost 90 per cent in emissions from metal production in this period. In the same period, emissions from stationary combustion have been reduced by about one fourth, while there has been a weak rise in emissions from road traffic. Most of the reduction in emissions has taken place after 2000. The overall reduction from 1995 to 2005 is 46 per cent.

Figure 9.22. Emissions of dioxins to air by source. 1990-2005*



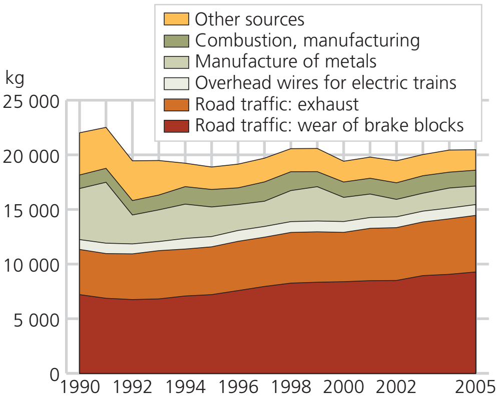
Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Dioxins

- In 2005, emissions of dioxins totalled 24 g, a reduction of 25 per cent from the year before. This was almost entirely due to a considerable reduction in emissions from a few metal producers.
- More than 60 per cent of total emissions in 2005 were generated by stationary combustion. Households accounted for 40 per cent of the total, of which three-quarters was from fuelwood use. House fires are another important source. The most important sources otherwise are shipping (20 per cent) and metal production (17 per cent).

- Total emissions of dioxins have been reduced by more than 80 per cent from 1990 to 2005. The main reasons for this are the closure of an iron ore mine and a steep reduction in emissions from magnesium production. As a result of improvements in pollution abatement technology, emissions from waste incineration have been cut by 98 per cent, while emissions from road traffic have dropped by 87 per cent. From 1995 to 2005, total emissions have been reduced by 66 per cent.

Figure 9.23. Emissions of copper to air by source. 1990-2005*

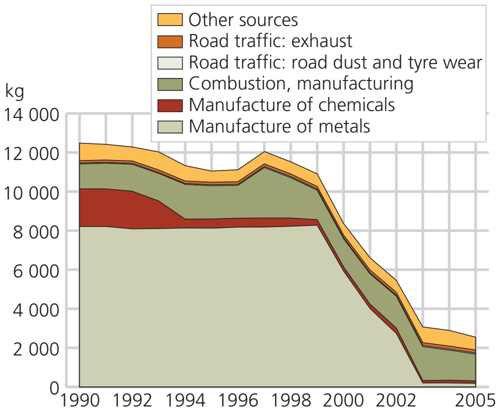


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Copper (Cu)

- In 2005, emissions of copper to air totalled 20 tonnes, about the same level as in 2004. Road traffic is by far the largest source of emissions: in 2005, wear of brake blocks accounted for 45 per cent of the total, and exhaust emissions from petrol and diesel vehicles for 25 per cent. Road traffic emissions (wear of brake blocks included) rose by 2 per cent from 2004 to 2005.
- Total copper emissions were 7 per cent lower in 2005 than in 1990, but 8 per cent higher than in 1995, when they reached the lowest level in the period 1990-2005. In the period 1995-2005, road traffic emissions (wear of brake blocks included) rose by 25 per cent. Copper emissions from metal production decreased by 37 per cent in the same period, and by 64 per cent in the period 1990-2005.

Figure 9.24. Emissions of chromium to air by source. 1990-2005*

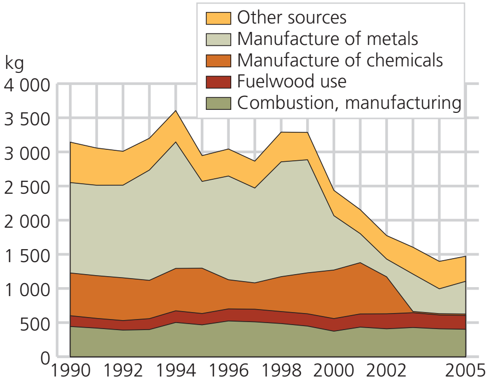


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Chromium (Cr)

- In 2005, emissions of chromium to air totalled about 2.5 tonnes, a decrease of 12 per cent from 2004. Combustion in the wood processing industry is the most important source, and accounted for 31 per cent of total emissions in 2005. Stationary combustion accounted for 71 per cent of emissions in 2005, and process emissions and mobile combustion for 17 and 12 per cent respectively.
- From 1990 to 2005, chromium emissions were reduced by 80 per cent. The greatest reduction was in emissions from the manufacture of ferro-alloys, which dropped by 98 per cent in this period. Emissions from this source accounted for 63 per cent of the total in 1990, but only 7 per cent in 2005. The reduction is partly explained by the closure of a ferro-chromium plant, but the most important reason is the installation of pollution abatement equipment. Most of the reduction in emissions has taken place after 2000. The overall reduction from 1995 to 2005 is 77 per cent.

Figure 9.25. Emissions of arsenic to air by source. 1990-2005*



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

Arsenic (As)

- In 2005, arsenic emissions totalled almost 1.5 tonnes, which is a rise of 5 per cent since 2004. This is explained by annual variations in the arsenic content of the coke used in anode production.
- In 2005, emissions from metal production accounted for 33 per cent of the total, and combustion in the pulp and paper industry and in households accounted for 16 and 15 per cent respectively, generated mainly by combustion of wood, wood waste and black liquor. Mobile combustion accounted for 19 per cent of the total, and more than half of this was generated by road traffic.
- Total emissions of arsenic have been reduced by more than half since 1990, and most of the reduction has taken place after 1995. This is mainly a result of lower emissions from metal and carbide production. Emissions from these sources were reduced by three quarters in the period 1990-2005.

9.6. 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).

National targets - Local air quality

1. The 24-hour mean concentration of particulate matter (PM_{10}) will not exceed 50 µg/m^3 on more than 25 days per year by 2005 and 7 days per year by 2010.
2. By 2010, the hourly mean concentration of nitrogen dioxide (NO_2) will not exceed 150 µg/m^3 for more than 8 hours per year.
3. The 24-hour mean concentration of sulphur dioxide (SO_2) will not exceed 90 µg/m^3.
4. By 2010, the annual mean concentration of benzene will not exceed 2 µg/m^3, measured as urban background concentration.

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

Box 9.14. 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. In addition, a survey of wood consumption in holiday homes in 2006 was carried out in 2007. Together, these surveys provide figures for total fuelwood consumption in 2006, and 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 two years 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.

On the basis of the surveys, fuelwood use and energy quantities have been calculated for different types of stoves and fireplaces. The effects on emissions of particulate matter and energy efficiency of replacing old stoves with new ones have also been estimated.

Statistics Norway continued the quarterly surveys in 2007 and also plans to do so in 2008, when it will be possible to include consumption of other energy commodities such as heating kerosene and fuel oil. Figures from these surveys now replaces figures from the comprehensive survey of consumer expenditure in calculations of emissions to air from fuelwood use.

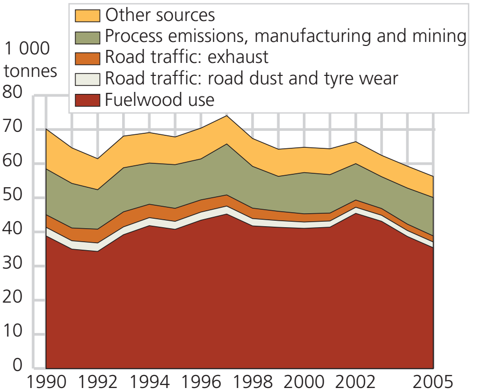
Read more in: Haakonsen, G. and E. Kvingedal (2001): *Utslipp til luft fra vedfyring i Norge. Utslippsfaktorer, ildstedsbestand og fyringsvaner.* (Emissions to air from fuelwood use in Norway. Emission factors, numbers of wood-burning stoves and open fireplaces, and heating habits). Reports 2001/36.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

Finstad, A. et al. (2004): *Vedforbruk, fyringsvaner og svevestøv. Undersøkelse om vedforbruk og fyringsvaner i Trondheim og Bergen 2003*. (Fuelwood consumption, heating habits and particulate matter. Survey of fuelwood consumption and heating habits in Trondheim and Bergen 2003). Reports 2004/27, Statistics Norway.

New stoves reduce emissions of particulate matter. http://www.ssb.no/english/magazine/art-2005-01-19-02-en.html

Figure 9.26. Emissions of particulate matter (PM_{10}) to air by source in Norway. 1990-2005*

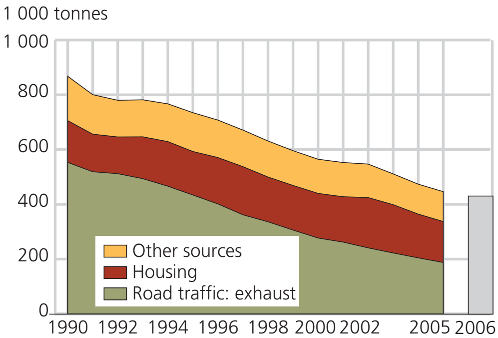


Source: Emission inventory from Statistics Norway and Norwegian Pollution Control Authority.

Particulate matter

- Three different fractions of particulate matter are distinguished: TSP (total suspended particles), PM_{10}, with a diameter of less than 10 µm and $PM_{2.5}$, with a diameter of less than 2.5 µm. Total emissions of the three fractions in 2005 were 73 500 tonnes, 56 300 tonnes and 49 600 tonnes respectively.
- Fuelwood use is the largest source of particulate matter emissions, and accounted for 63 and 71 per cent respectively of emissions of PM_{10} and $PM_{2.5}$ in 2005. For these two fractions, the next most important source of emissions is metal production.

Figure 9.27. Emissions of carbon monoxide to air by source in Norway. 1990-2006*



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

Carbon monoxide (CO)

- In 2006, emissions of carbon monoxide to air totalled 425 600 tonnes.
- The largest sources of CO emissions are road traffic and heating of housing, especially with fuelwood, and these accounted for 42 and 33 per cent respectively of the total in 2005.
- From 1990 to 2006, total CO emissions dropped by 51 per cent. The main reason is reduced emissions from road traffic because more cars are equipped with catalytic converters.

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Lisbet Høgset (lisbet.hogset@ssb.no).

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 measure noise annoyance outside people's 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 shows 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 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, Leq) 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.

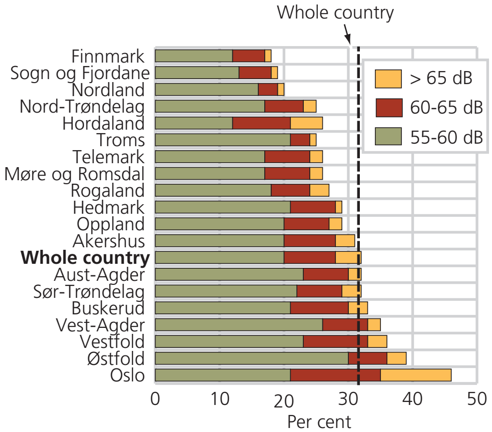
Uncertainty
The calculations are generally uncertain. However, the level of uncertainty varies from source to source. In general terms, it is lowest for areas where noise levels are high and the model is largely based on existing surveys (for example around Oslo airport (Gardermoen) and areas surveyed 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 over-simplified, 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.

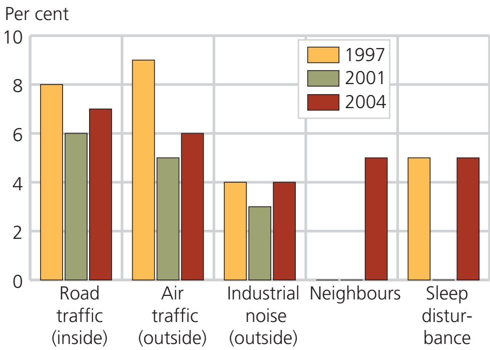
Distribution of road traffic noise by county

- 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.

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Useful websites

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

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11. Waste

The total quantities of waste generated in Norway are rising year by year. Since 1995, total waste generation has risen by 30 per cent to 9.6 million tonnes. In the same period, gross domestic product (GDP) rose by 37 per cent. However, preliminary figures indicate that waste generation grew somewhat more slowly in 2006. Norway's target is for waste generation to grow considerably more slowly than GDP.

Waste consists of anything that is discarded after production and consumption. Norway's waste management legislation is intended to prevent pollution of soil and water, greenhouse gas emissions, health problems and local problems such as littering and unpleasant smells. The authorities set standards for waste management facilities through regulations and the mandatory licensing system. Licences include 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. A series of voluntary agreements have also been established between various sectors of industry and the authorities to ensure the collection and sound management of selected waste types.

Preliminary figures from the waste accounts show that about 9.6 million tonnes of waste was generated in Norway in 2006. Waste generation by households has risen faster than generation of industrial waste. Every person in Norway generated an average of 414 kg household waste in 2006. This is 13 kg more than the year before. About 70 per cent of all waste for which information on treatment/disposal is available was recovered in 2006 (this does not include hazardous waste).

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 2005, at least 875 000 tonnes of hazardous waste was generated. 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 60 000 tonnes of hazardous waste in 2005. 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 - definition and classification

According to the Pollution Control Act, waste is defined as discarded objects of personal property or substances. Waste water and waste gases are not defined as 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.

National targets - waste and waste recovery

1. The growth in the quantity of waste generated will be considerably lower than the rate of economic growth.
2. The proportion of waste recovered will be raised to about 75 per cent of the total quantity in 2010 and subsequently to 80 per cent. This is based on the principle that the quantity of waste recovered should be increased to a level that is appropriate in economic and environmental terms.
3. Hazardous waste will be dealt with in an appropriate way, so that it is either recovered or sufficient treatment capacity is provided within Norway. The generation of each type of hazardous waste will be reduced by 2020 compared with the 2005 level.

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

Box 11.2. Waste and waste statistics - terminology

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

Composting: Controlled degradation of waste by living organisms with access to oxygen (aerobic biological treatment). Often considered to be a form of recovery.

Consumer waste: All waste that is not production waste. Includes both non-hazardous and hazardous waste, and also large items such as fittings and furnishings from private households and commercial undertakings.

EEE waste, or WEEE (waste electrical and electronic equipment): EEE items require an electric current or electromagnetic field to function, and need batteries, transformers, wires, etc. to generate, transmit, distribute or measure the current or field, and parts to cool, warm, protect, etc. the electric and/or electronic components. Means of transport are not included in this definition, and cooling equipment containing CFCs (fridges, freezers) is generally also excluded since a separate waste collection and recovery scheme has been established for such equipment.

Energy recovery: Use of the energy released by waste incineration, for example to heat buildings.

Energy recovery efficiency: describes how much of the waste incinerated is in practice converted to utilisable energy.

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

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

Household waste: Defined in the Pollution Control Act as waste from private households, including large objects such as furniture, etc.

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.

Landfilling: Final disposal of waste at an approved landfill.

Material recovery (or recycling): Use of the waste 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.

Production waste: Waste from production of goods and services which is significantly different in type or amount from consumer waste. Includes all waste that is not classified as consumer waste.

Re-use: Use of the waste in its original form. For example, discarded clothing may be sold in second-hand shops or sent abroad as emergency relief.

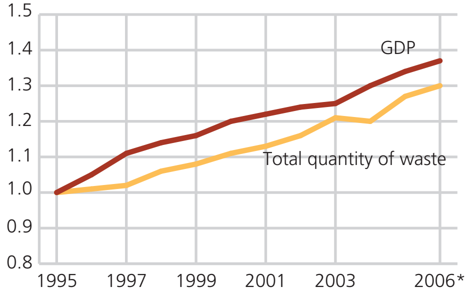
Waste management: Usually defined to include all operations from the moment when an object or substance is discarded until all treatment, recovery and disposal operations are completed. The term **treatment/disposal** is used in the waste accounts to include all waste management processes involving physical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

Waste recovery: Includes re-use, material recovery, incineration combined with energy use and, in many cases, composting.

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), 1995-2006*, index 1995=1

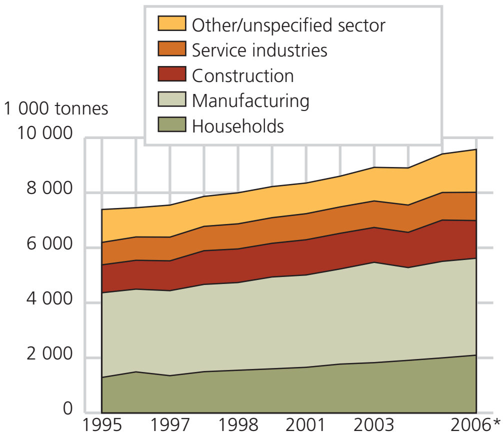


Source: Waste accounts and national accounts, Statistics Norway.

Trends in waste quantities

- According to the waste accounts, total annual waste generation rose from 7.4 to 9.6 million tonnes from 1995 to 2006, a rise of 30 per cent. In the same period, GDP rose by 37 per cent. Thus, waste generation has increased somewhat more slowly than GDP.
- Preliminary figures for 2006 show that the growth in waste generation has slowed somewhat: the rise from 2005 was about 170 000 tonnes (1.8 per cent), while GDP rose by 2.8 per cent in the same period.
- However, household waste generation has risen much faster, by a total of 63 per cent since 1995. This is also a considerably higher growth rate than for household consumption, which has risen by 51 per cent (see section 11.3).

Figure 11.2. Waste quantities in Norway, by source. 1995-2006*. 1 000 tonnes



Source: Waste statistics, Statistics Norway.

Sources of waste

- The quantity of industrial waste rose by 23 per cent in the period 1995-2006 and by 7 per cent in the last two years of this period.
- Manufacturing industries accounted for 37 per cent of total waste generation in 2006, and the quantity of waste generated by this sector has risen by 14 per cent since 1995. However, there has been a drop of 3 per cent since 2003.
- Production waste makes up about 90 per cent of all manufacturing waste.
- Most manufacturing waste is generated by the production of food, metals, wood products and paper.

Box 11.3. Waste accounts

The waste accounts are based on traditional principles for natural resource accounting and organised as a material balance between annual waste generation and the quantities treated or disposed of each year. In practice, the accounts are a multidimensional matrix, where the dimensions are represented by three selected characteristics of the waste. These are:

- source (e.g. agriculture, manufacturing industries)
- material type (e.g. paper, glass, metals)
- form of treatment/disposal (e.g. material recovery, incineration)

As a general principle, existing data sources such as statistics on external trade, production and waste have been used wherever possible. Where no such sources exist, Statistics Norway has carried out its own surveys, for example for waste from manufacturing, mining and quarrying, waste from services and households, and waste management.

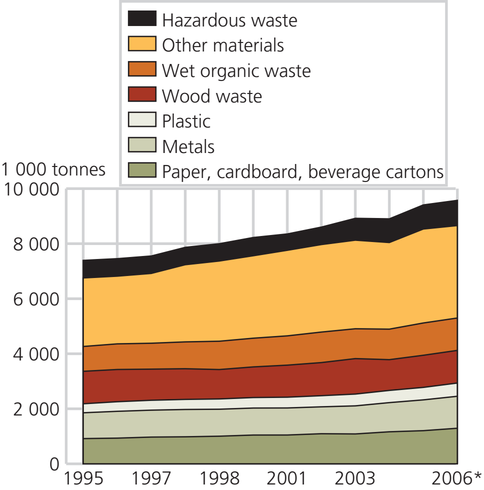
Two different methods are used to estimate waste quantities. One is called the "supply of goods method", and is a theoretical method of estimating waste quantities. It is based on the assumption that waste quantities are equal to the supply of goods after correction for the lifetime of the products. The supply of goods is calculated from statistics on import, export and production of goods. The second method is called the "waste statistics method": existing waste statistics are collected and harmonised, and waste quantities are estimated in cases where the existing statistics are inadequate.

The two methods give an estimate of waste quantities at two different points in the waste stream. The supply of goods method estimates the quantities of waste that are generated, while the waste statistics method shows the quantities delivered for various types of treatment. There may be a real difference between these quantities, for example if not all the waste generated is registered as delivered for treatment or disposal.

The waste accounts are back-calculated 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 11.3. Waste quantities in Norway, by material. 1995-2006*. 1 000 tonnes

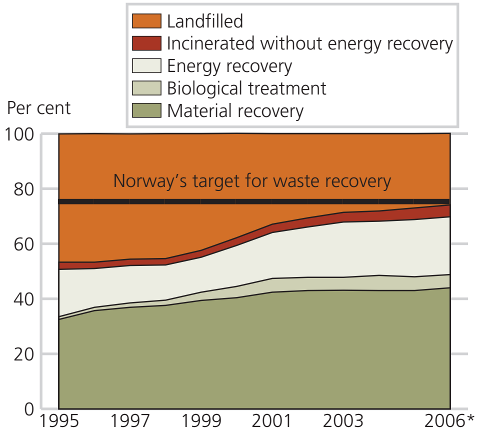


Source: Waste statistics, Statistics Norway.

Materials in waste

- In 2006, a total of 1.3 million tonnes of waste, paper, cardboard and beverage cartons and 0.5 million tonnes of waste plastic was generated. These are currently the most rapidly growing waste fractions, and rose by 7 and 6 per cent respectively from 2005 to 2006.
- The largest waste fraction in 2006 was paper, cardboard and beverage cartons, which made up 14 per cent of the total. Wood waste, metals and wet organic waste each accounted for 12 per cent, and plastic waste made up 5 per cent of the total quantity of waste.
- The category "other materials" made up 35 per cent of the total. It includes concrete and brick, organic and inorganic sludge, slag, rubber, glass, china and ceramics, and dust. 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 - 2006*. As a percentage of waste for which information is available on treatment/disposal



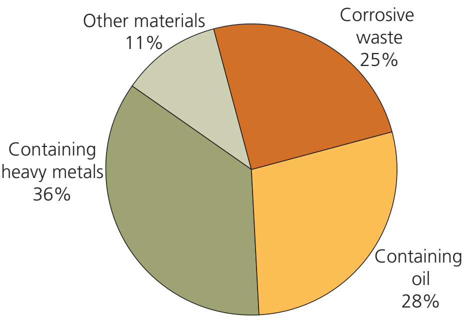
Source: Waste statistics, Statistics Norway.

Treatment/disposal

- Almost 70 per cent of the non-hazardous waste for which there was information on treatment/disposal was recovered in 2006. Of this, almost two thirds was recycled. The rest was either incinerated with energy recovery or treated biologically (aerobically or anaerobically).
- In 2006, 31 per cent of the total quantity of waste, including hazardous waste, was landfilled. This is 20 per cent lower than in 1995, but 4 per cent higher than in the period 2004-2006. About one quarter of the waste landfilled in 2006 was biodegradable and will therefore contribute to emissions of the greenhouse gas methane.
- In 2006, treatment/disposal was unknown for 22 per cent of all waste generated, and the percentage is increasing. A substantial proportion of this category consists of discarded products that are left where they were used, for example oil and other pipelines and underground cables. In addition, there is reason to believe that a growing proportion of waste is being dealt with outside waste treatment and disposal plants, for example delivered directly for use as new raw materials for industrial and energy purposes.

11.2. Hazardous waste

Figure 11.5. Hazardous waste handled at approved facilities, by material. 2005. Per cent



Source: Waste statistics, Statistics Norway.

Origin and materials

- In 2005, a total quantity of 875 000 tonnes of hazardous waste was handled at approved facilities. Of this, 790 000 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 two-thirds of all hazardous waste is generated by manufacturing industries. This includes almost all corrosive waste, most waste containing heavy metals and substantial proportions of other types of hazardous waste.
- Oil-contaminated waste is generated mainly by petroleum extraction, but manufacturing and service industries (especially petrol stations, workshops and transport) also account for substantial amounts.
- The underlying data from Statistics Norway's 2004 waste survey have been revised, and the estimate of the quantity of hazardous waste handled at approved facilities has been reduced by 5 per cent.

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 often have special agreements with transport firms that collect the waste directly from the site.

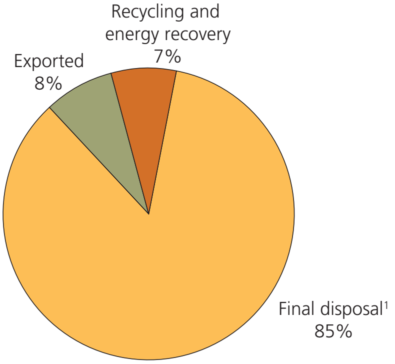
Some industrial plants that generate large quantities of hazardous waste can document sound management of the waste on site. They may be granted permits to dispose of their own hazardous waste. This applies mainly to landfilling of slag containing heavy metals.

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 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, 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. 2005. Per cent



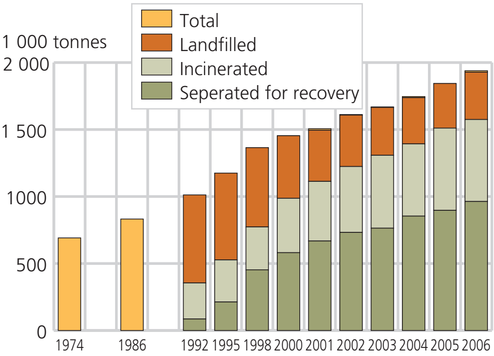
[1] Includes all types of landfilling, permanent storage, incineration without energy recovery and treatment that results only in non-hazardous products.
Source: Waste statistics, Statistics Norway.

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 2005, no information on disposal or treatment was available for about 60 000 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.

11.3. Household waste

Figure 11.7. Household waste by method of recovery or disposal. 1974-2006



Source: Waste statistics, Statistics Norway.

Quantities and methods of disposal

- In 2006, per capita generation of household waste was 414 kg, 177 kg more than in 1992 and 13 kg more than in 2005.
- In all, 972 000 tonnes of household waste, or 50 per cent of the total, was separated for recovery in 2006.
- The quantity of household waste landfilled rose by 6 per cent from the year before, to 353 000 tonnes.
- 752 000 tonnes (39 per cent) of household waste was incinerated in 2006.
- Generation of household waste has risen faster than household consumption throughout the period 1996-2005 (see Chapter 14, figure 14.7).

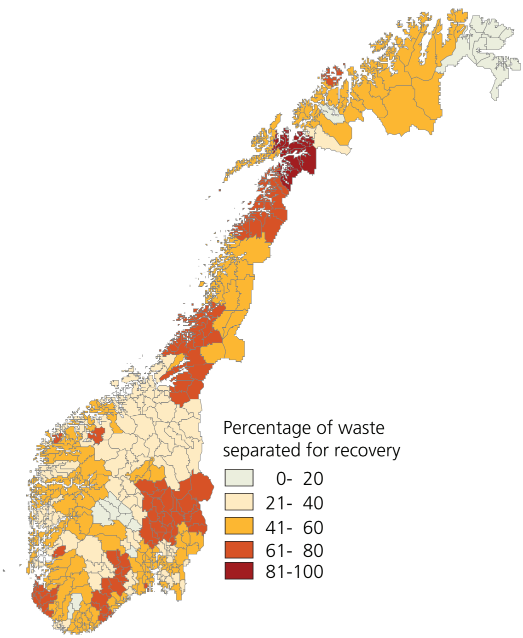
Box 11.5. Legislation relating to waste management in Norway

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)

Figure 11.8. Percentage of household waste separated for recovery, by municipality. 2006.



Source: Waste statistics, Statistics Norway.

Waste recovery

- In 2006, each person in Norway separated 208 kg of household waste for recovery, 10 kg more than in 2005. The proportion of household waste delivered for final disposal (incineration without energy recovery and landfilling) in 2006 was 29 per cent.
- The highest proportions of household waste were separated in Hedmark and Nord-Trøndelag counties, 69 and 65 per cent respectively.
- The county with the highest rate of recovery (including incineration with energy recovery) was Vestfold, at 80 per cent.
- The quantity of household waste recycled rose by 8 per cent from 2005 to 2006, to a total of 784 000 tonnes. A total of 752 000 tonnes of household waste was incinerated, of which 564 000 tonnes, or 75 per cent, was incinerated with energy recovery.
- From 2005 to 2006, the proportion of waste separated rose most for plastics and EEE waste (by 36 and 16 per cent respectively). The largest single fraction separated for recovery was paper and cardboard (313 000 tonnes), while the largest rise was for wood waste, where the quantity recovered rose by 17 000 tonnes to 146 000 tonnes in 2006.

11.4. Some environmental problems related to waste management

Table 11.1. Emissions from waste incineration and landfills. Percentages of total Norwegian emissions in 2005 and change since 1990

	Percentage of total Norwegian emissions	Percentage change from 1990
Incineration plants:		
Quantity of waste incinerated	.	+ 92
Sulphur dioxide	0.7	- 54
Nitrogen oxides	0.4	- 31
Carbon dioxide[1]	0.3	+ 74
Particulate matter, PM_{10}	0.0	- 99
Lead	0.5	- 98
Cadmium	0.8	- 95
Mercury	11.4	- 53
Arsenic	0.2	- 97
Chromium	0.5	- 96
Copper	0.1	- 92
Total PAH	0.6	- 32
Dioxins	1.8	- 98
NMVOCs	0.2	+ 75
Landfills:		
Methane (greenhouse gas)[1]	2.5	-20

[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).

Utslipp til luft og sigevann

- 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 relatively small proportions 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 2005, methane emissions from landfills accounted for about 30 per cent of total methane emissions and 2.5 per cent of Norway's aggregate greenhouse gas emissions. The model used to calculate methane emissions from landfills was revised in 2006, and the estimated level of emissions has been substantially reduced.
- Leachate from landfills may contain 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.

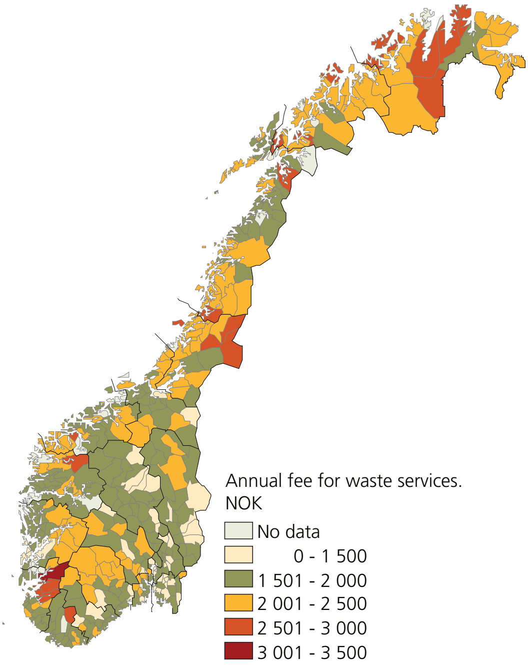
Organic solvents are highly flammable and it is therefore dangerous to mix them with ordinary waste. In most cases, their acute toxicity is not very high and they are easily broken down in the environment. This means that they are not generally very harmful to the environment. Waste containing solvents 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, for example in electronic circuit boards, textiles and fittings for vehicles, to prevent fire. 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, men it is the municipal councils that have the authority to set the fees for waste management services.

Figure 11.9. Annual fee for waste management services. Municipalities. 2007. NOK



Source: KOSTRA, Statistics Norway.

- The average annual fee per subscriber for household waste was NOK 1 942 in 2007, an increase of 3.2 per cent from 2006. The annual fees in individual municipalities varied from NOK 535 to NOK 3 075.
- The very highest fees are in municipalities where settlement is scattered, but apart from this there is no clear relationship between settlement patterns and the size of the fees in different municipalities.

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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

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 an important source of pollution, and is considered to be the largest source of acute pollution in Norwegian coastal waters today. As water resources are used in almost all forms of economic activity and are vulnerable to exploitation and pollution, it is important to monitor their state and environmental trends. This provides a basis for dealing with any problems related to conflicting user interests and water quality.

Discharges of phosphorus and nitrogen have been a matter of concern for many years, because these plant nutrients play an important role in the eutrophication of rivers, lakes and coastal areas. Eutrophication causes excessive growth of algae and oxygen depletion. Waste water, agriculture, aquaculture and manufacturing industries are important sources of large nutrient inputs to inland waters and coastal areas.

In recent years, both Norway and other countries that drain to the Skagerrak and the North Sea basin have invested substantial resources in reducing discharges of pollutants. The main reason has been that the pollution load in these waters has resulted in eutrophication and periodical algal blooms. In addition, Norway has signed the North Sea Declarations and thereby undertaken to halve inputs of phosphorus and nitrogen compared with the 1985 levels.

The targets in the ministerial declarations have been important for Norway's water-related environmental targets and water resources management. Calculations show that in 2005, Norway had achieved the reduction target for phosphorus but not for nitrogen. Since 1985, inputs of phosphorus and nitrogen to the North Sea have been reduced by 64 and 42 per cent respectively. According to Report No. 26 (2006-2007) to the Storting, eutrophication will continue to be a substantial environmental problem in

Norway. Despite the considerable reductions in anthropogenic inputs of nutrients, further measures to reduce discharges will be necessary to achieve the national targets for this area.

Norway has achieved a satisfactory 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 discharges from Norway have 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).

National targets - eutrophication and oil pollution

Eutrophication and sediment deposition

1. Norwegian inputs of nutrients and particulate matter to inland and marine waters that are being affected by eutrophication or sediment deposition will be reduced to a level that will ensure good ecological status by 2021, in accordance with the requirements of the Water Management Regulations.
2. There will be no deterioration in the status of any water body (downgrading) as a result of an increase in inputs of nutrients or particulate matter, in accordance with the requirements of the Water Management Regulations.

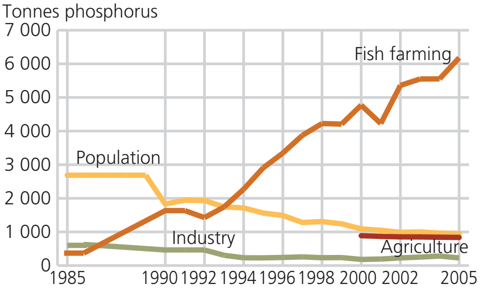
Oil pollution

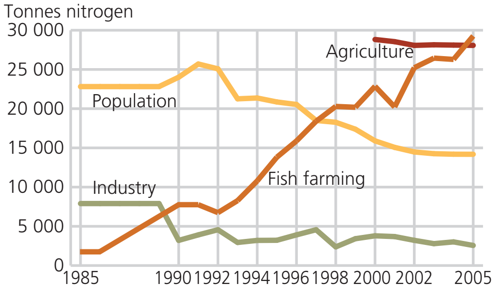
1. Operational discharges of oil will not result in unacceptable harm to health or the environment, or result in a rise in background levels of oil or other environmentally hazardous substances in the long term.
2. A low level of risk of harm to health or the environment as a result of acute pollution will be maintained, and continuous efforts will be made to reduce the level of risk. This will also be a guiding principle for activities that represent a risk of acute pollution.

Source: http://www.ospar.org/eng/html/welcome.html

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. 1985-2005





[1] Inputs from agriculture have not been back-calculated/modelled for data sets prior to 2000.
Source: Selvik et al. (2006).

The Norwegian coast

- In the period 2000-2005, total anthropogenic inputs of phosphorus and nitrogen to the coast increased by an estimated 18 and 4 per cent respectively.
- As a result of the expansion of the fish farming industry along the coast from the county of Rogaland and northwards, the discharges from this industry have increased substantially since 1985. In 2005, phosphorus discharges were 5 800 tonnes higher and nitrogen discharges 26 400 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 75 and 40 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 are now about 1 per cent higher.

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

North Sea Declarations and the OSPAR Convention

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 the targets was to halve the total inputs of nitrogen and phosphorus during the period 1985 to 1995. Since Norway had not reached the nitrogen target by the end of 1995, the national time limit was extended to 2005.

A key agreement is the OSPAR Convention for the protection of the marine environment of the North-East Atlantic. The Convention was opened for signature at the Ministerial Meeting of the Oslo and Paris Commissions in Paris on 22 September 1992. The following countries have ratified the Convention: Belgium, Denmark, Finland, France, Iceland, Ireland, Luxembourg, the Netherlands, Norway, Portugal, Spain, UK, Sweden, Switzerland and Germany. The Convention entered into force on 25 March 1998.

Source: http://www.ospar.org/eng/html/welcome.html

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.

Trophic status and eutrophication

Trophic status describes the plant nutrient and biological production conditions in water bodies. Water bodies that are rich in nutrients and very productive biologically are called eutrophic, while those that are poor in nutrients and relatively unproductive are termed oligotrophic. Water bodies of intermediate status are termed mesotrophic. In fresh water, eutrophication is usually caused primarily by phosphorus inputs, although nitrogen and other substances also play a role.

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.

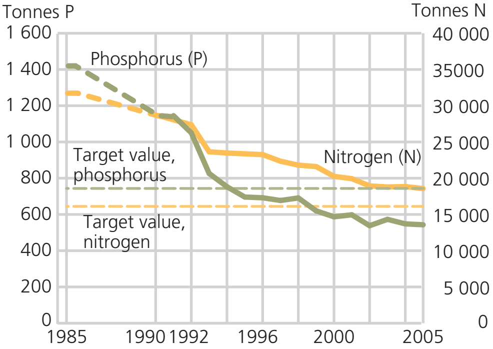
The sensitive area for phosphorus

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

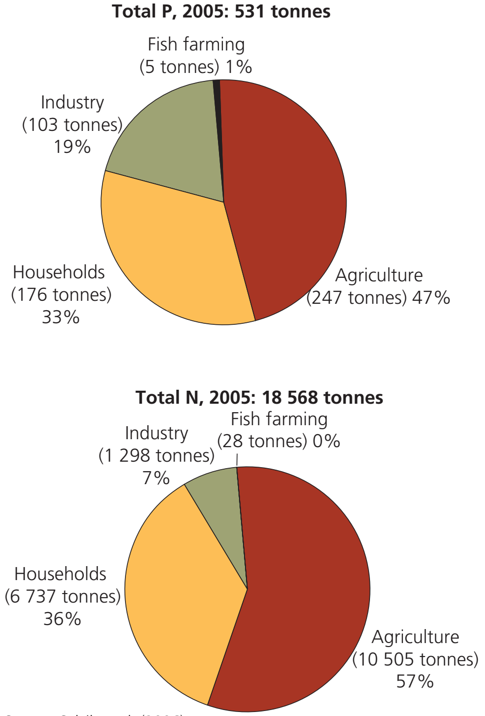
The inner Oslofjord, the area Hvaler-Singlefjorden (around the estuary of the river Glomma) and the Glomma and Halden river basins are regarded as particularly sensitive to nitrogen inputs. In these areas, the authorities have issued instructions for nitrogen removal at six waste water treatment plants.

Figure 12.2. Inputs of phosphorus and nitrogen to the North Sea region. 1985-2005



Source: Selvik et al. (2006).

Figure 12.3. Inputs of phosphorus and nitrogen to the North Sea region, by households and important industries. 2005



Source: Selvik et al. (2006).

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 64 and 42 per cent respectively from 1985 to 2005.
- Thus, Norway has already achieved the target of a 50 per cent reduction in phosphorus inputs set out in the North Sea Agreements, but nitrogen inputs are still about 8 per cent above the target level (see box 12.1).
- Phosphorus inputs from municipal waste water treatment plants (mainly from households) have been reduced by 752 tonnes (81 per cent) since 1985 and nitrogen inputs by 5 192 tonnes (44 per cent).
- Phosphorus inputs from agriculture have been reduced by around 38 per cent and nitrogen inputs by 28 per cent since 1985.
- Phosphorus and nitrogen inputs from manufacturing industries have been reduced by 22 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 2005 show that aquaculture accounts for just under 1 per cent of total inputs of both phosphorus and nitrogen to this area.

Box 12.2. The Urban Waste Water Treatment Directive and new Norwegian legislation

The objective of 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) 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. If waste water treatment is inadequate, this may result in various kinds of pollution in Norwegian coastal waters and river systems.

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. It includes specific time limits and treatment requirements for urban waste water in agglomerations with a population equivalent (p.e.) of more than 2 000 for discharges to inland water bodies and river estuaries and more than 10 000 p.e. for discharges to coastal waters.

The directive sets out a general requirement for secondary treatment (see box 12.3), but it is assumed that many treatment plants along the coast between Lindesnes and Grense-Jakobselv on the Russian border only need to carry out primary treatment under an exception provision in the directive. This presupposes, however, that municipalities carry out thorough investigations to document that the discharges will not adversely affect the environment.

The treatment requirements will depend on the area to which waste water is discharged. Particularly stringent treatment is required before waste water is discharged to "sensitive areas" with respect to pollution. The identification of "sensitive areas" will be reviewed every four years.

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 sanitary 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. They are entering into force over a period of time.

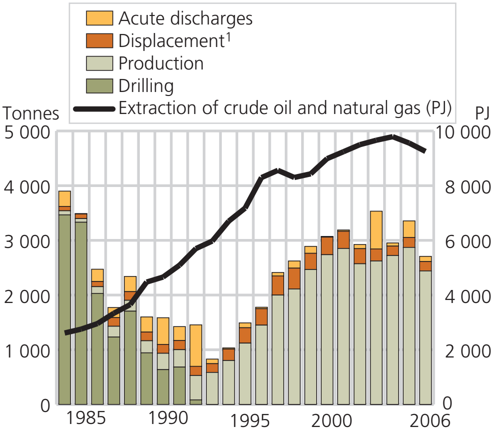
The division of authority between state and municipal level is no longer based only on the size of each waste water treatment plant; it also depends on the size of the urban settlement it serves. The county governors are responsible for enforcing new treatment requirements and requirements relating to 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, the 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. Tonnes. Production of crude oil, natural gas and other petroleum products. PJ. 1984-2006



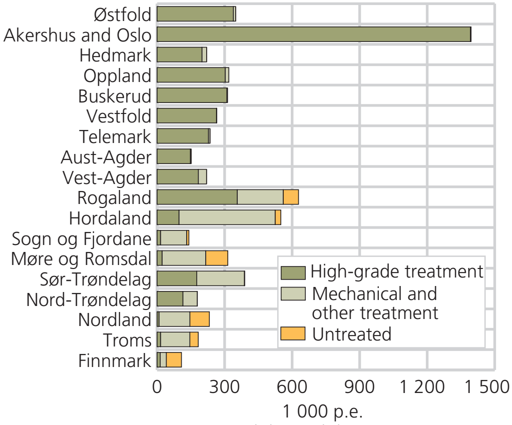
[1] Oil-contaminated ballast water in storage cells on production platforms, displaced when the cells are filled with produced oil.
Source: Norwegian Pollution Control Authority and Energy Statistics, Statistics Norway.

Oil discharges

- Oil production results in both uncontrolled (acute) discharges and legal, licensed (operational) discharges.
- Operational discharges are the largest category. They have risen considerably since 1992, but decreased from 2005 to 2006. The largest source of oil discharges from the oil and gas industry today is 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.
- Acute discharges from oil production and other activities have varied widely in the period 1984-2005. The level was high in 2003 as a result of a large spill on the Draugen field. In 2005, the largest discharge was a spill of 286 tonnes from the Norne field, and acute discharges totalled more than three times as much in 2005 as in 2006.

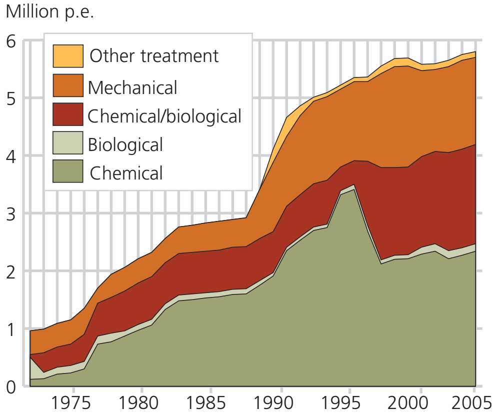
12.3. Municipal waste water treatment

Figure 12.5. Hydraulic capacity of waste water treatment plants, by treatment method. By county. Facilities with a capacity of more than 50 p.e. 2005



Source: Waste water treatment statistics, Statistics Norway.

Figure 12.6. Trend in treatment capacity at waste water treatment plants[1] ≥50 p.e. Whole country. 1972-2005



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

Treatment capacity at waste water treatment facilities

- 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.
- Since the publication of *Natural Resources and the Environment 2006*, treatment capacity has been back-calculated for the period 1998-2004, and previously published figures have been adjusted.

Box 12.3. Terms, municipal waste water treatment

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

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

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.

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.

Storm water is water at surface level. It is mainly a result of precipitation (see also the definition of overflow).

An **overflow** (weir) is a technical device to conduct water out of the sewer system in the event of an overload in the system. The water is diverted away via other systems (ditches, etc.), bypassing any treatment devices.

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

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

A **private sewer system** is a sewer system to which connection is not permitted for the general public.

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.

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.

Mechanical waste water treatment plants include sludge separators, screens, strainers, sand traps and sedimentation plants. They remove only the largest particles from the waste water.

High-grade waste water treatment plants are those that provide a biological and/or chemical treatment phase. Biological treatment mainly removes readily degradable organic material using microorganisms. The chemical phase involves the addition of various chemicals to remove phosphorus. High-grade plants reduce the amounts of phosphorus and other pollutants in the effluent more effectively than mechanical plants.

Natural purification processes include facilities where the waste water is treated for example using wetland filters (constructed wetlands). In these and other facilities using a similar system, microorganisms decompose the organic material in the waste water and plants utilise the nutrients.

Treatment is generally divided into three types:

1. **Primary treatment** means treatment of waste water by a physical and/or chemical process involving settlement of suspended solids, or other processes in which the BOD5 of the incoming waste water is reduced by at least 20 per cent before discharge and the total suspended solids of the incoming waste water are reduced by at least 50 per cent.
2. **Secondary treatment** means further reduction of organic material in relation to primary treatment requirements (see above). The requirements may be met by means of a treatment efficiency requirement (minimum percentage reduction) or a concentration requirement (maximum concentration of organic material).
3. **Tertiary treatment** means the strictest requirements as to treatment methods and the reduction of phosphorus and nitrogen in the waste water before discharge to the recipient.

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.

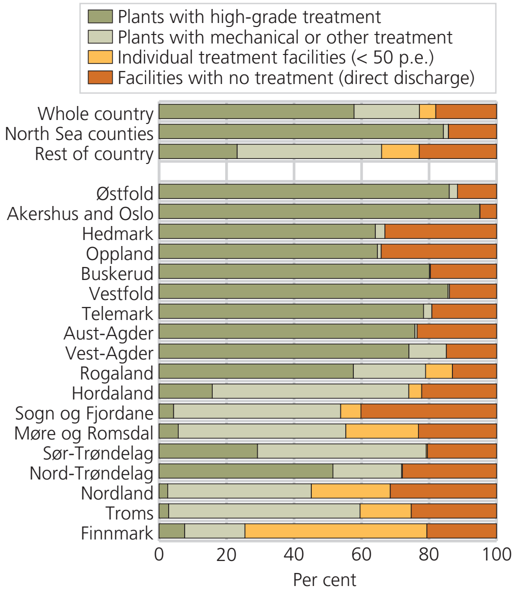
The **hydraulic capacity** of a treatment plant is the amount of waste water, expressed in p.e., it is designed to treat. Direct (untreated) discharges are not included.

The **hydraulic load** is the amount of waste water a treatment plant actually treats, expressed in p.e.

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 12.7. Percentage of population connected to various types of treatment plants. By county. 2005



Source: Waste water treatment statistics, Statistics Norway.

Connection to waste water treatment plants

- In 2005, 80 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 remaining 20 per cent were connected to smaller, individual treatment facilities (< 50 p.e.).
- Just below 57 per cent of the population were connected to high-grade treatment plants in 2005. In the North Sea counties, this proportion was over 86 per cent, while the figure for the rest of the country was 22 per cent.

Discharges of plant nutrients from waste water treatment plants

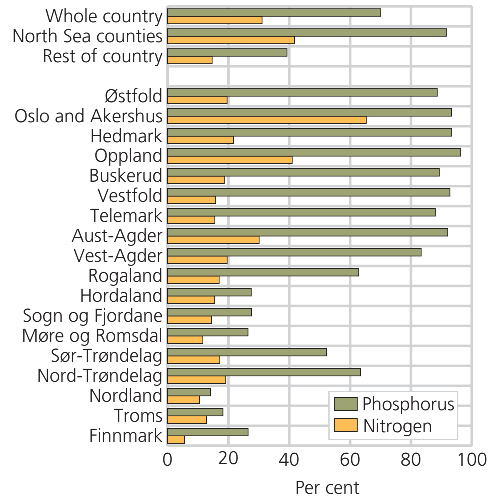
- Discharges of phosphorus and nitrogen from the waste water treatment sector in 2005 totalled 1 179 and 15 900 tonnes respectively. This includes leakages from sewers and discharges from individual treatment facilities (< 50 p.e.).
- Plants in the North Sea counties accounted for 26 per cent of the phosphorus discharges and 50 per cent of the nitrogen discharges. This corresponds to a discharge of 0.12 kg phosphorus and 3.04 kg nitrogen per capita per year, which is about the same level as the year before.
- The equivalent figures for the rest of the country were 0.44 kg phosphorus and 4.00 kg nitrogen. These are about the same as the 2004 levels.

Table 12.1. Total discharges of phosphorus and nitrogen from sewerage systems. By county. 2005

	Phosphorurs					Nitrogen				
	Total	Discharges from municipal treatment plants	Leakages from sewers[1]	Discharges from indvidual treatment facilities	Discharges per inhabitant	Total	Discharges from municipal treatment plants	Leakages from sewers[1]	Discharges from indvidual treatment facilities	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	**1 280**	**795**	**123**	**362**	**0.28**	**16 723**	**12 303**	**860**	**3 560**	**3.71**
Total 2002	**1 186**	**725**	**120**	**347**	**0.26**	**15 802**	**11 785**	**830**	**3 246**	**3.49**
Total 2003	**1 228**	**756**	**121**	**351**	**0.27**	**15 599**	**11 426**	**835**	**3 338**	**3.41**
Total 2004	**1 170**	**708**	**122**	**340**	**0.26**	**15 501**	**11 494**	**800**	**3 207**	**3.40**
Total 2005	**1 179**	**727**	**121**	**331**	**0,26**	**15 901**	**11 879**	**862**	**3 160**	**3.45**
North Sea counties (01-10)	305	117	71	117	0.12	7 931	6 105	523	1 302	3.04
Other counties (11-20)	874	609	50	214	0,44	7 970	5 774	338	1 858	4,00
01 Østfold	34	15	7	11	0.13	980	829	52	99	3.68
02-03 Akershus and Oslo	97	45	33	19	0.09	2 088	1 664	240	184	1.98
04 Hedmark	28	7	5	16	0.14	795	547	35	212	4.09
05 Oppland	25	3	4	18	0.13	630	369	31	230	3.35
06 Buskerud	33	13	6	14	0.14	965	757	47	161	4.12
07 Vestfold	27	8	5	14	0.12	854	698	41	114	3.81
08 Telemark	27	11	5	11	0.15	689	533	32	125	3.85
09 Aust-Agder	12	4	2	7	0.11	356	247	18	91	3.26
10 Vest-Agder	22	12	4	6	0.14	576	461	29	86	3.61
11 Rogaland	108	75	10	22	0.28	1 486	1 214	73	199	3.87
12 Hordaland	193	138	10	46	0.44	1 719	1 260	75	385	3.95
14 Sogn og Fjordane	57	36	2	19	0.54	454	273	16	165	4.28
15 Møre og Romsdal	124	91	6	27	0.50	1 002	732	41	228	4.08
16 Sør-Trøndelag	113	78	8	26	0.46	982	704	43	235	4.02
17 Nord-Trøndelag	43	27	4	13	0.34	478	320	20	138	3.75
18 Nordland	120	79	5	37	0.53	928	600	34	294	4.09
19 Troms	79	57	3	19	0.52	617	436	25	156	4.05
20 Finnmark	37	29	2	6	0.52	305	234	12	58	4.27

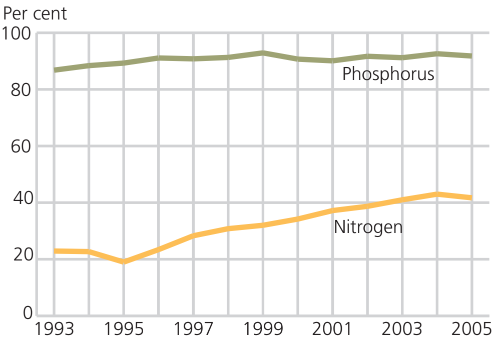
[1] Estimated at 5 per cent of the content of phosphorus and nitrogen in waste water before treatment.
Source: Waste water treatment statistics, Statistics Norway.

Figure 12.8. Estimated treatment efficiency for phosphorus and nitrogen. By county. 2005. Per cent



Source: Waste water treatment statistics, Statistics Norway.

Figure 12.9. Trend in treatment efficiency for phosphorus and nitrogen in the North Sea region. 1993-2005. Per cent

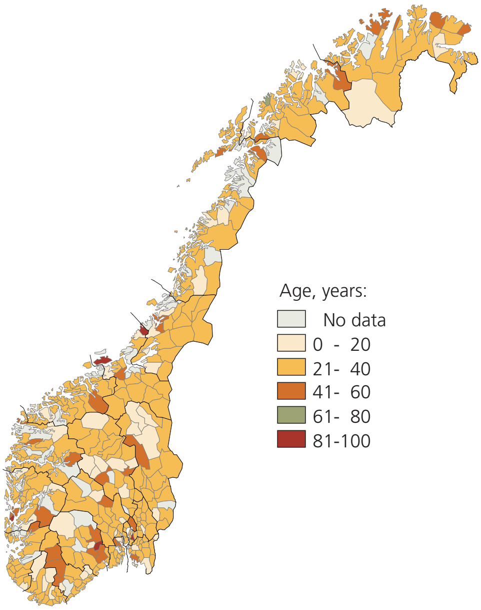


Source: Waste water treatment statistics, Statistics Norway.

Treatment efficiency

- In 2005, waste water treatment plants in the North Sea counties removed on average 92 per cent of the phosphorus and 42 per cent of the nitrogen load processed by the plants. In the rest of the country, treatment efficiency for these nutrients was 39 and 15 per cent respectively.
- In Oslo and Akershus, treatment efficiency for nitrogen is 65 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 41 per cent, while it is considerably lower in the other counties.
- There has been a steady increase in treatment efficiency for nitrogen in the North Sea region over the past 10 years, while treatment efficiency for phosphorus has remained steady at around 90 per cent. The apparent drop in treatment efficiency in 2005, particularly for nitrogen, is partly attributed to uncertainties in the underlying data, and it is too early to say whether this indicates 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.
- From 1995 to 2005, treatment efficiency for nitrogen in the North Sea region has been improved from about 20 per cent to just under 42 per cent due to the construction of nitrogen removal plants in the Oslofjord area.

Figure 12.10. Average age of municipal sewer systems. 2006

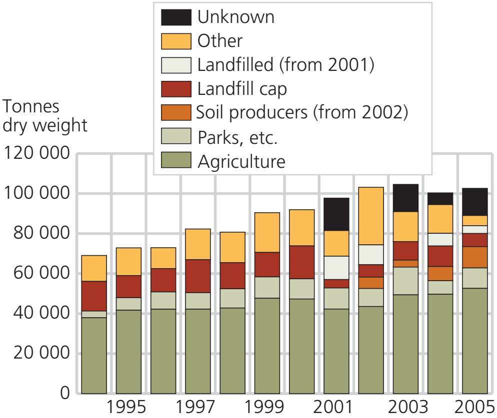


Map data: Norwegian Mapping Authority.
Source: KOSTRA, Statistics Norway.

Sewer systems

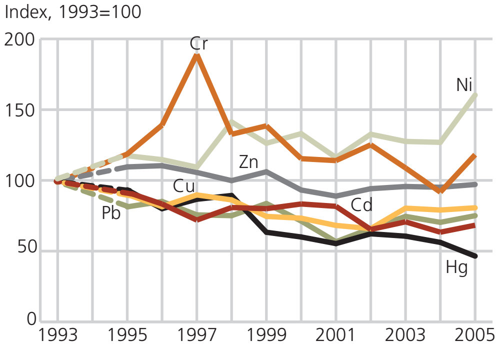
- Calculations show that Norway had a total of 34 210 km of municipal sewage pipelines in 2006. This corresponds to 4/5 of the earth's circumference at the equator. The figure is about 0.5 per cent lower than in 2005, largely due to adjustments in the underlying data provided by the municipalities.
- 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 contribute to higher treatment costs due to surface water and groundwater draining into the sewer system.
- The average rate of renewal for sewer systems in Norwegian municipalities in 2006 is estimated at 0.51 per cent per year. The rate of renewal is highest for the oldest sewer systems, varying from 1.15 per cent per year for sewers laid before 1940 to 0.30 per cent for sewers laid after 1980.
- The average age of the sewers is estimated to be about 32 years. About 8 per cent of the sewers were laid before 1940 and about 48 per cent after 1980.

Figure 12.11. Quantities of sewage sludge used for different purposes[1]. Tonnes dry weight. Whole country. 1994-2005



[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.

Figure 12.12. Trends for content of heavy metals in sludge. 1993-2005. Whole country. Index, 1993=100



Source: Norwegian Pollution Control Authority (SESAM) and 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.
- In 2005, 103 000 tonnes of sludge, expressed as dry weight, was used for various purposes. The statistics for the use of sewage sludge have been back-calculated for the period 1994-2004, and the figures therefore differ somewhat from those published last year.
- 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 2005, 83 per cent of the sludge was used as a soil conditioner or in parks and green spaces, or was delivered to soil producers.

- 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 exception is nickel, which has maintained a persistently high level 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. 2005

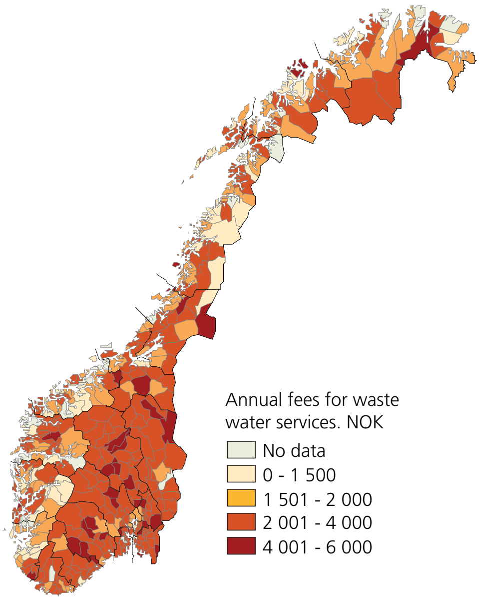
Heavy metal	Mean value	Average of maximum values	Limit value agriculture (quality class II)	Limit value parks, etc. (quality class II)	Change in mean value 2004-2005
	Milligrams per kg expressed as dry weight				Per cent
Cadmium (Cd)	0.8	1.3	2	5	7.7
Chromium (Cr)	25.4	38.6	100	150	28.9
Copper (Cu)	268.5	379.4	650	1 000	2.0
Mercury (Hg)	0.7	1.0	3	5	-17.3
Nickel (Ni)	17.5	30.8	50	80	26.3
Lead (Pb)	21.7	32.3	80	200	6.6
Zinc (Zn)	330.8	407.4	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. Annual fees for waste water services, by municipality. 2007



Source: KOSTRA, Statistics Norway.

Waste water services

- For the country as a whole, waste water fees showed an increase of 2.9 per cent from 2006 to 2007.
- The size of the fee varies widely between municipalities, from NOK 376 to NOK 5 554.
- In general, fees are highest in 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 chemicals

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.

In Norway, the chemical industry employs about 13 600 people, or more than 5 per cent of the industrial labour force. In addition, consumption of chemicals is high in many industries, where they are for example needed for large numbers of industrial processes. 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 chemicals 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.

The Norwegian authorities have defined the management of chemicals as an important priority area both of environmental policy (see national targets in Box 13.3) and in their strategy for sustainable development (see Chapter 2). We know that there have been substantial reductions in releases of many of the most dangerous substances. However, new substances are constantly being added to the List of Dangerous Substances. Although a great deal of detailed information exists on the risks associated with the widespread use of chemicals, a good deal of work still needs to be done before this information is complete enough to provide a suitable a basis for political decisions and changes of policy. Over the past few years, Statistics Norway has been developing statistics to provide more information on the consumption of chemicals and indicate how this is linked to the risk of damage from the use and release of hazardous substances (see box 13.6). This process involves the development of statistics on the use and releases of hazardous substances, based so far on information from the Product Register[1]. Statistics Norway also wishes to include more sources and substances in the

[1] The Product Register runs the authorities' central register of dangerous chemicals. See box 13.4.

statistics, in addition to those that are declared to the Product Register. The intention is to develop complete statistics that will provide useful information for use by the authorities, the business sector, environmental organisations and the general public in efforts to limit the harmful effects of the use and releases of chemicals. Since the statistics are still being developed, there is a high level of uncertainty in the results. The results presented in this chapter are therefore only preliminary.

Box 13.1. What are chemicals?

«Chemicals» is a generic term for both substances and preparations.

Substances: chemical elements and their compounds in the natural state or obtained by any production process.
Preparations: solutions or solid, liquid or gaseous mixtures composed of two or more substances.

Hazardous chemicals are substances or preparations that may be hazardous to health or the environment. Norway's official List of Dangerous Substances contains information on about 3 500 substances that are classified as hazardous to health or the environment.

Source: State of the Environment Norway (www.environment.no).

Box 13.2. What kinds of health and environmental damage can chemicals cause?

- The use of chemicals is suspected of being 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 chemicals are endocrine disruptors, which can cause sterility and disrupt reproduction in birds, fish, amphibians and molluscs.
- Some chemicals 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. Chemicals can also accumulate in breast milk.
- According to two European studies[1], a third of all recognised occupational skin and respiratory diseases in Europe are related to exposure to chemicals.

[1] «*The impact of REACH on occupational health*», School of Health and Related Research (University of Sheffield, UK), September 2005 and «*Skin sensitisers*», Facts, Issue 40, European Agency for Safety and Health at Work, June 2002.
Source: EC 2006.

Box 13.3. National targets - hazardous substances

1. Releases of certain ecological toxins (see the priority list) will be eliminated or substantially reduced by 2005 or 2010.
2. Releases and use of substances that pose a serious threat to health or the environment will be continuously reduced with a view to eliminating them within one generation (by the year 2020).
3. The risk that releases and use of chemicals will cause injury to health or environmental damage will be minimised.
4. The dispersal of ecological toxins from contaminated soil will be stopped or substantially reduced. Steps to reduce the dispersal of other hazardous substances will be taken on the basis of case-by-case risk assessments.
5. Contamination of sediments with substances that are hazardous to health or the environment will not give rise to serious pollution problems.

Source: Report No. 14 (2006-2007) to the Storting: *Working together towards a non-toxic environment and a safer future - Norway's chemicals policy.*

Box 13.4. The Product Register

All chemical products for which warning labelling is mandatory under the Chemical Labelling Regulations must be declared to the Product Register, which runs the authorities' central register of dangerous chemicals. Companies 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. There is a general exemption from the duty to declare for products that are placed on the market in quantities of less than 100 kg per year.

Box 13.5. REACH - the new EU chemicals legislation

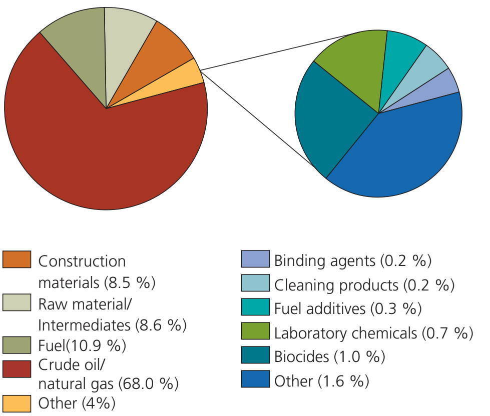
The new EU chemicals legislation, REACH, entered into force on 1 June 2007. REACH stands for Registration, Evaluation, Authorisation and Restriction of Chemicals. The legislation is intended to ensure a high level of protection of human health and the environment against chemicals and at the same time maintain a competitive chemicals industry. Under these 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

13.1. Consumption of hazardous chemicals in Norway

Figure 13.1. Consumption of hazardous products, by product type. 2005



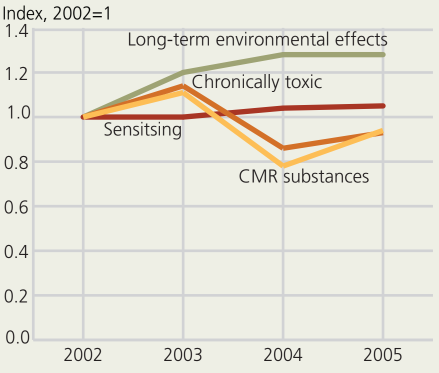
Source: Product Register 2006.

- Almost 30 000 different products containing hazardous chemicals were declared to the Product Register in 2005 (see Box 13.5). This is an increase of almost 19 000 products from 2000. However, the increase is partly explained by the introduction of stricter requirements for declaration.
- Consumption of products containing hazardous chemicals totalled about 165 million tonnes in 2005. Petroleum products such as crude oil and natural gas make up by far the largest category by volume. This category and two others (construction materials such as cement, concrete and mortar; and raw materials and intermediates) account for about 96 per cent by volume of all products declared to the Product Register. However, people are not exposed to most petroleum products and raw materials to any great extent, so that these figures give a somewhat skewed picture of the quantities of hazardous products on the Norwegian market. Neither of these product categories is much used by private consumers.
- Most of the 30 000 products belong to other product categories than those mentioned above. Laboratory chemicals and binding agents are important product categories that are mainly used for industrial purposes, while biocides, cleaning products and paints and varnishes (largely included in «other») are also widely used by private consumers. Other product categories include cosmetics, leather and textile impregnating agents, closing net proofing and car care products.

Box 13.6. Development of chemicals statistics

In the last few years, Statistics Norway has been cooperating closely with the Norwegian Pollution Control Authority and the Product Register to develop tools for use in reducing the risk from chemicals (see national target number 3). A model that can be used to estimate emissions of selected hazardous substances from the use of chemicals in Norway has been developed. Emissions of hazardous substances are considered to be a good indicator of the risk of health and environmental damage, since higher emissions will increase the probability that organisms are exposed to such substances. The calculations of emissions are based on information on sales of substances from the Product Register and assessments of patterns of use carried out by the Swedish Chemicals Inspectorate and Swedish Methodology for Environmental Data. Thus 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. Emission figures are calculated by combining figures for use with specific emission factors.

Emissions[1] of hazardous substances in the period 2002-2005. Emissions in 2002=1. Four hazard categories[2]: CMR, chronically toxic, sensitising and dangerous for the environment



[1] Emissions are estimated by calculating quantity manufactured + import – export, weighted according to the probability that the substance will be released to the environment. Data for crude oil and natural gas are not included in the calculations.
[2] Substances are aggregated into groups according to the risk phrases given in the List of Dangerous Substances.
Source: Hansen 2006.

The quantities released have been calculated for four hazard categories. One consists of substances that are dangerous for the environment and may have long-term adverse effects, and the other three are hazardous to health - CMR substances (carcinogenic, mutagenic or reprotoxic), chronically toxic substances and sensitising substances. Substances with several of these properties are included in more than one hazard category. CMR substances are considered to have the most serious impacts on health. The method includes an annual update and recalculation of the entire time series. This will ensure that consistent time series are always used and that they take into account the most recently available information. Annual evaluations and improvements of the model will gradually make the results more relevant and the indicator more precisely targeted. The expertise available among producers and users of chemicals is being utilised in the process of adjusting the emission factors used in the model.

Preliminary results
According to the calculations, overall emissions of selected environmentally hazardous substances rose by more than 5 000 tonnes from 2002 to 2005 as a result of a rise in the quantities of chemicals used during this period.

The largest emissions appear to originate from the use of bleaches in paper production, raw materials and intermediates used in metal production, binding agents and cleaning products. Further investigations of how these chemicals are handled are needed to check whether the calculated trend for the risk indicator is correct.

Emissions of selected substances that are hazardous to health were about the same in 2005 as in 2002. This indicates that the risk of damage to health from the production and use of chemicals has remained fairly constant during this period, despite the general increase in consumption. Cleaning products are one category of chemicals that illustrate these trends. Total sales of these products have risen, but the quantity of chronically toxic substances they contain has declined in the past four years. On the other hand, the quantity of sensitising substances in cleaning products has remained relatively stable. Emissions of environmentally hazardous substances from

Cont.

cont.

cleaning products are rising faster than total consumption of the products themselves.

Uncertainty
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 to correct for the quantities of hazardous substances that are not released to the environment. In addition, there are a number of factors that the model does not take into account, such as the persistence of some hazardous substances (meaning that they still pose a risk one year after their release). In addition, not all hazardous substances are included in the calculations. It is also important to be aware that there are limitations and weaknesses in the data from the Product Register, and that these can result in errors in the estimated consumption figures.

For more information, see: Hansen, K.L. (2006): Indikatorer på kjemikalieområdet, risiko for skade på helse og miljø grunnet bruk av kjemiske stoffer (Indicators for chemicals: risk of health and environmental damage from the use of chemicals). Notater 2006/25, Statistics Norway.

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Useful websites

State of the Environment Norway: http://environment.no/
Product Register: http://sft.no/seksjonsartikkel____41814.aspx
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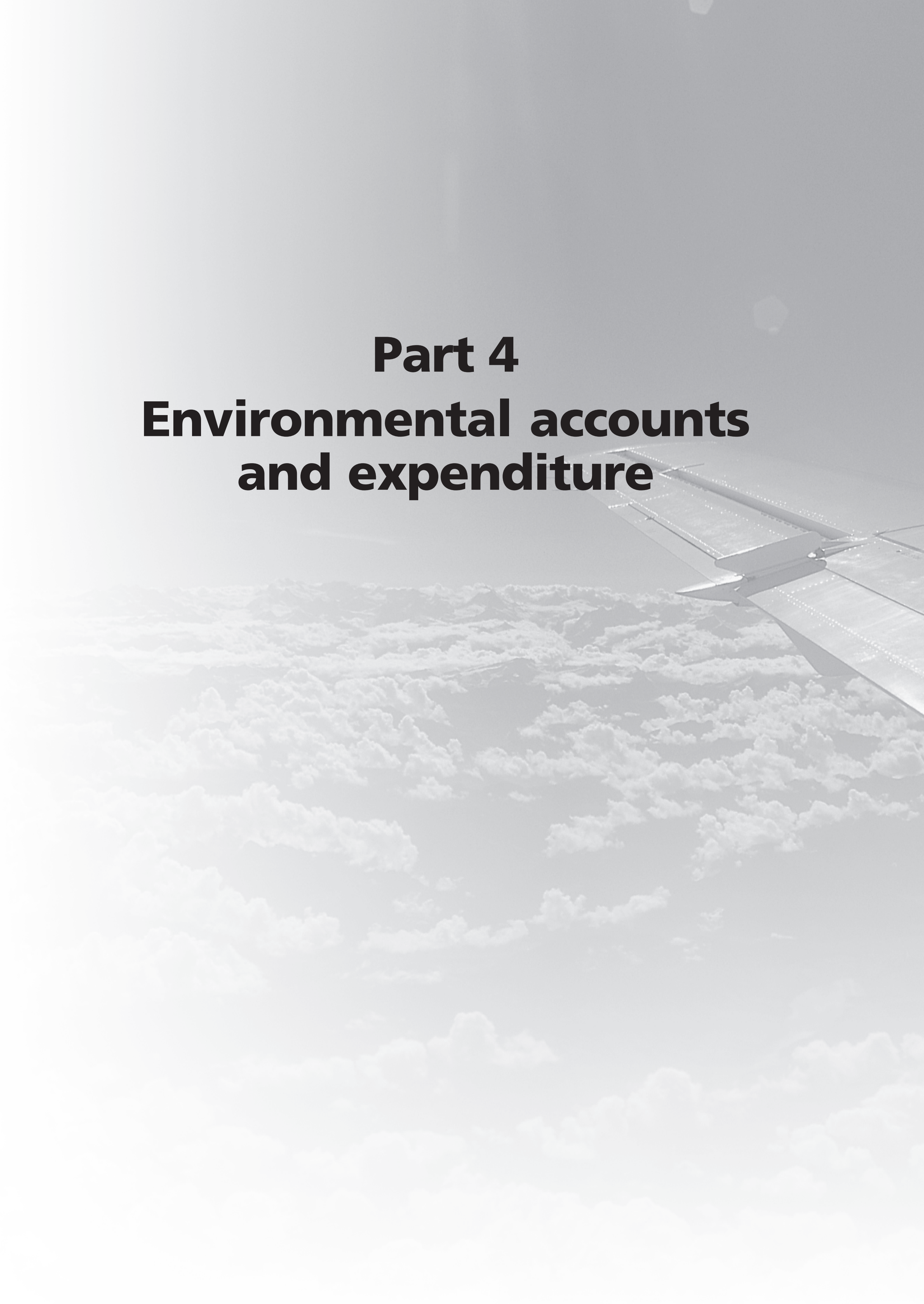
Part 4
Environmental accounts and expenditure



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 and by taxation. It is a common perception that environmental regulation leads to higher costs. However, firms can also find new market opportunities by offering goods and services that reduce environmental impacts.

National accounts data and emission statistics at the level of specific industries have been linked and used to calculate emission intensities. An industry becomes more emission-efficient when its emission intensity decreases. In the period 1990-2005, greenhouse gas emissions rose, while emissions of acidifying gases and ozone precursors were reduced. GDP rose so strongly in the same period that there was an overall decrease in emission intensity in Norway. The growth in value added has primarily taken place in industries where emission intensity is lowest.

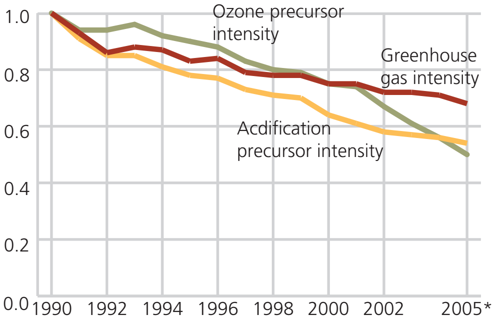
Environmental protection expenditure means the additional expenses an establishment incurs for environmental protection measures. Such measures may either be required by the authorities or voluntary. Environmental protection expenditure in manufacturing industries and mining and quarrying totalled more than NOK 3.0 billion in 2004 and NOK 3.4 billion in 2005. Expenditure on environmental protection measures is particularly high in four manufacturing industries: basic metals; food products, beverages and tobacco; oil refining and chemicals; and pulp and paper.

The environment industry consists of establishments that supply goods and services intended to reduce the environmental impacts of production and consumption. The authorities in Norway and the rest of Europe are showing growing interest in identifying the potential of this sector. In 2006, a pilot study was carried out using official statistics to identify the establishments that belong to the environment industry in Norway. The establishments that can be identified using this method are considered to form the “core” of the environment industry. A first estimate indicates that about 16 000 people are employed in the core environment industry in Norway.

14.1. Trends in emissions and economic growth

The NAMEA system (National Account Matrix including Environmental Accounts) is an integrated system that links national accounts data and emission statistics at the level of specific industries. The relationship between emissions of a particular type in an industry and value added is called the emission intensity (measured as emissions per NOK of value added). An industry becomes more emission-efficient when its emission intensity decreases. A reduction in emission intensity means that value added is growing more strongly than emissions air.

Figure 14.1. Emission intensities. Norway, excluding ocean transport. 1990-2005*. Index: 1990=1

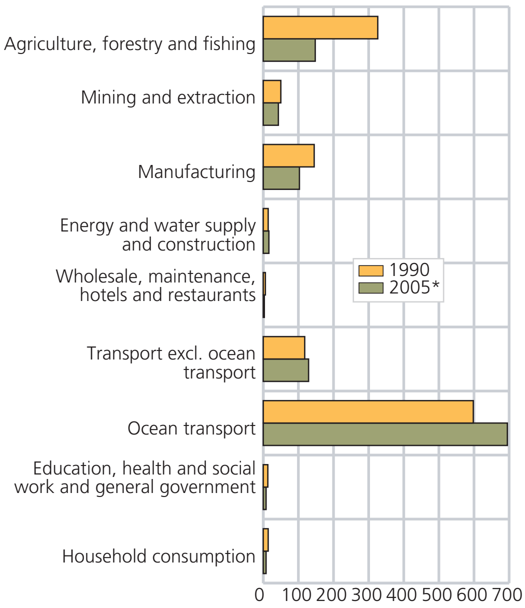


Source: National accounts and environment, 1990–2005*, Statistics Norway (2007b)..

Emission intensities

- Preliminary figures for 2005 show a slight improvement in greenhouse gas intensity and acidification intensity from the previous year and a continued strong downward trend for ozone precursor intensity.
- However, the picture is complex, and for several specific industries, economic growth has been lower than the growth in emissions.

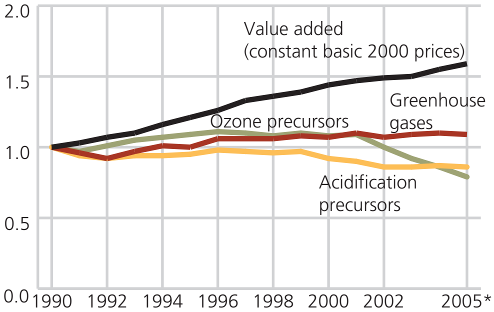
Figure 14.2. Greenhouse gas emission intensities by industry. 1990 and 2005. Tonnes CO_2 equivalents per million NOK value added



Source: National accounts and environment, 1990–2005*, Statistics Norway (2007b).

- Greenhouse gas emissions were highest relative to value added in the transport industry, agriculture, forestry and fisheries, and manufacturing industries.
- Most industries except the transport industry and ocean transport have become more emission-efficient in the period 1990-2005.

Figure 14.3. Emissions to air and value added (constant prices). Norway excluding ocean transport. 1990-2005*[1]. Index: 1990=1

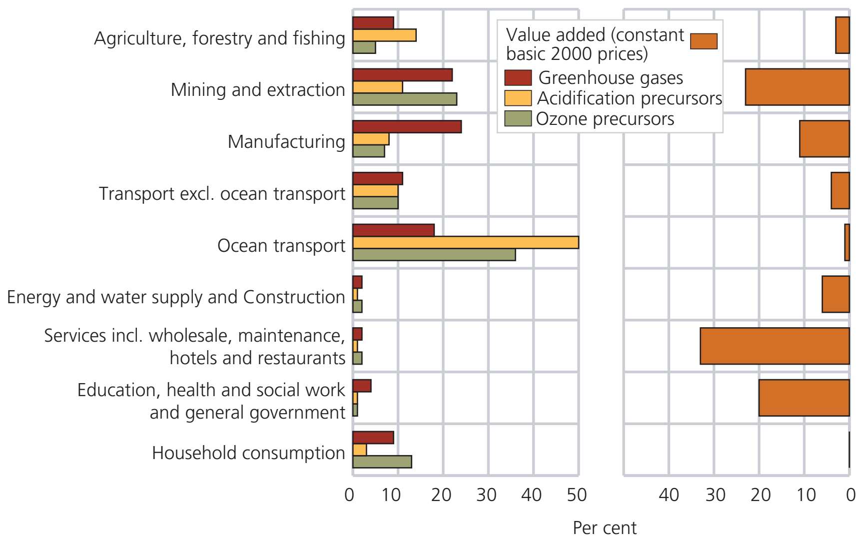


Source: National accounts and environment, 1990–2005*, Statistics Norway (2007b).

Emissions and economic growth

- Measured in constant prices, Norway's GDP has grown every year since 1990. Total value added rose by 2.4 per cent in 2005, as compared with 3.2 per cent in 2004.
- In the period 1990-2005, the overall picture is that Norwegian industries have shown steady economic growth, without a corresponding increase in emissions to air of greenhouse gases, acidification precursors, and ozone precursors.
- Even though economic growth has been greater than the growth in emissions at national level, growth in value added and trends in emissions to air have varied widely from one industry to another.
- Economic growth has been particularly strong in the service industries in recent years. However, since 2002 there has also been economic growth in the manufacturing industries, without a corresponding increase in emissions to air.

Figure 14.4. Emissions to air and value added (constant basic 2000 prices) for industrial sectors and households. 2005*. Per cent

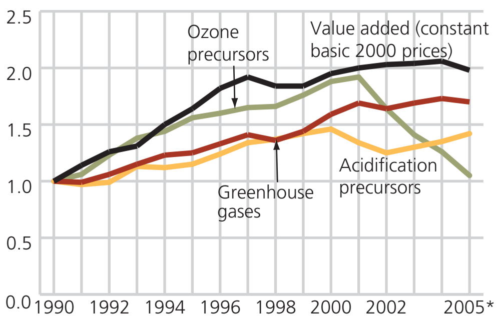


Source: National accounts and environment, 1990–2005*, Statistics Norway (2007b).

Oil and gas extraction

Although oil and gas extraction including mining accounts for a large proportion of total emissions to air in Norway, it is not one of the most emission-intensive sectors. This is because oil and gas extraction also accounts for a large proportion of total value added (23 per cent in 2005), and because value added for the industry includes a considerable resource rent.

Figure 14.5. Value added (constant basic prices) and emissions to air from oil and gas extraction including mining. 1990-2005*. Index: 1990=1



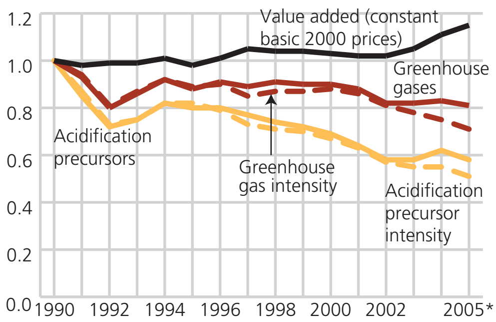
Source: National accounts and environment, 1990–2005*, Statistics Norway (2007b).

- Emissions of greenhouse gases and acidification precursors have risen with economic growth in oil and gas extraction, but since 2002 emissions have been rising faster than value added, so that there has been an increase in pollution per unit of value added.
- In 2005, there was a weak reduction in greenhouse gas emissions, while emissions of acidification precursors rose. This was explained by the continued rise in gas production, accompanied by a drop in oil production.
- Since 2000, there has been a relatively rapid increase in greenhouse gas emissions, which is explained by a rise in energy-intensive production of natural gas relative to oil production. Production of natural gas generates larger emissions of greenhouse gases and acidification precursors per unit produced than oil production. Thus, the emission efficiency of oil and gas extraction with respect to both greenhouse gases and acidification precursors has worsened in the last few years.
- Measures to reduce emissions of NMVOCs have resulted in a 44 per cent reduction in emissions of ozone precursors between 2000 and 2005. The installation of VOC recovery equipment at offshore facilities just after 2000 is the main reason for the substantial reduction in total emissions of NMVOCs in the last few years.

Manufacturing

In the 1990s, emissions of greenhouse gases and acidification precursors from manufacturing industries were closely linked to economic growth, but since the late 1990s, emission intensity for these substances has been dropping. However, manufacturing industries still account for 24 per cent of total greenhouse gas emissions and 8 per cent of total emissions of acidification precursors.

Figure 14.6. Value added (constant basic prices), emissions to air and emission intensity for greenhouse gases and acidification precursors. Manufacturing. 1990-2005*. Index: 1990=1



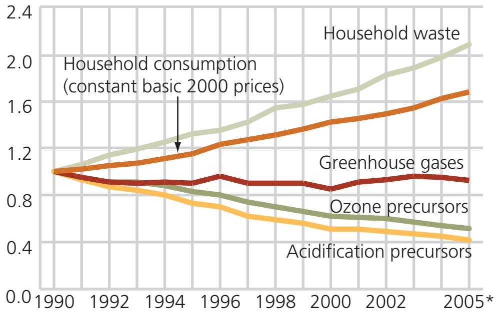
Source: National accounts and environment, 1990–2005*, Statistics Norway (2007b).

- In 2005, manufacturing of basic metals, chemicals and mineral products, and refined petroleum products accounted for 89 per cent of total greenhouse gas emissions and 83 per cent of total emissions of acidification precursors from manufacturing.
- Emissions of greenhouse gases and acidification precursors from manufacturing dropped by 19 and 42 per cent respectively from 1990 to 2005.
- Most of the reduction in greenhouse gas emissions from manufacturing was achieved by cuts in emissions of PFCs and SF_6 through measures such as a changeover to less polluting production technology and better process management and by the closure of one firm that generated large SF_6 emissions.
- The reduction in emissions of acidification precursors from manufacturing is mainly the result of large cuts in SO_2 emissions, especially from manufacturing of basic metals.
- Metals manufacturing became more emission-effective in the period 1990-2005 as a result of large cuts in emissions of greenhouse gases and acidification precursors. This is linked to large environmental protection investments immediately after the turn of the century.
- There has been faster economic growth in manufacturing since 2002. In certain manufacturing industries, both exports and domestic sales have risen, and in others there has been a reduction in the number of firms, and the most profitable have survived.
- In 2005, the sectors that contributed most to economic growth in Norwegian manufacturing were machinery and other equipment, ships and oil platforms, and wood and wood products.

Households

Household consumption has various impacts on the environment. In 2005, households generated 22 per cent of the total quantity of waste. They also accounted for 13 per cent of emissions of ozone precursors and about 9 per cent of Norwegian greenhouse gas emissions.

Figure 14.7. Consumption (constant basic prices), solid waste and emissions to air. Households. 1990-2005*. Index: 1990=1



Source: National accounts and environment, 1990–2005*, Statistics Norway (2007b).

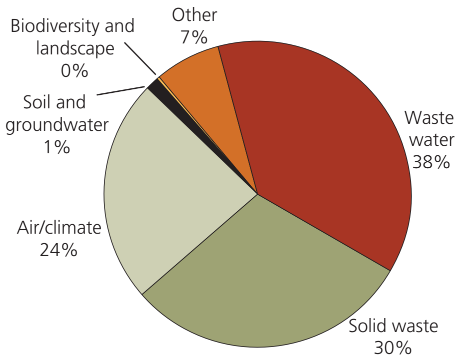
- Both household consumption and the total quantity of household waste increased substantially from 2003 to 2005. Waste generation by households rose faster than household consumption.
- In 2005, the total quantity of waste generated by households rose by 5.6 per cent, and per capita waste generation rose from 378 kg to 407 kg.
- Household consumption of goods and services rose by 3.2 per cent from 2004 to 2005, measured in constant prices. Household consumption abroad rose most in this period, by 12.9 per cent measured in constant prices.
- From 1990 to 2005, emissions to air from households have generally followed the opposite trend from waste generation and consumption.
- In 2005, emissions of greenhouse gases, acidification precursors and ozone precursors from household activities showed a slight decrease from the year before in 2005.
- The main sources of emissions to air from households are the use of energy for heating and lighting and the use of private means of transport. Household emissions to air do not include emissions linked to imported goods, and are not an expression of total consumption-related emissions.

14.2. Environmental protection expenditure in manufacturing industries and mining and quarrying

Manufacturing industries and mining and quarrying excluding the oil and gas industry

Since the publication of *Natural Resources and the Environment 2006*, updated figures have been published for environmental protection expenditure in manufacturing industries and mining and quarrying in 2004 and 2005. The statistics are based on a sample survey. This survey was linked to the annual industrial statistics, which include all companies classified in the sectors manufacturing and mining and quarrying. The industries where environmental protection investments and current expenditure were expected to be highest are best represented in the sample. The oil and gas industry is excluded. In 2005, 5 per cent of investments and 1 per cent of current expenditure in the largest manufacturing and mining establishments were related to environmental protection. These results are similar to those obtained for 2004.

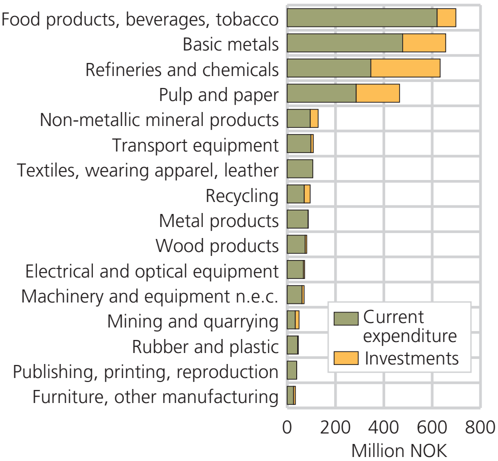
Figure 14.8. Environmental protection expenditure, by domain. Manufacturing industries and mining and quarrying. 2005. Per cent



Source: Environmental protection expenditure statistics, Statistics Norway (2007a).

- About 70 per cent of environmental protection expenditure was in the domains waste water treatment and waste management.
- Total reported environmental protection expenditure in manufacturing industries and mining and quarrying was NOK 3.0 billion in 2004 and NOK 3.4 billion in 2005.
- In both years, current expenditure accounted for more than 70 per cent of the total. Examples of such expenditure are municipal fees for waste water treatment, expenses related to removal of waste, and the costs of operating, maintaining and repairing environmental protection equipment.
- Investments in environmental protection measures by manufacturing and mining establishments totalled more than NOK 800 million in 2005. The largest share of investments was in the domain air/climate. Investments made in 2005 included the replacement of furnaces, tanks, containers and burners, and alterations to treatment, filtering and recovery plants. In 2004, investments were somewhat lower (NOK 655 million) than in 2005. The largest share of investments was in the domain air/climate in 2004 as well: and included noise abatement measures, replacement of equipment containing PCBs, and waste compressors, burners and containers.

Figure 14.9. Investments and current expenditure for environmental protection in manufacturing and mining, by industry. 2005. NOK million



Source: Environmental protection expenditure statistics, Statistics Norway (2007a).

- Current expenditure on environmental protection was higher than investments for all industries in the manufacturing and mining sector in both 2004 and 2005.
- Environmental protection expenditure is particularly high in four industries: basic metals; food products, beverages and tobacco; oil refining and chemicals; and pulp and paper. Expenditure exceeded NOK 400 million in each of these industries, and their total environmental protection expenditure was more than NOK 2.5 billion in 2005. This is about 70 per cent of total environmental protection expenditure in the manufacturing and mining industries. Environmental protection expenditure was particularly high in the same industries in 2004.
- The proportion of gross investments used for environmental protection was particularly high in three sectors in 2005. These were "manufacture of pulp, paper and paper products" where such investments accounted for 23 per cent of the total, “recycling” (15 per cent), and manufacturing of basic metals (11 per cent). In other industries, this type of investment makes up 1 to 7 per cent of total gross investments.

14.3. The environment industry

The production of goods and services has environmental impacts at all stages from the extraction of raw materials, through production processes to distribution and 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.

Box 14.1. What is the environment industry?

The environment industry consists of establishments that produce goods and services capable of measuring, preventing, limiting, minimising or correcting:
- Environmental damage to water, air and soil, and
- Problems related to waste, noise, and ecosystems.

This includes technologies, products and services that:
- Prevent environmental damage
- Reduce pollution and resource use.

The definition also includes 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 study resulted in a first estimate of employment in these sectors of 16 000 people.

The core industry consists of the following NACE categories:

- NACE 25.12: Retreading and rebuilding of rubber tyres
- NACE 37: Recycling
- NACE 40.101: Production of electricity
- NACE 40.3: Steam and hot water supply (only production from waste incineration, wood chips, waste heat and heat pumps)
- NACE 41: Collection, purification and distribution of water
- NACE 51.57: Wholesale of waste and scrap
- NACE 90: Sewage and refuse disposal, sanitation and similar activities

The entire category "production of electricity" (NACE 40.101) is included because almost all electricity production in Norway is based on hydropower.

Studies in other countries show that waste water treatment and waste management make up a large proportion of the environment industry. In the EU, it is estimated that these two sectors account for about 50 per cent of employment in the environment industry.

The environment industry also includes activities that are classified in different NACE categories, for example establishments in the renewable energy sector. However, the current NACE categories are too aggregated to make it possible to identify these establishments. Supplementary information from other sources is needed to determine the proportion of environment industry establishments in other NACE categories. The NACE classification system is currently being reorganised, and it may be possible to identify more core categories in the new system. However, it will still be difficult to identify those establishments that fall outside the typical environmental NACE codes.

Table 14.1. Initial estimate of employment in the core environment industry. Number of employees. 2004

NACE category	No. of employees	Source
Total	16 236	
Pollution management:	10 446	
25.12 Retreading and rebuilding of rubber tyres	158	Structural business statistics
37.10 Recycling of metal waste and scrap	820	National accounts
37.20 Recycling of non-metal waste and scrap	360	National accounts
51.57 Wholesale of waste and scrap	478	Structural business statistics
90 Sewage and refuse disposal, sanitation and similar activities	8 630	National accounts
Natural resource management:	5 790	
40.101 Production of electricity	3 600	National accounts
40.3 Steam and hot water supply	400	National accounts
41 Collection, purification and distribution of water	1 790	National accounts

Table 14.2. Turnover and production value in the core environment industry. NOK million. 2004

NACE category	Structural business statistics Turnover	National accounts Production value
Pollution management:		
25.12 Retreading and rebuilding of rubber tyres	:	..
37.10 Recycling of metal waste and scrap	2 126	2 138
37.20 Recycling of non-metal waste and scrap	581	579
51.57 Wholesale of waste and scrap	1 141	..
90 Sewage and refuse disposal, sanitation and similar activities	9 696	18 303
90.10 Collection and treatment of sewage	891	..
90.20 Collection and treatment of other waste	8 514	..
90.30 Sanitation, remediation and similar activities	291	..
Natural resource management:		
40.101 Production of electricity	..	27 308
40.3 Steam and hot water supply	615	983
41 Collection, purification and distribution of water	..	3 804

The project also sought to provide estimates of turnover and production value for the core environment industry. Data sources were found for all categories in the core industry. However, confidentiality problems for one category (NACE 25.12) and inconsistencies between the definitions used in the sources for turnover and production value made it impossible to construct estimates for the entire core industry.

The differences between the figures for sewage and refuse disposal (NACE 90) from the two sources are explained by the fact that the turnover figures from the structural business statistics only include privately-owned establishments, whereas the national accounts also include publicly-owned establishments.

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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 for Statistics Norway. This chapter describes some current research projects in the environmental field, focusing mainly on the links between energy and the environment.

15.1. Introduction

Climate change is an issue that has been attracting more and more attention in recent years. The latest IPCC assessment report (IPCC 2007), the Stern review (Stern 2006), the report from the Norwegian Low Emission Commission (NOU 2006:18) and the 2007 white paper on Norwegian climate policy (Report No. 34 (2006-2007) to the Storting) have resulted in extensive political and scientific debate. Experts in a variety of fields are engaged in discussions of the theoretical, practical and political aspects of international climate agreements, emissions trading and technology developments. The debate has made it clear that there are many different views on the conditions that must be fulfilled for different measures to be appropriate and effective. This highlights the importance of research to improve our understanding of the best ways of developing various climate-related measures, both separately and given their effects on each other.

The 11 research projects presented in this chapter deal with a number of issues related to climate change, energy, natural resources and the environment. The first is a study of international cooperation on climate change, which focuses on why the international community has not yet been able to agree on substantial cuts in greenhouse gas emissions. Exploiting the situation as a free rider is still an attractive option, which acts as a barrier to binding agreements on large cuts in emissions. Another study looks at how the measures the authorities implement to meet Norway's Kyoto commitment will affect the Norwegian economy. It describes the economic consequences of different climate policy scenarios for the part of the Norwegian economy that will not be included in the EU emissions trading scheme. The calculations show that the different scenarios result in only small changes in welfare, but that there can be substantial changes in resource allocation between sectors.

Globalisation of the world's gas markets is having a considerable impact on world energy use and for Norwegian gas exports. The reduction in transport costs for gas has been driving the globalisation of natural gas markets. This is particularly the case for liquefied natural gas (LNG), which can be transported by ship. One study has found that lower LNG costs can actually result in higher gas prices in Europe because it will become more profitable to ship gas across the Atlantic to the US. On the other hand, falling pipeline transport costs may result in lower European gas prices because it will be cheaper to transport gas from Russia and the Middle East to Europe. The market for Norwegian gas in Europe is very dependent on the gas supplies available from other large producers. A study of the gas market has looked particularly at what implications reorganisation of Russian gas exports would have for gas prices in Europe. Gazprom is currently the only Russian company that has the right to export natural gas to Europe. If Russia reorganises its gas exports and competition in Europe increases, this may have negative impacts on Norway as a result of lower gas prices in Europe and reduced gas exports from Norway.

A review of energy taxes has shown wide differences both between sectors and between countries. The tax system in the energy sector is also used to correct failure in other parts of the market. This makes the consequences of the taxation system unpredictable, and means that different instruments may cancel each other out. Another study has considered the electricity situation in Central Norway, where electricity consumption has risen sharply, particularly in energy-intensive manufacturing, and this trend is expected to continue. The current situation, combined with plans for industrial expansion, has caused concern in the region. Fears of high electricity prices and electricity rationing have resulted in demands for the expansion of production and transmission capacity.

Encouraging the expansion of research and development on climate-friendly technologies is one possible tool for achieving national targets for reducing greenhouse gas emissions. A research project has looked at the effects of subsidising R&D and the type of time profile such subsidies should have. The analysis indicates that subsidies with a falling time profile are more effective than a constant rate of subsidy in encouraging the development of environmental technology. Another study discusses a switch to a «hydrogen economy» and whether society is currently «locked in» to fossil-fuel based technologies. If this is the case, it may mean that hydrogen will not be introduced in the transport market without support from the authorities, regardless of how competitive hydrogen vehicles are.

Finally, a study of the economy and the environment in the Arctic is presented. The Arctic is strongly affected by climate change and global economic developments. The impacts of climate change are greater at higher latitudes, and are expected to alter the environment and living conditions in the Arctic profoundly. The rich natural resources of the region - petroleum, minerals, fish and forests - are an important factor in the Arctic economy. Economic output, measured as gross domestic product (GDP), is unevenly distributed across the Arctic, and is highest in the petroleum-rich Russian provinces and Alaska. However, because it is not adjusted for the extraction of natural resources, GDP can be misleading as a measure of economic output in areas that are rich in natural resources.

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15.2. International cooperation on climate change – a difficult process

Bjart Holtsmark

The problem of climate change can only be dealt with through international cooperation. Game theoretical analysis indicates that unconditional pledges by individual countries to make deep cuts in their emissions may make it more difficult, not easier, to achieve an effective international climate agreement.

Negotiations on an international agreement to limit greenhouse gas emissions have been in progress for more than 15 years. Despite this, there is still no agreement that can bring about large emission reductions. The Kyoto Protocol regulates less than 30 per cent of global emissions, and currently only applies to the period 2008-2012. Moreover, negotiations on a more effective agreement to follow on from Kyoto have come to a standstill. The US is not willing to join an agreement before leading developing countries such as India and China also do so, and India and China insist that the rich countries must reduce their emissions substantially before they will consider taking action.

In other words, despite general agreement that we are facing a problem, the international community has not been able to agree on a strategy for substantial cuts in emissions.

This situation fits well with the results of game theoretical research on the problem of climate change. Some frequently cited papers from the literature in this field conclude that it will be difficult to achieve a broad coalition of countries that are willing to enter into a binding agreement on deep cuts in emissions, for example Barrett (1994). It is true that most countries will see such an agreement as being in their interest, and this will still be the case if a country accedes to the agreement and thus takes on a commitment to reduce its emissions substantially. The problem is that each country can see that the benefits will be even greater if other countries adopt an agreement while it exploits the situation as a free rider.

Because countries that act as free riders while others reduce their emissions enjoy such a favourable situation, there is a high probability that one country after another will drop out of an ambitious international agreement and fail to meet its commitments. The larger the number of parties to an agreement, the greater the benefits of abandoning it to become a free rider. Under these circumstances, it is also to be expected that political leaders will find creative arguments for why precisely their country should not commit itself to major cuts in emissions.

However, game theorists have also concluded that we are unlikely to make real progress without one or more international climate agreements with broad support. An essential point is that it is considerably more profitable for an individual country to reduce emissions if it knows that this will result in emission reductions in a number of other countries as well. This means that international agreements can enforce the deep cuts in emissions that are needed to solve the problem of climate changes. If countries act independently of each other, there is reason to believe that the resultant cuts in emissions will be far smaller than needed in a global perspective.

Nevertheless, the political debate in Norway and the EU reflects a common belief that individual countries or small groups of countries should set a good example by cutting their own emissions, and that others will then follow their lead. Here in Norway, for example, the Prime Minister has announced that the Government intends Norway to make large cuts in emissions on a unilateral basis so that the country is carbon neutral by 2050.

It is paradoxical that according to the modelling framework frequently used by researchers in this field, such well-meant unilateral pledges to reduce emissions in fact make it more difficult to achieve a comprehensive international agreement, resulting in a global rise in emissions, which is the opposite of what is intended, as described by Holtsmark (2007). This happens because unilateral cuts in emissions reduce the benefits other countries gain by joining an international climate agreement. Game theory thus suggests that going it alone, as proposed by the Norwegian Government, can in fact make it more difficult to achieve broad support for an agreement on large cuts in emissions.

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15. 3. Economic consequences of different scenarios for Norwegian greenhouse gas taxes

Geir H. Bjertnæs, Cathrine Hagem and Birger Strøm

The way in which the authorities choose to meet Norway's Kyoto commitment will affect the Norwegian economy. This article describes the economic consequences of different climate policy scenarios for the part of the Norwegian economy that will not be included in the EU emissions trading scheme. The calculations show that the different scenarios result in only small changes in welfare, but that there can be substantial changes in resource allocation between sectors. They also show that there is no loss of welfare even if the CO_2 tax is twice as high as the international price of emission units.

A committee was appointed to review special taxes in Norway (Official Norwegian Report 2007:8), and asked Statistics Norway to evaluate the consequences for the Norwegian economy of different climate policy scenarios for the non-ETS sector, i.e. the part of the Norwegian economy that will not be included in the EU emissions trading scheme (Bjertnæs et al. 2007). The scenarios were chosen so that it was possible both to illustrate the consequences of using differentiated tax rates in Norway and to evaluate the effect of introducing measures to limit the quantity of emission units purchased outside Norway. All the scenarios are based on the assumption that Norway will join the EU emissions trading scheme (EU ETS). Firms that are included in the EU ETS must hold a quantity of emission allowances corresponding to their CO_2 emissions. The state must obtain emission units corresponding to the volume of greenhouse gas emissions from the rest of the economy (several types of emission units are recognised under the Kyoto protocol). In the calculations, the price of both EU emission allowances and Kyoto emission units is assumed to be NOK 150 per tonne CO_2 equivalent. We considered the following four scenarios:

Reference scenario. Cost-effective climate policy, no measures to limit emissions trading:
All emission sources in the non-ETS sector subject to a tax equal to the international price of Kyoto emission units. No measures to limit purchases of Kyoto emission units.

Climate policy not cost-effective, no measures to limit emissions trading:
The authorities retain the current differentiated tax rates in the non-ETS sector. No measures to limit purchases of Kyoto emission units.

Climate policy not cost-effective, measures introduced to limit emissions trading:
To limit purchases of Kyoto emission units, current tax rates are increased by a factor of four.

Cost-effective climate policy, measures introduced to limit emissions trading:
All emission sources in the non-ETS sector taxed at the same rate. The tax level is high enough to ensure that volume of Kyoto emission units purchased is the same as in scenario 3.

Table 15.1. Figures from the reference scenario and percentage changes in the other climate policy scenarios, for selected economic variables

		Percentage change from reference scenario		
	Scenario 1. Reference scenario, long-term figures	Scenario 2. Climate policy cost-ineffective, no measures to limit emissions trading	Scenario 3. Climate policy cost-ineffective, measures to limit emissions trading	Scenario 4. Climate policy cost-effective, measures to limit emissions trading
CO_2 emissions covered by ETS, million tonnes	19.8	-0.06	-0.84	-0.24
Emissions from non-ETS sector, million tonnes	38.5	1.20	-2.53	-2.53
Net import EU allowances, million tonnes	5.7	-0.21	-2.91	-0.84
Net import Kyoto emission units, million tonnes	7.1	6.48	-13.69	-13.69
Total net import emission units, million tonnes	12.8	3.51	-8.91	-7.99
Revenue from taxation of greenhouse gas emissions, million NOK	5 775	-16.2	212.6	98.8
Production, metal industry, million NOK .	30 140	8.39	7.10	-8.35
Privat consumption of petrol and oil, million NOK	32 332	-2.4	-13.1	-2.1
GDP, million NOK	1 583 762	0.017	-0.039	-0.047
Average rate of employers' social security contribution	13.8	-1.78	-18.65	-4.27
Labour supply, Million hours	3 111	0.058	0.182	-0.016
Utility, aggregate of private consumption and leisure		-0.04	-0.12	0.002
Utility, current value		-0.04	-0.13	0.004

The calculations were made using Statistics Norway's equilibrium model MSG-6 (Heide et al. 2004). It was assumed that the public-sector budget balance remained unchanged, and changes in the taxation of emissions were therefore neutralised by changes in the employers' social security contribution. The main results are shown in table 15.1.

In today's tax system, emissions from petrol are taxed at a high rate, while process emissions from the metal industry are exempt from the CO_2 tax. The EU ETS does not cover emissions from either of these sources. Harmonisation of the CO_2 tax would therefore result in relatively higher emissions from petrol consumption and lower production in the metal industry, and therefore lower emissions. Continuing the current system of differentiated tax rates (scenario 2) would result in a loss of welfare of 0.04 per cent compared with the reference scenario. Both the reference scenario and scenario 2 would result in a considerable net import of emission units to meet Norway's Kyoto commitment. In the reference scenario, total purchases of EU allowances and Kyoto emission units correspond to about 28 per cent of Norway's total assigned amount under the Kyoto Protocol.

The calculations show that even raising today's differentiated tax rates by a factor of four (scenario 3) would not reduce purchases of Kyoto emission units from outside

Norway by more than 13.7 per cent. However, welfare (as measured by utility in table 15.1) would decline by 0.13 per cent. The same reduction in purchases of Kyoto emission units could be achieved by harmonising the tax level for non-ETS sector at about twice the price of Kyoto units (scenario 4). This scenario results in a small increase in welfare.

The welfare gain obtained by increasing the tax level above the price of emission units is explained by the fact that there is initially a certain degree of inefficient resource use in the economy as a result of other distortionary taxes and subsidies. For example, the metal industry currently benefits from exemption from the CO_2 tax for process emissions, electricity contracts on favourable terms, a lower rate of employers' social security contributions in the areas where firms are situated, and exemption from the electricity tax. In contrast, petrol is more heavily taxed, so petrol consumption is below the optimal level in economic terms. This gives a high marginal return on petrol use. However, it should be noted that external effects related to fuel consumption are not included in MSG6. Thus, the analysis does not take into account the possibility that reducing fuel consumption will reduce negative external effects such as congestion, noise and local pollution. The welfare loss resulting from a high tax on petrol would be smaller if these externalities were taken into account.

Raising the tax rates so that they are higher than the price of emission units redistributes resources for purposes that give a higher economic return. In addition, higher taxes generate tax revenues that can be used to reduce employers' social security contributions. This increases welfare, since a substantial tax wedge in the labour market means that the marginal return on work is larger than the marginal utility value of leisure.

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15.4. People's attitudes to environmental issues

Per Arild Garnåsjordet

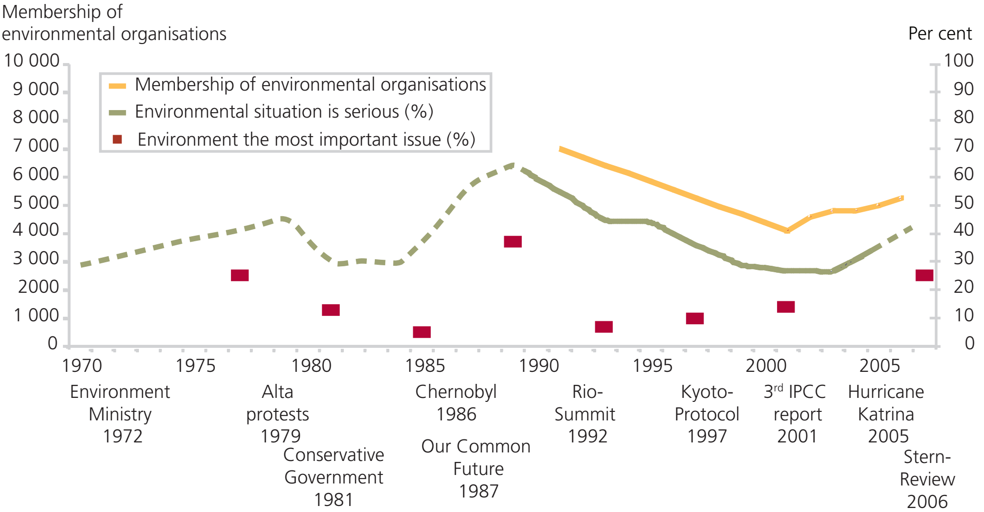
People's views on environmental issues are of interest because they provide a basis for political decisions and collective action. In other areas, citizens express their views and preferences more directly through the market and the formation of interest groups. Resolving environmental problems requires collective action. If we make choices on the basis of our short-term individual convenience, this will prevent us from achieving the results that are possible if we all work together.

People's environmental awareness developed during the 1960s and 1970s. In 1962, Rachel Carson published *Silent Spring*, and 30 years later, in 1962, it was selected as the most influential book of the previous 50 years. In the US, public concern about the environment reached a peak in 1969, and the first Earth Day was arranged in 1970. There was a similar trend in Norway, where environmental activist groups were established in 1969, and in 1970 took part in the "battle of Mardøla", where they engaged in civil disobedience in an attempt to prevent regulation of the river and the construction of a power plant. This generated a great deal of support for an active role for the environmental authorities, and the Ministry of the Environment was established in 1972.

In the early 1970s, pollution and nature conservation issues were very much in focus. According to a survey by Norsk Gallup AS, 28 per cent of the population considered pollution to be a serious threat, and 46 per cent approved of protection as an instrument of environmental policy. Towards the end of the 1970s, the Hardangervidda national park was established, and plans to build a dam on the Alta river led to protests and civil disobedience in 1979. It is difficult to judge the level of public support in 1979, but a comparison of voter polls in 1977 and 1981 shows a clear decline (from 25 to 13 per cent) in the number of people who considered the environment to be the most important issue in the election.

Support for environmental protection weakened with the rise of liberalism in both the US and Norway in the early 1980s. After the Norwegian election in 1985, almost half of all respondents said that they were somewhat less interested in nature conservation than previously. Then the picture changed again, partly as a result of the 1986 Chernobyl accident. Other factors that probably had an effect on public opinion were the publication of *Our Common Future*, the report of the World Commission for Environment and Development, in 1987, and the high priority given to environmental issues by the Norwegian Government (which for example drew up a master plan for water resources). By the 1989 election, 37 per cent of voters stated that they considered the environment to be the most important issue. In the same year, the market research institute Synovate MMI began its surveys. Since then, respondents have been given the following four options in surveys every two years:

Figure 15.1. Trends in the proportion of the population who consider the environmental situation to be serious, membership in environmental organisations, and the proportion of voters quoting the environment as the most important issue in general elections in the period 1977-2001 and in an opinion poll in 2007



- «The situation isn't that bad, it's easy to exaggerate»
- «Patience and perseverance will enable us to reverse the trend towards environmental degradation in the end.»
- «The situation is serious. We must take immediate and drastic action to solve the problems.»
- «Things have gone too far. It's too late to do anything about it. We are heading for disaster.»

So far, there has been little support for the fourth option (1-3 per cent), while support for the third option seems to give a clear picture of changes in public opinion. In figure 15.1, these two categories together are used to indicate the level of concern about the environment in the period 1989-2005. There is a steady decline until the curve levels off in 2000-2003. It looks as though Norwegians no longer believed in an environmental crisis.

Before the general election in 1997, it was claimed that the environment had been depoliticised. A new surge in environmental awareness appears to have begun around 2001. At this stage, membership of Norwegian environmental organisations had fallen to a minimum. The most important of these organisations - Friends of the Earth Norway, Nature & Youth, WWF-Norway, The Future in Our Hands, Greenpeace, and Green Warriors of Norway lost a total of 23 000 members between 1991 and 2000. However, since 2000 their total membership has risen again by 11 000. It is interesting to note that in 2006, the relative growth rate was highest in the most «radical» of these organisations (Nature & Youth, WWF-Norway, The Future in Our Hands). This is in some ways similar to the situation in the early 1970s, when the environmental movement was becoming radicalised and gaining more support among young people.

In 2005, the damage caused by Hurricane Katrina in New Orleans was seen as a warning, and climate change rose to the top of the agenda again. The Al Gore film *An Inconvenient Truth* and the *Stern Review* appeared at the end of 2006, and together with the IPCC Fourth Assessment Report, published in 2007, have influenced people's views and the political agenda. Recent opinion polls show that people are worried about the situation. In April 2007, 25 per cent of voters said that the environment is the most important issue for them when they choose which party to vote for, just ahead of schools and education (24.5 per cent). This shows a strong rise in interest in the environment compared with the election day surveys in the 1990s and 2001. A number of other surveys, such as the May 2007 nature and environment barometer from TNS Gallup, also show that the Norwegian public's interest in environmental issues is rising.

There are a number of reasons for the variations discussed here. Major economic fluctuations, as measured by the number of people unemployed, may explain some large shifts in public opinion. The decline in interest in environmental issues during the 1990s and up to a few years ago also coincides well with cuts in releases of a number of serious pollutants. There is nothing unusual about the trends in Norway. Surveys of voters in the US show a similar pattern with a peak in 1990, and interest in environmental issues rose considerably both in the EU and in the US in the late 1980s. Recent international opinion polls also show that interest in environmental issues is currently growing.

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15.5. What does Norway's national wealth consist of?

Mads Greaker

Norway is a very wealthy country by international standards, and certainly as measured by comparing per capita national income, and its prosperity is commonly attributed to the abundant supplies of natural resources such as fish, hydropower, and oil and gas. However, it is not possible to determine the extent to which a natural resource contributes to welfare solely by considering the income generated from it. Harvesting natural resources uses labour and capital that could otherwise have been used to generate income in other sectors. By deducting the value of these factor inputs, it is possible to find the real contribution from each natural resource, which is called the resource rent.

The next factor that must be taken into account is whether a natural resource is renewable or whether it will be depleted over time. Oil and gas are examples of non-renewable resources. The petroleum sector currently generates a large positive resource rent, but this will only continue as long as there are commercially viable oil and gas fields within Norway's exclusive economic zone. If Norway were to consume the whole or part of the resource rent from the oil and gas sector every year, this would, if all other factors remained unchanged, reduce opportunities for consumption in the future. Exporting oil and gas in reality moves wealth from one type of «account» to another, and it is only the return on this component of the national wealth that can be regarded as income.

To form an idea of the importance of natural resources and other resources for welfare, the value of each resource stock can be calculated. Resources are often divided into five main groups. Renewable natural resources include agricultural land, forests, fish stocks and hydropower. The most important non-renewable natural resources are oil and gas. The next two categories are human capital and real capital. Human capital is an expression of the wealth creation we expect from the people in the labour force and the knowledge and skills they can offer, while real capital consists of machinery, buildings and equipment etc. The final category is net foreign assets which includes the Government Pension Fund - Global.

To find the value of the stocks of each resource, it is first necessary to decompose Norway's net national income (NNI) to obtain the net income from each resource. This is done for all resources except income from human capital, which is calculated residually: in other words, it is assumed that all income that cannot be assigned to natural resources or real capital is derived from human capital. In addition, since the income from human capital is calculated residually, this income will also include any other sources of income that are not included in the other categories, such as interaction effects between labour, real capital and technology. After this, the lifetime of each resource stock is evaluated, and future income from the resource is calculated. The present value of the future income from a resource is its contribution to the national wealth, and the sum of these figures for all resource stocks is a measure of the total national wealth. A more detailed description of these calculations is presented in Greaker et al. 2005.

Figure 15.2. Composition of Norway's national wealth. Percentages. 2006

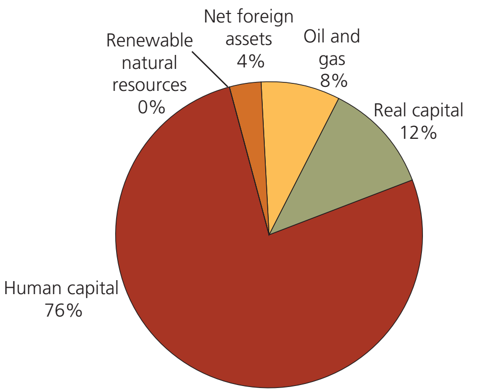

Figure 15.2 presents the results of these calculations, and shows that human capital accounted for 76 per cent of Norway's national wealth at the end of 2006. This is not very different from the situation in other developed countries, where human capital also accounts for much the largest proportion of the national wealth. The importance of human capital has been stable over the years, whereas the importance of the remaining oil and gas resources is declining. They currently make up about 8 per cent of Norway's national wealth, as compared with 12 per cent 10 years ago. This trend will continue as the oil and gas resources are depleted. On the other hand, the value of net foreign assets, including the Government Pension Fund - Global, has risen, and according to the calculations accounted for about 3 per cent of the national wealth at the end of 2006. Renewable natural resources only make a weak positive contribution to the national wealth despite the fact that hydropower is a renewable resource with a high positive resource rent. This is because the income from agriculture is negative as a result of high inputs of labour and capital compared with the directly measurable value added generated by the sector. The share of the national wealth provided by renewable natural resources is therefore not visible in the figure.

People's perceptions of what contributes to Norway's wealth will be one of the factors that determine society's priorities in the future. It is therefore important to have as correct as possible an understanding of the basis for Norway's welfare. It is also important to be aware of the most important weaknesses of calculations of the type described above. Because the calculations are based on the national accounts, many key environmental resources, such as the value of access to national parks and undisturbed nature, biodiversity, and a stable climate, have been omitted. This does not mean that they are less important than the resources that are included, but it is always complicated and time-consuming to make decisions weighing up resources of this type against resources that can more easily be assigned an economic value.

It would also be possible to improve the method of calculating human capital. As explained above, this is currently calculated residually, so that all income that is not assigned to natural resources, real capital or net foreign assets is considered to be human capital. The results using this approach may well prove to agree closely with those that would be obtained by calculating the value of human capital on the basis of the number of hours worked and an average wage rate (Greaker 2007). However, we need better ways of explaining and predicting trends in labour input and the average wage rate. This can be done by looking at the expected lifetime income for each person in Norway. The sum of all expected lifetime incomes should give an even better estimate of the human capital.

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15.6. Globalisation of gas markets

Knut Einar Rosendahl and Eirik Lund Sagen

The reduction in transport costs for gas has been driving the globalisation of natural gas markets. This is particularly the case for liquefied natural gas (LNG), which can be transported by ship. A recent study found that lower LNG costs can actually result in higher gas prices in Europe because it will become more profitable to ship gas across the Atlantic to the US. On the other hand, falling pipeline transport costs may result in lower European gas prices because it will be cheaper to transport gas from Russia and the Middle East to Europe.

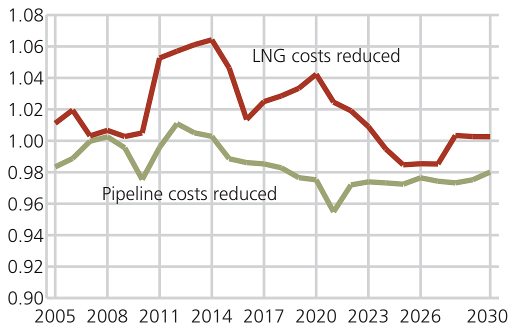
Natural gas has traditionally been traded in regional markets such as the European, North American and Asia-Pacific markets. In Europe and the US, pipeline transport has dominated, whereas in the Asia-Pacific market most gas has been transported by ship, mainly to Japan. Gas that is shipped is first cooled and condensed to liquid form (LNG) and then loaded on specially constructed vessels. At its destination, the LNG is regasified and can be sold in the same way as other natural gas. Until now, Norwegian natural gas has been exported by pipeline to the rest of Europe, but gas from the Snøhvit field in Finnmark is to be exported as LNG, for example to the US.

The costs of LNG transport, and particularly the liquefaction process, used to be high. This is one reason why LNG has not been widely used outside the Asia-Pacific region. However, in the last ten years the costs of LNG transport have fallen considerably. It is true that costs have risen again the last year or two, but this is part of a general rise in costs in the energy sector caused by high prices for steel and other factor inputs. The decline in LNG costs makes it more profitable to transport gas over long distances, for example across the Atlantic. The result is closer integration of the world's regional gas markets and increased price convergence. The process has been somewhat delayed because long-term contracts for fixed destinations used to be the norm in gas markets. However, in recent years spot trade in gas has been expanding in response to short-term but marked price differentials between Europe and the US.

Almost two-thirds of the world's gas reserves are located in Russia and the Middle East. Russia also consumes large volumes of gas, and it is uncertain whether the country will be able to increase its gas exports to any great extent. There is a much greater potential for increased gas exports from the Middle East, particularly Qatar and Iran, but conditions in Iran and other countries with large reserves are not very favourable at present. An important exception is Qatar, which is already the world's largest exporter of LNG, and may have the world's highest per capita GDP in only a few years' time. If other countries in the region follow the same pattern, there is reason to expect considerable exports of gas from the Middle East to the US, Europe and the Asia-Pacific region. Countries in Africa and Central Asia may also export large quantities of gas to these regions, where there is a growing demand for imports.

What will happen to gas prices in Europe if the reduction in transport costs continues? Since Europe is a net importer of gas, it would be reasonable to expect a drop in prices if it becomes cheaper to transport gas to Europe. This has recently been investigated using a detailed numerical model of the world's gas markets (Rosendahl and Sagen 2007). Two scenarios were tested, in which either LNG or pipeline transport costs were reduced by 4 per cent per year up to 2030. It was found that the answer depended on which form of transport was made cheaper. If pipeline transport costs were reduced, a general decline in prices in Europe was also found, as expected. This was explained by the decline in the cost of transporting gas by pipeline from Russia and the Middle East to Europe. This can be seen in figure 15.3, which shows how prices change relative to a reference scenario with constant transport costs.

Figure 15.3. Trends in European gas prices if transport costs are reduced. Changes relative to a reference scenario in which transport prices remain constant



Source: Rosendahl and Sagen (2007).

The scenario in which LNG transport prices were reduced, on the other hand, produced higher gas prices in Europe for most of the period. In this scenario, the price of transporting gas both across the Atlantic to the US and to Japan was reduced, with a resulting rise in the demand for gas in these countries. This pushed up prices in the Middle East and other exporting countries. Since Europe imports most of its gas via pipelines, where the cost was kept unchanged, the price rise was found to spread to Europe. It was found that even if LNG costs were to drop so much that there was a large rise in LNG imports to Europe, this would not necessarily depress prices in Europe because of the relatively short distances to producer countries, and gas prices in Europe would therefore remain high.

LNG technology is developing rapidly, and it is expected that the costs of using LNG will continue to fall. According to the results presented here, this may result in higher prices for gas consumers in the EU, which would be favourable for gas producers like Norway. However, this conclusion assumes that trade in gas is based solely on considerations of profitability. In the current situation this is somewhat doubtful, but there is a clear trend towards more liberal and flexible gas markets. On the other hand, there is a growing focus on energy security, and the EU wishes to diversify its gas supplies. If European countries deliberately decide to increase their LNG imports for these reasons, the results may be different.

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15.7. The value of Norwegian natural gas in Europe: consequences of reform of the Russian gas industry

Marina Tsygankova

Gazprom is currently the only Russian company that has the right to export natural gas to Europe. At present, more than one quarter of all the natural gas consumed in the EU is sold by Gazprom. Permitting exports by more than one Russian gas producer has been one of the topics in the energy dialogue between Russia and the EU for several years. So far, there have been no significant structural changes in the Russian gas industry, but Gazprom has begun to make more use of its market power in Europe. This has increased the demand for Norwegian gas in Europe. If Russia reorganises its gas exports and competition in Europe increases, this may have negative impacts on Norway as a result of lower gas prices in Europe and reduced gas exports from Norway. Two studies have looked at various possible ways of structuring the Russian gas industry, assuming that more than one Russian gas producer exports gas to Europe. These studies investigated the conditions under which it would benefit Russia to reorganise its gas exports.

Russia is Norway's neighbour and one of its main competitors in the European gas market. This means that developments in the Russian gas market and in Russian energy policy will have an important bearing on trends in demand and profitability for Norwegian gas.

Gazprom is Russia's leading gas producer, and the Russian state is the main shareholder in Gazprom. Developments in the Russian gas industry in recent years have further strengthened Gazprom's position in both the Russian and the European gas market. In 2006, Gazprom's exclusive right to export gas to Europe was formalised in Russian legislation. In the domestic market, Gazprom has been increasing its dominance by buying up its competitors to gain control of gas resources owned by other Russian gas producers.

Gazprom's strengthened position has increased concern about European dependence on Russian gas. A number of countries that have traditionally imported gas from Russia have therefore been showing an interest in buying Norwegian gas instead. If the structure of the Russian gas industry remains unchanged, with Gazprom as the dominant actor, it is likely that demand for Norwegian gas will increase.

Structural reforms

There has been intense debate on restructuring of Gazprom to increase competition in the Russian gas market since 1997, and several reform proposals have been discussed. One proposal was to split up Gazprom into several production companies. Another was to retain the current structure of the Russian gas market, but open the export market to other Russian gas producers, often called «independent producers». The debate came to an end in 2003, when President Vladimir Putin publicly announced that he did not intend to restructure Gazprom.

It is clear that political interests will play an important role in how the Russian gas industry is structured in the future, but economic factors will also be taken into consideration. According to the economic literature, increasing competition in a market increases overall economic welfare. However, this situation may change if a producer also has the opportunity to export to an international market where it has market power. The smaller the number of exporting companies, the more use can be made of market power, and the greater the total export profits. Thus, one large actor's export profits can compensate for the welfare loss caused by reduced competition in the domestic market.

In two studies, the long-term outcome of different options for the future structure of the Russian gas industry were calculated and compared, using national welfare as the criterion for comparison. National welfare was defined as the sum of consumer surplus on the domestic market and the profits made by Russian producers on both the domestic and the global market.

The effects of allowing independent Russian gas producers export to Europe were analysed in Tsygankova (2007a). These producers currently sell only to consumers in Russia. If they were to sell to Europe as well, they might reduce the quantity of gas they sell in the domestic market, thus increasing Gazprom's market power in the domestic market. This would result in higher prices in the domestic market, which would have a negative impact on consumers in Russia. At the same time, an expansion of Russian exports would reduce gas prices in Europe. The calculations show that for liberalisation of gas exports to generate greater welfare in Russia, the market share of independent producers would have to be considerably larger than it is today.

Another study (Tsygankova 2007b) analysed the effects of splitting up Gazprom so that its production units compete with each other on both the domestic and the export market. It was found that splitting up Gazprom may reduce Russian welfare from the current level. This is because reduced export profits counterbalance the benefits for Russian consumers. The reduction in export profits was found to decrease as the number of foreign companies competing with Gazprom in Europe increased. The option of shipping natural gas as LNG would open up the European market to other exporters in North Africa and the Middle East. Thus, an increase in the supply of LNG would reduce the fall in export profits that results from splitting up Gazprom. If all planned LNG projects in Europe are realised, splitting up Gazprom might increase national welfare in Russia.

Assuming that the Russian government focuses primarily on overall national welfare, structural reforms in the Russian gas industry would not be beneficial given the current situation in the European and Russian gas markets. The conclusion is that Gazprom's dominance on both the domestic and the European market would have to be reduced for Russia to find it favourable to open the export market to competition, while its dominance on the European market would have to be reduced for restructuring of the company to yield benefits.

These conclusions have important implications for the development of demand for Norwegian gas in Europe. If Russia decides that there is no benefit to be gained from competition in the export market in the next few years, this may increase demand for Norwegian gas. On the other hand, a rise in the supply of LNG would challenge Gazprom's position in Europe. If this happens, Russia may conclude that it would gain from reorganisation of Gazprom, which could have negative impacts on Norway in the form of lower gas prices and a reduction in Norwegian gas exports.

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15.8. Energy policy instruments

Torstein Bye and Annegrete Bruvoll

A review of energy taxes shows wide differences both between sectors and between countries. This is true even in cases where the theoretical basis would imply equal taxes. There are several theoretical reasons for taxing energy. However, in practice there are far more instruments in use than there are goals. The tax system in the energy sector is also used to some extent to correct failure in other parts of the market. This makes the consequences of the taxation system unpredictable, and means that different instruments may cancel each other out.

Theoretical basis for energy taxes

The main theoretical reasons for taxes on energy are the provision of government revenues, taxation of economic rent, taxation of monopoly profit, and correction of environmental damage and other forms of market failure. According to economic theory, government revenues should be obtained by taxing goods most heavily where there will be least effect on demand. Tax levels may therefore vary between countries according to the general level of taxation, and between sectors according to how demand is influenced. As mentioned, one important reason for energy taxes is taxation of economic rent - the yield exceeding the normal rate of return that results from a shortage of energy resources. Moreover, almost all production and use of energy has adverse environmental impacts, for example as a result of emissions of greenhouse gases, sulphur or other local air pollutants, or alteration of the physical environment. Taxation of environmental degradation should vary according to the severity of the damage. For greenhouse gas emissions, the tax level should be the same for all sectors and countries, since the impacts of these emissions are the same regardless of where they take place. In most other cases, for example acid rain, emissions of particulate matter, and the environmental impacts of wind turbines, impacts may vary widely, and variations in tax levels are also reasonable. Several types of market failure provide an additional basis for taxation - for example, uncertainty, imperfect competition, and the fact that infrastructure (roads, use of the electricity grid) is not priced directly in the market.

Policy in practice

In practice, politicians have to take many factors into account. Tax rates may differ between industries, for regional policy reasons, or because of distributional considerations. This reduces the effectiveness of taxation as an instrument for achieving a specific goal. Another problem arises when several instruments, each of which is basically intended to achieve the same goals, are used in combination, despite the fact that it is most effective to use one instrument per goal. For example, green certificates and subsidies are used to promote technologies that are considered to be environmentally friendly, while energy taxes and white certificates are intended to reduce energy use generally. The underlying goal is the same as that of taxing greenhouse gas emissions, setting up emission trading schemes and regulating development projects - to limit emissions, global warming and other environmental damage. In addition, there are extensive systems of exemptions from the different instruments. This undermines their effects, and together with the use of several different instruments to obtain the same results, means that it is difficult to identify the way they interact and the overall effects on the energy sector and the environment.

A review of energy-related taxes in different countries shows very large variations both between countries and between sectors in the same country. Although there are theoretical reasons for some of this variation, the large differences suggest that tax levels are partly determined by other considerations than effectiveness.

Electricity taxes vary from 5 per cent of the electricity price in Portugal to 50 per cent in Denmark. In general, taxes on both electricity and oil products are far lower for industry than for households. Thus, industry competitiveness is given priority in all countries. Differences between countries may also be explained by differences in the environmental costs of electricity production or in the size of the public sector. For example, Norwegian electricity production is based almost entirely on hydropower, whereas in Denmark it is largely based on coal. Another example is the differences between taxes on transport oils. A number of taxation arguments provide a basis for these taxes, including pollution, road construction costs and the provision of government revenues. Within the OECD, the diesel tax varies from 10 per cent in New Zealand and the US to 70 per cent in Denmark, and the petrol tax varies from 20 per cent in the US to 70 per cent in Turkey. These variations are so large that they can hardly be explained by differences in the theoretical reasons for levying them, such as levels of local pollution, road construction costs or the need for government revenues.

Environmental taxes are relatively limited in scope in most countries, and tax levels vary widely between those countries that do make use of them. This applies not least to taxes on greenhouse gas emissions. As mentioned earlier, the damage caused by these emissions does not depend on where they take place, and the tax level should theoretically be the same for all emission sources in all countries. Norway is one of the few countries that has introduced a carbon tax, and the tax level varies considerably even within the country. Emissions trading usually applies to emissions that are not subject to a carbon tax. In practice, the introduction of environmental taxes has often involved redefinition of energy taxes, so that the overall increase in taxation has been smaller than the claimed increase in environmental taxation over time.

Subsidies used in energy policy are generally provided in the form of loans, grants and exemptions from taxation, all intended to encourage different forms of energy production. Such subsidies can have the opposite effect of environmental taxes, since they encourage energy production. A review of the support granted to various sectors in different countries shows that the most heavily polluting sectors, including metal production, receive most public funding. Another example is coal-based power production, which receives about one third of all energy subsidies in the OECD countries. In the Nordic countries, subsidies are largely used with a view to increasing the production of renewable energy. For example, green certificates have been introduced in Sweden and several other EU countries, and more countries are planning to introduce both green and white certificates. Complex combinations of instruments are the rule rather than the exception in different countries. In addition, the relative weight given to particular instruments varies widely. This indicates that coordinating energy-related instruments would yield benefits in many countries.

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15.9. Is there a looming electricity crisis in Central Norway?

Torgeir Ericson and Bente Halvorsen

There has been a great deal of discussion of the electricity situation in Central Norway (the counties of Møre og Romsdal, Sør-Trøndelag and Nord-Trøndelag). Developments in Møre og Romsdal will be particularly important for the electricity supply situation in the region. In recent years, electricity consumption has risen sharply in the county, particularly in energy-intensive manufacturing, and this trend is expected to continue. However, it is very uncertain when or even whether there will be any increase in production capacity. There are plans to increase transmission capacity to the region, but these will not provide any increase in power supplies until 2009-10 at the earliest. The current situation, combined with plans for industrial expansion, has caused concern in the region. Fears of high electricity prices and electricity rationing have hit the headlines, and resulted in demands for the expansion of production and transmission capacity.

An electricity crisis means a situation in which system security is threatened and it is necessary to impose physical rationing. Electricity crises can be divided into two types: capacity shortages, where there are problems in maintaining an adequate day-to-day supply of electricity, and energy shortages, where the supply of energy is inadequate over a longer period of time. The answer to whether a crisis is predicted will depend on whether the conclusion is that today's power market can cope with a capacity or energy shortage, or whether extraordinary measures will be called for.

With the current production and transmission capacity, there will not normally be a shortage of either energy or capacity in the region in years when precipitation is normal. However, in very dry years, maintaining the energy balance in the region will only be possible if the market sends adequate price signals to consumers and producers. Provided that demand in the spot and end-user markets responds to price changes, the market will be able to cope with shortages, and no electricity crisis will develop. Figures for the region indicate that there is an appreciable response in demand by both end users in the region and the spot market. Thus, there is nothing to indicate that today's market is unable to cope with dry years. However, a market solution may have consequences that are politically or socially unacceptable. If shortages arise, the market solution may result in very high and fluctuating electricity prices that differ from those in the rest of the country. A prolonged shortage with accompanying high prices in the region would rapidly become politically unacceptable on grounds of regional, distributional and industrial policy, and pressure for political intervention might arise.

When electricity prices rise, the introduction of maximum prices for end users is often proposed. However, if this is done, one result might be that the market mechanism would no longer function during a capacity or energy shortage, since price signals would not reach consumers. As a result, they would continue to use electricity as before. This might reduce the ability of the market to allocate resources, and in the worst case, actually create an electricity crisis.

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15.10. Subsidising research and development on environmental energy technology in a small open economy

Tom-Reiel Heggedal and Karl Jacobsen

Encouraging the expansion of research and development on climate-friendly technologies is one possible tool for achieving national targets for reducing greenhouse gas emissions. A recent study has looked at the effects of subsidising R&D and the type of time profile such subsidies should have. The analysis indicates that in the case of environmental technology, subsidies with a falling time profile give a greater welfare gain than a constant rate of subsidy.

The study used a macroeconomic model of the Norwegian economy in which economic growth is partly determined by activity in two R&D sectors. One of these generates general knowledge that provides benefits more or less throughout the economy in the form of greater productivity. The other develops climate-friendly technology, as exemplified by carbon capture and storage (CCS) technology for gas-fired power plants. Norway plans to install such technology at the Mongstad power plant.

The full costs of emissions from production and consumption are not normally reflected in the market prices of emission-intensive goods and services. According to economic theory, this market failure should be corrected using policy instruments. Subsidising environmental R&D clearly has a positive effect on emissions, since gas-fired power plants that install CCS technology will improve their productivity and thus become more competitive. Nevertheless, such subsidies do not correct the market failure related to emissions as effectively as a carbon tax. The theoretical basis suggests that direct regulation of emissions, for example through a carbon tax, deals with market failure more effectively because all emissions are subject to the same price.

However, if there are imperfections in the R&D market, it will be most efficient to subsidise environmental R&D. Market failure in R&D markets is a well-known phenomenon. The private returns from R&D are often lower than the social returns, which leads to underinvestment in R&D. This is because firms do not take into account the positive knowledge spillover effect of their R&D activities on other firms. Each actor's R&D activities increase the accumulated stock of knowledge in the economy, and other actors can make use of this. Subsidising R&D activities increases the private returns, so that the volume of R&D approaches the socially optimal level, resulting in welfare gains.

In this study, it was assumed that Norway would have to reduce its emissions relative to the level in a business-as-usual (BAU) scenario in order to achieve specific targets. In the BAU scenario, the carbon tax and other taxes and subsidies were kept at their current levels, and this determined the volume of emissions. Two scenarios were then constructed, using different levels of ambition for reduction of emissions from the BAU level in 2050. In the scenarios, emissions were gradually reduced from day one, and the carbon tax was adjusted over time to give the desired reduction in emissions.

The overall amount of subsidies for environmental R&D was assumed to be fixed, and the analyses looked at which time profile would give the greatest welfare gain from these subsidies. Preliminary analyses using a simulation model show that a falling time profile is more effective than a constant rate of subsidy. In other words, despite the fact that emissions must be reduced more over time, subsidies should be gradually reduced. This suggests that the degree of market failure associated with knowledge spillover from environmental R&D is greatest at the beginning of the period.

Subsidies also have an effect on emissions. This means that the most appropriate time profile for subsidies may be affected by how strict the emission reduction regime is. The results so far suggest that the economic efficiency of subsidies is most closely linked to their time profile in the case of a ambitious emission reduction regime. The benefits of a falling time profile rather than a constant subsidy rate are greater in this case. This suggests that the stricter the emission target, the greater degree of market failure to start with.

By analysing the effects of subsidies for environmental R&D in a model for the whole Norwegian economy, it is possible to identify the indirect effects on emissions as well as the direct effects, and thus to find the taxation level needed to achieve the climate target. The direct effect is improvement of the productivity of gas power production with CCS. This sector therefore takes market shares from gas power production without CCS. Part of the demand for electricity is thus shifted from gas power without CCS to gas power with CCS. For a given carbon tax level, this reduces emissions from the economy as a whole. However, this substitution effect is counteracted by the indirect effects on emissions of lower electricity prices. Production in the rest of the economy therefore rises, which increases emissions for a given carbon tax level. Preliminary calculations indicate that this effect is greater than the substitution effect. The perhaps rather surprising conclusion is therefore that subsidising environmental R&D has a negative effect on emission reductions.

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15.11. The authorities' support for hydrogen cars and the phenomenon of technological lock-in

Mads Greaker and Tom-Reiel Heggedal

The «hydrogen economy» is a recurrent theme in today's environmental debate. In Norway, the authorities are investing heavily in the establishment of a «hydrogen highway» from Stavanger to Oslo. A research project has looked more closely at the arguments for this. It is possible that such investments can be justified if they are temporary and there will be a transition to another market equilibrium with widespread use of hydrogen cars. However, the question is whether the authorities are acting prematurely.

The «hydrogen economy» is a recurrent theme in today's environmental debate. In Norway, the authorities are investing heavily in the establishment of a «hydrogen highway» from Stavanger to Oslo. According to the media, the authorities intend to make Svalbard carbon-neutral, partly by ensuring that all vehicles there run on hydrogen. The reason why hydrogen is so attractive is that the main constituent of vehicle exhaust is water. In other words, with hydrogen in the tank we can drive as far as we like without worrying about global warming.

So how can we achieve a changeover to hydrogen in the transport sector? Economists answer that emissions from petrol and diesel vehicles must be taxed to make CO_2-free forms of transport such as hydrogen vehicles more competitive. However, Norway has levied a carbon tax for many years, currently at a rate corresponding to more than NOK 300 per tonne CO_2 emitted, but this has not increased the popularity of hydrogen vehicles. According to supporters of these vehicles, this is because society is "locked in" to fossil-fuel based technologies. This means that hydrogen will not be introduced in the transport market without support from the authorities, regardless of how competitive hydrogen vehicles become.

This claim has been examined more closely in a research project (Greaker and Heggedal 2007) based on the theory of network externalities. According to this theory, one consumer benefits if other consumers use the same type of technology, but consumers do not take into account the fact that the benefits to other consumers are affected by their choice of technology. For example, the larger the number of petrol cars in use, the more the number of ordinary filling stations will rise. More filling stations gives more freedom of choice, and price competition between filling stations will lower the price of petrol. Thus, the benefit to a consumer of owning a petrol vehicle is linked to the number of other consumers who also own such vehicles.

In the current situation, it is clearly not attractive for consumers to switch to hydrogen cars, since it is difficult to find fuel. Consumers are dependent on more people making the same choice before a network of filling stations for hydrogen is developed. Equally, it is not attractive to open a filling station for hydrogen since there are so few hydrogen cars. Theoretically, this could result in a situation where hydrogen cars never break into the market even though a large fleet of hydrogen cars and a network of filling stations would be an environmentally sound solution.

This phenomenon is known as «technological lock-in» or «path-dependent development». In this context, it means that some or all of the actors in the transport market are locked into the use of fossil fuels, even though it would have been better if some or all of them used hydrogen technology. Thus, in a situation with technological lock-in, the welfare gain would increase if we could move to another market equilibrium using hydrogen technology instead of petrol and diesel. In other words, the possibility of technological lock-in means that we cannot rely on market forces alone.

Greaker and Heggedal (2007) found that if the costs associated with hydrogen technology are not too high compared with today's technology, technological lock-in is a possibility. Several possible equilibria will exist in the transport market, including little use and widespread use of hydrogen cars, but it was not possible to conclude from the analysis which of the equilibria the market would choose. Thus, it cannot be concluded that the market would choose the equilibrium that gives the highest welfare gain. In this situation, the authorities should seek to coordinate the market to the equilibrium with the highest welfare gain, for example by temporarily introducing subsidies in some form or another. It should only be necessary to provide subsidies temporarily, since once the new equilibrium is established, it will be maintained without further subsidies.

However, the analysis shows that this is a very difficult decision for the authorities to make. The potential hydrogen equilibrium is not automatically preferable to the current equilibrium involving only petrol and diesel cars. And since network externalities operate in both directions, providing subsidies may in the long run result in a shift to the hydrogen equilibrium even if this is not the best option. Although the hydrogen equilibrium would be an improvement in environmental terms, this improvement might not be great enough to justify the shift if hydrogen technology is still relatively expensive and the costs of closing down already established petrol stations too early are high.

Greaker and Heggedal (2007) also found that there is no technological lock-in to fossil fuel technology if the costs of hydrogen technology are high. In this case, temporary subsidies would not be able to alter the market equilibrium. As soon as subsidies were withdrawn, the market would begin to revert to the original equilibrium. In this situation, there is even less reason for the authorities to intervene, at least if subsidies are introduced to overcome technological lock-in.

The question is whether today's situation involves technological lock-in. The model in this study was not advanced enough to answer this question, but the authors reasoned further outside the model as follows. It is often forgotten that hydrogen is an energy carrier, not an energy source. Hydrogen can only be produced by using energy in some form or another. Thus, the «hydrogen economy» is only a solution to the problem of climate change if hydrogen is produced without generating CO_2 emissions. There are no large-scale methods available for this today, and those that exist produce expensive fuel.

Moreover, most technology experts agree that the hydrogen cars available today are not competitive with petrol and diesel cars in terms of convenience and price. For example, the fuel cells that are required to convert hydrogen to energy are still expensive and not very reliable. Furthermore, hydrogen storage in cars is difficult, which limits their driving range. The most reasonable conclusion thus seems to be that the authorities should not introduce measures to promote the use of hydrogen cars until the technology has been further developed.

One could ask how the technology can be developed further if there are no opportunities for testing it in the market. The answer is that there are probably other areas where it can be tested more easily. For example, it has been claimed for a long time that reasonably-priced and reliable fuel cells would be able to take over the entire market for batteries for laptops. This indicates that any actor who can develop better fuel cells and a better storage method for hydrogen could make substantial profits.

The analysis also shows that there is good reason to be cautious about introducing subsidies even if better hydrogen cars are developed. Even if a complete changeover to hydrogen cars is possible, this is not necessarily the best solution. There are many other ways of reducing CO_2 emissions from the transport sector, for example by driving less and using public transport. In many cases, the authorities should do no more than ensure that all options enjoy equal conditions of competition. It is easy to forget that subsidising hydrogen cars makes other alternatives, such as «driving less» relatively more expensive (section 15.8 on energy policy instruments discusses the disadvantages of using several instruments to achieve the same goals).

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15.12. The economy, environment and living conditions in the Arctic

Solveig Glomsrød, Iulie Aslaksen and Bjart Holtsmark

The Arctic is strongly affected by climate change and global economic developments. The impacts of climate change are greater at higher latitudes, and are expected to alter the environment and living conditions in the Arctic profoundly. The rich natural resources of the region - petroleum, minerals, fish and forests - are an important factor in the Arctic economy. Value added, measured as gross domestic product (GDP) is unevenly distributed across the Arctic, and is highest in the petroleum-rich Russian provinces and Alaska. However, because it is not adjusted for the extraction of natural resources, GDP will be misleading as a measure of value added in areas that are rich in natural resources. Despite the importance of natural resources in the Arctic economy, the tertiary sector is the largest sector of the economy.

Introduction

The Arctic is rich in natural resources such as petroleum, minerals, fish and forests. Strong economic growth internationally has increased the demand for such raw materials. Despite high extraction costs, the Arctic is an attractive supplier because other resource-rich areas suffer from political instability or unpredictable framework conditions. However, the Arctic is suffering disproportionately from the negative consequences of strong global economic growth. Long-range pollutants, such as mercury released from coal-fired power plants in Asia, are transported by the dominant air and ocean currents and deposited in the Arctic. This is a threat to both human health and the environment. Global warming is expected to result in far greater changes to the environment and living conditions in the Arctic than those that are already being observed.

Scientific work under the Arctic Council, which was established in 1996, has resulted in important reports on both climate change and social issues (Arctic Climate Impact Assessment (ACIA) 2005, Arctic Human Development Report (AHDR) 2004). Statistics Norway is carrying out a project to coordinate and develop relevant economic statistics for the Arctic, and to analyse them in the context of observed and projected climate change. The project is being supported by the Norwegian Ministry of Foreign Affairs and the Nordic Council of Ministers, and is being carried out in cooperation with the Center for International Climate and Environmental Research (CICERO). This article briefly discusses some of the main results presented in a report from the project *The Economy of the North* (Glomsrød and Aslaksen (ed.) 2006). The Arctic is defined as including the northerly administrative regions of Canada, Russia, the US, Finland, Norway and Sweden, and the whole of Greenland, Iceland and the Faeroes, a total of 28 regions.

Arctic natural resources in a global perspective

The Arctic contributes 10 and 25 per cent respectively of global production of oil and gas. Petroleum production takes place mainly in two Russian provinces (Yamalo-Nenets and Khanty-Mansi) and Alaska. The proven reserves of oil and gas in the Arctic make up about 5 and 22 per cent respectively of the global total. Almost all the proven gas reserves in the Arctic are in Russia, which also has about 90 per cent of the proven Arctic oil reserves.

There are also rich mineral resources in the Arctic. Extraction of nickel, cobalt, platinum and tungsten in the Arctic accounts for 10-15 per cent of the world production of these minerals. Extraction of minerals takes place largely in Arctic Russia, which in addition accounted for about 20 per cent of world production of diamonds in 2002. Diamond production in Canada is also growing rapidly after the recent discovery of gem-quality deposits.

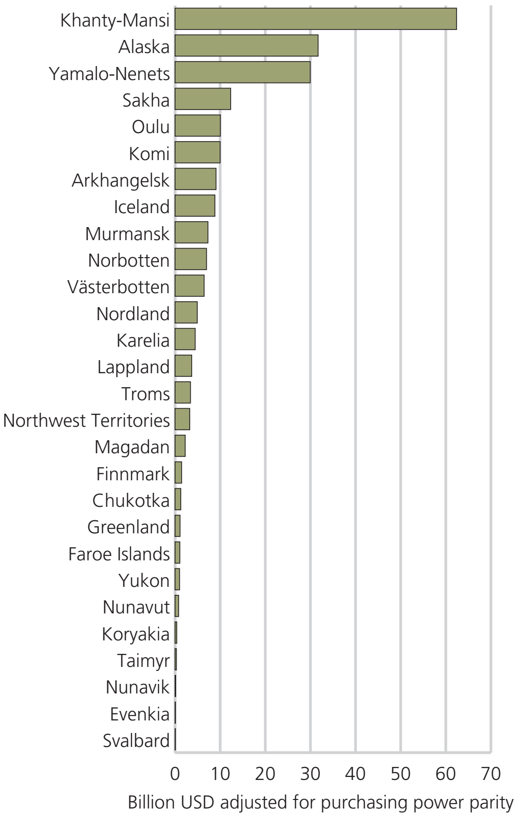
About 10 per cent of the world catch of fish is taken in the Arctic. Whether these large catches can be continued will depend on whether overfishing of Arctic fish stocks can be avoided, and on how well these stocks adapt to the impacts of climate change. In addition to catches of wild fish and shellfish, about 8 per cent of world production of farmed salmon takes place in the Arctic.

Eight per cent of the global wood volume of forests is found in the Arctic, but only two per cent of total global wood removal takes place in the Arctic. The low level of the harvest relative to wood volume is explained partly by the remoteness of the region and difficult transport conditions, but also by a much lower growth rate in the Arctic than further south.

Economic output and economic structure in the Arctic

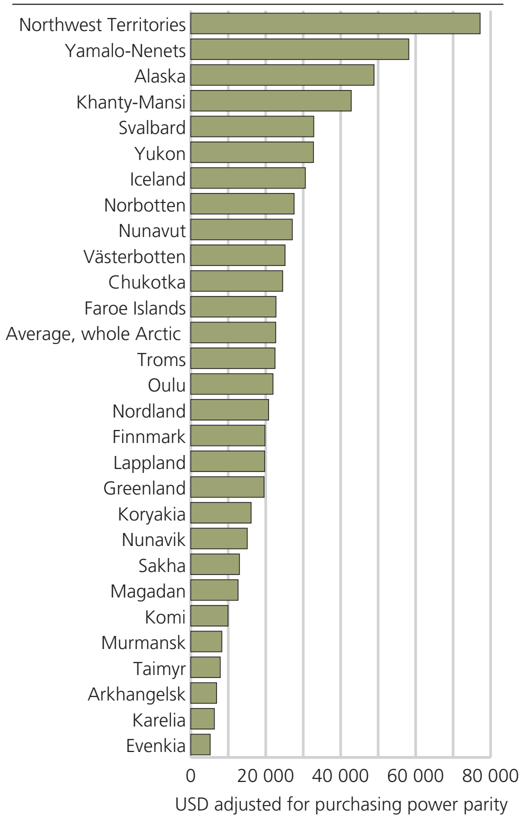
To provide an overview over economic output in different regions of the Arctic, figure 15.4 shows GDP in each of the 28 administrative regions in the Arctic, and figure 15.5 shows per capita GDP in these regions. Both population and resources are very unevenly distributed between the different regions. The calculations on which figure 15.5 is based show that the regions with the highest per capita GDP derive a large proportion of their revenues from natural resources, particularly petroleum and diamonds. In these circumstances, high per capita GDP does not necessarily mean that there is a high level of disposable income in the region. Transfers of resource rents out of Arctic regions and state transfers into Arctic regions are other important elements that influence regional disposable income and welfare. The two figures together show that the economic centre of gravity of the Arctic consists of Northwest Territories in Canada, Alaska, and the two Russian provinces of Khanty-Mansi and Yamalo-Nenets, both of which produce considerable amounts of petroleum. Alaska is the second largest regional economy in the Arctic as measured by GDP, and also has oil production as its main industry. The region with the highest per capita GDP is Northwest Territories, which has large revenues from diamond extraction. Per capita GDP in the Scandinavian Arctic regions is around the average for the Arctic as a whole, while Nunavik in Canada and nine regions in Russia rank as the 10 lowest of the 28 regions.

Figure 15.4. GDP for Arctic regions. 2003



Source: Glomsrød and Aslaksen (ed.) (2006).

Figure 15.5. Per capita GDP for Arctic regions. 2003



Source: Glomsrød and Aslaksen (ed.) (2006).

Subsistence activities, the market economy and the impacts of climate change in the Arctic

Subsistence activities play a major role in the lives of the indigenous peoples of the Arctic. Hunting, fishing, reindeer husbandry and gathering are important for their contribution to the diet, in social relationships and for a sense of cultural identity. Most indigenous peoples in the Arctic are also consumers and employees in the market economy. However, many of them still fish and hunt, and these activities are under threat from climate change. In areas where sea ice no longer forms, the local people cannot hunt from the ice. Knowledge of the scale of subsistence activities is important for an understanding of their economic, ecological and cultural significance. *The Economy of the North* describes the findings of the *Survey of Living Conditions in the Arctic* (SLiCA) on subsistence activities in some Arctic communities. The survey was based on interviews with 7 000 people from indigenous populations in Alaska, Canada, Greenland and Chukotka in Russia. Half of the households interviewed reported that they harvested at least 50 per cent of their consumption of fish and meat themselves.

Climate change is a serious threat to the environment and living conditions in the Arctic. One of the main conclusions of the *Arctic Climate Impact Assessment* (ACIA 2005) was that rising temperatures are likely to result in a reduction in populations of animals that are dependent on sea ice, such as polar bears, seals, walruses and certain seabirds. Reindeer husbandry will suffer in mild winters with high precipitation, when grazing areas will be ice-covered. A warmer Arctic climate will also result in damage to infrastructure. Roads, power lines, oil pipelines and the foundations of buildings will be damaged when the permafrost melts. On the other hand, new maritime transport routes will open up as sea areas become ice free, and new petroleum and mineral deposits may become accessible. Developing strategies for adaptation to a changing climate requires more knowledge about the impacts of climate change on economic activity and people's ways of life.

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