Facts 2004

The energy sector and water resources in Norway

Ministry of Petroleum and Energy

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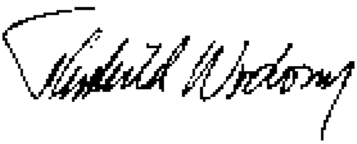
Foreword

This presentation of the energy sector and water resources in Norway is an annual publication from the Ministry of Petroleum and Energy. It provides information on energy production and consumption. Hydropower is described in detail, and separate chapters cover electricity transmission and the power market. The general management of ground water and river systems is also described.

No major changes from the 2002 edition have been made in this year's publication. One new feature is a description of the difficult position experienced in the Nordic electricity market during the winter of 2002–03. The coverage of research and development has been significantly revised to reflect changes to research programmes, while the review of international cooperation is restructured.

Every effort has been made to present the most up-to-date statistical material available. In virtually every case, figures for 2003 are presented.

This edition went to press on 26 May 2004.



Thorhild Widvey

Minister of Petroleum and Energy

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1.1 Introduction

Reliable energy supplies are becoming increasingly important for the normal functioning of a modern society. Energy is important everywhere – in industry, in business and in the home. Norway is well-endowed by nature with a number of primary energy sources, including crude oil, natural gas and water and wind power. These resources have been an important basis for economic growth and will continue to be important in the future.

This publication gives a general account of the energy resource base and energy production, transport, trade and use, with special emphasis on hydropower. The legislative framework for the energy supply sector in mainland Norway is described. All production, transport and use of energy involves adverse environmental impacts of various kinds and degrees, and these effects are also discussed. The purpose is to present facts about energy in Norway and to show how different aspects of energy production and use are interrelated. Explaining the principles underlying the political and administrative choices made, and the statutes and regulations adopted, has been important. Various statutes have marked important changes in the developmental framework for the energy sector in Norway. Two of these are the 1990 Energy Act and the 2000 Water Resources Act. The Energy Act facilitates competition in power generation and trading. Liberalisation and competition in the power sector also represent a fundamental principle for achieving socio-economic utilisation of the resources. The Water Resources Act takes a more resource-oriented approach to management of the country's river systems than earlier legislation. It regulates all types of interventions in watercourses, not primarily hydropower development.

The growing exchange of power between Norway and neighbouring countries is another consequence of the opening of the power market by the Energy Act, which has led to greater flexibility and more rational operation of the power supply sector. Involvement in international cooperation is another important result, since Norway also participates in the European energy market under the European Energy Area agreement. These issues are discussed in greater detail.

Oil and gas activities on the Norwegian continental shelf are described in other fact sheets from the Ministry of Petroleum and Energy. See its web site at www.odin.dep.no/oed

1.2 Summary

Chapter 1.3 describes government organisation of the energy and water resources sectors, with the emphasis on the responsibilities of the Ministry of Petroleum and Energy for the administration of domestic stationary energy supplies.

Chapter 2 describes various distinctive features of electricity generation. The main emphasis is on various aspects of hydropower generation because of its important role in Norwegian electricity supply. Hydropower accounts for 99 per cent of the electricity generated. The average production capability of Norway's hydropower stations is estimated to be about 119 TWh/year. Annual production varies to a great extent in line with precipitation levels. In 2003, electricity generation totalled 107.1 TWh as against a record level of 143 TWh in 2000 and only 105 TWh in 1996. Figures from Statistics Norway show that the power supply sector accounted for about three per cent of mainland Norway's gross domestic product in 2000. This corresponds to NOK 37.2 billion.

Electricity generation from sources such as natural gas and wind is also discussed in Chapter 2. In 2003, 0.22 TWh of wind power and one TWh of thermal electricity were generated. The environmental impact of some types of electricity generation are discussed, and the chapter also covers taxes and fees in the power sector.

Chapter 3 describes energy use and factors influencing its development. Net domestic energy use was 787 PJ (corresponding to 219 TWh) in 2003. About two-thirds of this, or 588 PJ, was used for stationary purposes[1]. Net stationary consumption of electricity was 103 TWh in 2003 (corresponding to about 370 PJ), or about two-thirds of total stationary energy use. Consumption of heating oils, paraffin and so forth accounted for 11.9 per cent of total stationary energy use, and natural gas for about 2.7 per cent. Recorded use of bio-energy (wood, black liquor and waste) provided 6.5 per cent and district heating one per cent. Households and the service sector used six PJ of district heating in 2003, corresponding to 0.9 per cent of total stationary energy use. Waste accounted for half the energy used to generate district heating.

Other topics discussed in Chapter 3 include the use of gas in Norway and the environmental impact of energy use. Hydrogen as an energy carrier is discussed. Measures to limit energy use are described, along with Enova SF and its contribution to restructuring energy production and use.

Legislation relating to energy and water resource management regulates every area from hydropower development via transport to energy use. Chapter 4 describes the legislative framework for the sector. Among other things, the legislation governs relations between different user groups and includes provisions relating to environmental considerations and landscape conservation.

The power supply sector consists of many different types of energy utilities. These vary in both size and their form of business organisation and ownership. About 85 per cent of production capacity is publicly owned, 55 per cent by counties and local authorities, and 30 per cent by central government. The structure of the market is constantly changing through acquisitions and mergers. Chapter 5 describes the latest developments in organisation and ownership of the power supply sector. Key figures for the sector are also presented.

Most energy carriers are transported by road and rail, like other goods. However, the transmission of electricity depends on a continuous infrastructure of transmission and distribution grids. This infrastructure is regarded as a natural monopoly. Monopoly regulation has therefore been established to safeguard consumer rights and ensure efficient development of the grid. Regulation of grid management and operations is described in Chapter 6.

Chapter 7 describes the framework for electricity trading in the Nordic region. It covers the physical basis for the single power market which now exists in Norway, Sweden and Finland, and Norway's transmission connections to other countries. An introduction is provided to the functioning of the power market and the organisation of its component markets. The chapter also provides an introduction to price formation in the Nordic power market and how this relates to production conditions in the region.

Technological and political developments internationally can affect operating conditions for the sector. For example, international climate negotiations may determine important parameters for trends in energy use and production in Norway, and for the value of hydropower. Chapter 8 discusses research and development, while international energy cooperation is described in Chapter 9.

Many conflicting interests collide when river systems are utilised for specific purposes. Water supply is the oldest use we know of. Fishing, communications, irrigation and hydropower generation are also widespread applications. The importance of different interests and uses varies from one river to another. User interests have also changed over the years. Chapter 10 describes the management of water resources in Norway.

The energy and power units used in this publication are defined in Appendix 1,

[1] Stationary energy use represents net domestic energy use minus energy for transport purposes, international maritime transport and the energy sector itself.

which also presents conversion factors between the most commonly used energy units. In addition, the appendix specifies the energy content of various fuels.

Water inflow to the hydropower stations in Norway, Sweden and Finland was unusually low during the autumn of 2002, which led in turn to a tight electricity supply position in the Nordic market during the winter of 2002–03. These conditions and the power balance in Norway are discussed in appendix 2

Appendix 3 provides an overview of transmission capacity between the Nordic countries, while appendix 4 lists the web sites of some important players in the energy sector.

Unless otherwise stated, statistical data relating to energy production and use in this publication are taken from the energy accounts compiled by Statistics Norway. More information on the energy accounts can be found on Statistics Norway's web site at www.ssb.no.

1.3 State organisation of the energy and water resources sector

The Storting (parliament) determines the political framework for the energy sector and water resource management in Norway. The Ministry of Petroleum and Energy (MPE) has overall administrative responsibility for these sectors, and is responsible for ensuring that activities follow the guidelines drawn up by the Storting.

1.3.1 The Ministry of Petroleum and Energy

The Ministry of Petroleum and Energy has overall responsibility for an integrated energy policy based on efficient utilisation of energy resources.

It comprises four departments, for energy and water resources, petroleum, E&P and market, and administration, budgets and accounting. See figure 1.1

The departments for E&P (exploration and production) and market and for petroleum are responsible for administering oil and gas activities on the Norwegian continental shelf. This part of the Ministry's responsibilities is not discussed here. More information can be found in *Facts 2004 – The Norwegian petroleum sector, Environment 2004 – the petroleum sector in Norway* and on the Ministry's web site at www.odin.dep.no/oed.

The administration, budgets and accounting department deals with administrative matters and general services. Its tasks include organisational matters, personnel management, budgeting and economic affairs.

The responsibilities of the energy and water resources department are the subject of this publication. Its main objective is to ensure sound management, in both economic and environmental terms, of water and hydropower resources and other domestic energy sources. The department acts for the government as owner of the Statnett and Enova state enterprises. The Norwegian Water Resources and Energy Directorate (NVE) is a subordinate agency of the MPE responsible for the management of energy and water resources in mainland Norway.

On 1 January 2002, responsibility for exercising the government's ownership function for Statkraft SF was transferred from the Ministry of Petroleum and Energy to the Ministry of Trade and Industry.

The energy and water resources department consists of the following sections:

Water resources
Its responsibilities include water resource management, watercourse regulation and hydropower development. It also deals with water resource legislation in general and issues related to watercourse protection and licensing.

New renewable energy sources and energy use
This section is responsible for policy instruments intended to achieve a shift in energy production and use. It also administers

funds earmarked for increasing environmentally-sound energy production and for raising people's awareness of their energy use, and acts for the government as owner of the new Enova state enterprise. In addition, research and development issues are part of its responsibilities.

Power market

The main responsibilities of this section are the power market in Norway and trade in power with other countries, and the government's ownership function in relation to Statnett SF. Following up Statkraft's contracts with energy-intensive industry is among its duties. These also include regulation of grid management and operations, issues relating to transmission tariffs, and economic topics relevant to the power supply sector, including taxes and fees.

Energy

The section's main responsibilities are general energy policy issues and analyses relating to the energy and power balance. It also deals with environmental issues raised by stationary energy supplies.

Energy law

The section's main responsibilities are legal issues related to administration of the energy sector. These include licensing procedures under the Energy Act for electrical installations, power lines and district heating facilities. The section is also responsible for considering exemptions from licence requirements and pre-emption rights for power stations.

International

The section is responsible for internal coordination of international issues in the energy and water resources department and for administrative matters. Administrative responsibility for the NVE also lies here.

1.3.2 Norwegian Water Resources and Energy Directorate

The NVE is a subordinate agency of the Ministry of Petroleum and Energy responsible for administration of Norway's water and energy resources.

Its job is to ensure coherent and environmentally-sound management of river systems and to promote efficient electricity trading, cost-effective energy systems and effective energy use. It also plays a central role in emergency response to flooding and dam failure, and heads contingency planning for power supply.

Other duties relate to research and development work and to international cooperation within its sphere of responsibility. In addition it serves as Norway's national hydrological institution.

1.3.3 Norwegian Petroleum Directorate

The Storting resolved on 2 June 1972 to establish a Norwegian Petroleum Directorate (NPD). This is a subordinate agency of the Ministry of Petroleum and Energy. From 1 January 2004, the directorate was split into two independent agencies, the NPD and the Petroleum Safety Authority Norway (PSA) – see below.

The NPD's most important duties are:

to exercise the administrative and financial control required to ensure that exploration for and production of petroleum accord with statutes, regulations, decisions, licence terms and so forth

to ensure that exploration for and production of petroleum resources accord with the guidelines laid down by the Ministry

to advise the Ministry on issues relating to exploration for or production of submarine natural resources.

1.3.4 Petroleum Safety Authority Norway

The PSA was established on 1 January 2004 through a division of the NPD. This regulator is responsible for safety, emergency response and the working environment in the petroleum business, and is a subordinate agency of the Ministry of Labour and Social Affairs.

1.3.5 Statnett SF

Statnett SF was founded in 1992. The Ministry of Petroleum and Energy acts as its owner on behalf of the government, as specified in the Act of 30 August 1991 relating to state enterprises.

Statnett SF is responsible for the construction and operation of the central electricity grid. It owns about 87 per cent of the central grid, and operates the entire system. Statnett also has short- and long-term system responsibility. This means that it coordinates the operation of the entire Norwegian electricity supply system, and ensures that the amount of electricity generated is always equal to the amount consumed.

Statnett's revenues are regulated by the NVE as part of its regulation of monopoly operations.

1.3.6 Enova SF

Enova SF was founded on 22 June 2001. Based in Trondheim, it is subordinate to the Ministry of Petroleum and Energy.

On 1 January 2002, Enova became responsible for government efforts to restructure energy production and use. This work had previously been split between the NVE and the electricity distribution utilities. Enova's activities are financed from an Energy Fund, which receives the revenues generated by a levy of NOK 0.01 per kWh on the distribution tariff, and from ordinary appropriations over the central government budget. Its tasks are to promote more efficient energy use, the production of new renewable forms of energy, and environment-friendly uses of natural gas. Quantitative goals have been set for Enova's activities.

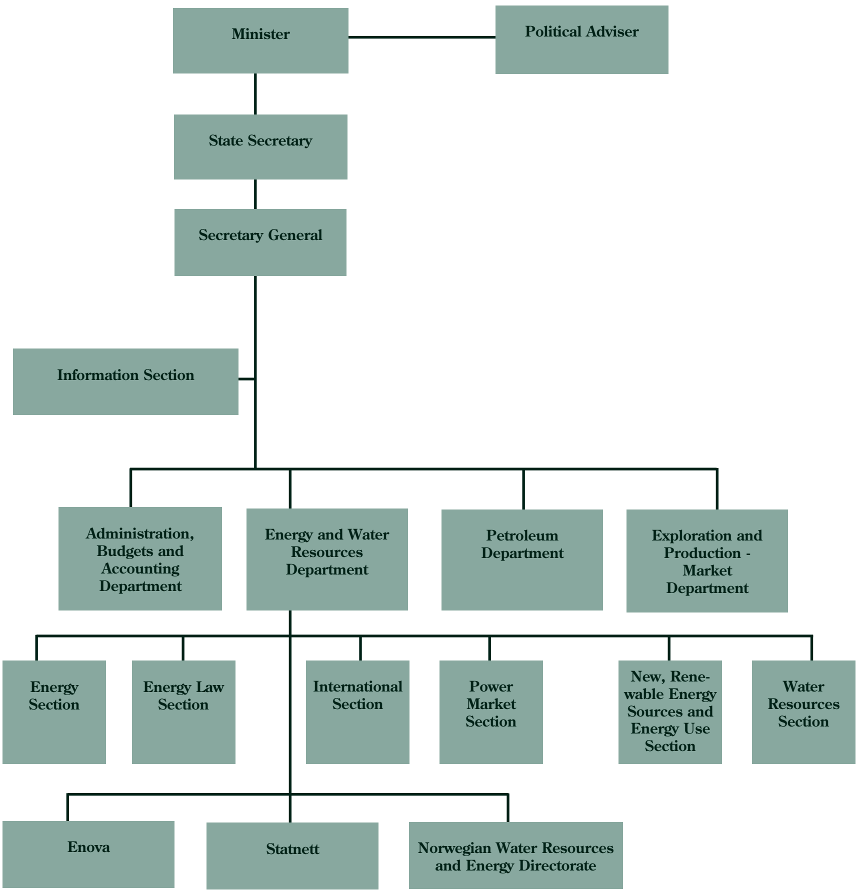

Figure 1.1 Organisation of the Ministry of Petroleum and Energy

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Electricity generation

– Hydropower

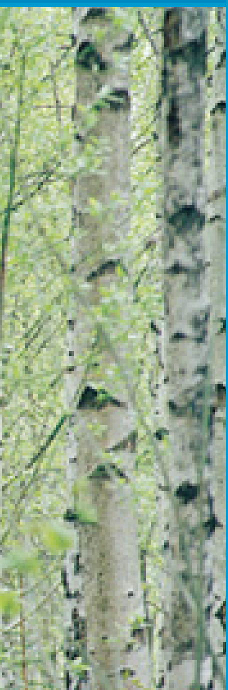
– Wind power

– Gas-fired power stations

– Other forms of electricity generation

– Taxes and fees in the power sector

– The role of the electricity supply sector in the Norwegian economy



2.1 Hydropower

Norway's river systems are very important both for commercial interests and for public interest generally – in connection with outdoor recreation, for instance. Electricity generation is the most important commercial use of Norwegian river systems.

A river system comprises a river and all its tributaries from source to sea, including any lakes, snowfields and glaciers in the catchment area. There are about 4 000 river systems in Norway. In some counties, almost all the larger rivers have been developed. Seven of Norway's 10 highest waterfalls have been developed, and the remaining three are permanently protected against such developments. See table 2.1. To increase electricity output, water is commonly transferred from one part of a river system to another or even between neighbouring river systems. In many cases, several power stations have been built in the same river system.

Great variations in topography, precipitation and climate in Norway mean that its river systems include a wide range of types. Rivers in western Norway, Nordland county and parts of Troms county are generally short and steep, with many waterfalls, while eastern Norway, the Trøndelag region and Finnmark county have much longer systems which carry a large water volume but drop more gently to the sea.

Volume and head of water determine the potential energy of a waterfall. The head of water is the height difference between reservoir intake and power station outlet. Water is directed into pressure shafts leading down to a power station, where it strikes the turbine runner at high pressure. The kinetic energy of the water is transmitted via the propeller shaft to a generator, which converts it into electrical energy.

Low-head power stations often utilise a large water volume but have a small head, as in a run-of-river power station. Since regulating the flow of water is difficult, it is generally used as and when available. The amount of electricity generated therefore rises considerably when the river is carrying more water –during the spring thaw, for example, or when precipitation is very high. Most run-of-river power stations are situated in lowland areas, particularly in eastern Norway and Trøndelag. Several run-of-river power stations stand along the Glomma river. Solbergfoss power station at Askim in Akershus county has the largest low-head turbine in Norway.

High-head power stations are generally constructed to utilise a large head but smaller volume of water than run-of-river installations. Such facilities depend on water storage in reservoirs, and are also called power stations with reservoirs. They usually have a larger installed capacity than run-of-river sta-

Table 2.1 Norway's highest waterfalls (height of vertical drop)

Waterfall	Height (m)	State	Licensed or protected
Tyssestrengen	300	Developed	1964 Tyssefaldene A/S
Ringdalsfossen	300	Developed	1964 Tyssefaldene A/S
Skykkjedalsfossen	300	Developed	1973 Statkraft
Vettisfossen	275	Permanently protected	1923 Nature Protection Act
Austerkrokfossen	256	Developed	1966 Elektrokjemisk A/S
Søre Mardalsfossen	250	Developed	1973 Statkraft
Storhoggfossen i Ulla	210	Developed	1973 Statkraft
Vedalsfossen	200	Permanently protected	1980 Protection plan II
Feigefossen	200	Permanently protected	1986 Protection plan III
Glutrefossen	171	Partly developed	1973 Statkraft

Source: Committee on the Watercourses Act tions, but a shorter utilisation period. A high-head power station is often excavated near the reservoirs used to regulate the volume of its water supply. Power station and reservoirs are connected by tunnels through the rock or pipes down the mountainside.

Power stations with an installed capacity of up to 10 MW are designated as small, and usually sub-divided into the following categories:

- micro (installed capacity below 0.1 MW)
- mini (installed capacity from 0.1-1 MW)
- small (installed capacity from 1-10 MW)

Small power stations are often installed on streams and small rivers without regulation reservoirs. Their output will then vary with the level of water flow.

2.1.1 Water inflow

Water inflow is the volume of water flowing from the entire catchment area of a river system into the reservoirs. A catchment area is the geographical area which collects the precipitation which runs into a particular river system. Useful inflow is the amount of water which can be used for hydropower generation.

Precipitation levels vary from one part of the country to another, between seasons, and between years. Precipitation is highest in coastal and central parts of western Norway. There is also a clear tendency for precipitation to increase with elevation above sea level. Mean annual precipitation is lowest in the upper Otta valley (300 mm) and in inland parts of Finnmark county (250 mm). The mean annual precipitation in much of western Norway is 3 000-3 500 mm.

Inflow is high during the spring thaw, but normally decreases during summer. High rainfall generally results in an increase before the onset of winter, when inflow is normally very low.

It also varies during the year, depending on local geographical and climatic conditions. The spring thaw is later in inland regions and in the mountains than near the coast and in lowland areas. In much of lowland eastern Norway, western Norway and Trøndelag, the rivers run highest during May. The highest water levels near the coast occur at the end of April, but are delayed until June or July in inland and upland regions. In northern Norway, discharge volumes reach a peak in June, or somewhat earlier in coastal areas.

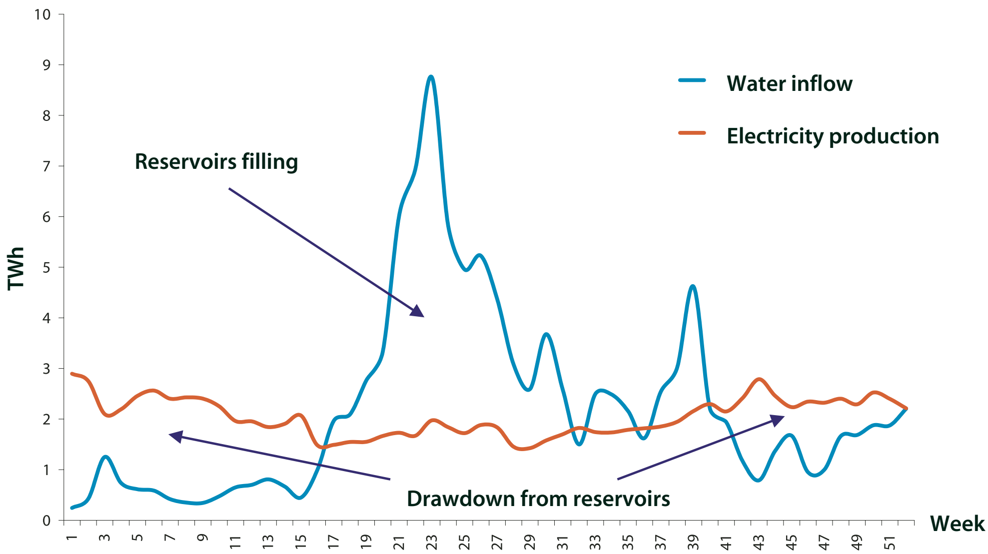


Figure 2.1 Variations in water inflow and electricity output during a year

Source: Nord Pool

Precipitation varies substantially from year to year and is more than twice as high in the wettest years as in the driest ones.

From 1980 and 1993, precipitation in several years was high and ensured high water inflow for power generation. It was relatively low in 1993 and 1994 but very high in 1995 – resulting in record power generation. Inflow and electricity generation were considerably below normal levels in 1996. Since then, the level of inflow has been relatively high, and particularly so in 2000. Inflow in both 2002 and 2003 was below the normal level. However, variations through the year were considerable in 2002. From January-July, inflow was 89 TWh or 12 TWh above the normal level. However, the autumn was unusually dry with very low inflow. It was no more than 22 TWh, or 19 TWh below normal. Variations in actual power generation from year to year over the past decade can be attributed primarily to differences in inflow, since generating capacity increased very little.

In addition to variations in inflow, electricity demand fluctuates over the year and is much higher in winter than in summer. In fact, the pattern of demand – and thus the amount which must be generated – is generally the reverse of inflow variations. When inflow is high, output is often low – and vice versa. Figure 2.1 shows the relationship between mean output and useful inflow over a year. Consumption can also vary considerably between years because temperature changes affect the amount of electricity needed for heating.

2.1.2 Regulation reservoirs

The potential energy of water can be stored in regulation reservoirs constructed either in natural lakes or in artificial basins created by damming a river. Water is collected in the regulation reservoirs when inflow is high and consumption low. When inflow is low and consumption high, stored water can be drawn from the reservoirs and used to generate electricity. Regulation reservoirs are generally situated in sparsely populated areas, and usually at high altitudes in the mountains in order to make the fullest possible use of the head of water. The difference between the highest and lowest permitted water levels in a reservoir is stipulated in a watercourse regulation licence (rules for reservoir drawdown), which takes into account of such factors as topography and environmental considerations.

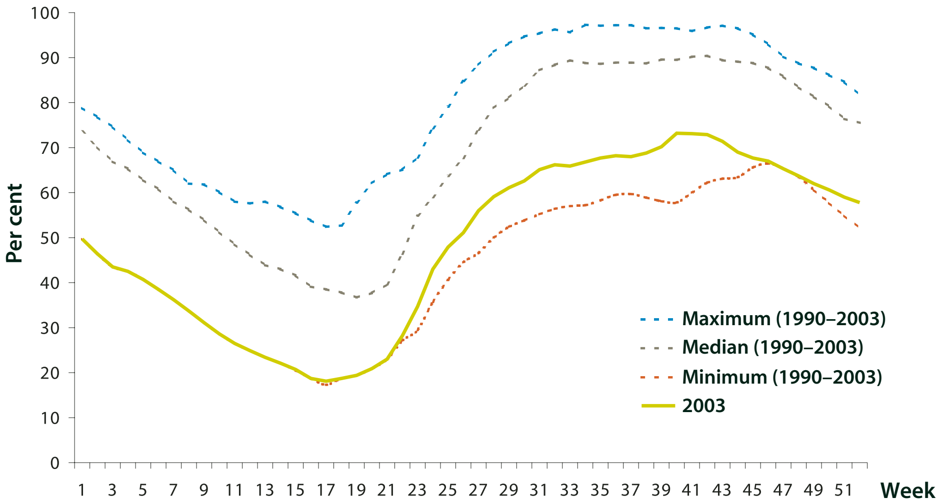


Figure 2.2 Degree of filling of reservoirs in 2003

Source: Norwegian Water Resources and Energy Directorate

Storing water in the summer for use in winter months, when the demand for power peaks, is known as seasonal regulation.

Dry- or multi-year regulation is made possible by large reservoirs which can store water in wet years for use in years when precipitation is low. Short-term regulation involves a daily or weekly filling and emptying cycle.

A reservoir's energy capability is the amount of power which can be generated when it is full. Since 1980, the energy capability of Norway's reservoirs has risen by just over 26.5 TWh. At 1 January 2004, the total energy capability was about 84.3 TWh, corresponding to just over two-thirds of annual electricity consumption. The degree of filling of the reservoirs is a measure of how much water (potential energy) they contain at any given time. Figure 2.2 shows changes in the degree of filling during 2003, and the minimum, median and maximum degree of filling in the 1990–2003 period, expressed as a percentage of the total energy capability of the reservoirs.

Normally, water will be drawn off during the autumn and winter when electricity demand is highest. Demand reaches its lowest level in spring and summer, and the reservoirs refill. Changes in the degree of filling of the reservoirs reflect variations in electricity generation and water inflow during the year.

An economic gain can be obtained by pumping water uphill to a reservoir with a greater head of water, because the potential energy of water increases in proportion to its head. If electricity prices are low, it may be profitable for operators to use power to move water to a reservoir at a higher altitude, so that the water can be used for generation when prices rise again.

2.1.3 Electricity generation

Norway now has a total installed capacity of about 27 700 MW at 581 hydropower stations larger than 1 MW. In addition come 255 MW from thermal[2] and 100 MW from wind power stations. The mean annual generating capability of a hydropower station is calculated from its installed capacity and the expected annual inflow in a year of normal precipitation. Thirty years is the standard period used to calculate normal

[2] "Thermal power station" includes all facilities generating electricity from fossil fuels, biofuels or nuclear energy.

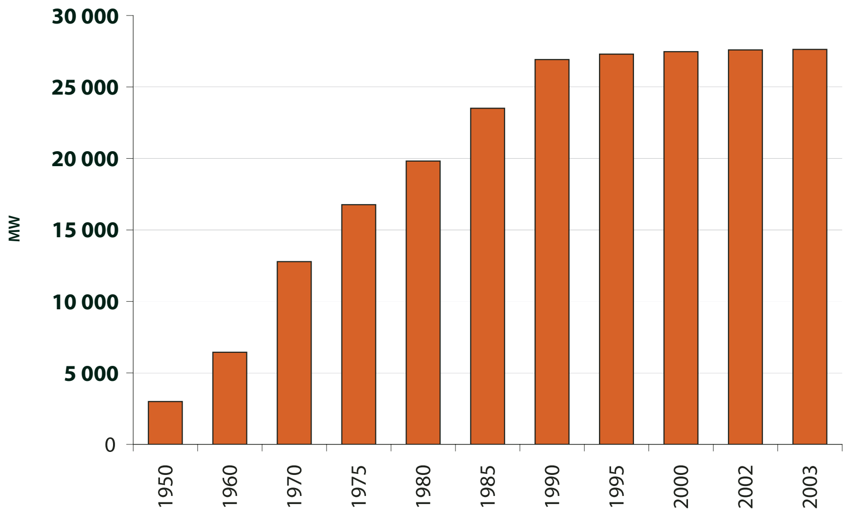


Figure 2.3 Installed capacity

Sources: Norwegian Water Resources and Energy Directorate and Statistics Norway

Table 2.2 The 10 largest power stations in Norway, 1 January 2004

Power station	County	Max capacity MW	Mean annual output GWh/year
Kvilldal	Rogaland	1 240	3 517
Tonstad	Vest-Agder	960	4 169
Aurland I	Sogn og Fjordane	675	2 407
Saurdal*	Rogaland	640	1 291
Sy-Sima	Hordaland	620	2 075
Rana	Nordland	500	2 123
Lang-Sima	Hordaland	500	1 329
Tokke	Telemark	430	2 221
Svartisen	Nordland	350	1 996
Brokke	Aust-Agder	330	1 407

** Pumped storage power station*

Source: Norwegian Water Resources and Energy Directorate

values for meteorological and hydrological variables. Generation from the Norwegian electricity system – hydro, wind and thermal power – in a normal year is now calculated to be about 119 TWh.

The largest hydropower development projects were carried out between 1970 and 1985, when installed capacity increased by 10 730 MW, or an average of 4.1 per cent per year. Towards the end of the 1980s, Norway's rate of hydropower development declined. Expansion in generating capacity was small during the 1990s, rising by about 750 MW from 1993-2004. The increase in the 1990s came from upgrading and expanding older power stations to make better use of their capacity, and from the construction of some new small-scale installations. Figure 2.3 shows the growth in installed capacity.

The 10 largest power stations in Norway account for about a quarter of the country's generating capacity. Statkraft SF is the largest electricity generator in the country, accounting for about 30 per cent of total capacity. Table 2.2 lists the 10 largest power stations in Norway at 1 January 2002.

Installed capacity, mean output and utilisation period

The maximum power output (MW) of a hydroelectric power station increases in proportion to the product of the head of water and the water volume per unit time, but is limited by the installed machine capacity. The amount of electricity generated (MWh) in a given time period is equal to the product of the average power output and the time. For example, a power station which operates on average at an installed capacity of one MW for one year (8 760 hours) will generate 8 760 MWh (8.76 GWh).

Variations in water inflow and electricity consumption mean that a hydropower station does not operate continuously at maximum capacity. The average utilisation period for a power station is defined as the number of hours required to generate electricity equivalent to mean annual output when operating at maximum capacity. Thus, a power station with a mean annual inflow equivalent to 200 GWh and an installed capacity of 50 MW has a utilisation period of 4 000 hours. The average utilisation period for most Norwegian power stations is between 3 500 and 5 000 hours per year.

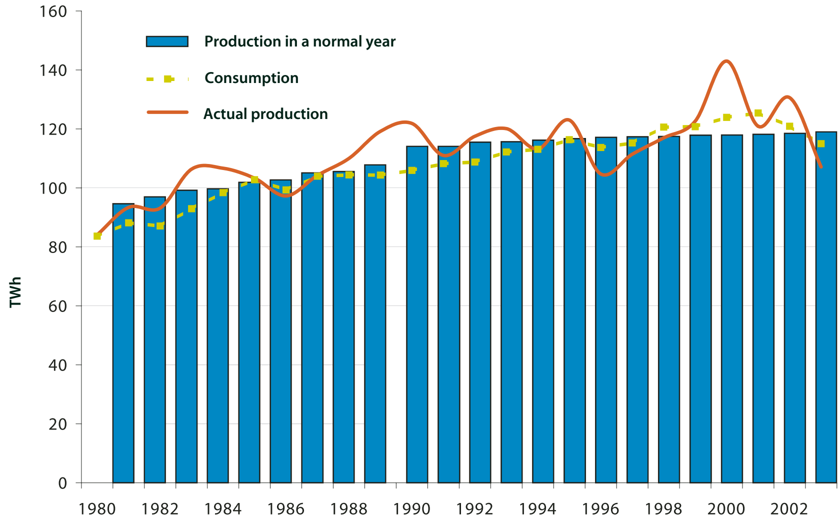


Figure 2.4 Trends in hydropower output and mean annual generating capability

Source: Norwegian Water Resources and Energy Directorate

Kvilldal power station in Rogaland county is Norway's largest, with a maximum generating capacity of 1 240 MW. This corresponds to about 4.5 per cent of the Norwegian total. Table 2.3 shows the numbers and installed capacity of hydroelectric power stations in various size groups at 1 January 2002.

Electricity output in western and southern Norway and in Nordland county exceeds local consumption. In eastern Norway, on the other hand, electricity consumption is much higher than the amount generated in the region. This means that power must be transmitted from western and northern regions to the south and east of the country.

The flow of electric power between regions of Norway is also influenced by power exchange with Denmark, Sweden and Finland. Current transmission capacity from Norway to its neighbours is about 4 000 MW. The connections are used for both import and export of power (see Chapter 7). Power output was generally above average in the second half of the 1980s and the beginning of the 1990s because inflow was high. It was below the mean level in both 1996 and 1997. In 1998–2001, hydropower output was generally relatively high. Precipitation was above normal for several years in a row, with hydropower output high as a result. In 2000, a new generation record of

Table 2.3 Hydropower stations in operation at 1 January 2004 by size and total installed capacity *

MW	Number	Total installed capacity, MW	Mean annual output, GWh/year
0–0.1	74	3	18
0.1–1	98	14	74
1–10	258	952	4 323
10–100	246	8 985	40 766
100–	77	17 764	73 326

** Figures for power stations below one MW are based on a study of micro and mini power stations connected to the grid, carried out by SKM Energy Consulting and completed in 2000.*

Source: Norwegian Water Resources and Energy Directorate

143 TWh was set, while total output in 2001 was only slightly higher than in a normal year at 120.9 TWh. Figure 2.4 shows trends in mean annual generating capability and actual hydropower output in Norway from 1980 to 2001.

2.1.4 Hydropower potential

Norway's hydropower potential is the amount of energy in its river systems which is technically and financially available to generate electricity, and was calculated to be 186.5 TWh/year at 1 January 2004. These calculations are based on 1970–99 the reference period. Figure 2.5 shows Norway's hydropower potential at 1 January 2004. This includes river systems developed for hydropower, under development and protected. Other categories are rivers covered by licence applications, for which licences have been granted or refused, and for which prior notification of applications has been submitted.

Of Norway's total hydropower potential, 36.5 TWh is in protected watercourses, and applications for development projects corresponding to 1.4 TWh have been refused. These two categories are therefore unavailable for development, leaving a potential of 30.2 TWh in river systems not protected from hydropower development.

At 1 January 2004, the developed mean annual generating capability was 118.4 TWh. In addition, projects with a capacity of 1.2 TWh were under construction, and the development of a further 1.4 TWh had been licensed.

Most hydropower projects were classified in the White Paper on a Master Plan for Water Resources. The various categories used in this Master Plan indicate the order in which river systems should be developed. Giving priority to the lowest-cost projects and those with the fewest conflicts of interest is considered important. The Master Plan is further discussed in Chapter 4.2.1.

Upgrading hydropower stations involves modernising them to use more of the potential energy of the water. In addition, operating costs can be reduced and operating reliability improved. The head loss can be reduced by widening water channels and increasing tunnel cross section, for instance. Utilisation rates can also be improved by using more modern turbine and generator technology.

Expansion involves major works such as transferring water from other catchment areas, enlarging existing regulation reservoirs or constructing new ones, increasing the head of water or expanding technical installations to increase the available power

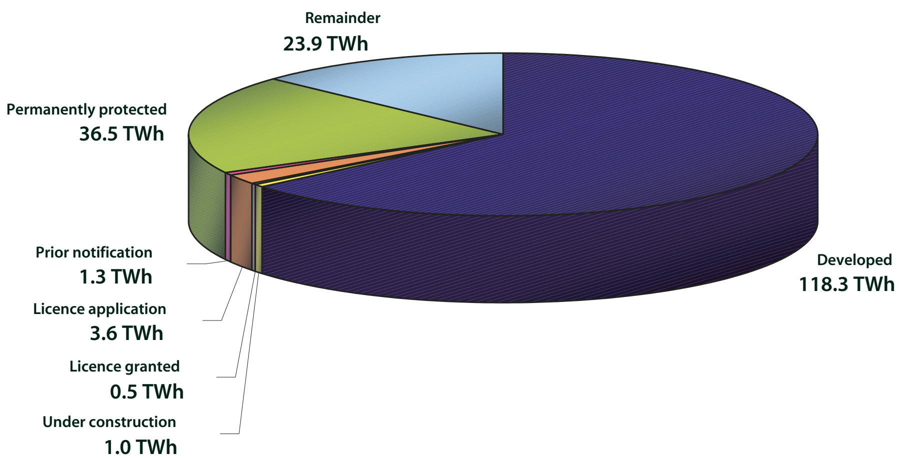


Figure 2.5 Norway's hydropower potential at 1 January 2003, TWh/year

Source: Norwegian Water Resources and Energy Directorate

output. It is estimated that upgrading and expansion can be used to increase output by about 11 TWh/year. Upgrading combined with expansion generally yields a bigger increase in electricity generation and better profitability than upgrading alone.

Most upgrading and expansion projects are classified as category I in the Master Plan for Water Resources. Some fall into category II, while others are not dealt with in the Master Plan or were exempted from it.

Developers themselves take the initiative on new projects, and also carry the economic risk. The latter is particularly high for hydropower developments because projects are very capital-intensive, the future price of electricity is uncertain, and their costs vary widely.

2.1.5 Norwegian expertise in the hydropower sector

Norway is the sixth largest hydropower generator in the world and the biggest in Europe. The Norwegian hydropower industry is more than a century old. During this period, Norway has developed expertise covering all stages of hydropower development, from planning and design to the delivery and installation of technical equipment. In addition, the authorities have built up expertise in statutory regulation and management of hydroelectric resources.

Norway has already developed a large proportion of its available hydropower potential, and Norwegian industry is now competing for assignments abroad. Norwegian companies operate in many parts of the world, including southern and eastern Africa, South America and Asia. They provide consultancy services in planning, design and engineering as well as turbines and electromechanical products. In addition, demand for Norwegian expertise in system operation and power market development is growing.

2.1.6 Environmental impact of hydropower developments

Converting hydropower to electricity is a clean process. Norway generates more than 99 per cent of its electricity in this way. However, the development of river systems does have an environmental impact, directly in the form of land use and more indirectly in the fragmentation of areas of the natural environment and in the regulation of lakes. In addition to the actual generating installations, facilities such as access roads, quarries and rock tips are generally needed. Access roads tend to increase traffic and may result in changes to land use.

Such developments can reduce the aesthetic value of the landscape. At the same time, however, a number of the older hydropower installations are considered to be important cultural and industrial monuments.

Hydropower development and generation can have various impacts on the flora and fauna in and around river systems. Rapid changes in generation and therefore in water volumes discharged are characteristic outcomes. Changes in discharge volume can affect fish stocks and other freshwater organisms.

The anticipated environmental impact is the main reason why many Norwegian rivers are protected against hydropower development. See Chapter 4.2.1. Licence applications for hydropower projects in other river systems go through extensive procedures, including a thorough review of the environmental impact. An application may be refused on environmental grounds. The authorities may also require measures to mitigate the impact of a development project. Examples include requirements to establish a fund for stock enhancement or rules on the minimum permitted rate of flow if regulation damages fish stocks in a river. The legislative framework for hydropower developments is described in more detail in Chapter 4.

2.2 Wind power

A wind power station comprises one or more wind turbines and the necessary electrical installations. When several turbines are installed, it is often called a wind farm. The wind turbine consists of tower, rotor and blades, and a turbine head containing a generator and control system. Wind energy is transmitted via the propeller shaft to a generator inside the turbine head. The generator converts the kinetic energy into electricity, which is then transmitted via cables. Several types of wind turbine exist.

A modern wind turbine generates electricity when the wind speed at hub height reaches four to 25 metres per second (m/s) – from gentle breeze to storm. At wind speeds exceeding 25 m/s, the blades lock and the turbine shuts down. The available wind power is proportional to the cube of the wind speed. In practice, a wind turbine utilises up to 40 per cent of the wind energy which passes the blades. The maximum theoretical energy utilisation rate is about 60 per cent.

The annual utilisation period for a wind turbine in Norway is expected to exceed 3 000 hours at favourable sites. In many places, the average annual wind speed over a year is six to eight m/s at a height of 10 m above ground. The wind speed will typically be 10-20 per cent higher at the relevant operating height for wind turbines, depending on the local topography. See the box in section 2.1.3 for a more detailed explanation of the utilisation period.

A number of suitable sites for wind power development are found all along the Norwegian coast, from Lindesnes in the south to Kirkenes in the north, and in the mountains. Norway had 55 wind turbines at 1 January 2004 with an installed capacity of about 100 MW. Some 220 GWh (0.22 TWh) was generated during 2003.

In addition to the facilities built and put into operation, six new wind power projects have been licensed by the NVE. These could generate about 1.5 TWh/year if they are all constructed. See table 2.4. Another six projects with a potential annual output totalling 1.8 TWh are under consideration by the NVE. More information about these schemes can be found on the directorate's web site at www.nve.no.

Technological developments and longer production series have contributed to a substantial reduction in the investment cost of wind power. Over the past 15 years, the investment cost per square metre of blade area have been halved while output has risen considerably. Current generation costs are estimated to be about NOK 0.25–0.30 per kWh at sites with good wind conditions and moderate development costs. Costs may even be below this level for certain projects where these factors are particularly favourable.

Table 2.4: Wind power projects licensed at 1 January 2004 but not yet operational

	Capacity MW	Annual output GWh/year	Licensed
Gartefjellet, Finnmark	40.0	120	August 2003
Hundhammerfjellet 3, Nord-Trøndelag	45.0	160	February 2002
Hitra, Sør-Trøndelag	56.0	150	September 2001
Smøla II, Møre og Romsdal	104.0	310	September 2001
Valsneset, Sør-Trøndelag	5.5	17	August 2001
Nygårdsfjellet, Nord-Trøndelag	7.0	21	July 2001
Kvitfjell, Troms	200.0	660	February 2001
SUM	457.5	1438	

Source: Norwegian Water Resources and Energy Directorate

Report No. 29 (1998-1999) to the Storting on Norwegian energy policy set a target of building wind power stations with a generating capacity of three TWh by 2010.

From 1 January 2002, the Ministry of Petroleum and Energy has charged Enova SF with promoting wind power development. Investment grants represent the most important policy instrument in this context and are awarded only to facilities which have been granted a licence.

Wind power cannot be regulated in the same way as hydropower. Since such facilities necessarily operate when the wind is blowing, they can only cover part of electricity requirements.

2.2.1 Environmental impact of wind power developments

Wind power is a renewable energy source with no polluting emissions. However, wind farms can disturb plant and animal habitats. Birds may collide with the installations, and their construction may result in the decline and degradation of biotopes. Stations could reduce the aesthetic value of the landscape, and come into conflict with protection of the cultural heritage or business interests.

Insufficient experience is currently available to evaluate all the consequences of wind farms on Norwegian ecosystems. Most studies conclude that the risk of bird collisions is low, and suggest that it does not increase with installation height or rotor diameter.

A single wind turbine does not occupy much space (10-12 sq.m), but the total area lost may be considerable where the number of wind turbines is large, with a permanent access road and power lines connecting the wind farm to the existing electricity grid. However, crops can be grown and animals grazed very close to the wind turbines.

2.3 Gas-fired power stations

The term “gas-fired power station” is often used as a general designation for all facilities which use natural gas to generate electricity and possibly heat. Several types exist. One in which gas turbines generate all the electricity is known as a simple-cycle gas turbine station. Such facilities can be started up and closed down at short notice, and are therefore suitable for providing peak-load power. Running costs are relatively high. Plants of this type are currently found on fixed installations in the North Sea.

Generating electricity from gas turbines also produces heat. Combined-cycle gas turbine stations (CCGT) and cogeneration (combined heat and power – CHP) stations exploit this heat, making them considerably more efficient than simple-cycle gas turbine units. In CCGT stations, steam turbines are used to generate electricity from the waste heat given off by the gas turbines. In combination, these turbines can give a net efficiency for electricity generation of up to 60 per cent.

A cogeneration facility produces both electricity and heat – for space heating, for example. Surplus heat from steam turbines or in gas turbine exhaust fumes is carried to heat exchangers in an infrastructure which can use this energy. A cogeneration plant produces less electricity than a CCGT plant for the same level of gas consumption. However, it converts a larger proportion of the energy content of the gas to usable energy (more than 80 per cent) in the form of both electricity and heat.

Norway generally has a limited potential for using heat from electricity generation. The district heating infrastructure is less well developed in the large cities than in other European countries. A high concentration of users is required to make a district heating network or industrial utilisation of the heat profitable. However, cogeneration stations could be relevant for industrial applications in Norway.

A number of plans currently exist for building gas-fired power stations in Norway, and four projects have so far been licensed. Naturkraft AS has received licences for two facilities, Industrikraft Midt-Norge AS for one and Statoil for an integrated gas-fired power plant at its Snøhvit gas liquefaction plant in northern Norway. Only the last of these is under construction.

Naturkraft was granted construction and operating licences in 1997 for two gas-fired power stations at Kollsnes near Bergen and Kårstø north of Stavanger. Each of these CCGT facilities is due to have an installed capacity of about 400 MW, corresponding to an annual output of about three TWh each.

Naturkraft was granted discharge permits for the plants in 1999. The Storting debated the construction of gas-fired power stations in Norway during its consideration of the White Paper on Norwegian energy policy, and resolved that standards for CO_2 emissions from Norwegian gas-fired power stations should not to be stricter than those usually applied in other EEA states. In the autumn of 2000, the terms of Naturkraft's discharge permits were altered to accord with this decision. The amended permits were confirmed by royal decree in the following summer. Naturkraft's power station licences require construction to start no later than the autumn of 2007.

Industrikraft Midt-Norge was granted final construction and operating licences and a discharge permit for a cogeneration power station at Skogn in Nord-Trøndelag county during 2001. Plans call for a facility with an installed capacity of 800 MW, corresponding to an annual output of about 6.4 TWh of electricity and roughly 1.5 TWh of heat. The deadline for bringing this station into operation was postponed until 2009 in 2003, and the company has yet to take an investment decision.

Energy requirements for the Snøhvit gas liquefaction project are to be met by an integrated gas-fired power station providing 215 MW of electricity and 167 MW of heat, which was licensed in 2003. Plans call for an annual output of about 1.5 TWh. The gas-fired power station is due to be completed before the Snøhvit gas liquefaction plant comes on stream in 2006.

2.3.1 Sequestration of CO_2

Research into separation and deposition (sequestration) of CO_2 from power stations is currently being pursued in the USA, Japan and Europe, including Norway. CO_2 can be separated out either before or after being burnt for electricity generation, and several different technological concepts have been presented in recent years. The maturity of the various solutions varies. In some cases, substantial development work remains to be done, not least in relation to turbines. However, a common feature of these technologies is that the CO_2 reduction process is energy-intensive, and will therefore be expensive by comparison with other forms of power generation.

2.4 Other forms of electricity generation

Production processes in many industrial companies generate waste heat which can be used to generate electricity. The opportunities for and costs of this vary from company to company, depending on process technologies and location. Three ferro-alloy plants currently have heat recovery plants which generate just under 200 GWh/year of electricity. The annual potential for increased power generation from heat recovery in the ferro-alloy industry is estimated to be in the order of one TWh.

When district heating is produced from waste, some of the heat is provided for electricity generation. About 60 GWh was generated in this way in 2002.

Total thermal power generation was roughly one TWh in 2003.

Small quantities of electricity are generated by gas turbines at petroleum plants along the Norwegian coast. Modest quantities of electricity are also generated with gas turbines and engines. Gas from the Grønmo landfill in Oslo is used to generate electricity, for instance.

2.5 Taxes and fees in the power sector

Electricity consumption is subject to a tax which stands at NOK 0.0967 per kWh in 2004. All consumers in Finnmark county and some local authorities in northern Troms county are exempt from this tax. Central government revenues from the electricity tax are expected to total about NOK 4.4 billion in 2004. The tax rate was NOK 0.095 per kWh in 2003 and NOK 0.093 per kWh in 2002. With effect from 1 January 2004, the grid companies took over responsibility for collecting the tax. It had previously been collected by the electricity suppliers through their invoices.

All business activities have been exempted from the electricity tax with effect from 1 January 2004. A new electricity tax system was introduced on 1 July 2004. This made part of the electricity consumed by business activities subject to the tax.

Activities at the state-owned Enova company are financed through an energy fund, which receives income generated by a levy of NOK 0.1 per kWh on the grid tariff in 2004 as well as ordinary appropriations over the central government budget. Enova is charged with promoting more efficient energy use, new renewable energy forms and environment-friendly use of natural gas. See the section on Enova in chapter 3.8.

VAT is charged on electricity at the standard rate of 24 per cent levied on other goods and services subject to this tax. However, consumers in the northern Nordland, Troms and Finnmark counties are exempt from VAT on electricity.

All power utilities pay income tax at 20 per cent on their ordinary income to central government. Each local authority can opt to charge property tax on such companies. Utilities subject to the latter tax pay up to 0.7 per cent of the appraised value of their real property. This is calculated primarily on a profitability basis intended to reflect the market value of the property. In addition, hydropower is subject to a natural resource extraction tax and a tax on economic rent. About NOK 3.5 billion was raised by the natural resource extraction, economic rent and property taxes in 2002.

Local authorities and county councils receive a natural resource extraction tax of NOK 0.013 per kWh generated within their borders. Of this, NOK 0.011 is allocated to the local authority and NOK 0.002 to the county council. The calculation base for the tax on natural resource extraction is determined for each power station, and is the average of the plant's total output of electricity in the income year and the six preceding years. This ensures a stable level of income for the local authorities and county councils. The natural resource extraction tax does not impose any additional burden on the companies, since it is deductible from income tax. Should the natural resource extraction tax exceed income tax, the excess can be carried forward for deduction in later years.

Economic rent is the share of profit which exceeds the normal return on capital. Power utilities must pay tax to the central government at a rate of 27 per cent on any economic rent. Such rent arises because the company concerned is exploiting a natural resource which can be utilised with varying degrees of ease. Together with other taxes, the tax on economic rent ensures that a large part of the economic rent in this sector falls to the community.

Licence fees represent compensation for damage caused to districts in which water resources are exploited. They are also an instrument for allowing these districts to share in the financial return on hydropower development. With specified maximum and minimum limits, fees are determined by assessment. This evaluation gives weight to such factors as the degree of environmental disturbance and the profitability of the development. As the licensing authority, the NVE is entitled to adjust the licence fee every five years. Licence fees provided

NOK 475 million to local authorities and NOK 122 million to central government in 2003.

Local authorities affected by hydroelectric development are also entitled to buy a proportion of the power generated. The licensee can be required to sell up to 10 per cent of the electricity generated to the local authorities concerned. If this exceeds general power consumption in the local authority, the county council is entitled to buy the surplus. The licensee can also be required to sell five per cent of the power generated to the central government, but the latter has not exercised this right so far. The price paid by the power recipient must correspond roughly to generating costs or the full cost of delivery. Deliveries under these provisions total about 8.5 TWh/year. Taxes, power supplied under licence terms and fees from power installations account for a large proportion of total revenues in local authorities which host major hydroelectric developments.

2.6 The role of the electricity supply sector in the Norwegian economy

The gross product in the electricity supply sector in 2003 was NOK 37.2 billion, or roughly three per cent of gross domestic product in mainland Norway.

Real capital in the electricity supply system amounted to NOK 170 billion in 2003, corresponding to 5.3 per cent of fixed real capital in mainland Norway.

Investment in the power supply sector totalled about NOK 6 billion in 2003. Gross investment in the sector has declined over the past 15 years, particularly for the construction of new power stations. Investment in the grid has also fallen. Figure 2.6 shows trends in gross investments in the electricity supply system since 1980.

Employment in the electricity supply sector rose steadily during the 1980s and stabilised after 1989. The number of people employed has declined in recent years. About 15 000 people worked in the electricity supply sector in 2003.

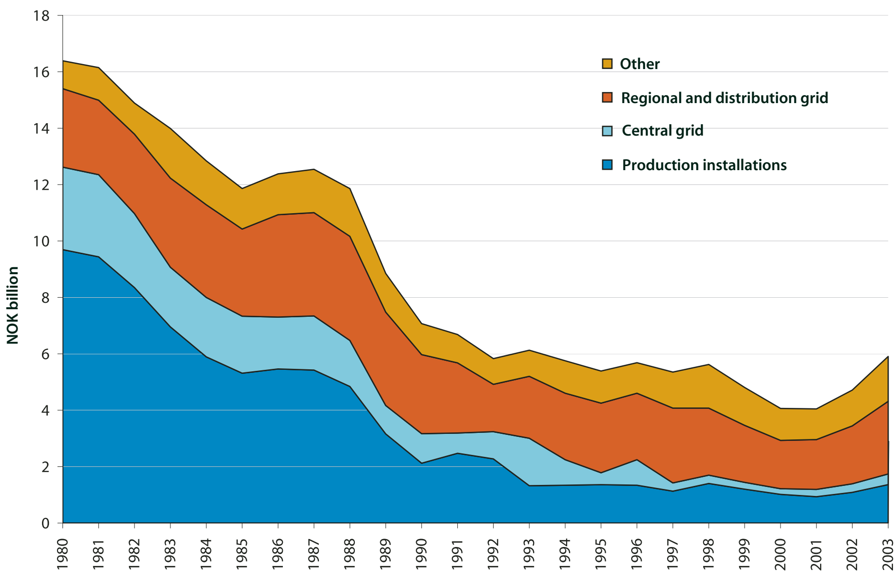


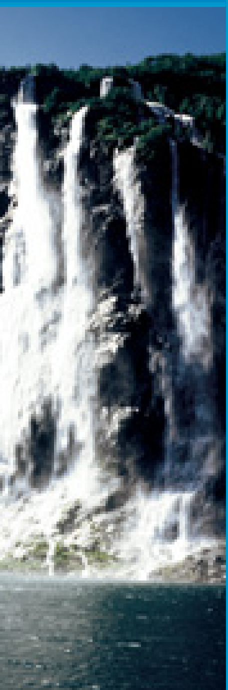
Figure 2.6 Gross investment in the electricity supply system. Fixed 2003 NOK

Sources: Norwegian Water Resources and Energy Directorate, Ministry of Petroleum and Energy

3

Energy use and heat production

- Factors influencing energy use trends
- Trends in energy use
- Energy use by sector
- Utilisation of various energy sources for heating
- Gas consumption in Norway
- Hydrogen
- Environmental impact of energy use
- Measures to limit energy use



3.1. Factors influencing energy use trends

A country's energy use and material living conditions are normally closely related. Generally speaking, energy use rises with economic growth because the need for energy increases as more goods and services are produced. Economic growth means higher household incomes which are devoted in part to expanding consumption, including the direct and indirect use of energy.

The effect of economic growth on energy use will depend on which sectors of the Norwegian economy are growing. Energy usage varies widely from one sector to another in terms of both energy mix and energy intensity in production.

Considerable developments have occurred with electrical products for private households and industry. Falling product prices combined with rising disposable incomes have made new products available to more people. Many products once confined to the few are now to be found in most homes.

Demographic factors such as population size, age structure, settlement patterns and the number and size of households have an impact on energy demand. Population growth leads to an increase in energy use because more houses, schools and commercial buildings are built, and these need heating and lighting. Population growth also results in higher consumption of goods and services produced with the aid of energy.

Energy use will be higher for a given number of people living in many small households rather than in fewer large households. Over the past few years, the number of Norwegian households has increased by more than would be expected from population growth alone.

Energy use also depends on energy prices. Higher energy prices boost production costs for industry as well as the cost to households of using electricity and other energy carriers. This usually constrains energy use.

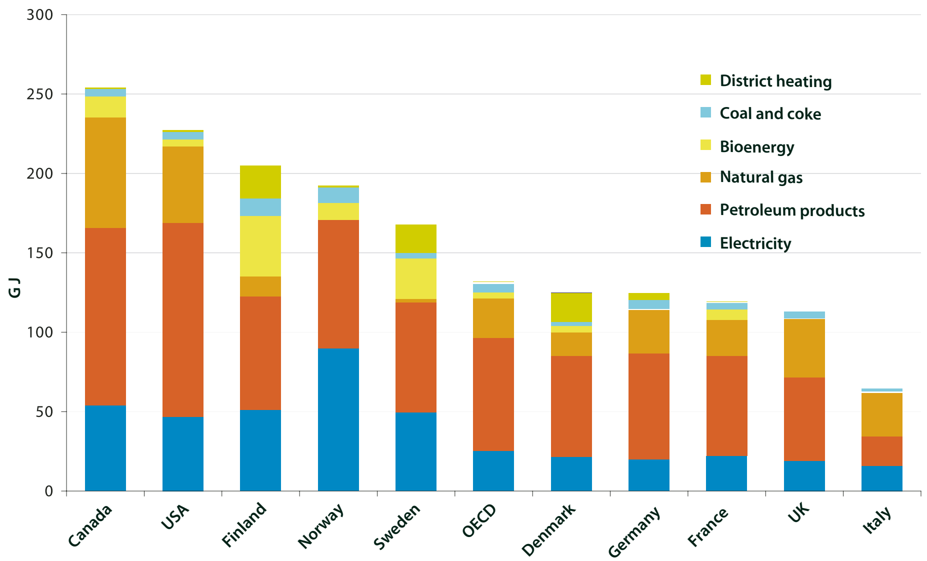


Figure 3.1 Per capita energy use in OECD countries, 2002

Source: Energy balances of OECD countries, IEA/OECD Paris

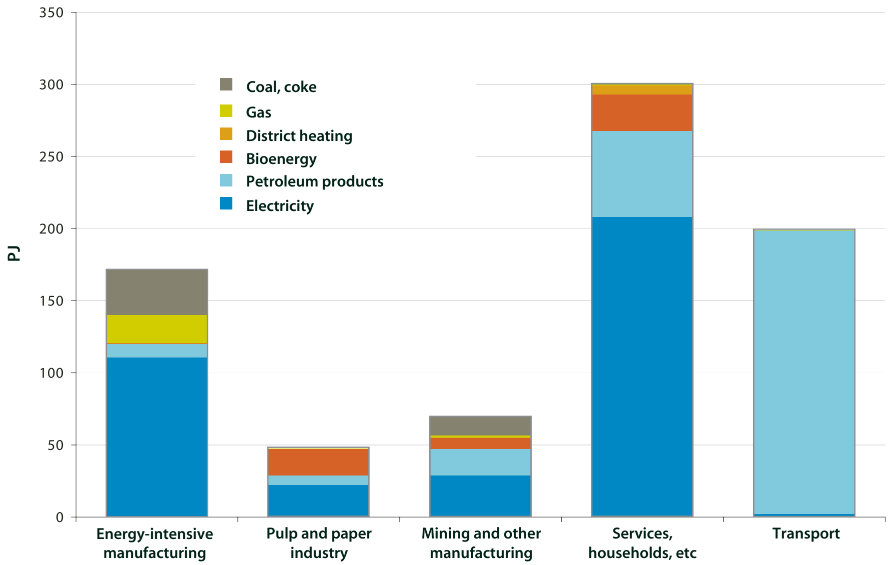


Figure 3.2 Energy use by carrier and category in 2003

Source: Energy accounts, Statistics Norway

3.2 Trends in energy use

Per capita energy use in Norway is somewhat higher than the OECD average. See figure 3.1. However, the proportion of energy use accounted for by electricity is considerably higher than in other countries. The main reasons for the high proportion of electricity use are that Norway has had access to plentiful supplies of relatively cheap hydropower, and that government investment has focused on hydropower development. A large energy-intensive industrial sector has developed as a result, and electricity is widely used to heat buildings and water.

Net domestic energy use in Norway during 2003 came to 787 PJ, corresponding to 219 TWh. From 1980 to 2003, net domestic energy use increased by an average of 1.4 per cent per year. Figure 3.2 shows energy use by carrier and consumer category in 2003.

Stationary energy use is defined as net domestic energy use minus energy utilised for transport purposes. Stationary energy

Gross and net energy use

Gross energy use represents domestic production plus imports minus exports. When calculating gross consumption of petroleum products, adjustments are also made for changes in bunkers and stocks.

Net domestic energy use is defined as gross energy use minus the energy utilised to convert and transport energy ready for the end user, energy carriers used as raw materials, and transmission losses.

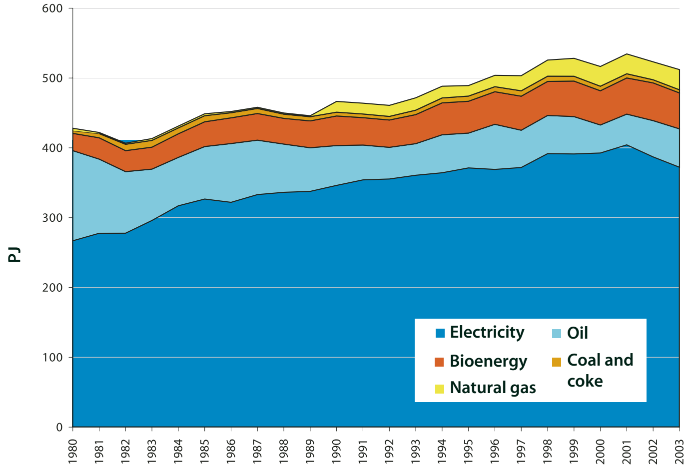


Figure 3.3 Trends in stationary energy use

Source: Energy accounts, Statistics Norway

use in Norway came to 588 PJ in 2003, corresponding to 163 TWh. This was up by 3.4 per cent from the year before. Figure 3.3 shows trends in stationary energy use by energy carrier from 1980 to 2001.

Electricity is the most important Norwegian energy carrier. Stationary electricity consumption in 2003 totalled 103 TWh, corresponding to 372 PJ. Oil products, wood and waste (bioenergy) are the next most important stationary energy carriers in Norway. Stationary consumption of oil products in 2003 totalled 94 PJ, corresponding to 26 TWh, while consumption of various types of gas came to 21 PJ, corresponding to almost six TWh. Recorded use of bioenergy totalled 51 PJ, corresponding to 14 TWh. District heating contributed seven PJ, corresponding to the consumption of almost two TWh by end users – of which households and service sectors accounted for six PJ. In addition, some coal and coke are used.

A marked shift from oil products to electricity has taken place over the past 20

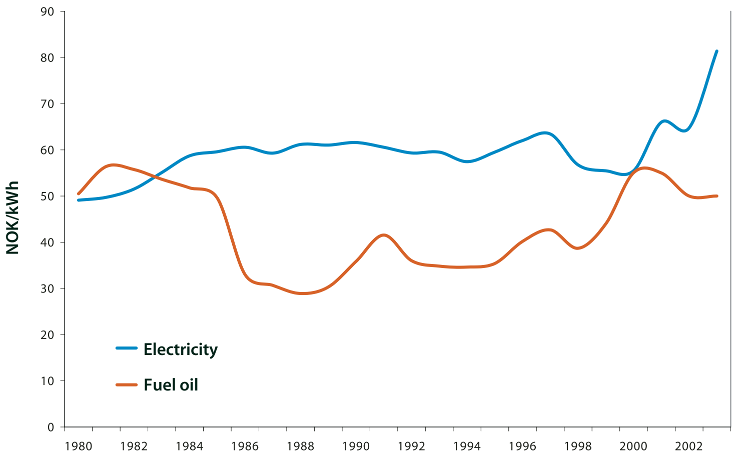


Figure 3.4 Price of utilised energy for households, including taxes. Fixed 2003 NOK

Sources: Statistics Norway and Ministry of Petroleum and Energy

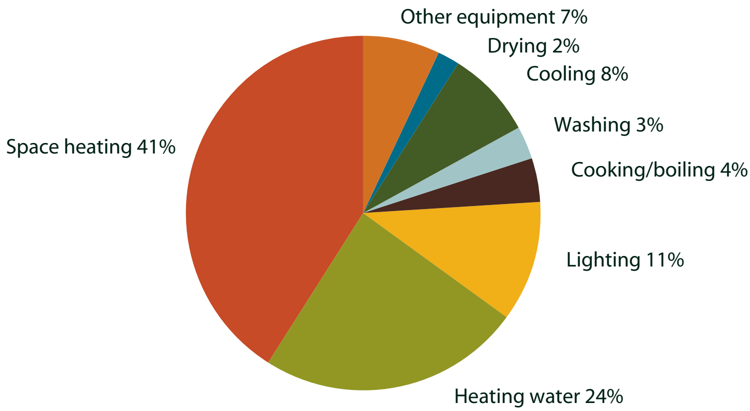


Figure 3.5 Electricity consumption in households by purpose

Source: Statistics Norway

years, with consumption of the latter up by about 50 per cent since 1980. Stationary oil consumption has declined by about 65 per cent over the same period. Partly because of the effect of the water inflow shortfall on electricity supplies, however, consumption of heating oils increased relatively sharply from 2002 to 2003. A normalisation of conditions in the power market will probably lead to a readjustment of stationary oil consumption.

The latter experienced its sharpest decline up to the start of the 1990s, and has since fluctuated somewhat from year to year. Heavy heating oil has seen the biggest fall in consumption. See chapter 3.4.1. Bioenergy consumption has shown a rising trend since 1980.

The changeover from heating oils to electricity took place primarily up to the start of the 1990s. Figure 3.4 shows price trends for heating oil and electricity to households.

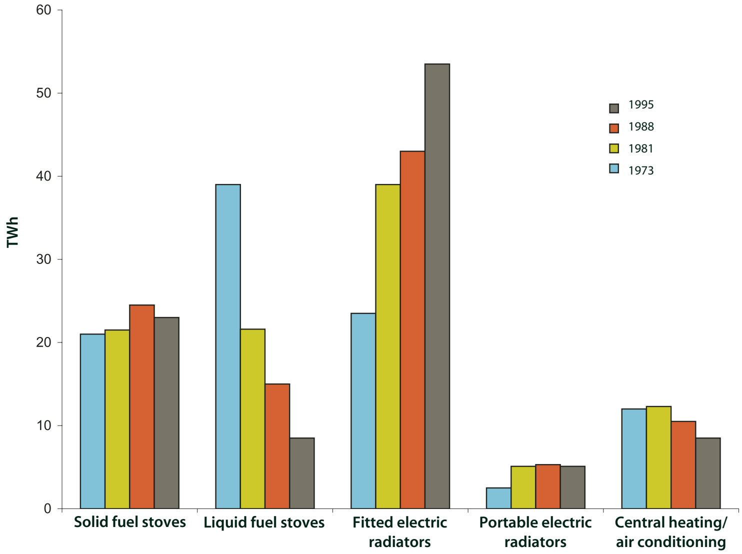


Figure 3.6 Residential heating methods in Norway

Source: Statistics Norway

That part of consumption used for technical purposes is called “electricity-specific”, and can only be met by this form of energy. A large number of electricity-specific products for operating technical equipment are found in all sectors. Most other electricity consumption is accounted for by space and water heating. No regular statistics on electricity consumption for heating are available. In its 1992 household survey, Statistics Norway looked how electricity was used in Norwegian households. This study estimated that space heating accounted for 41 per cent.

The consumer can use various energy carriers for heating purposes. The possibility of alternating between different heating methods is crucial to the reliability of a supply system based on hydropower. To be able to change energy carrier at short notice, consumers must have installed several types of heating equipment. Figure 3.6 shows trends in the use of the most important methods of residential heating in Norway since 1973. Of the dwellings with two or more heating systems in 1990, most used a combination of wood-burning stoves and electric radiators. This gives an indication of the possibilities for substituting one energy carrier with another at short notice.

3.3 Energy use by sector

Studies of the distribution of stationary energy use between different consumer groups usually distinguish between manufacturing and mining, private and public services and households. Manufacturing is usually sub-divided into energy-intensive manufacturing, the pulp and paper industry and other manufacturing. Figure 3.7 shows trends in stationary energy use by sector. Electricity accounts for about three quarters of total stationary energy use in Norway.

Growth in energy use over the past 20 years has been highest in the household and service sectors. Energy use has risen by 70 per cent in the private services sector and 25 per cent in households since 1980.

Stationary energy use in energy-intensive industry and the pulp and paper sector has increased by 39 per cent since 1980.

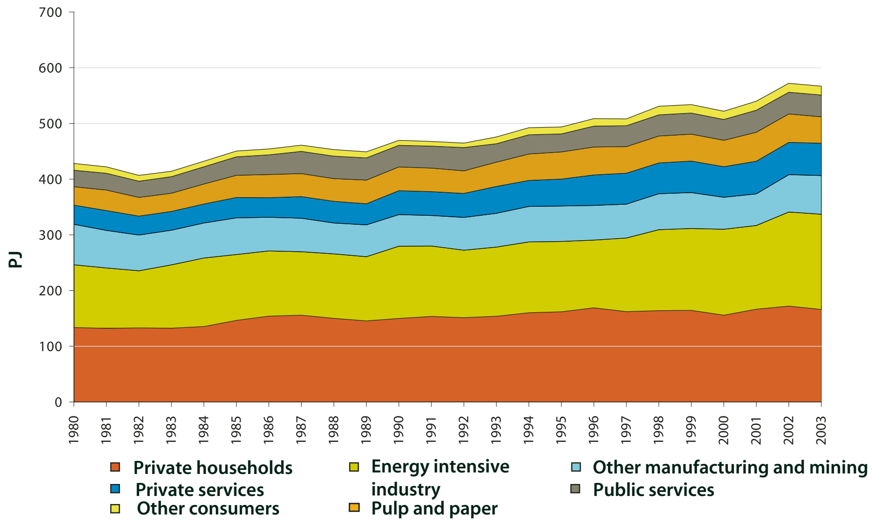


Figure 3.7 Stationary energy use by sector

Source: Energy accounts, Statistics Norway

Energy use in 2003 totalled 171 PJ, corresponding to 48 TWh, for energy-intensive industry and 48 PJ, corresponding to 13 TWh, for the pulp and paper sector. Electricity is the most important energy carrier in the energy-intensive sector, and consumption totalled almost 31 TWh in 2003. This figure has been relatively stable over the past 10 years. Electricity also meets the bulk of energy requirements in the paper and pulp industry, which consumed six TWh in 2003.

Energy-intensive and pulp/paper production differ from other consumer categories in that their energy use is stable over 24 hours and over the year. Energy-intensive industry also differs by taking power from the grid at high voltages.

About 19 TWh/year of power consumption by energy-intensive industry is currently met through long-term contracts with Statkraft SF on terms fixed by the Storting. These agreements expire between 2004 and 2011. Parts of the industry have also concluded new agreements with Statkraft, again on terms set by the Storting. The new contracts will begin to run in 2007–11 and continue until 2020–30. This sector meets its remaining power requirements largely from its own power plants as well as from contracts with other power suppliers and purchases on the spot market.

Other manufacturing and mining used about 69 PJ or 19 TWh in 2003, of which eight TWh was electricity. The remaining energy was supplied by petroleum products, natural gas, biofuel, coal, coke and district heating. Energy use in other manufacturing and mining has remained relatively stable over the past 20 years.

3.4 Utilisation of various energy sources for heating

3.4.1 Oil for stationary consumption

The total stationary consumption of oil products in 2003 corresponded to 94 PJ of utilised energy, or 26 TWh. Oil is mainly used for space and water heating, and to generate heat for various applications in industry and elsewhere. About 23 per cent is used to heat residential and commercial buildings.

Figure 3.8 shows historical trends in the consumption (sale) of heating oil for stationary purposes measured in millions of litres. This shows that consumption declined until 1990, and has since levelled off.

Sales of oil for stationary consumption are split between paraffin, light heating oil, heavy distillates and heavy heating oil. They differ in density and sulphur content. As figure 3.8 shows, the products which contain most sulphur have shown the greatest reduction in use. At the same time, the sulphur content of most oil products has been greatly reduced. This is illustrated by the fact that the average sulphur content of heating oil in 1998 was only 27 per cent of the 1980 level.

Paraffin is used mainly in stoves in private households. Light heating oil is used both in small heating systems in private households and in larger systems in commercial buildings and industry. Light heating oil is largely used in water-based central heating systems. Heavy heating oils with a higher sulphur content are cheaper than light heating oils, and are used in larger combustion plants where stricter emission standards apply. The oil is also used to produce hot water or steam in these plants.

Efficiency differences exist between old and new paraffin and oil heating systems. The efficiency of older installations averages about 80 per cent, whereas it may be as high as 95 per cent in new systems.

Oil companies Shell, Statoil, Hydro Texaco and Esso account between them for more than 99 per cent of the Norwegian heating oil market.

Under current conditions, oil provides valuable flexibility in the Norwegian energy system, and can make it easier to adapt to dry years and peaks in consumption. It is possible to increase oil consumption both in

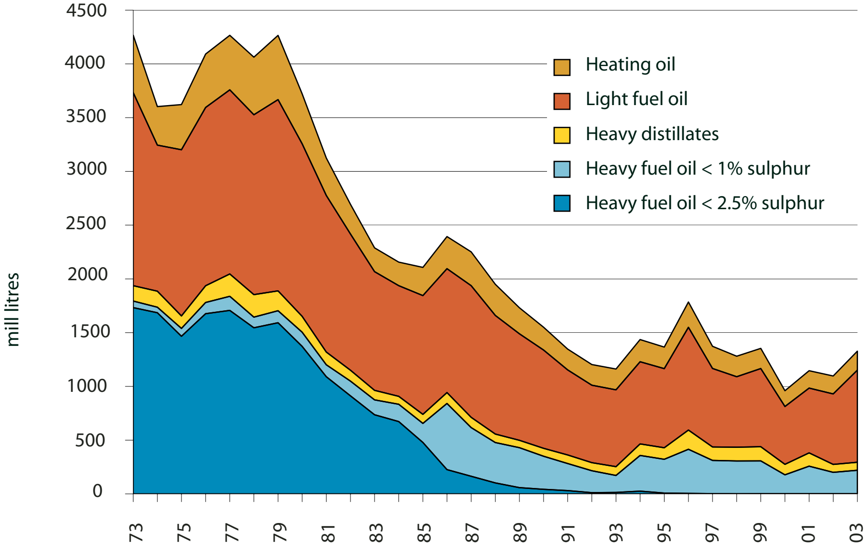


Figure 3.8 Consumption of oil for stationary combustion by product

Source: Norwegian Petroleum Institute

business and industry and in private households when necessary. Rapid switching between different energy carriers is possible in systems utilising combined oil/electric boilers.

Oil is the principal fuel used in Norwegian water-based central heating systems. Renewable energy sources, heat pumps and waste heat can also be used in such systems.

3.4.2 Biomass

Bioenergy can be produced by incinerating or fermenting biomass or by treating it chemically. Biomass includes firewood, black liquor[3], bark and other forms of wood waste, and waste from households and industry used to provide district heating. Fuel such as gas, oil, pellets and briquettes can be produced from biomass.

Recorded use of bioenergy in 2003 totalled about 51 PJ, corresponding to 14 TWh. The pulp and paper industry used some 38 per cent of this, with black liquor accounting for about two thirds and bark for one third. Roughly six PJ/year of bark, chippings and other waste is processed to produce other energy carriers. Other industries used wood and other biofuels equivalent to about 48 per cent of total bioenergy use in 2003. Firewood used to provide heating accounts for a substantial proportion of this.

The extent to which biofuel is used and its applications depend on factors such as available supplies and their quality and emission standards. Manufacturing of paper and pulp and of wood and wood products requires large amounts of heat for various drying processes, so that the energy in wood waste such as bark and chippings can be used without further processing in large incineration plants. A proportion of the waste in large landfills can be incinerated, and the heat energy can be used directly or in thermal power generati-

[3] Black liquor is the residue from wood used to produce chemical pulp.

on. Biofuel used in households and in small incineration plants often requires more processing to be suitable for transport, storage and handling.

Processing of biofuel has increased in recent years. Biofuel in the form of pellets and briquettes is more suitable for storage, transport and use in automated incineration plants.

3.4.3 Electricity

The 1995 survey of living conditions by Statistics Norway and the Norwegian Building Research Institute showed that fitted and portable electric radiators were the most important source of heating in 58 per cent of dwellings. A major shift from heating oil to electricity as the primary source of heat occurred in 1973-95. See figure 3.6.

Over half the dwellings with only one source of heat use electricity for heating. In dwellings with two or more sources of heat, a combination of electricity and wood is most common.

Studies for the Norwegian Water Resources and Energy Directorate (NVE) show that rather more than half of all energy use in commercial buildings is for heating purposes, and that two thirds of the energy used for heating is electricity.

3.4.4 District heating

The technology used to supply hot water or steam to households, commercial buildings and other consumers from a central source is known as district heating. Heat transported through insulated pipes is mainly used for space heating and hot water.

District heating systems can utilise energy extracted from waste and sewage, or waste heat and gas from industrial sources which would otherwise be lost. Hot water or steam in district heating installations can also be produced using heat pumps, electricity, gas, oil, chippings or coal. About half of Norway's net deliveries of district heating derive from waste incineration plants.

Preliminary figures for 2003 show that consumption of district heating was about seven PJ, or roughly two TWh. Some two-thirds is used in service sectors, while households and manufacturing/mining used about 15 per cent each.

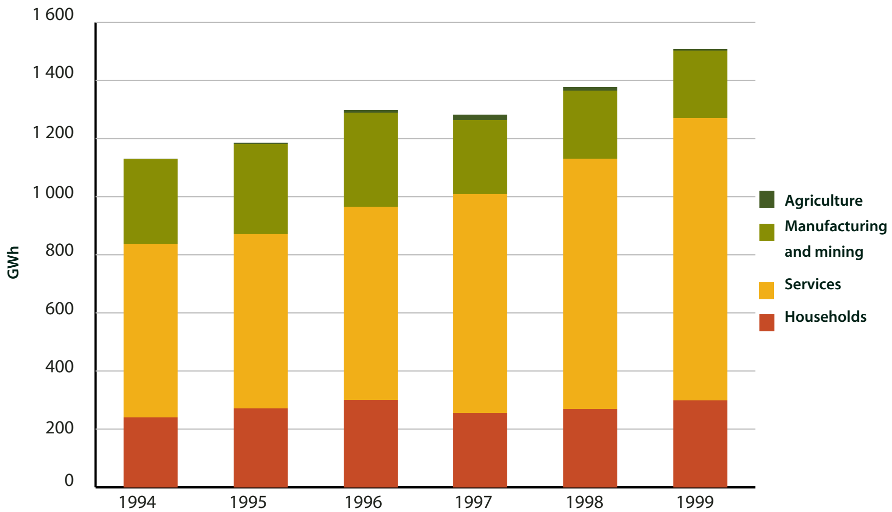


Figure 3.9 Consumption of district heating by various consumer groups

Source: Statistics Norway

District heating in Oslo

The district heating system in Oslo is the largest in the country and accounts for about half the total in Norway. Figure 3.10 shows trends in district heating for Oslo.

The Viken Energinett company distributed and sold about one TWh of district heating in 2003. In the course of a year, production is split more or less evenly between waste incineration and oil/electricity. Year-on-year variations in whether oil or electricity is chosen depend on the relative prices of these energy carriers.

Development of the district heating system in central Oslo began in 1937, but only really got going in the early 1980s in order to utilise heat from two waste incineration plants. These are the main heat sources today. In addition, electric and oil-fired boilers are used to meet peak demand for power in winter. When the outdoor temperature is low, the hot water/steam is piped into the network at a temperature of about 120°C. It is distributed to individual customers from substations normally located in customer cellars, and is returned to the central installation at a temperature of about 70°C. About 750 large customers and 2 250 individual dwellings are linked to the district heating system.

Oslo's district heating installations now meet about 15 per cent of its heating needs. These systems have been developed in the city centre and three other areas, and three of these areas have been linked together in a single network since 1998. The main campus of the University of Oslo and Ullevål University Hospital are two examples of large customers. The hospital's boiler room is now used mainly to meet its special needs for steam, but it can also be used as part of the district heating system – either to help meet peak power demand or as a reserve source of heat. All the hospital's heating needs have been met by district heating since the autumn of 1999. Most of the individual dwellings which use district heating are in one of Oslo's newer residential areas, where each is equipped with district heating via an individual substation, and energy consumption is also metered individually.

By replacing small oil-fired boilers, district heating helps to eliminate emissions immediately above roof level in residential areas and the city centre. This helps to improve air quality in Oslo.

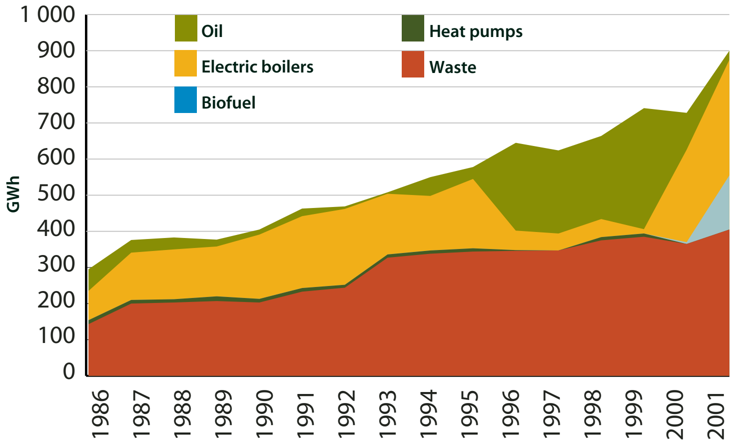


Figure 3.10 District heating in Oslo 1986–2001

Source: KanEnergi

District heating output in 2003 totalled nine PJ, corresponding to two TWh. A certain proportion of gross output is lost to the air by cooling during transport to the consumer.

District heating is most widely used in Oslo, Fredrikstad and Trondheim. About 80 per cent of the district heating used in Norway is delivered to these areas. The country has 30 district heating installations. Much less use is made of this form of heating in Norway than in other Scandinavian countries. While district heating accounts for about two per cent of the Norwegian energy delivered for heating, the corresponding figures in Denmark and Sweden are around 50 and 35 per cent respectively.

A byproduct of district heating is district cooling, produced in modest amounts and utilised for cooling instead of heating. Only two district heating installations in Norway currently offer cooling.

District heating is regulated by the Energy Act. See Chapter 4.3.7. District heating installations included in the system of mandatory connection to a grid are not permitted to charge a higher price than for the equivalent amount of electrical heating in the same area.

Since 1997, the authorities have provided support for the utilisation of bioenergy and other renewable energy sources to produce heat. Total support for heating installations is around NOK 100 million per year.

Examples of heating systems

Electricity-based heating

In electricity-based heating systems, electricity is converted to heat by being conducted through a resistance such as a filament. Common electricity-based heating systems are convectors, underfloor heating cables, portable fan heaters and radiators, and electrical hot water tanks.

Water-based central heating

In water-based heating systems, a central source is used to heat water which then circulates through a piping system (radiators, convectors or underfloor pipes), releasing heat to the surroundings. A water-based heating system can utilise various sources of heat. Among the most common are oil, electricity, biomass, heat pumps and district heating, but gas, solar energy and geothermal energy can also be used.

Warm-air heating

Various solutions exist for distributing heat through the air. Warm air can circulate through a closed piping system which then releases heat, or the warm air can be blown directly into the space to be heated. As in the water-based systems described above, a number of heat sources can be used to warm up the air in these systems.

Independent heating devices

Independent heating devices such as wood-burning stoves, fireplaces and paraffin stoves are widely used in Norway. About 80 per cent of its 1.8 million households have installed some kind of independent heating device. The most widely used are wood-burning stoves, and about 70 per cent of all households can use firewood for heating in one way or another.

Expected annual energy production from installations receiving support in 1997-2001 is calculated to be around 5.8 PJ, which corresponds to 1.6 TWh. From 1 January 2002, Enova SF is responsible for administering the funding of such installations.

3.5 Gas consumption in Norway

Natural gas has not been used to any great extent in Norway. Consumption is highest in the areas around the landfall terminals for gas pipelines from the Norwegian continental shelf. A commitment is being made to increasing the use of natural gas in these regions. Propane (liquefied petroleum gas) consumption is rising in all parts of the country. Consisting primarily of methane, natural gas can be distributed in three ways: by pipeline, as compressed natural gas (CNG) or as liquefied natural gas (LNG). See the box about natural gas on page 402 for an explanation of these terms.

Two main applications exist for natural gas:

- energy purposes
- chemical conversion to other products, such as methanol, which are used in turn as raw materials for other production processes.

Norway currently has three pipeline terminals for natural gas: Kårstø north of Stavanger, Kollsnes near Bergen and Tjeldbergodden west of Trondheim. Gas consumption is most widespread around these facilities. It has also been resolved to land gas from the Ormen Lange field in Aukra local authority in mid-Norway, and from the Snøhvit field on Melkøya island outside Hammerfest in northern Norway.

Gasnor has constructed a pipeline network in the Haugesund area of south-west Norway to distribute natural gas from the Kårstø terminal. About 60 km of low-pressure pipelines have been laid so far, and almost 60 industrial and commercial customers are linked to the network. Some 20 homes are also connected, and several housing estates are under construction with gas supply to each home. Gasnor delivered about 42 million standard cubic metres (scm) through its network in 2003. Its customers are mainly large commercial users who have replaced heating oil with natural gas. The largest of these is Hydro Aluminium Karmøy, which consumes about 20 million scm of gas annually – corresponding to roughly 0.2 TWh or 0.7 PJ.

Natural gas is also being used as a motor fuel in the Haugesund area. Two filling stations are operational, with one of them specially designed to fuel buses. More than 70 vehicles in the area run on natural gas.

Gasnor has also built a gas liquefaction plant on the island of Karmøy south of Haugesund. LNG from this plant is delivered to four receiving terminals in the Jæren district south of Stavanger, and several new terminals are planned or under construction. The Karmøy facility can produce LNG corresponding to about 25 million scm – or about 260 GWh – of natural gas on an annual basis.

The Kårstø plant also produces 620 000 tonnes of ethane per annum. Most of this output is delivered to the petrochemical complex in the Grenland area south of Oslo.

Lyse Gass has constructed a 50-km high-pressure pipeline from Kårstø to Risavik in Sola local authority south of Stavanger. This system can carry about one billion scm of natural gas per year. The project also includes a spur to Nørdrevågen in Rennesøy local authority, where a distribution network is planned primarily to supply greenhouse-based cultivation in Rennesøy and Finnøy local authority. A 300-km distribution system being laid from Risavika will ultimately cover large parts of the Jæren district. By March 2003, 150 km of this system had been laid. Lyse Gass held sales contracts at the same date for about 35 million

Natural gas

Natural gas from Norwegian offshore fields is called rich gas and usually contains 60–95 per cent methane. This is separated into natural gas liquids (NGL) and dry gas (methane) at the landfall terminal. Also called wet gas, NGL comprises ethane, propane, butanes, natural gasoline and condensate. Liquefied petroleum gases (LPG) comprise propane and butanes. Propane, butanes and naphtha are shipped to customers in Norway and abroad by tanker, while most of the dry gas is piped to continental Europe. Gas is exported from Kårstø and Kollsnes through the major Europipe, Statpipe, Zeepipe and Franpipe systems.

Pipeline distribution of gas involves high investment costs. The larger the volume of gas transported through a pipeline system, the lower the cost per unit transported.

Compressed natural gas (CNG) is natural gas stored at a pressure of 250-300 bar (250-300 times atmospheric pressure). This makes it suitable for distributing relatively small gas volumes over short distances.

Liquefied natural gas (LNG) is created by refrigerating natural gas to -162°C, when it liquefies. Stored in insulated vessels under atmospheric pressure, LNG occupies only about one-600th of its gaseous volume. Because its energy density is much higher than with CNG, it can be transported over greater distances by road, sea or rail at lower cost. LNG can be stored or regasified for transport to end users as CNG or by pipeline.

Gas liquefaction involves substantial investments, largely because of high costs associated with refrigerating the gas. This is also an energy-intensive process. Some five to 10 per cent of the energy in the natural gas is utilised during the liquefaction process, depending on how well the waste heat for electricity generation is used.

Liquefied petroleum gases (LPG)

LPG is a mixture of propane and butane, and is liquid under moderate pressure or temperature. It forms part of the natural gas liquids, and can be separated from natural gas or produced during the refining of crude oil. These gases are easier to store and transport than natural gas.

Applications for LPG include heating or processing by industry or space and water heating in households. Norway's total consumption in 2003 was 304 000 scm – an increase of 18 per cent from the year before. That corresponds to about two TWh. Most of this was used by industry, but there was also a marked increase in consumption by private individuals. A growing number of industrial customers of all sizes are converting to LPG.

The figures for LPG in the environmental accounts are comparable with those for natural gas, but CO_2 emissions from LPG are somewhat higher.

Source: Norwegian Petroleum Institute

scm of natural gas per year. These deliveries cover both commercial customers and households.

Gas landed at Tjeldbergodden is used for industrial purposes. The largest recipient is a methanol plant which produced 915 000 tonnes of this chemical in 2003 from roughly 770 million scm of natural gas. Waste water from the plant is used to farm halibut and turbot. The Norferm plant in the complex produces bioprotein for such applications as fish feed.

About 12 000 tonnes LNG a year is also produced at Tjeldbergodden, corresponding to roughly 16 million scm of natural gas. LNG is transported to Trondheim, where users include a district heating installation belonging to the Trondheim Energiverk utility and the Peterson Ranheim paper mill.

Naturgass Vest has established a CNG distribution network in the Bergen area over the past four-five years. The gas is carried in road tankers to about 15 receiving points in the city and region. According to Naturgass Vest, it has replaced about 15 per cent of the heating oil previously consumed in Bergen.

A gas liquefaction plant has also been built by Naturgass Vest at Kollsnes, with an annual capacity of 40 000 tonnes (54 million scm), corresponding to about 550 GWh. This facility delivers LNG to a number of locations in southern Norway, including two supply ships sailing for Statoil as well as Hydro Aluminium at Sunndalsøra, Sør-Norge Aluminium at Husnes, Norzink in Odda, the Ewo fish feed plant in Forø and Bergen's district heating network.

Naturgass Vest distributes LNG in a specially constructed coastal tanker – the first vessel of its kind in Europe – and in road tankers. The company delivered about 13 million scm of natural gas in 2003, and expects to supply some 38 million scm in 2004.

3.6 Hydrogen

Hydrogen is the simplest of the elements, and the most abundant in the universe. It is highly reactive and therefore does not exist on Earth in a free form, but only in compounds with other elements. Hydrogen must accordingly be separated from a compound in order to use it as energy. Natural gas and water stand out as the most suitable sources, through separation of CO_2 and electrolysis respectively. The electrical energy required for electrolysis must be generated from renewable sources if hydrogen production is not to emit greenhouse gases or pollutants.

Hydrogen is little used for energy purposes at present, but has a number of properties which could make it an important future energy carrier:

- it can be produced from all primary energy carriers, both fossil and renewable
- it can be stored
- greenhouse gas emissions from its end uses are very limited.

How far hydrogen is an environment-friendly energy carrier depends on the mode of production and the source of the primary energy.

The international transport sector is conducting research into both direct use of hydrogen as a motor fuel and its conversion to electricity in fuel cells for electrically-driven vehicles.

In a distributed energy supply system for stationary purposes, hydrogen or natural gas can be used in small power plants based on fuel cells or microturbines for combined heat and power generation.

A certain amount of hydrogen is produced for industrial purposes both in Norway and in other countries. Norsk Hydro used to produce hydrogen by electrolysis of water, but has converted for economic reasons to fossil fuels in recent years. Similarly, Statoil produces hydrogen at its Tjeldbergodden methanol plant and at the

Mongstad refinery near Bergen. Hydrogen is also a byproduct in other parts of Norwegian industry.

With today's technology, both production and use of hydrogen are very costly. Major and expensive technological challenges must be overcome before any significant commercial use can be made of this element.

Critical factors for hydrogen development relate to:
- cheaper production solutions
- satisfactory solutions for storage and distribution of pure hydrogen
- clear improvements in fuel cell technology for conversion to electricity.

A government-appointed commission presented a report on hydrogen as the energy bearer of the future (NOU 2004:11) on 1 June 2004.

This inquiry identified three principal reasons for making a commitment to hydrogen in Norway:
- opportunities for environment-friendly production of hydrogen from Norwegian natural gas
- opportunities to reduce emissions of greenhouse gases, particularly in the transport sector
- opportunities for value creation in Norwegian industry with hydrogen-related expertise.

On this basis, the commission recommended four specific priority areas for a Norwegian commitment to hydrogen:
- environment-friendly production of hydrogen from Norwegian gas
- early adoption of hydrogen-powered vehicles
- hydrogen storage
- development of a hydrogen technology.

Specific targets for this commitment were also proposed. According to the commission, hydrogen could be extensively used in the Norwegian transport sector. Using hydrogen in stationary energy supply could also be possible in certain niche areas.

Establishing a 10-year programme for hydrogen research, development and demonstration is recommended, with funding of roughly NOK 900 million over the period.

This report can be found, in Norwegian only, at http://odin.dep.no/oed/norsk/publ/utredninger/bn.html.

3.7 Environmental impact of energy use

The environmental impact of energy use relates largely to the combustion of energy commodities. This is done mainly in directly-fuelled furnaces burning energy commodities to provide heat for an industrial process, boilers using energy commodities to heat water for steam, and small stoves burning oil or wood to heat dwellings. In addition come emissions from mobile combustion and processes.

3.7.1 Emissions to the air from stationary combustion

Emissions from stationary combustion derive from many different sources of energy in a wide variety of applications. Waste, heating oil, biomass and gas are all among the fuels used in district heating plants, for instance. Industry utilises heavy and light heating oils, natural gas, coal and coke. Some sectors, including pulp and paper, also employ large quantities of wood waste and black liquor.

Burning oil releases sulphur dioxide (SO_2), carbon dioxide (CO_2), nitrogen oxides (NO_x) and some particulate matter (PM10). The size of these emissions depends on the technologies and fuels used. Key factors are the size and age of the boiler and the quality of the fuel.

Biomass embraces wood, wood waste, bark and black liquor as well as waste from households and commercial activities burnt in district heating systems. Burning biomass releases polycyclic aromatic hydrocarbons (PAHs), PM10, NOx, carbon monoxide (CO) and benzene. The size of these emissions and the damage they cause depends on a number of factors. The most important are whether the wood is wet or dry, the type of furnace/stove and the amount of air supplied. The time when the furnace is used can also be significant for the effect on local air quality, with the impact being lower at weekends and in the evenings when emissions from other sources are low.

Figures 3.11 and 3.12 show emissions of various pollutants from burning different types of fuels in boilers – in a central heating system, for instance – and in stand-alone locations such as wood-burning stoves. These figures are calculated averages for emissions per tonne of fuel, and may deviate considerably from actual emissions by a particular boiler or furnace/stove.

Norway has accepted a number of international commitments to reduce emissions of CO^2, NO_x and SO^2. Under the Kyoto protocol, the country is committed to preventing its greenhouse gas emissions from rising by more than one per cent from 1990 to the 2008–12 period. CO_2 emissions totalled 40.9 million tonnes in 2002, as against with 42 million tonnes the year before. This represents a decline of 2.4 per cent. Such emissions have risen by just over 17 per cent since 1990.

In December 1999, Norway signed the Gothenburg protocol on long-range transboundary air pollution in Europe. This applies to emissions causing acidification, eutrophication and the formation of ground-level ozone. NO_x are among the substances regulated, and Norway has accepted an emission ceiling for NO_x of 156 000 tonnes in 2010. This calls for a decline of about 26 per cent from 2002, when emissions totalled 213 000 tonnes. SO_2 emissions are also regulated by the protocol, with Norway committed to a 25 per cent reduction from the 1998 level by 2010. Norwegian SO^2 emissions have declined sharply in recent years, from 30 000 tonnes in 1998 to 22 100 in 2002. That represents a reduction of 26.3 per cent.

Table 3.1 Emissions of selected substances in Norway in 2002* (1 000 tonnes)

	CO_2	SO_2	NO_x	Particulate matter	PAHs (tonnes)	nmVOCs
Total emissions	40 945	22.1	213.0	61..6	162.3	344.9
Process emissions	7781	13.3	9.6	12.9	97.8	278.0
Mobile combustion	15 568	3.3	146.7	4.9	10.2	54.5
Stationary combustion	17 596	5.5	56.7	43.8	54.4	12.4
• fuel oil/paraffin						
wood/wood waste/black liquor	0	0.7	2.8	40.3	47.6	9.6
• natural gas	12 994	0.0	39.3	0.6	0.1	1.5
• diesel, gas and light heating oil, special distillates	2 603	1.4	8.3	0.2	0.2	0.7
• waste (used in district heating)	146	0.2	1.1	0.0	0.5	0.4
• other sources	1 854	3.2	5.2	2.7	5.9	0.2

** Preliminary figures*

Source: Statistics Norway

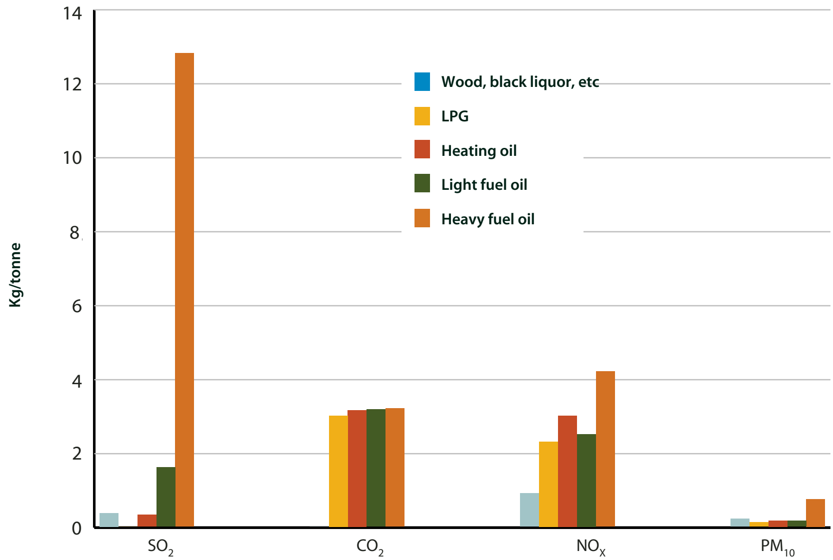


Figure 3.11 Emissions to the air from boilers (kg/tonne fuel)

Source: Statistics Norway

Table 3.1 shows total emissions of CO_2, NO_x and SO_2 by the three most important sources: mobile combustion, process emissions and stationary combustion. The figures relate to 2002, which are the latest available.

Unlike other energy statistics, the figures for stationary combustion include emissions from oil and gas activities on the Norwegian continental shelf. These operations account for almost 60 per cent of Norway's CO_2 emissions and just over 97 per cent of its NO_x emissions from stationary combustion in 2002.

Apart from electricity, the most important energy carriers for heating are biomass (wood, wood waste and black liquor) and various types of heating oils. Their contribution to emissions from stationary combustion are also shown in table 3.1.

The table shows that various types of heating oil accounted for about 14 per cent of total CO_2 emissions from stationary combustion, and about six per cent of Norway's total CO_2 emissions. Burning wood and oil contributed about 9.5 per cent of total SO_2 emissions in 2002. Some 19 per cent of NOx emissions derived from heating based on wood and oil in 2002, while such fuels as natural gas, propane and landfill gas accounted for almost 70 per cent of such emissions from stationary combustion.

Fuelwood accounted for 92 and 87.5 per cent of total PM10 and PAH emissions respectively. About eight per cent of the total PM10 emissions in 2002 derived from mobile combustion. In addition comes asphalt dust from vehicles using studded tyres in winter. See also the discussion of particulate matter in chapter 3.8.2.

Emissions of non-methane volatile organic compounds (nmVOC) from fuelwood made up almost three per cent of total emissions in 2002. Natural gas, propane and landfill gas contributed only 0.4 per cent, while the largest source in 2002 was industrial processes. These accounted for 80 per cent of the total.

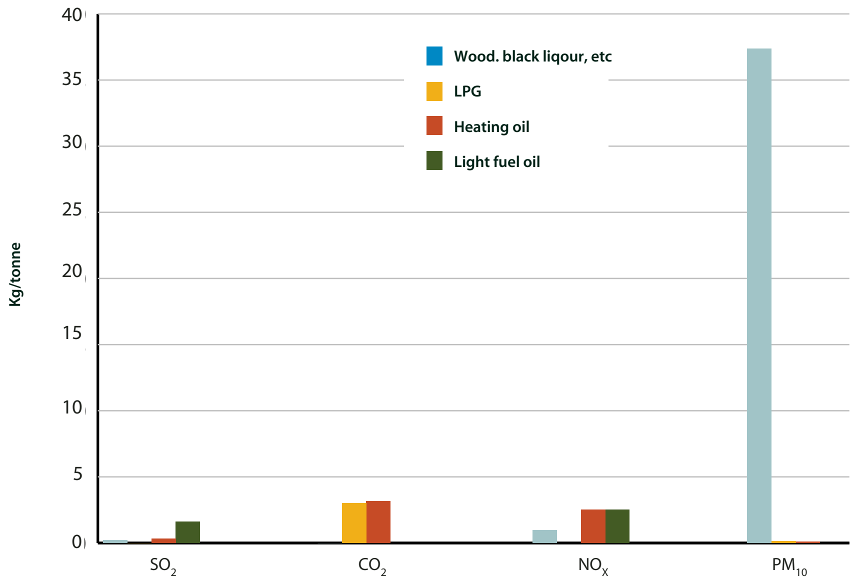


Figure 3.12 Emissions to air the from small stoves (kg/tonne fuel)

Source: Statistics Norway

3.7.2 Instruments to limit emissions of pollutants and greenhouse gases

Extensive measures have been initiated to limit emissions of pollutants and greenhouse gases. Mineral oils (including paraffin, light and heavy heating oil and autodiesel), petrol, coal and coke are subject to a carbon tax, which currently applies to about 64 per cent of Norway's CO_2 emissions. The CO_2 tax on mineral oil in 2004 is NOK 0.51 per litre. Heating oil is also subject to a basic tax of NOK 0.405 per litre. Natural gas is exempt from the carbon tax.

Sulphur tax is also levied on most mineral oil consumption at a rate of NOK 0.07 per litre for each 0.25 per cent of sulphur content by weight. This corresponds to about NOK 17 per kilogram of SO_2. The sulphur tax is not levied on oil with a sulphur content of 0.05 per cent by weight or less. The sulphur content of a number of product categories has been reduced to less than 0.05 per cent by weight in order to escape the tax. Sulphur tax can also be wholly or partly refunded if it can be documented that the sulphur has been removed.

NOx emissions are to a large extent technology-related and difficult to reduce through such policy instruments as taxes. However, large emission sources must be covered by discharge permits under the Pollution Control Act.

Emissions of PM_{10} can be reduced by treating the flue gases. At present, only large incineration plants are required to reduce emissions of PM_{10} under the Pollution Control Act. No such requirements apply to emissions from small heating systems, but their users can be held financially responsible under the regulations on local air quality for their contribution to poor air quality. Reduced use of studded tyres, new EU requirements for vehicle exhaust emissions, expected reductions in the contribution of long-distance transport to pollution and the conversion to clean-burning furnaces/stoves will make a substantial contribution to meeting limit values for local air quality. All newly-installed wood-burning furnaces/stoves in dwellings must be clean-burning. The cities face the greatest problems from high concentrations of PM10 in the air. A grant of NOK 3 000 per stove is available in 2004 to the first 1 000 Oslo residents to replace old stoves with new cleaner types.

A more detailed description of emissions by source and sector and the impact of these emissions can be found in Natural Resources and the Environment 20013 from Statistics Norway and on the latter's web site at www.ssb.no.

3.8 Measures to limit energy use

Measures to limit energy use have been incorporated in Norwegian energy policy since the 1970s. This section describes measures funded through Enova SF and other policy instruments which influence the use of energy for stationary purposes.

3.8.1 Enova SF and measures to limit energy use

Enova is responsible for government efforts to achieve a restructuring of energy production and use. Its activities are financed by the Energy Fund, which receives the revenues generated by a levy of NOK 0.01 per kWh on grid tariffs, and ordinary appropriations over the central government budget. In 2004, this income will amount to about NOK 565 million.

Enova draws on the Energy Fund to initiate measures which promote energy savings, reduced electricity consumption for heating, and new environment-friendly forms of energy production. Another task is to facilitate an environment-friendly development of the energy sector in the long term. The company has divided its commitment between information and educational activities and measures aimed at yielding specific results via energy saving.

Contractual reductions in energy consumption corresponding to 424 GWh had been secured by Enova in 2003. These cuts are divided between several programme areas, with energy management in commercial buildings as the largest. Some NOK 101 million was allocated to various energy consumption programmes in 2004.

Information and educational measures

Enova offers a nationwide information and advisory service relating to efficient use of renewable energy sources. The aim of is to provide purposeful, direct and specific information in response to enquiries, and to meet the information needs of private individuals, industry and commerce, the authorities, schools and nursery schools in order to enhance energy efficiency nationwide.

Energy saving

A network has been developed for managers of buildings in the private and public sectors. Network members can obtain grants to analyse their energy consumption and identify opportunities for savings, or to carry out major improvements. These are conditional on recipients undertaking to pursue certain activities.

The industrial network is continuing to identify and implement energy savings in industry. Among other benefits, network members can obtain grants to analyse the potential for energy savings and benchmark their performance against other companies.

Enova also provides support for companies which introduce energy-efficient technologies, products or services to the market.

More information on Enova and its activities and services can be found on its web site at www.enova.no. Enova has also established a telephone service which provides free information on energy saving and consumption.

3.8.3 Other government measures affecting energy use

The provisions of the Energy and Planning and Building Acts, labelling requirements and standards for electrical equipment, various grant schemes funded by other ministries and taxes all influence energy use.

A system of informative electricity bills has been introduced in Norway. All customers expected to consume more than 8 000 kWh per year receive bills from the grid company for actual consumption. See chapter 7.2.4. Customers previously paid on the basis of estimated consumption. In addition, the bill must show how the customer's electricity consumption compares with the year before and specifies where advice on energy saving can be obtained. The aim is to make customers more aware of their electricity consumption. Further measures to improve the position of consumer are in preparation, including joint billing, reducing the time taken to change supplier and regulation of waiting tariffs.

The National Office of Building Technology and Administration is responsible for administering the building regulations. Technical regulations issued under the Planning and Building Act govern energy use in buildings. New requirements for such consumption and a different method for calculating energy use in new buildings are being studied.

Through the EEA agreement, Norway participates in international collaboration on energy labelling of a number of consumer products. Refrigerators, freezers, dishwashers, washing machines, tumble dryers and household lamps are all now labelled. An example is shown below. This labelling is intended to help consumers to select the most energy-efficient appliances. Products are labelled from A (highest efficiency) to G (lowest). Plans call for the system to be extended to air-conditioning appliances, ovens and hot water boilers.

The Norwegian State Housing Bank administers various loan and grant schemes designed to reduce domestic energy consumption. To encourage measures which yield healthy, environment-friendly and energy-efficient dwellings, the bank can provide loan supplements of NOK 20–580 000 for such measures as balanced ventilation with heat recovery and control systems for lighting and heating. The bank also gives grants to dwellings after a specific assessment. These grants will normally cover in the order of 20–50 per cent of the cost. Sustainable use of resources is a priority area.

Taxes and tax exemptions influence the relative price and cost of energy carriers, and in turn affect consumption. The most important taxes are the electricity tax and various taxes on heating oil. See chapters 2.5 and 3.7 respectively.

4

The legal framework for hydropower development

- Introduction
- Special legal framework for hydropower development
- The Energy Act
- Other legislation

4.1 Introduction

This chapter describes the legislative and political framework for the power sector. Chapter 10 discusses water resource management in more detail.

A developer must have a licence pursuant to the Watercourse Regulation Act to carry out regulatory measures or divert water in a watercourse. This Act also gives the licensee the authority to expropriate the necessary property and rights in order to carry out regulatory measures. The Industrial Concession Act specifies that anyone who acquires ownership or user rights to a waterfall must obtain a licence. Development of a waterfall and construction of a power station usually require an additional licence pursuant to the Water Resources Act. The Energy Act requires licensing of all installations to generate, transmit and distribute electricity, from power station to consumer. A licence pursuant to the Energy Act is also required to trade electricity.

The legislation mentioned above is of particular importance for the energy and water resources sector. Other general provisions relevant to the sector are discussed later in this chapter.

Figure 4.1 shows which legislation applies to the different parts of the Norwegian hydropower system, from impounding water in a regulation reservoir in the mountains until electricity is delivered to the consumer.

4.2 Special legal framework for hydropower development

When a watercourse is used for hydropower development, conflicts may arise between a number of user groups and environmental interests. It has therefore been necessary for the authorities to develop extensive legislation relating to hydropower, which lays down requirements for obtaining licences for various purposes. The most important elements in the framework for hydropower development are the protection plans for water resources, the Master Plan for Water Resources, the Industrial Concession Act, the Watercourse Regulation Act and the Water Resources Act. The water resource authorities are responsible for managing water resources within this framework.

The licensing authorities are the bodies responsible for processing licence applications and for issuing licences. They include the Storting, the government, the Ministry

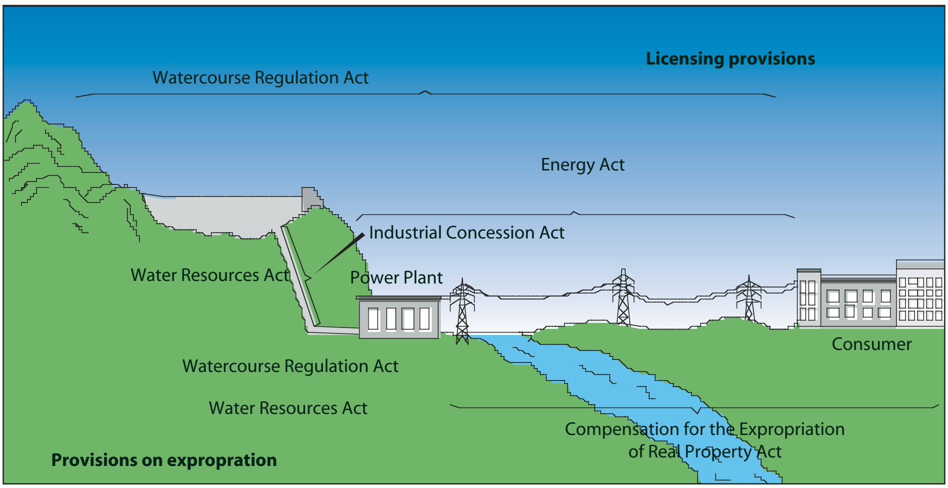
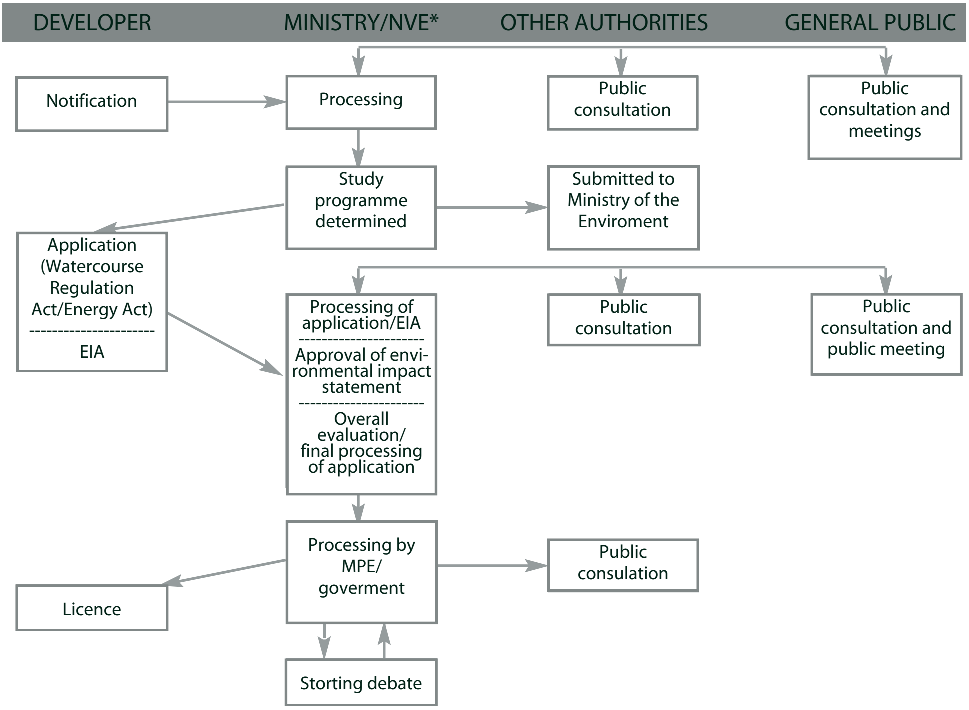


Figure 4.1 Legislation governing licensing in the hydropower sector



For major projects and projects which satisfy specific criteria, the first stage is always notification and an EIA pursuant to the Planning and Building Act. Projects which do not require an EIA pursuant to the Planning and Building Act begin with a application pursuant to the Watercourse Regulation Act and an application pursuant to the Energy Act for licences for electrical installations in connection with the power station, including power lines for connection to the existing grid. If the project must be licensed pursuant to the Watercourse Regulation Act, an EIA pursuant to this Act is required. Administrative procedures for electrical installations are shown in Figure 4.3.

Figure 4.2 Administrative procedures involved in licensing hydropower developments (more than 40 GWh/year) which require an EIA pursuant to the Planning and Building Act

of Petroleum and Energy and the Norwegian Water Resources and Energy Directorate (NVE).

In cases where a licence is required pursuant to the Industrial Concession Act, the Watercourse Regulation Act or the Water Resources Act, the NVE is responsible for coordinating application procedures. Once a project has been approved in the Master Plan for Watercourses, the actual application process starts when the developer sends notification of the project to the NVE. This notification is deposited for public inspection and circulated to local authorities and organisations for comment.

The NVE, in consultation with the local authorities concerned and other authorities, then decides whether an environmental impact assessment (EIA) must be carried out in accordance with the provisions of the Planning and Building Act. Even if notification is not required pursuant to the Planning and Building Act, the consequences of the project must be described in detail as part of the licence application.

If notification is required pursuant to the Planning and Building Act, the NVE will determine the final content of the study programme after submitting this to the Ministry of the Environment. The authorities and organisations which received the application for comment also receive a copy of the final study programme.

When the study programme has been completed, it is submitted together with the licence application. The application and environmental impact statement, if any, are then subject to a process of public consultation with government authorities, organisations and landowners affected by the proposal. The NVE then makes an overall evaluation of the project and submits its recommendations to the Ministry of Petroleum and Energy.

The Ministry prepares the matter for the government and submits its recommendation on the project. This recommendation is based on the application, the recommendations of the NVE, the views of the other ministries involved and of local authorities, and the Ministry of Petroleum and Energy's own evaluation. The government then makes a decision on development and regulation in the form of a royal decree. In the case of a major or controversial watercourse regulation or hydropower development, a Proposition is submitted to the Storting so that it has an opportunity to debate the matter before a licence is formally granted by the King in Council. Figure 4.2 shows the administrative procedures involved and what is done by the developer, the licensing authorities and other authorities involved, and in relation to landowners and other parties with an interest in the matter.

Power stations with an installed capacity of less than five MW are subject to a rather simpler process than larger projects. In addition, the Ministry has delegated the authority to licence power stations with an installed capacity of less than five MW pursuant to the Water Resources Act to the NVE. This also contributes to faster consideration.

4.2.1 Protection plans and the Master Plan for Water Resources

Many watercourses are permanently protected against hydropower developments. The Storting adopted four protection plans between 1973 and 1993. These plans represent binding instructions to the authorities not to licence regulation or development of the rivers included in the plan for the purpose of hydropower generation. When evaluating rivers to be included, safeguarding a representative cross-section of Norwegian river systems has been considered important. Any distinctive features and opportunities for outdoor recreation in and near the rivers are also important considerations. A total hydropower potential of about 35 TWh per year has been protected from hydropower development. River system protection was codified in the 2000 Water Resources Act, which defines what is meant by protected watercourses and lays down provisions for their protection from types of development other than hydropower projects. Additional watercourses are now being considered for protection to supplement the protection plans.

The Master Plan for Water Resources is a recommendation from the government to the Storting. See Report No 60 (1991–92) to the Storting. It sets priorities for considering individual hydropower projects and divides these into two categories. Those in category I can be considered for licensing now, as can certain projects exempted from the Master Plan. Projects in category II and projects not covered by the Master Plan cannot be considered for licensing at present, but may be used for hydropower development or other purposes at a later date. The order of priority for considering individual hydropower projects is based on economic considerations and the degree of conflict with other interests. In other words, the aim to ensure that those rivers which can provide the cheapest power with the smallest environmental impact are to be developed first. However, approval of a project in the Master Plan does not mean that the authorities have made an advance commitment to grant a licence. The licensing authorities have sometimes refused applications for projects in category I. Provisions in the Watercourse Regulation Act and the Water Resources Act provide the licensing authorities with the authority to postpone the processing of applications which, pursuant to the Master Plan, should not be considered for licensing at the present time.

Since the Storting considered the Master Plan in 1993, the framework for hydropower development has altered in a number of ways. Environmental policy principles have changed, and most projects notified today are different in technical, environmental and economic terms from those described in the Master Plan.

The government is accordingly planning considerable modification and simplification of the Master Plan, with the current division of hydropower projects by categories due to be replaced by one based on river systems.

4.2.2 Industrial concession plan

In order to utilise water for electricity generation, a waterfall or head is required which allows the potential energy to be exploited. The owner of a waterfall is the landowner. The acquisition of rights of ownership or use to a waterfall by others than the government requires a licence pursuant to the Industrial Concession Act if it is assumed that the waterfall can provide an output exceeding 4 000 natural horsepower (2 944 kW) after regulation, either alone or in conjunction with other waterfalls which would be technically and economically feasible to develop with it.

When the Act was passed in 1917, it was framed in a way which adequately safeguarded the interests of the government and the general public. This included provisions on pre-emption rights, licences of limited duration and the right of reversion to the government when a licence expires. The right of reversion means that the government takes over a waterfall and any hydropower installations free of charge when a licence expires. Pre-emption means that the central government or the county council has a right to enter into the purchase agreement instead of the purchaser, but with the same rights and obligations as are set out in the contract with the latter.

Pre-emption rights and the right of reversion to the government apply only in the case of private ownership. A power station is considered to be privately owned if public ownership is less than two thirds. When the share of private ownership exceeds one third, the government may exercise its pre-emption rights. If the government chooses not to do so, the licence duration becomes fixed instead of being unlimited. In such cases, the licence runs for 60 years from the date when the original licence was granted, and the rights revert to the government when the licence expires.

Until the Industrial Concession Act was amended in 1992, the government's pre-emption rights with respect to waterfalls and power stations could only be exercised the first time a waterfall or power station was acquired. After the amendment, the government may also exercise its pre-emption rights over the resale of local authority-owned power utilities or the sale of shares or interests in such companies. Pre-emption rights apply when a property transfer results in the public share of ownership dropping below two thirds, regardless of whether the privately-owned share is held by one or several companies.

The county authorities have pre-emption rights on the first occasion when a licence for the acquisition of a particular waterfall or power station is granted, but this only applies if the government chooses not to make use of its pre-emption rights. Decisions by counties to exercise their pre-emption rights must be approved by the King in Council.

The Industrial Concession Act includes mandatory terms relating to licence fees and the obligatory sale of power to the local authorities in which the waterfalls are situated. These entitle the local authority to buy

10 per cent of the power generated at cost. The Act also authorises the introduction of further conditions relating to environmental considerations, the local community and so forth.

4.2.3 The Watercourse Regulation Act

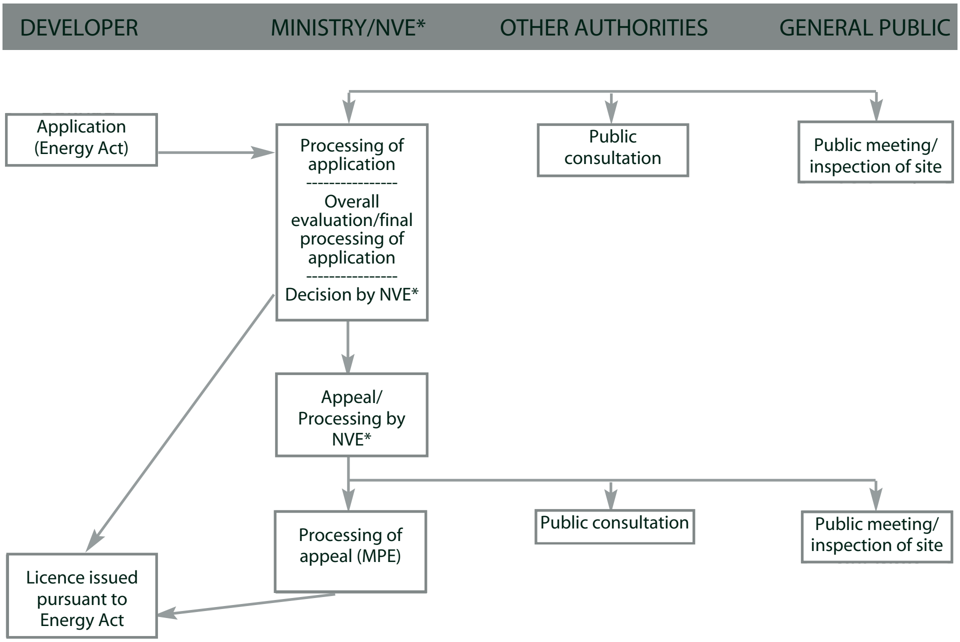
In order to regulate output from a power station over the year to correspond with varying demand, the ability to use a regulation reservoir to store water can be of crucial economic importance. See Chapter 2. Ownership rights to a waterfall do not in themselves confer the authority to use water from a regulation reservoir for power generation. This requires a separate licence pursuant to the Watercourse Regulation Act.

The Act applies to regulatory measures which even out fluctuations in water flow in a river during the year. As a general rule, it provides the authority to prescribe similar conditions to those authorised by the Industrial Concession Act, but additional special terms may be imposed to reduce the damage caused to a watercourse by regulation. For example, special rules may be specified about the establishment of a fishing fund if regulation damages the fish stocks in a watercourse. Rules for reservoir drawdown are also issued, including provisions on the minimum permitted rate of flow and the volume of water which may be released at different times of the year. The highest and lowest permitted water levels are specified in these rules. Licences for regulatory measures may be revised after 30 or 50 years, depending on when they were issued. The NVE decides whether revision is to take place after an authority outside central government (generally the local authority) or others representing the public interest have required revision of the conditions in a licence. This procedure primarily provides opportunities to specify new conditions to mitigate environmental damage which has occurred as a result of regulatory measures.

Licences for watercourse regulation also include requirements on obligatory sales of power and annual licence fees to central government and to the local authority or authorities in which the watercourse is situated. The fee is determined on the basis of the increase in electricity generation resulting from regulation, and is intended to compensate for any adverse effects. In addition, the creation of a business development fund for the local authority is generally required. Such funds are intended partly to compensate for any adverse effects, and partly to ensure that the local authorities enjoy a share of the economic benefits of hydropower development. Establishment of a business development fund may also be required pursuant to the Industrial Concession Act.

4.2.4 The Water Resources Act

Even if a developer already owns the rights to a head of water and does not need to regulate a watercourse, measures necessary to exploit the hydropower potential may require a separate licence pursuant to the Water Resources Act. The Water Resources Act is a general act which applies to all types of works in a watercourse. It came into force on 1 January 2001 to replace the 1940 Watercourses Act. Its purpose is to ensure that river systems and ground water are used and managed in accordance with the interests of society. The main criterion for giving permission for works in watercourses is that their benefits are greater than the damage or inconvenience to public and private interests in the river or catchment area. The Water Resources Act also provides the authority to impose a number of conditions to compensate for and mitigate the adverse impacts of developments in river systems. This Act is further discussed in Chapter 10.



This figure shows administrative procedures for licensing projects which come under the Energy Act, and the most important differences from the procedures pursuant to the water resources legislation, see figure 4.2.

Figure 4.3 Administrative procedures for licensing electrical installations pursuant to the Energy Act (power lines, gas-fired power stations, wind farms, etc)

4.3 The Energy Act

The 1990 Energy Act establishes the organisational framework for Norway's power supply system. It encourages competition in power generation and trading. By means of various licensing arrangements, the Act regulates the construction and operation of electrical installations, district heating systems, electricity trading, control of monopoly operations, foreign trade in power, metering, settlements and invoicing, the physical market for trade in power, system coordination, rationing, electricity supply quality, energy planning and contingency planning for power supplies. Together with certain other statutes, the Energy Act also implements the EU's electricity directive (96/92). See chapter 9.1.1.

The authority to make decisions pursuant to the Energy Act has largely been delegated to the NVE. The most important exception is that the Ministry of Petroleum and Energy has retained the authority to issue electricity export and import permits.

The Ministry of Petroleum and Energy is the appeals instance for decisions made by the NVE pursuant to the Energy Act. As a general rule, the Ministry will therefore only consider matters involving an appeal against a licensing decision made by the NVE. The King in Council is the appeals instance for matters dealt with in the first instance by the Ministry, such as export and import licences.

4.3.1 Administrative procedures pursuant to the Energy Act

If an EIA pursuant to the Planning and Building Act is required for a project, the same procedures are followed both for projects licensed under the Energy Act and for those licensed under legislation relating to water resources (see figure 4.2).

If no EIA is required pursuant to the Planning and Building Act (for example for power lines below certain limits), the first step is an application to the NVE pursuant to the Energy Act. In such cases, an impact assessment is required in connection with the application and its consideration by the directorate pursuant to the Energy Act. The NVE is responsible for public consultation, for making the documents available for inspection by those affected, and for holding public meetings if necessary.

Important differences from procedures for projects dealt with under the water resources legislation are that the NVE itself makes decisions in cases pursuant to the Energy Act, and that no recommendation is sent to the Ministry unless the Ministry is the first instance pursuant to the Act. See section 4.3 above.

In addition, the Energy Act does not include the special provisions found in the water resources legislation which require matters of principle and appeals to be submitted to the Storting. If there is no appeal against a decision by the NVE, the licensing decision is final. The only recourse then is to take legal action against it.

If an NVE licensing decision is appealed, an ordinary appeals procedure is initiated pursuant to the provisions of the Public Administration Act. The Ministry holds further public consultations as part of the appeals procedure if necessary, and a public meeting and inspection of the site generally take place as well. When the Ministry has made a decision on the appeal, it is final and the only recourse is to bring an action against it.

4.3.2 Local area licences

A local area licence is required for the construction and operation of lines and electrical installations carrying a voltage of 22 kV or less. An energy utility which holds a local area licence need not apply for a licence pursuant to the Energy Act for each separate installation. The procedures are thus simpler than in cases where a construction and operating licence must be obtained. Local area licences include a requirement for energy utilities to supply electricity to customers within the geographical area covered by the licence.

4.3.3 Construction and operating licences

Before the construction of power stations, transformer stations and transmission lines not covered by a local area licence as described above, the developer must apply for a separate construction and operating licence for each installation. This applies to all electrical installations, including gas-fired power stations, wind farms and facilities required for hydropower stations if these exceed the size limits specified in regulations issued pursuant to the Energy Act.

The purpose of this licensing system is to ensure that electrical installations are constructed and operated on the basis of uniform standards. Constructing high-tension transmission lines and transformers often has a substantial impact on the surrounding environment. In line with the object of the Energy Act, licensing procedures take account of both socio-economic considerations and the public interest – with regard to the environment, for instance.

A number of conditions can be stipulated in the licences. These are elaborated in regulations pursuant to the Energy Act. They include a requirement for the installation to contribute to rational energy supplies, provisions on project start-up, construction, technical operation, utilisation of capacity at each plant, terms intended to avoid or limit damage to the environment or cultural monuments, stipulations relating to the organisation and expertise of a company granted a licence, and other conditions which may be required in the individual case. When applications to construct gas-fired power stations at Kollsnes and Kårstø were processed, for instance, the licences included a requirement to plan for CO_2 removal from the flue gases at a later date.

An energy utility which applies for a licence must draw up a long-term plan for the development of the power supply system in the area in which it operates. Licensees are obliged to cooperate in harmonising their individual power supply plans with each other and with the national power supply system.

4.3.4 Trading licences

Any entity which trades electricity or which may be involved in monopoly operations must hold a trading licence. Only the state may trade electricity without a licence. They are issued by the NVE.

The largest group covered by these arrangements is made up of undertakings involved in the retail sale of electricity – either generated by themselves or purchased – transmitted via their own grid to end-users for general consumption in a specific area, and others which own a distribution or transmission grid. The licensing arrangements also apply to undertakings which trade in electricity on the power market. Electricity traders who buy and sell electricity in their own name and bear the financial risk for any losses must also obtain licences. If operations requiring a licence are limited in extent or only make up a small proportion of an undertaking's activities, a trading licence is issued on simplified terms. Power brokers who do not take any responsibility for the financial aspects of a contract do not need to hold licences.

Trading licences are an essential part of the market-based power trading system. They are intended to safeguard customer interests by helping to ensure financially-sound electricity trading and to regulate grid management and operation as a natural monopoly.

The system of trading licences provides the authority to regulate grid management and operation, which form a natural monopoly. Prices charged by the energy utilities for electricity transmission may not exceed what is required to cover grid investment and operating costs plus a reasonable return on investment. Vertically-integrated utilities which hold trading licences must keep separate accounts for grid management and operations and for operations subject to competition (sales and production). This enables the NVE, which is responsible for regulating monopoly operations, to evaluate whether prices set for power transmission are reasonable. Moreover, licensees are required to provide market access to all customers for grid services by offering non-discriminatory and objective point tariffs and terms. The NVE has issued further regulations on income frameworks, charges and metering, and settlement of electricity trades. See Chapter 6 for further details about the regulation of monopoly operations.

4.3.5 Marketplace licences

A licence is required for the organisation and operation of marketplaces for physical trading in electrical energy. Such marketplaces play a key role in market-based electricity trading. Marketplace licences make it possible for the energy authorities to specify conditions and regulate various factors, including price-setting, obligations of the marketplace towards system operators, transparency, conditions for players proposing to engage in trade, neutral behaviour and non-discrimination. Power trading is further discussed in Chapter 7.

4.3.6 Licences to trade power with other countries

Pursuant to the Energy Act, a licence is also required for foreign trade in electricity. The Ministry of Petroleum and Energy is responsible for issuing such licences. Requiring a licence provides the authorities with the control they need to safeguard the public interest – ensuring, for instance, that such trade is based on the principles of sound resource management, environmental considerations and reliable power supplies. Statnett SF and Nord Pool Spot are licensed to organise trade in power with the other Nordic countries. Foreign trade in electricity is further discussed in Chapter 7.

4.3.7 District heating systems

As a general rule, district heating systems must be licensed pursuant to the Energy Act. Regulations pursuant to the Act specify that licensing is mandatory for all installations with a maximum capacity of more than 10 MW. Applications for licences may also be submitted for smaller installations if they wish to be licensed and thereby included in the system of mandatory connection described in the next paragraph.

If a district heating installation is licensed pursuant to the Energy Act, the local council may decide to make connection to the system mandatory pursuant to the Planning and Building Act. This means that buildings constructed within the licensing area must be connected to the district heating system.

The Act also regulates the prices which may be charged for district heating. These must not exceed charges for electrical heating in the same supply area. If it is mandatory for the customer to be connected to the installation, it is also possible to appeal to the NVE over prices and other conditions.

4.3.8 Responsibilities for system coordination, rationing and delivery quality

System operator responsibilities include ensuring a balance between total generation and consumption of electricity at any given time, taking account of power exchanges with interconnected foreign systems. The system operator must also take steps to ensure a satisfactory quality of supply in all parts of the country. This important function is regulated by the Energy Act and associated regulations. The Ministry of Petroleum and Energy appoints the system operator and specifies terms for this appointment. The NVE has issued further regulations relating to the responsibilities of the system operator. For further information, see Chapter 5.4.

The Energy Act also contains a provision on electricity rationing, including enforced reductions in supply and requisitioning. Rationing can be put into effect if extraordinary circumstances make this necessary. The provision states that the NVE is the rationing authority and responsible for planning and administrative implementation of any measures required in connection with such action. Separate rationing regulations have been issued by the directorate.

The Act also confers the authority to issue regulations on delivery quality in the electricity system. Such regulations are currently under preparation by the NVE and due to come into force on 1 January 2005.

4.3.9 Energy planning

One chapter of the Energy Act deals with energy planning, which is intended to ensure the evaluation of different solutions for developing a rational energy supply system in social terms. Everyone licensed pursuant to the Act to operate electrical or district heating facilities is duty-bound to participate in such planning. The NVE has issued regulations on energy studies.

4.3.10 Contingency planning for power supplies

Because power supplies are so important for society, and because of the public interest related to power supplies, the Energy Act includes provisions which confer the authority to implement any contingency measures that experience suggests are necessary to protect installations against damage from natural conditions, technical failure or deliberate sabotage in peacetime or during a state of emergency or in the event of war. These provisions apply to power supplies in general, irrespective of whether or not undertakings are licensed pursuant to the Act.

During a state of emergency or in the event of war, control of power supplies passes to the Power Supply Preparedness Organisation. This body includes all the entities responsible for power supplies during peacetime. The NVE is charged with coordinating contingency planning during a state of emergency or in time of war.

The NVE may also assign duties to the preparedness organisation during peacetime in the event of damage to power supply installations from natural conditions, technical failure, terrorist action or sabotage. Regulations on contingency planning in the power system have been issued by the NVE.

4.4 Other legislation

4.4.1 The Planning and Building Act

The Planning and Building Act applies to a large extent in parallel with the energy and water resources legislation. This means that almost all projects must be processed in accordance with both sets of legislation.

Provisions in the Planning and Building Act which relate to an EIA apply to all projects pursuant to the energy and water resources legislation. Briefly, these provisions make an EIA mandatory for specified types of large project, and for smaller projects if they satisfy certain criteria.

Efforts are currently being made to harmonise the planning provisions of the Planning and Building Act with the provisions in the energy and water resources legislation relating to hydropower development and the construction of power lines.

The provisions of the Planning and Building Act relating to building are generally not applicable to projects pursuant to the energy and water resources legislation. This follows from the regulations relating to administrative procedures and regulation of building projects issued pursuant to the Planning and Building Act.

4.4.2 Competition legislation

Norwegian competition legislation provides the legal framework for the section of the power market subject to competition and applies in addition to the Energy Act.

The Competition Act is intended to promote competition in order to secure efficient use of society's resources. Enforcement gives particular weight to consumer interests.

Cooperation which inhibits competition and misuse of a dominant market position are prohibited under the Act. It also allows the competition authorities to impose substantial fines if these prohibitions are breached, and to reduce such penalties for companies which assist the authorities in exposing such violations. The Norwegian Competition Authority serves as the regulator in the power market.

4.4.3 Natural gas legislation

The adoption of the EU's gas market directive (98/30/EC) in Norwegian law has necessitated the creation of a legal framework for such operations in Norway.

Following the consideration of Proposition no 81 (2001–2002) to the Odelsting, the Storting adopted a separate framework Act which enshrines the key principles contained in the EU directive. This Act no 61 of 28 June 2002 on common rules for the internal market in natural gas (the Natural Gas Act) applies to the transmission, distribution, supply and storage of natural gas. It incorporates the directive's central principle that natural gas undertakings and qualified customers must be given access to natural gas transmission and distribution networks.

The Act contains a "sunset" clause which requires the Ministry to assess after five years whether the legislation needs to be revised. This will make it possible to consider in greater detail whether it would be appropriate to adopt more specific regulations for the downstream gas sector, and to what extent the rules in the framework

Act should instead be incorporated in the Energy Act.

Implementation of the gas directive in the downstream sector will also require further provisions to be included in regulations issued pursuant to the draft act.

In addition, the gas market directive has been implemented in the regulations issued pursuant to the Act (the natural gas regulations).

Chapter 2 of the natural gas regulations specifies more detailed rules about EIAs and licensing for different types of downstream natural gas infrastructure. Systems for transporting natural gas, including transmission pipelines, LNG installations and associated facilities primarily intended to deliver to natural gas undertakings in another region, cannot be constructed or operated without a licence from the Ministry. Minor LNG installations and small-scale facilities for transmission or distribution of natural gas do not need to be licensed.

Chapter 3 of the regulations contains rules about separate accounting in undertakings engaged in two or more of the activities of transmission, distribution or storage of natural gas. It also lays down rules on third-party (negotiated) access, the resolution of disputes relating to market access, and general behaviour. Chapter 4 provides general rules on regulation and supervision, and a provision on exemptions from the Natural Gas Act and regulations.

The EU adopted a new gas market directive (2003/55/EC) on 26 June 2003 to replace the existing provisions. This directive requires amendments to Norwegian regulations in the area. See chapter 9.1.1.

Downstream gas activities in Norway are described in greater detail in chapter 3.5.

4.4.4 Other legislation

In addition to the licensing procedures pursuant to the energy and water resources legislation and the Planning and Building Act discussed earlier, energy and water resources projects may also require permits pursuant to other legislation, such as the Pollution Control Act and the Cultural Heritage Act. This applies to gas-fired power stations, for example.

5

Owners and organisation of power supplies

- Owners and forms of business organisation
- Organisation and restructuring of the power supply sector
- Companies in the different operating categories
- Statnett SF
- Key financial data for the power supply sector

5.1 Owners and forms of business organisation

5.1.1 Owners

Everyone supplying or trading electricity must hold a trading licence. See chapter 4.3.4. Such licences were held by 320 companies in Norway on 1 January 2004[4]. This figure does not include holding companies not engaged in activities for which licences are required.

Table 5.1 breaks down companies holding trading licences by ownership. It shows that 231 companies are wholly or partly owned by local authorities, and that 140 of these are wholly owned by such authorities. A company which is wholly local-authority-owned may nevertheless have several local authorities as shareholders. The table gives no information on the number of owners in each company: many have several owners, and cross-ownership is on the increase in the sector.

Local authorities and county councils own some 55 per cent of Norway's electricity generation capacity, central government – through Statkraft SF – about 30 per cent and private companies roughly 15 per cent[5].

The central government owns a large proportion of the central grid. Private companies, counties and local authorities own the remainder. Central government ownership of the national grid is administered through Statkraft SF. Local authorities and county councils own most of the regional and distribution grids.

Private ownership is found in all areas of the power supply sector (generation, trading and transmission). Almost half the companies wholly in private ownership are solely engaged in trading.

Foreign ownership of the Norwegian power supply system is relatively limited, but some foreign companies have secured a trading licence in Norway. These concentrate mainly on the wholesale and spot markets. In addition, foreign enterprises have bought into Norwegian companies with trading licences or established their own Norwegian-registered subsidiaries. Foreigners have concentrated largely on trading companies, but foreign holdings can also be found in generating or network operations.

Table 5.1 Ownership of companies with trading licences at 1 January 2004

Ownership	Share of ownership	Sole owner
Local authorities	231	140
County councils	40	11
Central government	25	4
Private	136	67

Source: Norwegian Water Resources and Energy Directorate

5.1.2 Forms of business organisation

In recent years, many power utilities have converted from local authority ownership to limited companies, and the latter mode of organisation is now used by 73 per cent of all enterprises in the Norwegian power sector. Figure 5.1 illustrates forms of company organisation at 1 January 2004.

One reason why many owners opt for limited company status is that the regulations pursuant to the Energy Act require the holder of a trading licence to keep accounts in accordance with the Accounting Act. A limited company also allows owners to restrict their personal financial liability. They are liable for their share of the paid-up capital, but not for any debts. Companies owned by counties or local authorities, on the other hand, have unlimited liability for all their operations – including debts.

[4] This does not include local authorities reselling power supplied under licence terms to energy utilities in which they have no ownership interest, or companies which hold licences on simplified terms (industrial entrerprises). See Chapter 4.3.4.

[5] A number of companies are owned by a mix of county councils, local authorities, central government and private interests. The percentage distribution is based on the majority owner.

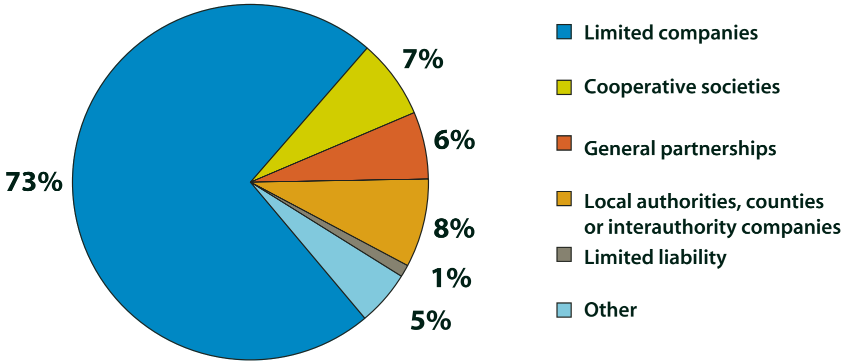


Figure 5.1 Forms of company organisation

Source: Norwegian Water Resources and Energy Directorate

Central government ownership is managed through the Statnett SF and Statkraft SF state enterprises. For a company to be organised as a state enterprise, the government must be the sole owner. The differences between state enterprises and limited companies are otherwise not great.

More and more energy utilities are being organised as groups. This applies to almost 48 per cent of all holders of trading licences. About 60 per cent of parent companies are themselves involved in activities which require licences. The others are pure holding companies.

At 1 January 2004, 46 groups had a total of 134 subsidiaries. Subsidiary companies which intend to engage in activities which require a licence must hold their own trading licences. The formation of groups accordingly increases the number of licensees.

5.2 Organisation and restructuring of the power supply sector

5.2.1 Organisation

The power supply sector is organised in various ways around electricity generation, trading and transmission activities. Depending on which activity is being pursued, companies can be designated as generating, grid or trading enterprises, vertically-integrated utilities or industrial undertakings. In some cases, they are described collectively as energy utilities. Companies have also been established solely to negotiate power contracts.

Everyone supplying or trading electricity must hold a trading licence. Figure 5.2 shows the number of energy utilities which held such licences at 1 January 2004 by their type of activity. The overlapping circles indicate how far such utilities are involved in several types of activity. Seventy-six are engaged in electricity generation, trading, and grid management and operation, for instance, while 46 are only involved in grid management and operation. A total of 320 companies hold trading licences.

Figure 5.3 presents trends in the various operating categories during 1998-2003. This shows that the number of vertically-integrated utilities has declined, partly as a result of mergers which have formed larger vertically-integrated companies. The number of legal entities engaged solely in operations subject to competition has been rising since 1998, with the exception of 2001. For the first time, the number of such licensees in 2003 exceeded the total for vertically-integrated companies.

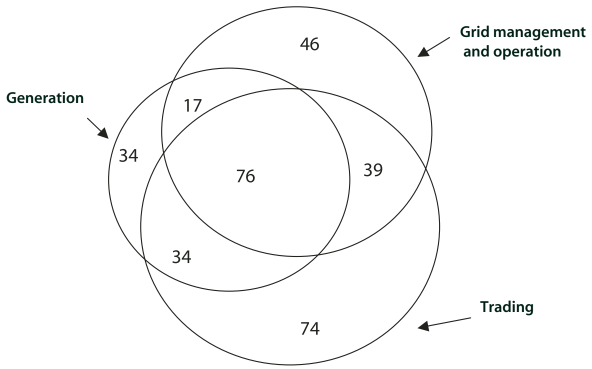


Figure 5.2 Companies holding trading licences by activity

Source: Norwegian Water Resources and Energy Directorate

5.2.2 Restructuring the power industry

In response to the deregulation of the energy sector in Europe, a substantial restructuring of the power industry is taking place in most European countries, also across national borders.

Many local authorities and counties in Norway have sold holdings in power companies. At the same time, larger regional power companies have been established, partly by acquisition and partly through mergers. Examples are Lyse Energi, Agder Energi, BKK and Skagerrak Energi.

Statkraft has acquired a stake in several large Norwegian power companies, and in Sweden's Sydkraft. Investment by Norwegian companies in other countries has otherwise been limited.

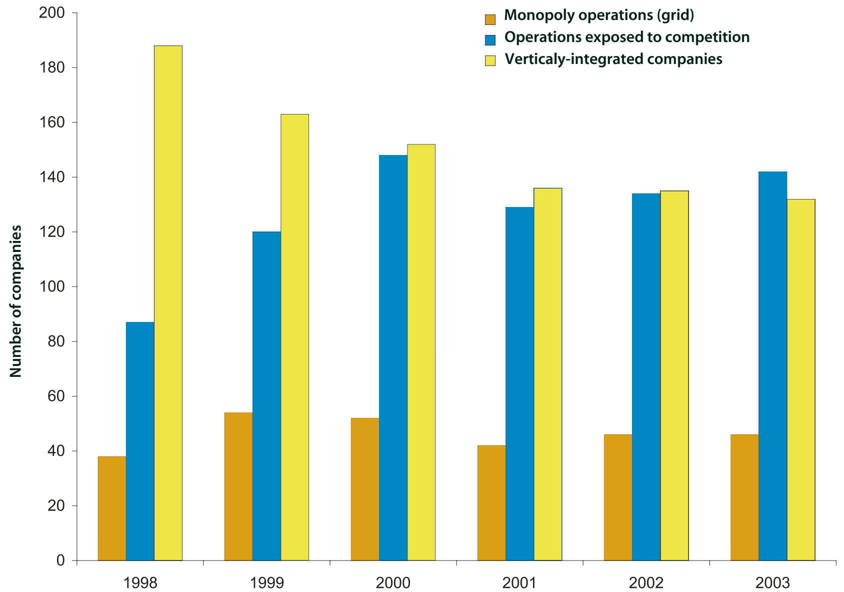


Figure 5.3 Trends in the various operation categories 1998–2003

Source: Norwegian Water Resources and Energy Directorate

The pace of restructuring in Norway has slackened considerably over the past two years by comparison with the 1999–2001 period.

Shares worth just over NOK 8 billion in Norwegian power companies were traded in 2003, which represented a slight increase from the year before.

A total of 21 transactions took place as against 26 in 2002. This compares with 60 in 2000, the peak year for such transactions, when traded shareholdings were worth about NOK 20 billion[5].

Restructuring other than the transfer of shareholdings has also declined in the Norwegian power industry.

Mergers in 2001 and 2000 involved assets worth some NOK 17 billion and NOK 30 billion respectively. The corresponding figures for 2003 and 2002 were NOK 400 million and NOK 1.6 billion respectively.

5.3 Companies in the different operating categories

5.3.1 Generating companies

Of the ordinary trading licensees, a total of 161 generate electricity in Norway. Thirty-four of these companies are engaged solely in the generating business.

The 10 largest generating companies in Norway account for about 70 per cent of the country's total mean generating capacity, and about the same proportion of installed capacity.

Of the 161 Norwegian generating companies, 111 are organised as limited companies. Most of the generating companies are owned by counties or local authorities, often jointly by several of the latter in the same region.

Many of the privately-owned generating companies are industrial enterprises which

[5] Figures from Pareto Securities.

Table 5.2 The 10 largest power generation companies at 1 January 2004

Generating company	Mean annual output		Installed capacity	
	TWh	Percentage	MW	Percentage
Statkraft SF	36.4	30.7	8 725	31.6
Norsk Hydro ASA	6.8	5.7	1 370	5.0
BKK AS	6.8	5.7	1 541	5.6
E-CO Vannkraft AS	6.8	5.7	1 891	6.8
Agder Energi AS	6.5	5.5	1 414	5.1
Lyse Produksjon AS	5.9	5.0	1 544	5.6
Skagerak Kraft AS	4.5	3.8	1 160	4.2
Trondheim Energiverk Kraft AS	3.2	2.7	746	2.7
Hafslund ASA - Sarpsborg	2.7	2.2	504	1.8
Nord-Trøndelag Elektrisitetsverk FKF	2.6	2.2	568	2.1

Excluding holdings in Sydkraft and Norwegian companies, except Norsk Hydro, where Hydro Aluminium Vekst AS and Norsk Hydro Produksjon AS are included.

Source: Norwegian Water Resources and Energy Directorate

primarily supply their own operations. They are granted trading licences on simplified terms. See Chapter 4.3.4. The 31 companies which hold trading licenses on simplified terms are not included in table 5.2.

5.3.2 Grid companies

A company in this category may own a local, regional or central grid. A total of 178 companies are engaged in grid management and operation at one or more levels. Of these, 46 are pure grid companies, with the remainder also engaged in electricity generation and/or trading. See figure 5.2. Most grid companies are wholly or partly owned by one or more local authorities. The Statnett SF state enterprise owns about 87 per cent of the central grid.

A total of 114 grid enterprises are organised as limited companies and 22 as cooperatives, while 19 are under local authority, county council or joint local authority ownership.

Table 5.3 shows the 10 largest grid and vertically-integrated companies with grid operations at 1 January 2003 by the number of customers and deliveries to end users.

5.3.3 Vertically-integrated companies

Vertically-integrated companies are engaged in grid, generation and/or trading activities. Like grid companies, they sell electricity to end users in the area where they own the distribution grid, and often compete for customers in areas served by other grid companies.

In all, 132 companies are engaged both in operations subject to competition (generation and/or trading) and in grid management and operation. Of these, 77 are engaged in generation, trading, and grid management and operation. The vertically-integrated utilities include 74 limited companies.

The formation of groups results in new types of vertical integration. Grid companies, for example, may be subsidiaries of a group which also embraces subsidiaries engaged in generation and trading.

5.3.4 Trading companies

Trading companies buy power in the market for resale, mainly to end-users. This corresponds fairly closely to the trading activities of traditional distribution utilities.

Table 5.3 The 10 largest grid companies at 1 January 2003

Grid company	No of customers	Quantity transmitted (GWh/year)
Viken Nett AS	368 777	10 917
Skagerak Nett AS	175 948	4 711
BKK Nett AS	172 817	4 596
Agder Energi Nett AS	153 422	3 673
Lyse Nett AS	109 300	3 607
Eidsiva Energinett AS	102 451	2 605
(Østnett AS*	101 775	2 968)
Østfold Energi Nett AS	93 231	2 248
Trondheim Energiverk Nett AS	87 594	2 235
Nord-Trøndelag Elektrisitetsverk FKF	76 019	1 961
Troms Kraft Nett AS	68 073	1 984

**Østnett went into liquidation with effect from 1 January 2003, and operations in Follo and Akershus were merged with Hafslund Nett Øst AS. Other activities were merged with Viken Nett AS*

Source: NVE

Table 5.4. The 10 largest energy trading companies at 1 January 2003 (GWh/year)

Comany	Total turnover	Households and holiday cabins	Other activities*
Statkraft SF	19 273	0	19 273
Norsk Hydro Produksjon AS**	13 814	0	13 814
Tindra AS	11 680	5 949	5 731
Fjordkraft AS	8 990	4 701	4 290
LOS AS	3 840	1 747	2 094
Lyse AS	3 305	1 703	1 602
Nord-Trøndelag Elektrisitetsverk FKF	2 784	777	2 007
Eidsiva Energi Omsetning AS	2 765	1 120	1 645
Østfold Energi Kraftsalg AS	2 260	981	1 279
Troms Kraft Marked AS	2 161	852	1 308

**Industrial production and other commercial activities.*

***Figures for Norsk Hydro Produksjon AS relate to 2001.*

Source: NVE

In addition to the traditional players in the power supply sector, other enterprises – such as oil companies – have also become involved in electricity sales.

A total of 223 companies are engaged in trading, and 74 of these have no other activities. Most trading undertakings are organised as limited companies.

Table 5.4 shows the 10 largest electricity trading companies ranked by supplies to end users at 1 January 2003. The table shows both the total quantity of electricity traded and the split between electricity for households and holiday cabins and for other activities. The two largest trading companies, Statkraft and Norsk Hydro Produksjon, supply electricity only to industrial and commercial activities.

5.3.5 Power brokers

Power brokers do not buy power themselves, but negotiate market-based offers and establish contact between buyers and sellers. Brokering activities do not require a trading licence.

5.4 Statnett SF

Statnett SF is responsible for construction and operation of the central grid, and operates the whole of this facility. As the transmission system operator (TSO) in Norway, it is also responsible for short- and long-term system coordination. This means that it coordinates the operation of the entire Norwegian power supply system so that the amount of electricity generated equals consumption at all times.

A clarification of the TSO's responsibilities when power is in very short supply was provided by Report no 18 (2003–2004) to the Storting on security of supply for electricity, etc. Statnett is responsible on a continuous basis for identifying and developing the instruments required to maintain a moment-to-moment balance between supply and demand at times when electricity supply is very tight. Its duties also include continuously evaluating the extent to which new measures are required in order to ensure that such a moment-to-moment balance is maintained in a better way than at present.

In addition, Statnett plays a central role in the development and operation of transmission connections to other countries, and must therefore cooperate closely with the system operators in the other Nordic countries. This cooperation is an important basis for the Nordic power market. Cooperation between the Nordic TSOs is also organised through the Nordel organisation. See the web site at www.nordel.org for further information. The Nordic power market is further discussed in Chapter 7.4 and 7.5.

Sweden's Affärsverket Svenska Kraftnät and Statnett SF currently own Nord Pool ASA on a 50-50 basis. Nord Pool is the Nordic power exchange, which organises markets for physical and financial trade in electric power. Nord Pool and the various markets are discussed further in Chapter 7.

5.5 Key financial data for the power supply sector

An operating profit of NOK 17.9 billion was achieved by Norway's power companies in 2001 as against NOK 11.6 billion the year before. Net profit came to NOK 9 billion, compared with NOK 6.7 billion in 2000. Dividend paid in 2001 totalled NOK 6.8 billion, up from NOK 3.9 billion the year before. The 2001 figure represented about 76 per cent of net profit as against roughly 58 per cent in 2000 and 53 per cent in 1999. The book value of assets in 2001 was NOK 252.5 billion, with a book equity ratio of about 47 per cent.

The return on total assets before tax[6] was eight per cent in 2001 as against six per cent the year before and 5.8 per cent in 1999. When calculating the return on total assets, financial income has been taken into account but not extraordinary items. The return on equity[7] after tax rose from 6.1 per cent in 2000 to 7.9 per cent in 2001.

[6] Return on total assets = ((profits before extraordinary items + interest paid) / mean total assets) x 100. Mean total assets are the average of total assets at 1 January and 31 December.

[7] Return on equity after tax = ((profits before extraordinary items – taxes paid) / mean equity) x 100. Mean equity is the average of equity at 1 January and 31 December.

Tabell 5.5 Key figures 1999–2001

Key figures, NOK billion	1999	2000	2001
Operating income	62.4	65.8	90.5
Operating profit	10.5	11.6	17.9
Profit before extraordinary items	7.8	9.2	14.0
Profit before taxes	8.2	9.6	14.0
Net profit	5.7	6.7	9.0
Dividends	3.0	3.9	6.8
Current assets	34.6	37.5	47.2
Power plants, waterfall rights, dams	93.1	90.5	89.6
Grid systems	45.3	45.4	47.7
Other fixed assets	48.6	62.1	67.8
Current debt	25.9	30.2	38.8
Long-term debt	90.2	92.8	93.8
Equity	105.5	112.5	119.8
Total liabilities and equity	221.5	235.4	252.5
Return on total assets before tax, %	5.8	6.0	8.0
Return on equity after tax, %	5.4	6.1	7.9

Source: Statistics Norway