Electricity market 2000

Swedish National Energy Administration

ELECTRICITY MARKET 2000

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The electricity markets in the Nordic countries have undergone major changes since the electricity market reform work was started in the early 1990s. Sweden, Norway and Finland have a common electricity market since 1996. The work of also reforming the Danish electricity market was begun in the year 2000.

The objective of the electricity market reform is to introduce increased competition, to give the consumers greater freedom of choice and also, by open and expanded trade in electricity, create the conditions for efficient pricing.

The Swedish National Energy Administration is the supervisory authority as specified in the Electricity Act, and one of the tasks entrusted to it by the Government is to follow developments on the electricity market and to regularly compile and report current market information.

The purpose of the "Electricity market 2000" publication is to meet the need for generalized and readily accessible information on the conditions on the Nordic markets. The publication includes summaries of information from recent years concerning electricity generation and utilization in the Nordic countries, the structure of the electricity market from the players' perspective, trade in electricity in the Nordic countries and in Northern Europe, electricity prices in the Nordic and other countries, and the impact of the electricity sector on the environment. ■

Eskilstuna, August 2000

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Director-General

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The electricity market in the Nordic countries has undergone extensive changes in the past decade. All of the Nordic countries, with the exception of Iceland, have now opened their electricity markets to competition. In Sweden, Norway and Finland, the market is open to all electricity users, whereas Denmark has opened its electricity market only to customers whose electricity consumption is high. During 1999, Jutland and Funen have joined the Nord Pool Nordic electricity exchange, and Zealand is expected to join Nord Pool during the year 2000.

If an integrated electricity market is to perform well, it is vitally important to establish common rules and conditions on the markets of the individual countries. The energy policies of other countries, and above all of the Nordic countries, have therefore become of growing importance to Sweden.

Another change is that environmental matters have become of growing importance in guiding the energy policy. In many countries, the energy sector is a major source of emissions of carbon dioxide, sulphur dioxide and also nitrogen oxides. However, with the exception of Denmark, the electricity generation sector has made a relatively modest contribution to the emissions in the Nordic countries, due to the high proportion of emission-free electricity generation.

Sweden

Sweden opened its electricity market to competition in 1996, when extensive changes were made to the Swedish electricity legislation. The purpose of the electricity market reform is to introduce increased competition and provide the consumers with greater freedom of choice and, by open and increased trade in electricity, to create the conditions for efficient pricing. The electricity networks throughout the country must be open to all players on the electricity market – electricity generators, electricity sellers and electricity customers who have paid a connection charge somewhere in the country. All consumers must have the right to free choice of supplier of the electricity they use.

However, for changing over to a different electricity supplier, every user initially had to have a meter for hourly metering of the electricity consumption, and it was therefore not economically viable for customers with a low electricity consumption to change over to a different electricity supplier. The Electricity Act (1997:857) came into force on 1 January 1998. The changes include rules on consumer protection in the purchase of electricity, and new regulations concerning trade with other countries. In addition, the rules concerning supervision of the electricity market were clarified. The Swedish National Energy Administration was given direct responsibility for supervising the electricity sales that took place within the framework of delivery concessions. The demand for hourly metering of electricity was withdrawn on 1 November 1999. At the same time, the delivery concession system was abolished.

Towards a sustainable energy system

The Riksdag decided on new guidelines for the Swedish energy policy in June 1997. The objective of the energy policy is to safeguard – in the short term and in the long term – the availability of electricity and energy from renewable energy sources on terms that are competitive in relation to the surrounding world. The energy policy must create the conditions for efficient energy utilization and a cost-effective Swedish energy supply. At the same time, the impact on health, the environment and the climate must be low, and conversion to an ecologically sound society must be facilitated. According to the decision, phasing out of nuclear power would be started. In December 1997, the Riksdag passed the Nuclear Power Decommissioning Act, and the Government decided in February 1998 that Barsebäck 1 would be decommissioned no later than the end of June 1998. However, shut down of Barsebäck 1 was postponed to 30 November 1999. According to the energy policy decision, Barsebäck 2 will be decommissioned in 2001, provided that the loss of generation capacity can be compensated by reduced electricity consumption and increased supply of electricity. The 1997 energy policy programme is now being evaluated, which will serve as a basis for a decision by the Riksdag concerning possible decommissioning of Barsebäck 2.

A comprehensive energy policy programme was started, with the aim of facilitating the change-over and development of the energy system. The work of implementing most of the programme and coordinating the change-over is led by the Swedish National Energy Administration, which was set up on 1 January 1998. A total of SEK 9 billion is being allocated over a period of 7 years.

Swedish climate strategy and proposed trade in emissions

In April 2000, the Climate Committee submitted its proposal for a Swedish climate strategy (SOU 2000:23), which includes targets aimed at Sweden meeting its national and international commitments, and also a plan of action for achieving the targets. According to the Climate Committee, the target is that the emissions of greenhouse gases in Sweden should be reduced by around 50 % by the year 2050 compared to the emissions in 1990, and should then be lowered further. As a short-term target for the period between 2008 and 2012, it is suggested that the emissions should be reduced by 2 %. However, Sweden's international undertakings in the Kyoto protocol give Sweden the right to increase its emissions by 4 %. The plan of action consists of a basic package of measures that can be decided and largely introduced immediately, and an additional package of measures to be introduced at a later date. The additional package includes actions and regulatory measures that allow for additional emission decreases beyond the basic package, but that demands further consideration.

During April 2000, the "Investigation into the opportunities available for utilizing the flexible mechanisms of the Kyoto protocol in Sweden" has also presented its final report (SOU 2000:45). The report suggests that Sweden, together with the EU, should introduce a system of trade in emissions up to the year 2005. According to the proposal, the trading system should cover emissions of carbon dioxide from activities that now pay the whole or half of the carbon dioxide tax. Activities that today pay no carbon dioxide tax should be exempted, e.g. emissions from industrial processes. When the trading system is introduced, it would replace the carbon dioxide tax. It is suggested that, from the year 2008, the trading system should be expanded to cover a larger number of emission sources and further greenhouse gases.

In addition, an inter-departmental committee was entrusted with the task of reviewing, during the spring 2000, the support system for renewable electricity generation. The matter will be considered further in future draft bills. The taxation system in the field of energy is now also being reviewed.

Norway

Norway opened its electricity market to competition back in 1991, and profile-settlements of consumption was introduced in 1995, whereby all electricity users were given the opportunity to change over to a different electricity supplier free of charge.

The 1999 energy strategy of the Norwegian Government specifies that the energy policy shall be drawn up so that it underpins an ambitious environmental policy. The generation and utilization of energy must conform to environmental demands, and the energy prices should reflect, as far as possible, the environmental costs. Increased generation should be based, to a greater extent, on renewable energy sources. The target is that a further 4 TWh of water-borne heat generated by renewable energy sources should be put to use and that wind power should be expanded so that the annual energy generation will increase to 3 TWh before the year 2010. Another main objective is to restrict the energy consumption and reduce the dependence on electric heating. The change-over in the utilization and generation of energy presupposes a gradual increase in electrical charges, combined with investment support.

A debate concerning possible expansion of gas power has been in progress in Norway for a number of years, and there is wide disagreement in the matter. The present government is favourably disposed to this expansion. In addition, a study (Quota Committee) submitted a proposal in December 1999 concerning a national system for transferable emission rights. According to the proposal, a national trading system will be introduced in the year 2008 and will comprise as many emission sources as possible, corresponding to almost 90 % of Norway's total emission of carbon dioxide.

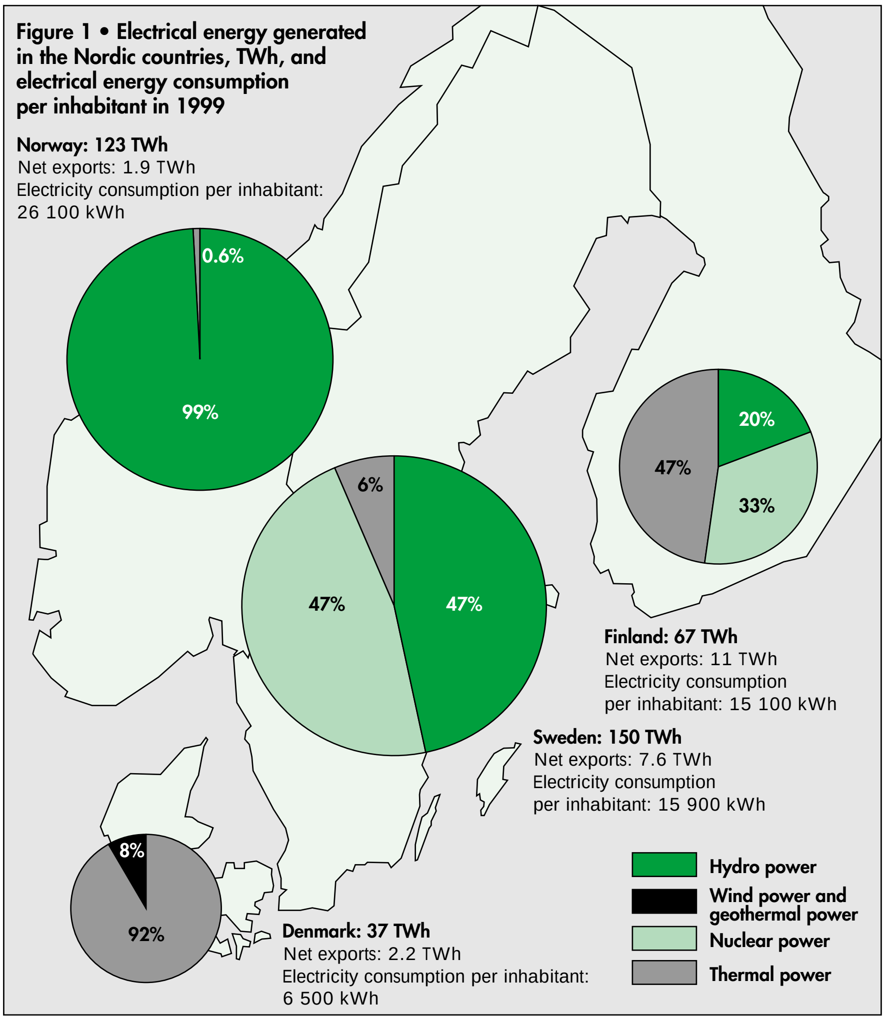

Figure 1 • Electrical energy generated in the Nordic countries, TWh, and electrical energy consumption per inhabitant in 1999

Source: Nordel

Finland

The Finnish Electricity Market Act came into force in 1996, and the electricity market was opened to all Finnish electricity users in November 1998, when profile-settlements of consumption was introduced for electricity customers with low consumption.

The two most important elements in Finland's energy strategy, which was approved by the Finnish Parliament in 1997, is energy efficiency improvement and increased use of renewable energy. According to the strategy, energy efficiency improvement will be achieved by a mixture of legislation, voluntary agreements and economic regulatory measures. However, the promotion of efficiency improvement must not be dependent on increased subsidies. Increased use of natural gas is also an important matter for Finland. In order to meet the undertakings in the Kyoto protocol, discussion is focused on expanding nuclear or natural gas power generation. However, no decision has been taken in the matter.

Denmark

The electricity market in Denmark has not yet been opened to competition to the same extent as in the other Nordic countries. The biggest step was taken in 1999, when the market was opened to electricity customers with a consumption in excess of 100 TWh annually. Since 1 April 2000, the market is open to customers with an annual consumption in excess of 10 GWh. Before the end of the year, all electricity consumers with an electricity consumption of more than 1 GWh will have the same opportunity. The Danish electricity market is expected to be fully open to competition by the 2002.

The Danish electricity policy is otherwise focused on reducing the environmental impact from electricity generation. "Energi 21", which is the Danish Government's plan of action, specifies that the most important means of achieving reduced environmental impact is to develop renewable energy sources, improve energy efficiency and adapt the energy sector to a reformed energy market. Coal will be phased out of the Danish electricity generation system by the year 2028 by measures such as conversion from coal to biofuel.

An agreement was reached in 1999 between the Government and parts of the opposition concerning the reform of the electricity sector, part of which consisted of the introduction of a system of transferable carbon dioxide quotas for electricity generation during the period 2000–2003. A ceiling of carbon dioxide emissions has been set at 23 million tonnes for the year 2000, compared to the 25 million tonnes emitted by electricity generation in 1998. The ceiling will then be reduced by 1 million tonnes annually. A carbon dioxide charge of DKK 40 per tonne of carbon dioxide will be imposed on emissions beyond the quota. The emission quota system has not yet been introduced as planned, but is expected to be introduced on 1 January 2001.

Another important part of the reform was the priority assigned to environment-friendly electricity generation. This will be achieved by creating a market for renewable energy by introducing a system of certificates for electricity from renewable sources, known as green certificates. These certificates cover electricity generated by wind power, biomass, solar cells, geothermal plants and hydro power (plants smaller than 10 MW). The green certificate market is expected to begin in the year 2002. Moreover, a regulation has been introduced in the Electricity Act specifying that all electricity consumers shall purchase a growing proportion of electricity from renewable sources. As a first stage, the minimum quota has been set at 20 %. ■

Electricity has been exchanged between the Nordic countries ever since transmission links have been in operation. In the past, interchange took place through the biggest players in each country. At the present time, all players are able to buy electricity abroad. Trading is facilitated today by a joint Nordic marketplace known as Nord Pool, on which the price of electricity is determined 24 hours beforehand for every hour of the following 24-hour period. Nord Pool has facilitated trading in electricity by providing generators, electricity traders and major consumers continual access to a marketplace, on which a sufficient number of business transactions are concluded to create a market price. Pricing on the Nordic electricity market has therefore become more efficient, and the transaction costs have dropped. In addition, the exchange price has been used as a reference for bilateral trade pursued outside Nord Pool. Border tariffs between Norway, Sweden and Finland have been removed, which has also contributed towards more efficient trading. In the Nordic electrical system, power is generated in plants in which the costs are lowest. As a result, generation plants with high generation costs have been taken out of service because they are unprofitable. An additional contributory reason for shutting down the plants in Sweden is that the companies no longer have to meet the demand for maintaining a power reserve.

Structural changes

The restructuring of the electricity trading market has increased in the Nordic countries. In Sweden, municipalities have intensified the sale of their electricity trading companies in pace with the stiffening competition, and the small private electricity trading companies have been bought up by bigger companies. In certain cases, municipal trading companies have merged to form bigger companies. New Swedish-owned and foreign-owned players who have neither electricity generation nor network operations have entered the electricity trading market in order to utilize the new competitive situation. However, developments are tending towards increased market concentration.

The large, dominating companies in the Nordic countries, such as Vattenfall, Statkraft and Fortum, have been buying holdings in recent years in their competitor companies on the Nordic market and have thus increased the market concentration. Moreover, the biggest players have taken market shares in other European countries. This was aimed at competing on the Northern European electricity market when other countries in Northern Europe are opening their electricity market to competition from outside. The EU electricity market directive demands that at least 33 % of the electricity markets of member states should be opened to competition by the year 2003. This should be on the principle that the biggest electricity users should gain access to the market first. In many countries, developments are forging ahead at a faster pace than that specified by the EU directive.

Network operations

Electricity transmission is a natural monopoly and has therefore not been opened to competition on a free market in the same way as electricity generation and trade in electricity. As a result, the tariffs and other terms of the Swedish network utilities are under the supervision of the Swedish National Energy Administration in accordance with the Electricity Act. Norway, Finland and Denmark have equivalent supervision. The Act gives the Administration the right to issue directives in order to induce companies to apply reasonable terms. The Swedish National Energy Administration has the task of supervising price levels, price developments and other terms for network services, so that the interests of the consumers in low and stable prices will be met. Particulars of the tariffs charged by all network utilities are collected every year. As a result of the annual follow-up by the Administration, consumers receive increased price information, and the transparency on the electricity market is improved. The prices for network services in Sweden have remained relatively unchanged since 1996.

Electrical system

A prerequisite for the electricity market to perform well is that all players must be given free access to the transmission networks of the country. At the same time, there is a need for a system operator who, independently of other players on the market, ensures that the electricity generated and the electricity used are in balance in the transmission system at all times. Svenska Kraftnät is responsible for the national grid in Sweden. ■

The supply of electricity in the Nordic countries is based on hydro power, nuclear power and combined heat and power (CHP) generation in district heating systems and in industry. In addition, there are minor amounts of oil-fired condensing power, gas turbines and wind power. In Norway, electricity is generated mainly by hydro power, and in Denmark, by conventional thermal power. The Finnish electricity generation system is based on conventional thermal power, nuclear power and hydro power. In Sweden, hydro power and nuclear power together normally account for around 95 % of the total electricity generated. In the past, Swedish oil-fired condensing power and gas turbine power have served as reserve capacity in the electricity generation system, although many of these plants have now been taken out of service for economic reasons.

Electricity generation in Sweden

Figure 2 shows the Swedish electricity balance week by week during 1998 and 1999. Electricity generation varies with the electricity consumption, and generation is therefore high during the winter and low in the summer. The annual overhauls of the nuclear power units are scheduled for the summer, when the electricity demand is at its lowest. The water reservoirs are filled during the spring and summer, and the water stored in them is then used during the winter and up to the spring floods. When the hydro power and nuclear power capacities are insufficient, the electricity shortfall is generated in conventional thermal power plants or is imported.

During 1999, hydro power and nuclear power each accounted for 47 % of the Swedish power generation, while fossil-fired and biofuel-fired generation accounted for just over 6 %. The total electrical energy generated dropped by around 3 % compared to 1998 and amounted to just over 150 TWh. The reason for the drop is that 1998 was an extremely wet year with an unusually high amount of hydro power generation. The energy generated in the Swedish nuclear power stations was also high during 1998. Net exports during 1999 were lower than in 1998 at 7 TWh compared to 10.7 TWh, as a result of the reduced generation in hydro and nuclear power stations.

Table 1 shows the Swedish electricity balance and the estimates made by the Swedish National Energy Administration of developments in the short term and in the somewhat longer perspective. The assessments are based on the energy policy decisions

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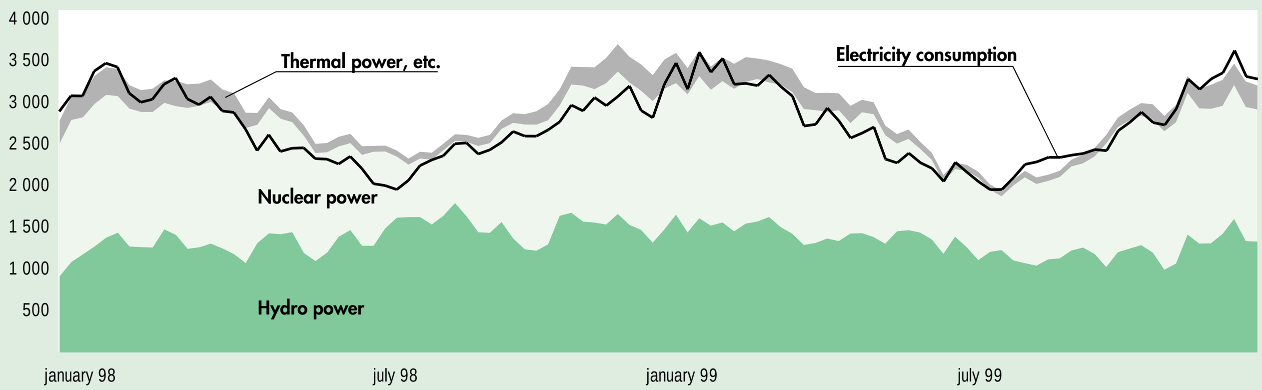
Figure 2 • Electrical energy generation and consumption in 1998 and 1999, GWh per week



Source: Compilation of information from "Kraftläget 1999" (Power situation in 1999), Swedish Power Association.

Table 1 • Electrical energy balance in 1990 and between 1995 and 1999, and forecasts for 2000 and 2010, TWh

	1990	1995	1996	1997	1998	1999[5]	*2000*	*2010*
Generation[1]	142.2	143.9	136.0	145.1	154.3	150.3	*142.9*	*149.4*
Hydro power	71.5	67.0	51.0	68.2	74.0	70.4	*64.2*	*67.0*
Wind power	0	0.1	0.1	0.2	0.3	0.4	*0.5*	*2.0*
Nuclear power	65.3	67.0	71.4	66.9	70.5	70.1	*67.8*	*68.3*
Other thermal power	5.6	9.8	13.5	9.9	9.8	9.5	*10.4*	*12.1*
CHP in district heating networks	2.1	5.5	5.4	5.3	5.1	4.8	*5.6*	*7.0*
CHP in industry	3.1	3.8	4.5	4.2	4.5	4.4	*4.5*	*4.9*
Condensing power	0.3	0.4	3.6	0.4	0.3	0.3	*0.3*	*0.2*
Gas turbines[2]	0.1	0.1	0.0	0.0	0.0	0.0	*0.0*	*0.0*
Consumption[3]	139.7	142.2	142.2	142.6	143.9	143.3	*146.1*	*154.6*
of which network losses	10.7	8.3	9.4	10.4	10.7	10.3	*10.1*	*11.3*
Imports–exports[4]	-2.5	-1.7	6.1	-2.7	-10.7	-7.0	*3.2*	*5.2*

[1] Net generation, i.e. excluding the power stations' own consumption.
[2] The item is redefined compared to 1996 and covers only gas turbines that serve as stand-by for the power system.
[3] Due to rounding-off, the total sums do not always agree with the sum of the individual items.
[4] For the year 1990, imports–exports also include a statistical carry-over.

Source: For the years 1990–1998, *Energiläget 1999* (Energy in Sweden 1999), National Energy Administration. For the years 1999–2000, *Energiförsörjningen i Sverige 00-02-29* (Energy supply in Sweden, 29 February 2000), National Energy Administration. For 2010, information from the National Energy Administration to the Climate Committee.

taken by the Riksdag, one of the elements of which is that today's system of taxes and charges is expected to persist throughout the forecast period. In both forecasts, the first reactor in Barsebäck is assumed to have been decommissioned. The assessments are otherwise based on various assumptions concerning the economic developments in the coming few years.

Electricity generation in Finland, Norway and Denmark

The values of electricity generated in Finland, Norway and Denmark are shown in Table 2.

Electricity generation in Denmark is based predominantly on coal firing and natural gas firing in combined heat and power plants and in condensing power stations. A minor proportion of electricity generation is based on biofuels. In 1999, the electricity generated in conventional thermal power stations accounted for 92 % of the total electricity generated in Denmark. Energi 21, which the Danish Government's long-term plan for sustainable development of energy in Denmark, has the objective that the use of biofuels for electricity generation should increase. This will take place by means such as increased use of straw and wood chips and by biofuel-fired boiler stations being converted to combined heat and power plants.

Denmark has the highest proportion of wind-generated electricity in the Nordic countries. In 1999, the Danish wind power stations accounted for 8 % of the total electricity generated in the country. Denmark also has a small amount of hydro power, although this is not visible in the statistics.

In Finland, electricity generation is based on conventional thermal power, nuclear power and hydro power. Conventional thermal power represents the highest proportion and accounted for 48 % of the total electricity generated in 1999, followed by nuclear power, which accounted for 33 %. Hydro power accounted for 19 % of the electricity generated in Finland in 1999. The most widely used fuels in the Finnish thermal power stations are biofuel, followed by coal, natural gas and peat. A small proportion of the electricity generated was based on fuel oil. Finland has relatively high imports from neighbouring countries, and the net electrical energy imported in 1999 amounted to around 11 TWh. To be able to meet the growing electricity consumption and to reduce the dependence on imports, the Finnish electricity generation system must be expanded. This has led to discussions on whether nuclear power should be expanded. Another alternative discussed is the construction of natural gas fired power plants. Due to the absence of a decision on which alternative is likely, it has been difficult to find a forecast for Finnish electricity generation.

Electricity generation in Norway is based principally on hydro power. In 1999, hydro power accounted for 99.3 % of the total elec-

Table 3 • Installed capacity in the Nordic countries on 31 December 1999, MW

	Denmark[1]	Finland	Norway	Sweden	Nordic[2]
Total installed capacity[3]	10 934	16 458	27 934	30 885	86 211
Hydro power	11	2 937	27 616	16 192[4]	46 756
Nuclear power		2 640		9 452	12 092
Other thermal power	9 156	10 843	305	5 026	25 330
condensing[5]	2 228[6]	3 912	73	452	6 665
CHP, district heating	6 310	3 617	12	2 248	12 187
CHP, industry	330	2 436	185	841	3 792
gas turbines, etc.	288	878	35	1 485	2 686
Wind power	1 767	38	13	215	2 033

1 Due to a new reporting routine in Denmark, the power is somewhat lower than last year
2 Excluding Iceland
3 The power is the sum of the net outputs of the individual units in the power system, and thus cannot be regarded as the total available power at any particular point in time.
4 Including Norwegian proportion of Linnvass River (25 MW)
5 Including long-term mothballed power in Finland (around 700 MW)
6 Including German share in Enstedværket (316 MW)
Source: Nordel.

Table 2 • Electrical energy generated in Finland, Denmark and Norway, TWh

	Finland					Denmark					Norway				
	1990	1995	1998	1999	2010[1]	1990	1995	1998	1999	2010	1990	1995	1998	1999	2010
Generation	52	61	67	67	96	24	34	41	37	54	120	121	115	123	137
Hydro power	11	13	15	13	14		...	...	...	...	120	121	114	122	121
Wind power	0	...	...	...	0.2	0.6	1.2	2.6	3.0	8.0	0	...	...	...	...
Nuclear power	18	18	21	22	21	0	0	0	0	0	0	0	0	0	0
Other thermal power	23	30	32	32	53	24	33	39	34	46	0.5	0.5	0.7	0.8	16
CHP in district heating networks	8.5	11	13	13	22	8	13	16		19					
CHP in industry	7.7	9.5	12	12	11	0	1.1	2.1	1.7	2.3					
Condensing	6.6	8.9	6.3	6.9	20	15	19	21	24	32[2]					
Gas turbines, diesels, etc.	...	...	...	...	...	0	0	0	0	0					
Imports–Exports	11	8.4	9.4	11	8.2	7.0	-0.8	-6.7	-2.2	-18	-16	-6.7	3.6	-1.8	-1.3
Consumption	62	69	77	78	[3]	31	34	34	35	36	105	114	119	121	136

... less than 0.1 TWh
1 The 1996/97 forecast for Finland is based on a BAU (Business As Usual) scenario, whereby development is assessed on the basis of political decisions already taken, including no increase in nuclear power.
2 Including generation in CHP stations
3 The electricity consumption in this forecast does not agree with the forecast in the section on Electricity consumption for Finland in 2010.
Source: Processed information from Finnish Energia, Danish Energy Administration, Nordel, Norwegian SSB and Norwegian public studies (NOU 1998:11, Energi- og kraftbalansen mot 2020 (Energy and power balance towards 2020)), and from the Ministry of Trade and Industry in Finland (Energy Economy in 2025)

tricity generated in Norway. The remaining generation consisted mainly of natural gas fired power. Expansion of natural gas fired electricity generation is also being considered in Norway. According to the forecast shown in Table 2, other thermal power is expected to increase substantially. This increase is expected to consist of gas-fired power.

Installed capacity in the Nordic countries

Table 3 shows the total net installed capacity in the Nordic countries at the end of 1999. A number of changes have been made during 1999. The wind power generation capacity has increased both in Sweden and in Denmark. In Sweden, the installed power has increased by more than 40 MW during 1999, while in Denmark, it has increased by around 300 MW. As a result of the decommissioning of Barsebäck 1, the total installed capacity in the Swedish nuclear power stations has dropped by 600 MW. In addition, several Swedish oil-fired condensing power stations have been mothballed in recent years for economic reasons, which is a consequence of developments on the electricity market. The installed power has dropped further at the beginning of the year 2000. At the time of writing – in April 2000 – only one of the major plants, with a joint output of around 340 MW, is available for generation. The installed gas turbine capacity has also dropped by 150 MW during 1999. ■

FACTS

Thermal power – power generated in a power station in which heat is converted into electricity. This includes condensing power, nuclear power and combined heat and power (CHP). Conventional thermal power excludes nuclear power.

Combined heat and power (CHP) - generation in a power station that produces both electricity and heat for an adjacent district heating network or for use in an industrial process.

A gas turbine plant is basically a “jet engine” that drives a generator. The main fuel used in Sweden is light fuel oil.

Condensing power station – a power station equipped with condensing steam turbines. These stations generate only electricity. The power stations in Sweden are fired mainly with oil. Condensing power is also generated in CHP stations with recoolers.

Hydro power station – power station that converts the kinetic energy of water into electrical energy.

Nuclear power – power generated in a condensing power station that uses heat from nuclear energy to generate electricity.

Wind power plant – a power plant that converts the kinetic energy of wind into electricity.

Natural gas combined cycle – a combined gas turbine and steam turbine plant fired with natural gas.

The development of electricity consumption is dependent on the growth rate of the national economy. Since 1990, the total electricity consumption in the Nordic countries has increased at an average rate of 1.2 % annually. The rate of increase was highest in the residential, commercial and service sector, which is due to factors such as the growing services sector in which increasing numbers of electrical equipment such as computers are used, and the increased use of electric space heating in Finland and Norway.

Electricity consumption in Sweden

Since the early 1970s, electricity consumption in Sweden has increased by an average of 3 % annually. The rate of increase was high in the 1970s, but then tapered off. During the period between 1990 and 1999, the actual electricity consumption increased by a total of 2.6 %, although after correction for ambient temperature, the increase in consumption during the period was only just over 1 %. The sector comprising dwellings, services, etc. now accounts for just under half of the total electricity consumption, while industrial consumption amounts to somewhat more than one third. The Swedish electricity consumption between the years 2000 and 2010 is shown in Table 4.

Industry

Electricity consumption in industry is linked to the economic activity in the various industrial sectors. During the 1980s, industrial production grew at a rate of about 2 % annually and electricity consumption at a rate of around 3 % annually. During the recession in the early 1990s, industrial production declined by an average of 3.5 % annually, which led to a downturn in electricity consumption by 1.3 % annually between 1990 and 1994. In 1998, electricity consumption in industry increased by just over 2 % compared to 1997, and continued to increase in 1999. The upturn was due mainly to the high growth rate in the pulp and paper industry.

Electricity consumption varies from one industrial sector to the next. Electricity-intensive industries, such as the mining industry, the pulp and paper industry, the basic chemicals industry, ironworks and steelworks accounted for around 65 % of the total industrial electricity consumption in 1999.

Table 4 • Electricity consumption between 1990 and 1999, and forecasts for 2000 and 2010, TWh

	1990	1995	1996	1997	*1998*	*1999*	*2000*	*2010*
Industry	53.3	51.7	50.9	52.6	53.7	54.3	*54.7*	*58.6*
of which pulp and paper industry	20.0	19.1	19.3	20.5	21.1	21.6	*21.8*	*23.2*
basic chemicals industry, etc.	6.2	5.6	5.5	5.8	6.0	6.0	*6.1*	*8.1*
ironworks and steelworks	4.8	5.0	4.9	5.0	5.0	5.0	*5.1*	*5.8*
engineering industry	7.2	7.1	7.0	7.0	7.1	7.0	*7.1*	*7.5*
Residential, commercial, services, etc.	63.3	72.3	73.0	70.3	70.3	69.9	*72.0*	*75.0*
of which electric heating	25.8	25.1	27.4	26.1	24.8	24.2	*25.9*	
domestic electricity	17.9	19.7	20.1	18.7	19.5	19.7	*19.9*	
electricity for appliances	19.6	27.5	25.5	25.5	26.0	26.0	*26.2*	
Transport	2.5	2.5	2.5	2.4	2.5	2.6	*2.6*	*3.2*
District heating, refineries	10.0	7.5	6.3	6.8	6.7	6.3	*6.7*	*6.6*
Conversion and distribution losses	10.7	8.3	9.4	10.4	10.7	10.3	*10.1*	*11.3*
Total net consumption	139.7	142.2	142.6	142.6	143.9	143.3	*146.1*	*154.6*
Total net temperature-corrected consumption	143.1	142.4	141.0	143.2	144.7	144.8	*146.1*	*154.6*

Note: Information on electric heating has been obtained from the Statistics Sweden Correction sheet *SM E16 9904*. The distribution between electric heating, domestic electricity and electricity for appliances in the residential, commercial and service sector is based on our own calculations and is corrected for all years.

Source: For the years 1990–1998, the information has been obtained from *"Energiläget 1999"* (Energy in Sweden 1999), for the years 1999 and 2000, from *"Energiförsörjningen i Sverige 00-02-29"* (Energy supply in Sweden, 29 February 2000), and for the year 2010, from the Swedish National Energy Administration information to the Climate Committee.

Table 5 • Electricity consumption in Finland, Denmark and Norway between 1990 and 1999, and forecasts for 2010, TWh

	Finland					Denmark					Norway				
	1990	1995	1998	1999	*2010*	1990	1995	1998	1999	*2010*	1990	1995	1998	1999	*2010*
Industry (incl. the energy sector)	33	37	42	43	*51*	9	10	10	10	*12*	47	46	49	49	*49*
Residential, commercial, services, etc.	26	29	32	32	*38*	20	21	21	23	*21*	51	58	61	62	*77*
Transport	0.4	0.5	0.5	0.5	[1]	0.2	0.2	0.3	[1]	*0.6*	0.6	0.7	0.7	[1]	*1.6*
Losses	2.9	3.0	3.0	2.7	*3.4*	2.3	2.3	2,4	2.3	*2.6*	6.9	9.4	8.8	10	*7.8*
Total consumption	62	69	77	78	*92*	31	34	34	35	*36*	105	114	119	121	*136*

[1] For certain years, transport is included in Residential, commercial, services, etc.

[2] The particulars for 1999 for Denmark and for 1998 and 1999 for Norway are not official statistics.

Source: Processed information from the Finnish Energywindows, Adato Energia Oy, the Danish Energy Administration, the Norwegian SSB and NOU 1998:11, Energi- og kraftbalansen mot 2020 (Energy and power balance towards 2020), Nordel.

The share of consumption in the engineering industry amounted to 13 %. Almost 90 % of the electricity consumption in industry was used for processes and for motor drives.

Residential, commercial, services, etc.

In the residential, commercial and service sector, electricity is used for heating single-family and multi-family dwellings, and commercial and public premises, for domestic electricity in dwellings, and for appliances in commercial and public premises. The electricity used for street and road lighting, and for water and sewage treatment is also included.

Electric space heating currently accounts for 35 % of the total electricity consumption in the residential, commercial and service sector. The actual consumption for electric heating varies from year to year, depending on factors such as temperature conditions. During the period between 1990 and 1999, the use of electricity for space heating decreased at an average rate of 0.7 % annually. During 1998, a grant was introduced for the conversion of electrically heated houses to district heating or to individual fuel firing with the aim of lowering the amount of electric heating, but these grants have been discontinued for the time being. Electric heating is expected to increase in the next few years, which is due to the increased construction of new single-family houses, and the high fuel oil prices[1].

Domestic electricity accounts for 28 % of the total electricity consumption in this sector, and this consumption has increased by an average of 1 % annually during the period between 1990 and 1999. Electricity for appliances, which currently accounts for around 40 % of the electricity consumption in this sector, has increased most in the 1990s, at an average rate of just over 3 % annually. This increase is due mainly to the large numbers of electrical equipment in the services sector.

Transport

In the transport sector, electricity is used mainly for powering trains, underground trains and trams. The transport sector accounts for a very small proportion of the total national electricity consumption, and today amounts to less than 2 %. The consumption between 1990 and 1999 has remained relatively stable at around 2.5 TWh annually.

District heating and refineries

The consumption of electricity in the district heating sector consists mainly of supplies to electric boilers and the power supplied for driving heat pumps. Supplies to electric boilers dropped from 6.2 TWh in 1990 to 1.4 TWh in 1999. During the same period, the electrical energy supplied for driving heat pumps remained stable at around 2 TWh annually. The electricity consumption in refineries is relatively constant and amounts to 0.8 TWh annually.

Forecast for the years 2000 and 2010

Table 4 shows the electricity consumption forecasts for the years 2000 and 2010. The assessments are based on the energy policy decisions taken by the Riksdag, so that today's taxation and charge system is expected to remain unchanged throughout the forecast period. However, it should be pointed out that both forecasts are based on different assumptions concerning economic developments and developments in oil prices in the coming few years.

The electricity consumption is expected to increase by a total of 8 % between the years 1999 and 2010.

Electricity consumption in Denmark, Norway and Finland

Electricity consumption between 1990 and 1999 has increased in all Nordic countries as shown in Table 5. The highest rate of increase was recorded in Finland, at an average of 2.5 % annually. During the same period, the increase rate in Sweden was 0.3 % annually.

In Norway and Finland, the industrial sector accounts for a large proportion of the total electricity consumption at 40 % and 50 % respectively. This is because, just like Sweden, both countries have a large proportion of energy-intensive industry. In Denmark, which has a different industrial structure, industry accounts for less than 30 % of the electricity consumption, but a larger proportion is used in the residential, commercial and service sector (more than 60 %). This is explained by the fact that the agricultural sector, which is relatively large in Denmark, is included in the figures for the residential, commercial and service sector.

Table 5 also shows the forecasts for the year 2010. These forecasts have been made at different times on the basis of different assumptions and economic conditions, and they are therefore not directly comparable. However, it is interesting to note that the forecasts for both Norway and Finland expect a steep increase in electricity consumption at a total of 12% and 18% respectively between the years 1999 and 2010, whereas the forecasts for Denmark envisage an increase of 4 % during the same period. In Finland, the highest increase is expected to take place in the industrial sector, whereas the highest increase in Norway is expected in the residential, commercial and service sector.

In the international perspective, all Nordic countries have a relatively high average energy consumption per inhabitant, due to their geographical location and their industrial structures. See also the section entitled "An international perspective". ■

[1] "Energiförsörjningen i Sverige 00-02-29", Swedish National Energy Administration.

In the Nordic countries, hydro power accounted for just under 55 % of the power generated in 1999. The total installed generation capacity at the end of 1999 was 46 756 MW. More than half the installed power is in Norway, just over 30 % in Sweden, and around 6 % in Finland. Denmark has a marginal amount of hydro power generation capacity. In a normal year, the total energy generated in the Nordic countries amounts to between 180 and 190 TWh, and the total energy generated in 1999 was 205 TWh.

Hydro power in Sweden

Sweden has more than 700 large hydro power stations, each with an installed power of more than 1.5 MW. In addition, there are also around 1200 small hydro power stations that generate around 1.5 TWh annually. The four biggest rivers account for around 65 % of the total energy generated by hydro power in Sweden (see Table 6).

During a year with normal water inflow, hydro power produces 63.8 TWh of electrical energy, excluding losses, which corresponds to roughly 45 % of the total electricity generated in the country. The electricity generated by hydro power can vary widely, depending on the inflow and the reservoir contents. During extremely dry years, such as 1996, production may amount to no more than 51 TWh, whereas in wet years, it could theoretically amount to 78 TWh. The highest annual electrical energy generated so far was recorded in 1998 and amounted to 74 TWh. The maximum water volume in long-term reservoirs corresponds to an energy of 33.6 TWh. In 1999, the energy generated amounted to 70.4 TWh. Figure 5 shows the energy generated by hydro power during the past three years.

Water inflow

Viewed over the whole year, 1999 was basically a normal year, even though production was higher than normal. Although the water inflow was above normal during the spring, it declined to below the normal value in the autumn. The total inflow during the year corresponded to 67.2 TWh. The inflow during a normal year, which is defined as the median for the inflow during the period between 1950 and 1996, corresponds to 64.5 TWh. 1998 was an extremely wet year, with an inflow corresponding to no less than 85.8 TWh. The water inflow rate in recent years is shown in Figure 3.

Reservoir contents

During the first half of 1999, the reservoir contents were above normal, but dropped to somewhat below normal during the second half of the year. This was due to the low inflow during the autumn. At the beginning of the year 2000, the reservoirs were 62.4 % full, which corresponds to 20.1 TWh. This is about 2 TWh below average and about 4 TWh lower than in the corresponding period in 1999.

Statistics of the reservoir contents show that the pattern has changed in recent years. In spite of the relatively abundant precipitation, the reservoir contents have not increased. This is probably due to the fact that, after the electricity market reform and after the 1994 and 1996 dry years, the power utilities have re-assessed the value of the reservoir contents. An additional contributory factor is the flooding that occurred in recent years. The reservoir contents in recent years and in a normal year are shown in Figure 4.

Investment grants for small-scale hydro power

The energy policy decision in June 1997 included an investment grant appropriation for small-scale hydro power. The grant appropriations for the five-year period beginning on 1 July 1997 amounted to SEK 150 million. The grant amounts to 15 % of the investment cost. This measure is expected to be capable of yielding 0.25 TWh of new generation capacity. No grants have been paid during 1997 or 1998 due to the doubts concerning the environmental demands that would be made on the plants if they were to qualify for the grant. The doubts have now been clarified, and 8 applications out of a total of 25 have been allowed during 1999. These 8 plants are expected to produce 0.01 GWh during a full year. Four of these plants are already in operation and are expected to

Table 7 • Electrical energy generated by hydro power in Norway, Finland and Denmark, TWh, and installed capacity, MW, in 1999

	Energy generated, TWh	Installed capacity, MW
Norway	122	27 616
Finland	13	2 937
Denmark	0.03	11

Source: Nordel

Table 6 • Energy generated by hydro power on various Swedish rivers between 1990 and 1999, TWh, and installed capacity on 31 December 1998, MW

	1990	1995	1996	1997	1998	1999	Installed capacity, MW
Lule River	15.8	14.0	14.1	16.0	12.4	15.8	4 355
Skellefte River	4.8	4.5	3.4	4.4	4.7	5.2	1 023
Ume River	9.3	8.0	5.4	8.3	9.1	8.2	1 743
Ångerman River	9.4	7.8	5.5	8.0	9.5	7.7	1 771
Fax River	4.7	4.3	2.8	4.0	4.1	3.8	807
Indal River	9.7	9.8	7.5	10.2	10.4	10.0	2 096
Ljungan	1.9	2.0	1.6	2.1	3.4	2.4	606
Ljusnan	3.5	3.8	3.2	3.7	4.1	3.8	803
Dal River	4.7	4.6	3.1	4.4	5.5	4.7	1 114
Klar River	2.3	2.4	1.9	1.6	1.7	1.7	375
Göta River	1.4	2.0	0.9	1.4	1.6	2.2	296
Other rivers	3.9	3.8	1.6	4.0	7.1	4.9	1 215
Total	71.4	67.0	51.0	68.1	73.6	70.4	16 204

Note. The totals for energy generated differ somewhat from the official statistics.
Source: Swedish Power Association. Statistical Yearbook 2000, Statistics Sweden.

Figure 3 • Water inflow during a normal year and in 1998 and 1999, GWh per week

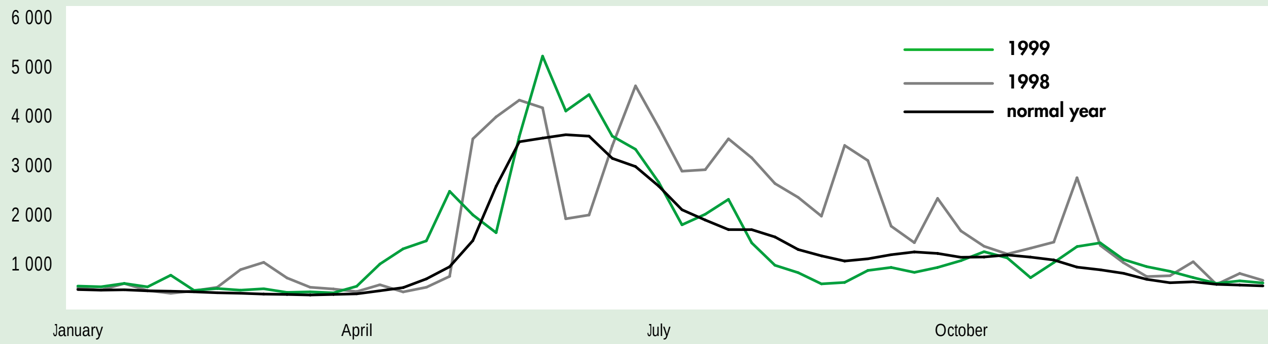


Figure 4 • Reservoir contents during an average year and in 1997–1999, percent

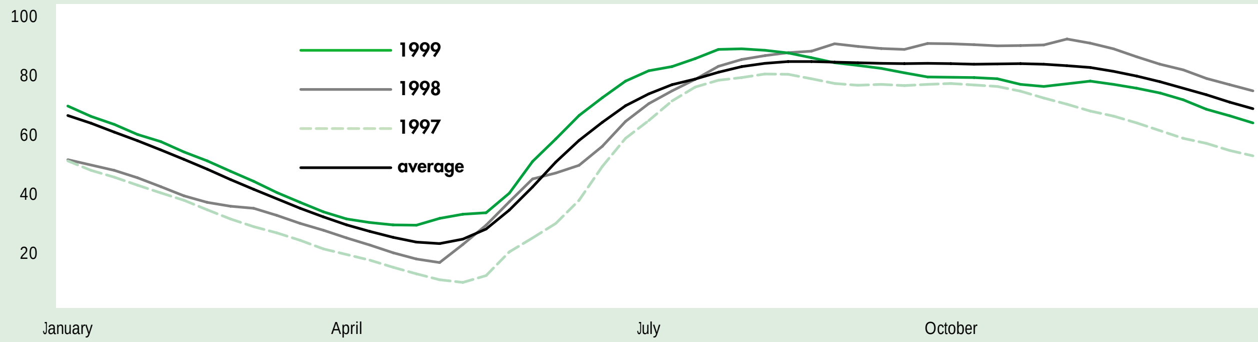
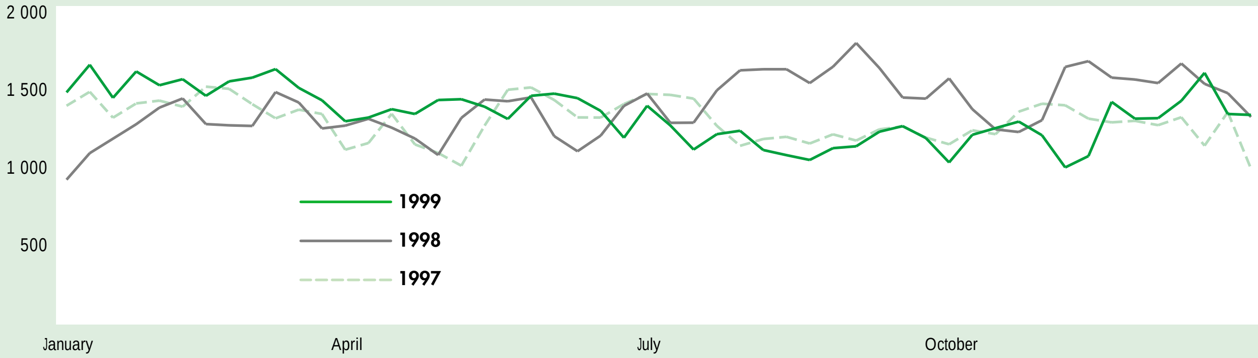


Figure 5 • Hydro power generation in 1997–1999, GWh per week



Source: Swedish Power Association

generate 0.005 GWh during one year. For the electricity generated in small-scale plants, i.e. those with an output of less than 1 500 kW, a temporary grant of 9 öre/kWh will be allowed during the period between November 1999 and December 2000.

Hydro power in Norway, Finland and Denmark

Virtually all of the electricity generated in Norway is based on hydro power, with only about 0.5 TWh coming from other generation sources. The energy generated during 1999 amounted to 122 TWh. During the same year, Finland generated 13 TWh of electricity in hydro power stations. The energy generated by hydro power in Denmark during the 1990s was marginal, and varied between 0.02 and 0.03 TWh. ■

Six nuclear power stations with a total of 15 reactors are now in operation in the Nordic countries. Out of this total, 11 reactors are in Sweden and four in Finland.

The electricity generated in a nuclear power station is determined by the availability of the plant and by its maximum output. The maximum output is restricted by the thermal loading and by the capacity of the generators. The electricity generated can be increased by raising the outputs of the nuclear power stations. In practice, an increase in output often involves major modifications or extensions to the plant.

Availability and energy utilization

Availability is determined by the unscheduled outages and by the annual overhaul shut-downs. During overhaul shut-downs, which take place in the summer when the electricity demand is a minimum, maintenance and inspection work are done on the reactors, and the reactors are also refuelled. The overhaul normally takes around four weeks and reduces the maximum full-year energy availability to 85–90 %.

The degree of energy utilization in nuclear power reactors is restricted by load reduction and by coast-down. Load reduction involves lowering the power output of the plant for economic reasons. The amount of load reduction is dependent on factors such as the demand for electricity and the availability of hydro power.

Coast-down involves adjusting the degree of enrichment of the fuel, with the aim of minimizing the fuel costs. As a result of variations in the demand for electricity, it is not economical to charge the reactors so that maximum output will be achieved. Fuel charging is therefore adjusted so that the generation capacity of the reactors gradually declines during the period of a few weeks prior to every overhaul shut-down.

Nuclear power in Sweden

In 1999, the electrical energy generated by nuclear power in Sweden amounted 70.1 TWh and accounted for 47 % of the total electricity generated. This is slightly lower than in 1998, when the 70.5 TWh of energy generated represented 46 % of the total.

In earlier years, the amount of electricity generated by nuclear power was determined by the electricity generated by hydro power. In years when hydro power generation was low, the electricity generated by nuclear power was high, and vice versa. However, this did not apply in 1998 and 1999, since the amount of electricity generated by both hydro power and nuclear power was relatively high. During 1999, the electricity generated in the Swedish nuclear power stations was somewhat above the average for the last five years. This was in spite of the fact that good availability of water gave rise to relatively extensive power balance regulation.

The availability of Swedish reactors in 1999 varied between around 53 % and 97 %, the average value being around 82 %. The equivalent international mean value for these reactor types was about 80 %. In six of the reactors, the energy availability was in excess of 90 % (see Table 9).

The availabilities of the various reactor types are affected by the durations of the annual overhaul shut-downs. During 1999, the shut-downs of several of the reactors were extended, which gave rise to relatively high generation shortfalls and lower availability figures. On the other hand, the overhaul shut-downs of two of the Forsmark reactors were shorter than planned.

Operating permits for nuclear power stations

The original permits for the Swedish nuclear power reactors had no time limits and there is no legal mechanism for restricting the time retroactively. However, according to Clause 8 of the Nuclear Engineering Operations Act, special conditions could be imposed to maintain safety. Several of the Swedish reactors have permits that are time-restricted by conditions. However, these permits must be extended by the Government

Table 8 • Production data for Swedish nuclear power reactors in 1999

Reactor	Net output, MW	Production, TWh Max. available [1]	Actual [2,3]	Losses [4], TWh Coast-down	Load reduction	Overhaul	Other outages[5]
Barsebäck 1	600	2.8	2.7	...	0.1	1.5	0.5
Barsebäck 2	600	3.7	3.5	...	0.1	0.5	1.2
Forsmark 1	968	8.2	7.6	...	0.5	0.3	0.1
Forsmark 2	969	7.8	7.3	...	0.4	0.6	0.2
Forsmark 3	1 158	9.2	8.8	...	0.2	0.7	0.3
Oskarshamn 1	445	3.4	3.3	0	0.1	0.3	0.3
Oskarshamn 2	605	3.4	3.2	...	0.1	1.8	0.3
Oskarshamn 3	1 160	9.1	8.6	...	0.4	1.1	0.1
Ringhals 1	835	5.3	5.0	0.1	0.2	0.7	1.4
Ringhals 2	875	7.1	6.6	0	0.5	0.6	0.1
Ringhals 3	918	7.2	7.0	...	0.2	0.7	0.1
Ringhals 4	923	7.4	7.1	...	0.2	0.5	0.2
Total	**10 056[6]**	**74.5**	**70.7**	**0.3**	**3.0**	**9.3**	4.8

[1] Net output x availability of the reactor x 8760 hours.
[2] Net output x utilization of the reactor x 8760 hours.
[3] Due to rounding-off in the calculation source material, the particulars do not agree with the statistics given in other tables. In addition, the statistics were obtained at different dates.
[4] Losses are defined at those that are not availability-dependent (coast-down, load reduction, effect of cooling water temperature and external faults) and those that are availability-dependent (periodic tests, faults and overhauls). Other outages include both types of losses, in which the effect of cooling water temperature, external faults, periodic tests and faults have been added together.
[5] For Ringhals 1 and 4, the extended annual overhaul shut-downs have been included in Other outages.
[6] Including Barsebäck 1. After 30 November 1999, the total installed nuclear power in Sweden is 9452 MW.
... less than 50 GWh
Note. Due to rounding-off, the actual production does not agree with the maximum available production – coast-down – load reduction.
Source: Summary of information from Kärnkraftssäkerhet och Utbildning AB – a company that specializes in nuclear safety and training.

as long as the permit-holder meets the legal safety requirements. This means that the time limitation serves in practice as a permit condition for intensified safety monitoring. To shut down a reactor, the Nuclear Power Decommissioning Act must be applied.

Barsebäck 1 was shut down on 30 November 1999

The Riksdag passed the Nuclear Power Decommissioning Act in December 1997. According Clause 2 of this Act, the Government may decide that the operations of any nuclear power reactor shall cease at a certain date. As a result of the Government decision in accordance with this Act, the validity of the operating permit for the first reactor at Barsebäck ceased on 30 November 1999. The reactor that was shut down had a rating of 600 MW, which corresponded to a loss of generation capacity of just under 6 % of the total installed power in the Swedish nuclear power stations. The loss of electrical energy in 1999 was estimated to be 0.36 TWh, and that in future years, around 4.2 TWh annually. Decommissioning of Swedish nuclear power will continue, provided that the loss of generation capacity can be compensated by reduced electricity consumption and increased supply of electricity from renewable energy sources. However, no final date has been set for nuclear power decommissioning.

Nuclear power in Finland

Finland has two nuclear power stations in operation, with a total of four reactors. These power stations account for around 30 % of the total electricity production in Finland. Table 10 shows the commissioning year, the gross output and the availability of the Finnish reactors in 1998. The gross output includes the stations' own power demand. During 1999, the energy generated by the Finnish nuclear power stations was 22 TWh, which is 1 TWh higher than the corresponding value in 1998. The increase in energy generated is due to good availability during 1999 and the output increases carried out. ■

FACTS

The annual *generation potential* of a reactor is calculated as the number of hours of operation per year, multiplied by the maximum output of the plant. Since a power station itself needs electricity for its operation, a distinction is made between gross and net power output. In Swedish reactor plants, the average net output is around 95 % of the gross output.

There are two ways of measuring the efficiency of a nuclear power station, i.e. utilization and availability. Energy utilization specifies the relationship between actual electricity generated and the theoretically attainable generation of electricity over a certain period of time. This is important for the valuation of the economy of the plant, and thus of the production costs.

Energy availability specifies the actual period of time during which the generator has been synchronized to the grid, regardless of the output.

Table 10 • Gross output, MW, and energy generated, TWh, by the Finnish reactors in 1998

Reactor	Commissioned in	Gross output MW	Energy generated in 1998, TWh	Availability in 1998, percent
Loviisa 1	1977	488	7.9	89.1
Loviisa 2	1981	488		
Olkiluoto 1	1979	840	13.4	94.6
Olkiluoto 2	1982	840		
Total		**2 656**	**21.3**	**91.9**

Source: Energywindows (www.energia.fi).

Table 9 • Net electrical energy generated by the Swedish reactors in the years 1990 to 1999, TWh

	Commissioned in	1990	1995	1996	1997	1998	1999	Total energy generated since commissioning, TWh	Availability in 1999, percent
Barsebäck 1	1975	4.3	3.9	4.1	3.7	4.3	2.6	92.7	52.9[1]
Barsebäck 2	1977	4.2	3.4	3.8	3.9	4.0	3.5	87.6	70.0
Forsmark 1	1980	6.2	7.3	7.3	5.4	7.3	7.6	126.7	96.8
Forsmark 2	1981	6.4	7.1	7.3	7.3	7.2	7.3	122.6	91.7
Forsmark 3	1985	7.9	8.9	8.8	9.0	9.0	8.8	121.0	91.1
Oskarshamn 1	1972	2.5	0.0	2.4	2.9	1.3	3.3	65.9	86.7
Oskarshamn 2	1974	4.0	4.2	3.8	4.4	4.4	3.2	97.0	63.3
Oskarshamn 3	1985	7.6	8.9	8.5	9.0	8.0	8.5	119.0	89.1
Ringhals 1	1976	4.5	5.7	6.5	2.2	5.6	4.9	108.2	73.1
Ringhals 2	1975	5.2	6.1	5.7	6.2	6.1	6.4	116.5	92.1
Ringhals 3	1981	5.9	4.9	6.8	6.6	6.4	7.0	105.9	90.0
Ringhals 4	1983	6.5	6.3	6.3	6.4	6.8	7.0	103.4	91.7
Total		**65.2**	**66.7**	**71.3**	**67.0**	**70.4**	**70.1**	**1 266.5**	**82.4**

[1] The low availability of Barsebäck 1 is due to the fact that the annual overhaul shut-down was substantially extended and the reactor was shut down on 30 November 1999.

Source: Compilation of information from the Swedish Power Association and the Kärnkraftssäkerhet och Utbildning AB (company that specializes in nuclear safety and training).

Conventional thermal power stations generate electricity by burning various fuels. The fuels used in the Nordic countries are coal, fuel oil, natural gas, peat and biofuels.

Conventional thermal power in Sweden

During 1999, the electrical energy generated in Sweden by conventional thermal power amounted to 10.3 TWh, which corresponds to roughly 7 % of the total electricity generated. In 1998, the corresponding figures were 9.8 TWh and 6.4 %. In CHP stations in district heating networks, coal and also blast furnace gases, accounted for 46 % and fuel oil for 29 % of the fuel supply for electricity generation in 1999. Natural gas and biofuels, peat, etc. supplied 7 % and 18 % respectively. Fuel oil and biofuels dominate in industrial CHP generation. These fuels accounted 51 % and 44 % respectively of the fuel supply for electricity generation during 1999.

The installed conventional thermal power capacity decreased in Sweden in recent years, due to the decommissioning of the condensing power stations. Power utilities did not consider it economically viable to operate the power stations, since they were used only for peak lopping and thus served as stand-by power. On the open Nordic electricity market, the power utilities import electricity instead from neighbouring countries. In 1996, there were seven major condensing power plants with a total rating of about 2820 MW. Today, only one of these plants, with an output of around 340 MW, is available for generation.

Conventional thermal power in the Nordic countries

In Denmark, conventional thermal power accounts for just over 90 % of the electrical energy generated. In Finland, the proportion of conventional thermal power is under 50 %, while in Norway, it is less than 1 % of the total electricity generated. Table 12 shows the electrical energy generated in conventional thermal power stations and wind power plants in the Nordic countries in 1999.

System of grants for renewable electricity generation in the Nordic countries

State investment grants administered by the National Energy Administration are available in Sweden for biofuel-fired CHP plants. Grants are available for investments that provide a new contribution to the electricity generation capacity. The total appropriation for grants is SEK 450 million for the period between 1 July 1997 and 30 June 2002, and should achieve an increase of at least 0.75 TWh on the annual electricity generated by biofuel-fired CHP plants.

During the period between 1997 and 1999, a total of 27 applications for investment grants for new biofuel-fired CHP plants were registered at the National Energy Administration, of which nine have been allowed. These nine plants have an output of 164 MW, and the estimated annual energy generated during a normal year will be 0.84 TWh. The plants will be taken into operation successively from the year 2000, and all plants are expected to be in operation by the year 2003.

A special grant amounting to 9 öre/kWh will be allowed during the period between November 1999 and December 2000 for electricity generated in small-scale plants, i.e. plants with an output of less than 1500 kW. In addition to this grant, new wind power plants in Sweden are subsidized by an investment grant and an operation grant (environmental bonus). The aim is to add a further 0.5 TWh of new generation capacity from wind power. To achieve this target, a total of SEK 60 million annually have been allocated to a new investment grant programme running for five years between July 1997 and June 2002. The grant amounts to 15 % of the total approved investment, which corresponds to roughly 6 öre/kWh. During 1999, the National Energy Administration has approved 31 applications for investment grants for new wind power plants. The plants for which grants have been approved comprise 56 new wind power units and an increase of 40 MW in the installed generation capacity. The operation grant is equivalent to the electricity tax in southern Sweden, i.e. 16.2 öre/kWh. A total of SEK 56 million have been paid to wind power owners during 1999. The present rules for operation grants and the 9 öre/kWh grant will terminate at the end of December 2000. A new grant system for renewable electricity generation by green certificates is currently being studied.

The Danish Government has adopted a long-term plan aimed at increasing the use of biofuels to 24 TWh by the year 2005 and to 40 TWh by the year 2030. Various programmes are being run to implement this increase. As an example, the publicly owned energy utilities must use an equivalent of 5.4 TWh of straw and wood chips every year as from the year 2000. Moreover, there are economic regulatory instruments in the form of taxes and subsidies. In 1999, grants for electricity generation based on natural gas, refuse, biofuels and wind power amounted to DKK 1.44 billion. This year, government grants are much lower, since funds for wind power are now taken from electricity users. Support is payable at different rates, ranging from 0.07 DKK/kWh_{el} for electricity from refuse and natural gas fired CHP generation, to 0.27 DKK/kWh_{el} for electricity from so-called non-central biofuel-fired CHP

Table 11 • Input of fuel for electricity generation in conventional thermal power plants in Sweden in 1999, TWh

Fuel	TWh
Fuel oil	5.3
Natural gas	0.6
Biofuels, peat, etc.	4.1
Coal (including blast furnace gas and coke oven gas)	3.2
Total	**13.1**

Source: *"Energiförsörjningen i Sverige 2000-02-29"* (Energy supply in Sweden, 29 February 2000), National Energy Administration.

Table 12 • Electrical energy generated by conventional thermal power and wind power in the Nordic countries in 1999, TWh

	Denmark	Finland	Norway	Sweden
Conventional thermal power	34	32	0.8	9.5
CHP in district heating networks		13		4.8
CHP in industry	1.6	12		4.4
Condensing power stations	21[1]	6.9		0.3
Gas turbines, diesels, etc.	0	0		0.01
Wind power	3.0	0.05	0.01	0.4

[1] CHP in district heating networks is included in condensing power generation.

Source: *"Energiläget 1999"* (Energy in Sweden 1999), National Energy Administration, and Nordel.

generation. (According to the Danish Electricity Act, certain plants are regarded as central, while others are non-central.) Government investment grants are also awarded for promoting the expansion of non-central CHP generation and the use of biofuels. The programme of grants also includes a number of measures concerning heat generation.

Investment grants administered by the Ministry of Trade and Industry are available in Finland. These grants are available for development and investment projects that promote energy efficiency, the use of renewable energy sources, and reduced emissions that are harmful to the environment. The grants allowed for such investments amount to 10–35 % of the approved investment sum. An operation grant in the form of refund of electricity tax (4.2 p/kWh) is also available for wind power plants.

Wind power is subsidized in Norway by means of an investment grant and an operation grant, and larger plants are given priority as long as they are more cost-effective than the smaller plants. Investment grants are therefore given to wind power farms with a total installed power in excess of 1 500 kW, and in which every unit has an output of at least 500 kW. The investment grant amounts to 25 % of the approved cost, with a ceiling of 8000 NOK/kW. The operation grant amounts to half the Norwegian electricity tax, which currently totals 4.28 N öre/kWh.

Growing interest in wind power

The interest in wind power is steadily growing in the Nordic countries. Contributory reasons for this are the decline in costs, growing awareness of climate matters, expectations that revenues from electricity sales will increase, and also the government grant system. In recent years, the sizes of the plants installed have increased, and most wind power plant suppliers now manufacture units with ratings of 1000 kW or more.

Almost 60 new wind power units were built in Sweden during 1999, and 480 wind power units with an output of more than 50 kW were in operation at the end of the year. The total power rating of Swedish wind power was then 215 MW. The contribution of wind power to the electrical energy generated during 1999 amounted to 0.37 TWh, which is an increase of 14 % on 1998. Wind power accounted for 0.24 % of the total electricity production in Sweden during 1999.

In Denmark, the interest in wind power has been even keener than in Sweden, which is largely due to the Danish grant system. At the end of 1999, around 5600 wind power units were in operation, with a total installed power of around 1770 MW. During 1999, the total electrical energy generated by Danish wind power plants was 3 TWh, which corresponds to 8 % of the total electricity generated. The forecast up to the year 2010 estimates that the wind power based electricity generation will increase to 8 TWh.

In the other Nordic countries, the installed wind power capacity is very low compared to Denmark and Sweden. At the end 1999, it was 13 MW in Norway and 38 MW in Finland. However, the installed wind power capacity in Finland was doubled during 1999.

New electricity generation technologies

For a new technology to achieve commercial viability, it must be competitive and must have a clear market in the foreseeable future. Even though the Swedish energy market is of special interest, the technology-developing companies must generally have the stimulus of a potential international market. In addition to its technical potential, the competitiveness of a new technology is determined by a number of other factors, such as the development of electricity prices, fuel prices, taxes, grants and the prospect of obtaining the necessary permits. An outline is presented below of the new electricity generation technologies, including CHP, which according to the report entitled “Electricity from new plants” published by Elforsk, (the Swedish Electric Utilities’ R&D Company) is nearest to achieving commercial breakthrough during the period up to the year 2010.

Evaporative gas turbine, which is also known as Humid Air Turbine (HAT). The technique is designed to increase the efficiency of a gas turbine by putting to use the energy in the hot exhaust gases. There is only one demonstration plant (600 kW_{el}) in the world today, but the interest is keen.

In the *gasification of biofuels,* the gas produced is used in a combined cycle, which leads to increased electrical efficiency. The electrical efficiency of demonstration plants is estimated to be just over 30 %, but in an optimized commercial scale plant, the attainable electrical efficiency could be between 40 and 45 %.

In an *indirectly-fired gas turbine,* the fuel is burned in a conventional solid fuel boiler, and the heat is transferred to the working medium of the turbine by means of a heat exchanger. The benefit of this arrangement is that there is no risk of the turbine being damaged by impurities from the fuel. The limitation lies in the capacity of the heat exchanger.

Microturbine is the designation given to gas turbines with an electrical output of between 30 and 200 kW. These could be used for distributed electricity generation and small-scale CHP generation. The automotive industry is also showing keen interest in microbturbines. Sweden is at the forefront of development, thanks to the efforts of Vattenfall and Volvo.

The *Stirling engine* is a heat engine with external combustion and the engine uses air or a gas as the working medium. Stirling engines are used today in various applications, such as in submarines. Another interesting application is in hybrid vehicles. In a perspective of more than ten years, small-scale, biofuel-fired CHP generation from Stirling engines may be of interest.

In a *fuel cell,* electrical energy is generated directly from chemical energy by means of an electro-chemical cell. The design of the electro-chemical cell is roughly the same as that of a battery, with one electrode on each side of an electrolyte. The difference is that the electrodes are not consumed, since the reacting elements, i.e. hydrogen and oxygen, are continuously supplied. Development of the fuel cell technique takes place mainly in North America and Japan. The strong driving force is the interest in applications in the field of transport. The technique may also be employed in small-scale CHP generation.

Solar cells can be used for converting solar light directly into electricity. The technique is considered to be too expensive for conventional power generation. As a result, the solar cell technique will continue to be used only in certain niche markets. Solar cells are typically used today in places to which it would difficult to run ordinary power supply cables, such as remotely located lighthouses.

Energy Administration supports new technology

The Swedish National Energy Administration promotes the development of new technology that contributes towards the emergence of an economically and ecologically sustainable energy system by supporting research and development in the field of energy. During 1999, five research programmes were in progress in the field of electrotechnology, with most of the financing provided by the National Energy Administration. These programmes comprise new techniques for electricity generation based on sun and wind, and also the development of fuel cells and superconductors. In addition, a number of development programmes and competence centres are partially financed by the Energy Administration. ■

In the Nordic countries as a whole, electric power generation accounts for only a small proportion of the emissions, since the system comprises a large proportion of hydro and nuclear power. The exception is Denmark, where power generation is based on firing with fossil fuels. Hydro and nuclear power plants are not without environmental impact, but they are virtually emission-free during normal operation.

Fuel-fired power generation

Combustion of a fuel gives rise to various types of atmospheric emissions. Carbon dioxide, nitrogen oxides and sulphur oxide are described in somewhat more detail below. In addition to these, emissions also include dust, hydrocarbons, carbon monoxide, reduced nitrogen (ammonia), nitrous oxide (N_2O) and dioxins. Dust (particulates) contribute towards fouling, but may also give rise to respiratory tract ailments. Hydrocarbons are carcinogenic and contribute towards the formation of photochemical smog, e.g. ozone. If inhaled, carbon monoxide suppresses the oxygen absorption capacity. To some extent, ammonia is oxidized to nitrate, nitrogen oxides and pure nitrogen, but most of it is deposited on the ground with the precipitation in the form of ammonium (NH_4^+). Nitrous oxide contributes towards the greenhouse effect. Dioxins are toxic if inhaled.

Out of the fossil fuels, natural gas is the "cleanest" fuel, being practically free from heavy metals and sulphur, and giving rise to about 40 % lower carbon dioxide emissions than coal and 25 % lower than fuel oil. The combustion of biofuels is assumed not to cause any net contribution to the carbon dioxide emissions to atmosphere, provided that the biomass harvesting rate does not exceed the growth rate. On the other hand, firing with biofuel gives rise to somewhat higher emissions of methane and nitrous oxide (greenhouse gases), carbon monoxide and ammonia than fossil fuels. Peat includes sulphur, the content of which varies with the type of peat. Peat extracted in the vicinity of sulphurous soil and rock strata often has sulphur contents of up to 10 % measured on the dry weight.

Carbon dioxide emissions

Carbon dioxide (CO_2) is a gas formed during combustion. Emissions of carbon dioxide lead to increased greenhouse effect. Carbon dioxide also leads indirectly to the breakdown of the ozone layer, since it causes a temperature increase in the atmospheric layer nearest to earth, which leads to a corresponding temperature drop in the layer beyond it, and ozone depleting compounds are more active at lower temperatures.

Nitrogen oxides and sulphur dioxide

Nitrogen and sulphur oxides (NO_x and SO_2) are formed during combustion. The nitrogen originates mainly from the combustion air, which contains almost 80 % nitrogen. The sulphur originates from the fuel. The gases are converted in the atmosphere into nitric acid and sulphuric acid (HNO_3 and H_2SO_4) and are deposited with the precipitation, which is known as wet deposition, or are deposited directly as sulphur dioxide or nitrogen oxide, which is known as dry deposition. Nitrogen oxides contribute towards acidification, but mainly to over-fertilization, since nitrogen is absorbed in biomass in a larger proportion than sulphur. Nitrogen oxides also contribute to the formation of photochemical smog, which causes damage to the flora and to the respiratory tracts of animals and people. Sulphur oxides contribute principally to acidification.

Hydro power

Unlike the environmental impact caused by the emission of atmospheric pollutants, the environmental impact of hydro power is mainly local and regional. The construction of a hydro power plant affects the environment by changing the landscape pattern and the biotopes, by reducing the biological diversity, and by disturbing fisheries, care of cultural relics, and open-air activities. The damage caused by hydro power to the landscape is serious and basically irreparable, and is not confined to the run of the river, but also affects the surrounding landscape.

Nuclear power

The limit values of radioactive emissions have been set so that individuals (personnel

Table 13 • Emissions of carbon dioxide, sulphur dioxide and nitrogen oxides in Sweden between 1990 and 1998

	1990	1995	1996	1997	1998
Carbon dioxide, million tonnes					
Electricity generation according to STEM	1.2	2.9	5.8	3.0	2.9
Total in Sweden	**59.4**	**58.1**	**63.4**	**62.1**	**59.8**
Nitrogen oxides, thousand tonnes					
Electricity generation according to SCB	3	3	6	2	2
Total in Sweden	**396**	**355**	**358**	**327**	**297**
Sulphur dioxide, thousand tonnes					
Electricity generation according to SCB	4	4	7	3	3
Total in Sweden	**130**	**94**	**100**	**72**	**65**

Source: Energiförsörjningen i Sverige (Energy supply in Sweden), Swedish National Energy Administration, and Statistics Sweden (SCB).

Table 14 • Emissions of sulphur dioxide, nitrogen oxide and carbon dioxide per kWh of electrical energy generated in Denmark, Finland and Sweden between 1990 and 1998

	SO_2 (mg/kWh)			NO_2 (mg/kWh)			CO_2 (g/kWh)		
	Denmark	Finland	Sweden	Denmark	Finland	Sweden	Denmark	Finland	Sweden
1990	4 303	1 014	30	3 001	734	30	821	189	11
1995	2 489	388	28	1 852	436	28	694	210	22
1996	2 518	423	51	2 003	473	59	718	272	31
1997	1 562	380	14	1 512	420	21	676	220	12
1998	1 188	300	13	1 243	330	20	608	170	11

Source: Nordel. Note. The figures quoted are not derived from official statistics.

at the power station) who are exposed to it will not receive an annual dose in excess of 0.1 mSv. Compared to this, the natural background radiation gives an annual dose of 4 mSv. Under normal conditions, the emissions are far below the limit value. The environmental impact of nuclear power lies in the management of the radioactive waste occurring during operation, and the risks of major emission incurred in the event of an accident, and also in the mining of uranium.

Wind power

Similarly to hydro power, the environmental impact of wind power consists of the changes it causes to the landscape pattern, since large areas of land are needed for a substantial contribution to be made to the total of electricity generated. During operation, wind power units can also emit sound that may be perceived as disturbing, and they may also cause radio communication interference. In the construction of offshore power plants, disturbances may be caused to the fauna, principally to birds. There is no evidence of any other direct environmental effects.

Emissions from power generation in Sweden

In 1999, power generation accounted for around 5 % of Sweden's total carbon dioxide emissions, which amounts to 3 million tonnes. Power generation is exempt from carbon dioxide tax, which has led to an increase in the use of fossil fuels for electricity generation. The high emissions in 1996 shown in Table 13 were due to that year being dry. The loss of hydro power generation capacity was compensated by increased production in plants such as oil-fired condensing power stations. Sweden's carbon dioxide emissions between 1990 and 1998 are shown in Table 13, whereas the emissions per kWh during the same period are shown in Table 14.

Sulphur and nitrogen emissions from power generation have remained constant during the 1990s, with the exception of 1996, which was a dry year and hydro power generation was consequently low. On the other hand, the total emissions have declined during the 1990s. The lower sulphur emissions are due to reduced fuel oil consumption and lower sulphur contents in the oil. The drop in nitrogen oxide emissions is due to the emission charges imposed on bigger boilers, and to emission control systems in cars. The sulphur emissions from power generation in 1998 were just over 4000 tonnes, and nitrogen oxide emissions were below 3100 tonnes.

Coal-fired power station in Copenhagen

Most of the sulphur and nitrogen precipitation in Sweden originates from sources abroad. This is due to the fact that sulphur and nitrogen compounds have a residence time in the atmosphere of a couple of days and sometimes up to a week before they are deposited onto the ground. Sweden, which is in the west wind belt, has an exposed location for low pressures and fronts from the west and north-west. Winds from the south also carry large quantities of air pollutants to Sweden when high pressures build up over the Continent. But Sweden also exports air pollutants to neighbouring countries, mainly to Russia, Finland, Norway, Poland and the Baltic States, even though most of the pollutants are deposited into the sea.

Emissions per kWh have been displaying a downward trend throughout the 1990s, with the exception of 1996, which was due to low hydro power generation during that year. Table 13 shows Sweden's total SO_2 and NO_2 emissions between 1990 and 1998. Table 14 shows the emissions per kWh during the same period.

Regulations on nitrogen oxide and sulphur dioxide emissions

The Swedish Riksdag has set guidelines for the emission of nitrogen oxides from combustion plants. Guideline and limit values are specified for each individual plant.

When the Environmental Act (1998:808) came into force, an ordinance (1998:897) on environmental quality standards was also introduced. The environmental quality standards list the 24-hour, weekly and annual mean values that must not be exceeded in population centres of a certain size, and also annual mean values for protecting the vegetation outside these centres. Environmental quality standards for sulphur dioxide have now been set and, from 1 January 2006, standards will also be in force for nitrogen dioxide. In addition to these, there are also standards for lead (only annual mean value). The various municipalities keep a check on conformance to the standards. No permit may be granted for new operations if the environmental quality standard would thereby be exceeded. In such cases, new operations could be permitted only if the disturbances from existing sources are reduced, so that a window is created for the new operations within the framework of the environmental quality standard.

Since 1992, an environmental charge has been levied on emissions of nitrogen oxides from boilers and gas turbines with an energy output of at least 25 GWh/year. The sulphur content of fuel oils is regulated by a special ordinance. This ordinance also contains limit values for sulphur for certain coal-fired plants. A sulphur tax is levied on fuels that contain sulphur. Biofuels are excepted from the sulphur tax.

Emissions from power generation in the Nordic countries

The emissions of sulphur and nitrogen oxides from the power generation system in Denmark is the highest among Nordic countries in terms of both total emissions and emissions per kWh of electricity generated (see Table 14). This is due to fact that power generation in Denmark is based principally on firing with fossil fuels. Finland also has a relatively high proportion of electricity generation based on combustion. Norway bases its electricity production on hydro power and therefore causes virtually no emissions from power generation.

The picture for carbon dioxide emissions is the same. Denmark has the highest emissions, followed by Finland. Table 14 shows the emissions per kWh of SO_2, NO_2 and CO_2 in Denmark, Finland and Sweden between 1990 and 1998. ■

Trade in electricity takes place between a variety of player types. Generation utilities sell electricity to distributors, end customers and other generators. Distributors sell electricity to end customers, other distributors and, in certain cases, to generators. The players trade through bilateral contracts or via Nord Pool – the Nordic electricity exchange.

Interchange of electricity between the Nordic countries began back in the 1960s. Trade between the countries was then managed by the dominating players in each country. Today, all players who pay the network charge can use the transmission links also for buying electricity abroad.

From generation optimization to Nordic electricity exchange

Swedish power utilities have long had close cooperation. National joint operation began in 1938, when Vattenfall and Krångede AB began interchanging power. Up to 1994, the major power generators had agreements concerning joint optimization of electricity generation. Temporary interchanges of power, within the framework of generation optimization, dominated sales among the generators. A new system was introduced in 1995 in which all electricity generators were included in the interchange of power. This optimization ceased at the 1995/96 turn of the year, when entirely new conditions were introduced for the players on the electricity market.

In January 1996, the existing electricity exchange in Norway, i.e. Statnett Marked AS, was made available to Norwegian and Swedish players on equal terms, and an office was opened in Stockholm. Statnett SF, the Norwegian grid utility, owned Statnett Marked AS. In April of the same year, the Svenska Kraftnät grid utility purchased 50 % of the shares. In conjunction with this, the name of company was changed to Nord Pool – the Nordic Electricity Exchange.

The Finnish electricity exchange, known as EL-EX, began operations in August 1996. The exchange initially had about 30 Finnish players. In September 1996, the Finnish IVS network utility took over responsibility for the northern links with Sweden, which meant, in practice, that these were opened to all players. Trade between Sweden and Finland had previously been handled via Vattenfall and Imatran Voiman Oy. As a result of the free access to the transmission links, Swedish and Norwegian players were now free to purchase electricity in Finland, and Finnish players could trade on the Swedish-Norwegian exchange. Norwegian and Swedish trade with Finnish electricity generators initially took place on EL-EX. Finnish electricity generators can now sell their electricity on Nord Pool, which had 32 Finnish players on 1 January 2000.

EL-EX is used today by Swedish and Finnish players only for selling or buying excess generation capacity in the same 24-hour period in which delivery is to take place, in order to balance generation with sales of electricity. Svenska Kraftnät now owns 50 % of the shares in EL-EX and FINGRID, the Finnish grid utility, owns the remaining 50 %.

More players and bigger trade volumes

During last year, the number of players and the volumes traded via Nord Pool have continued to increase. On 1 January 2000, there were 278 players, compared to 258 in 1999. The number of Swedish players increased from 45 on 1 January 1999 to 61 in 2000. The players on Nord Pool are power generators, distributors, industrial companies, and dealers or traders. Electricity on Nord Pool is traded on the spot market (24-hour market) and forward market (weekly market). The spot market handles contracts for delivery during the next 24-hour period. The forward market is a financial market and handles contracts with a time horizon of up to three years.

The volume of trade on the spot market increased during both 1998 and 1999. In 1999, the physical market turnover was 75.4 TWh of electricity, which represents an increase of 34 % on 1998. Trade on the forward market increased by more than 140% to 215.9 TWh. Moreover, 683.6 TWh were cleared in bilateral contracts, which is almost twice the volume in 1999. Clearing of bilateral contracts involves Nord Pool acting as the opposite party to sellers and buyers in bilateral forward contracts. The companies thus eliminate the risk of an opposite

Table 15 • Sweden's foreign trade in electricity between 1990 and 1999, TWh

		Denmark	Norway	Finland	Germany	Total
1990	imports	0.2	12.3	0.4	-	12.9
	exports	7.9	0.4	6.4	-	14.7
	imports-exports	*-7.7*	*11.9*	*-6.0*	-	*-1.8*
1991	imports	0.8	4.7	0.7	-	6.2
	exports	1.8	3.1	2.7	-	7.6
	imports-exports	*-1.0*	*1.6*	*-2.0*	-	*-1.4*
1992	imports	1.5	6.7	0.7	-	8.9
	exports	5.4	1.2	4.4	-	11.0
	imports-exports	*-3.9*	*5.5*	*-3.7*	-	*-2.1*
1993	imports	1.3	6.3	0.4	-	8.0
	exports	4.0	0.5	3.1	0.9	8.5
	imports-exports	*-2.7*	*5.8*	*-2.7*	*-0.9*	*-0.5*
1994	imports	1.9	4.5	0.3	-	6.7
	exports	0.7	2.8	1.7	1.2	6.4
	imports-exports	*1.2*	*1.7*	*-1.4*	*-1.2*	*0.3*
1995	imports	0.6	6.9	0.2	-	7.7
	exports	2.1	1.2	3.8	2.3	9.4
	imports-exports	*-1.5*	*5.7*	*-3.6*	*-2.3*	*-1.8*
1996	imports	8.6	4.1	2.1	1.0	15.8
	exports	0.3	7.9	1.4	0.1	9.6
	imports-exports	*8.3*	*-3.8*	*0.7*	*0.9*	*6.1*
1997	imports	5.2	3.6	0.9	0.4	10.2
	exports	0.9	6.8	4.3	0.8	12.8
	imports-exports	*4.3*	*-3.1*	*-3.4*	*-0.4*	*-2.6*
1998	imports	2.2	3.0	0.8	0.1	6.1
	exports	1.9	7.3	5.3	2.3	16.8
	imports-exports	*0.3*	*-4.3*	*-4.5*	*-2.2*	*-10.7*
1999	imports	1.6	5.9	0.9	0.1	8.5
	exports	2.1	5.9	6.8	1.3	16.1
	import-exports	*-0.5*	*0*	*-5.9*	*-1.2*	*-7.6*

Note. Rounding-off discrepancies occur. After deregulation of the electricity market, the Swedish interchanges are reported in the form of physical values per country, and they are therefore not entirely comparable with earlier years, when trade exchanges were reported. Being drawn from different sources, the figures in this table do not entirely agree with the figures in Table 2.

Source: Compilation of information from Statistics Sweden (SCB) and the Swedish Power Association.

party not being able to meet its contractual obligations. For this service, Nord Pool levies a clearing charge, and the companies must deposit a security sum in a blocked bank account, in order to cover the risk taken by the electricity exchange in acting as the opposite party. During 1999, Nord Pool has gained a further 18 Danish players who sell and buy electricity for west Jutland, which is now included as a price area in Nord Pool. However, border tariffs are still in force between Sweden and Denmark and between Norway and Denmark.

Electricity trade between the Nordic countries

As a result of the changes on the electricity markets in the four Nordic countries, Swedish electricity traders are now able to sell electricity directly to customers in Denmark, Norway or Finland, and Swedish customers can purchase electricity from foreign electricity trading companies that wish to establish themselves on the Swedish market. Several Swedish electricity trading companies now have agreements with generators in the neighbouring Nordic countries for the import and export of electricity on long-term contracts. Long-term contracts with customers in other countries are also becoming increasingly common. Several of the newly formed Swedish electricity trading companies purchase electricity in Norway and Finland. Moreover, Sydkraft became the first Swedish company to sell electricity in Denmark.

Trade in electricity can balance temporary national shortfalls and surpluses of electricity. The flows of trade between the Nordic countries vary over the year and from year to year, depending on the temperature and precipitation, and on fluctuations in the business climate. The most important guiding factor is the water inflow into the Swedish, Norwegian and Finnish reservoirs. During the winter, when the inflow into the reservoirs is low and the electricity demand is high, the need for imports in Sweden and Norway increases. During such periods, Sweden and Norway therefore import electricity from Denmark and Finland, both of which have a high proportion of condensing power generation. This generation has higher variable production costs than hydro power generation, but is not dependent on the weather and therefore serves as stand-by power in the Nordic electrical system. In the spring and summer, the Swedish and Norwegian water reservoirs are well filled, and the electricity consumption is low. Hydro power generation in the Nordic electrical system therefore covers a large proportion of the electricity needs in the Nordic countries during this period. As a result, Sweden and Norway are then net exporters of electricity. In wet years, Sweden and Norway are net exporters of electricity all the year round. Electricity is exported to countries such as Denmark and Finland, since the variable generation cost of hydro power is lower than that of condensing power. During years with low precipitation, the trade flow is reversed and Sweden and Norway have greater need for importing electricity, mainly from Denmark but also from Finland, both of which generate electricity in condensing power stations. Germany and Russia also participate in electricity trade with the Nordic countries, although they cannot trade on Nord Pool. By strengthening

Figure 6 • Electricity imported by Sweden in 1998 and 1999, GWh per week

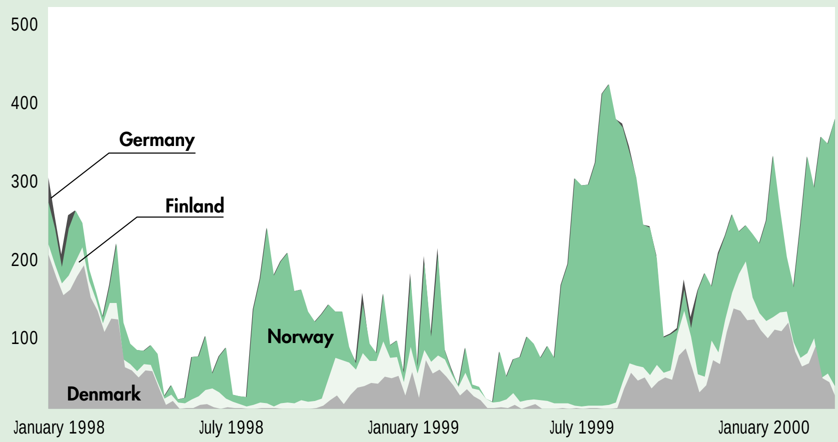


Figure 7 • Electricity exported by Sweden in 1998 and 1999, GWh per week

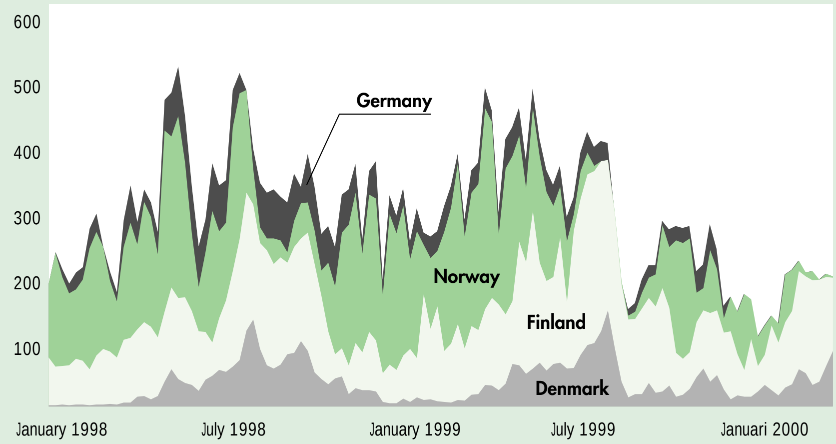
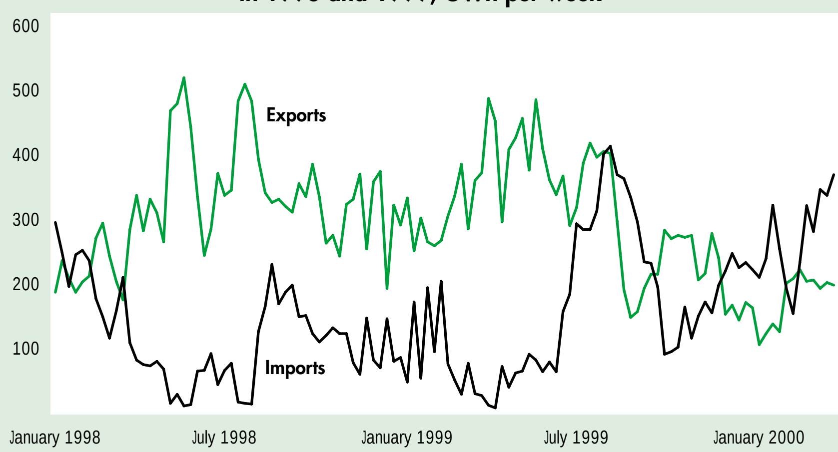


Figure 8 • Sweden´s electricity trade with foreign countries in 1998 and 1999, GWh per week



Source: Compiled information from the Swedish Power Association.

the German network the capacity of the transmission link between Sweden and Germany will increase. In addition, trade with Poland will begin in the near future on the cable link with Poland. Trade between Finland and Russia is currently the most extensive trade with countries outside the Nordic group. Figures 8, 9 and 10 show how the trade flows have changed during 1998 and 1999.

1996 was a distinctly dry year and, although normally a net exporter of electricity, Sweden imported large amounts of electricity, principally from Denmark. 1997, 1998 and 1999 were wet years with higher than normal inflows of water into the reservoirs, and Sweden was therefore a net exporter of electricity during those years.

Sweden's imports of electricity rose in 1999 to 8.5 TWh. Most of the electricity, i.e. 5.9 TWh, was imported from Norway, and 1.6 TWh from Denmark. Imports from Denmark were at their highest towards the end of the year. Norway exported much electricity to Sweden during the summer and early autumn, when the price of Norwegian electricity was low.

Sweden's total exports of electricity to neighbouring countries during 1999 amounted to 16.1 TWh, which represents a drop of 0.7 TWh from 1998. Exports to Denmark and Finland increased somewhat, and those to Norway and Germany decreased. The highest exports were to Finland whose imports from Sweden increased by 1.5 TWh. The highest proportion of electricity was exported during the first half of the year and in the summer months, when the supply of Swedish hydro power was high. During 1999, Swedish net exports amounted to 7.6 TWh as shown in Table 15 above, which is high compared to earlier years in the 1990s, but represents a drop compared to the record year in 1998.

Table 16 shows that Norway and Sweden are the countries in the Nord Pool area that trade most with one another. Denmark exports large amounts of electricity to Germany, which is the only country that has a land border with Denmark. The volume of trade between Finland and Russia is of the same order as that between Denmark and Germany. The difference is that Finland imports electricity only from Russia, whereas Denmark has both import and export trade in electricity with Germany. ■

Table 16 • Trade in electricity within the Nord Pool region and with countries outside the Nord Pool region during 1999, GWh

	Exports from						
	Denmark	Finland	Norway	Sweden	Germany	Russia	Total imports
Imports to							
Denmark			2 759	2 046	622		5 427
Finland			107	6 737		5 209	12 053
Norway	622	104		5 929		232	6 887
Sweden	1 614	825	5 904		93		8 436
Germany	5 356			1 312			6 668
Russia							0
Total exports	7 592	929	8 770	16 024	715	5 441	

Source: Nordel Quarterly Statistics, 4/99.

Disregarding taxes and grants, the costs of electricity from the various generation sources are roughly the same in the Nordic countries. The electricity generation costs shown in Figures 9 and 10 are based on Swedish electricity generation, but also show the approximate level of electricity generation costs in all Nordic countries.

Existing generation system

The variable electricity generation costs in the existing system consist of fuel costs and also operation and maintenance costs. The costs are shown in Figure 9, and are calculated as the average per type of power.

For hydro power stations, the variable costs are around 4 öre/kWh for all plants. The cost varies between 3 and 6 öre.

The variable generation costs of wind power are between 4 and 6 öre/kWh, depending on the wind conditions.

The average variable generation costs of nuclear power are estimated to be around 8 öre/kWh, including taxes and the nuclear waste charge. On 1 January 2000, the tax on nuclear power was raised from 2.2 to 2.7 öre/kWh.

Considering combined heat and power generation in industry, the pulp and paper industry and sawmills have access to fuel which is basically free of charge, e.g. bark and black liquors. The plants also use fossil fuels. The variable generation costs vary with the fuel costs, which are lower for biofuels and higher for oil.

The variable generation costs for combined heat and power generation in district heating systems vary with the fuel used. The lowest costs are for coal-fired generation and the highest for biofuels.

The variable generation costs in oil-fired condensing power stations vary between 20 and 30 öre/kWh if heavy fuel oil is used. If light fuel oil is used, the costs rise to between 30 and 40 öre/kWh. Gas turbines fired with light fuel oil have the highest variable generation costs.

Coal-fired condensing power stations have a variable generation cost of just over 16 öre/kWh.

New power generation plants

The total electricity generation costs for new power generation plants consist of variable costs, capital costs and other fixed costs. The costs shown in Figure 10 should be interpreted and used with caution, since every plant is unique, and local conditions are of major importance to the total costs. This applies particularly to the costs of condensing plants, since no such plants have been built in Sweden in the past two decades. The calculations are based on 4 % real interest rate and a depreciation period of 20 years, except for hydro power for which the depreciation period is 40 years.

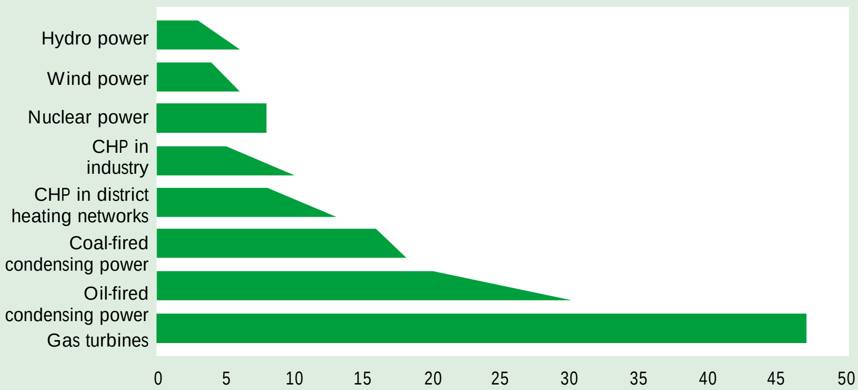
In large-scale construction of hydro power plant, the generation cost is around 18 öre/kWh. For individual large hydro power stations, the upper cost limit is estimated to be around 28 öre/kWh. For small-scale hydro power generation, an investment grant of up to 15 % of the investment cost is available. The cost of small-scale hydro power is estimated to vary between 35 and 50 öre/kWh without investment grant.

An investment grant of 15 % of the investment cost was introduced on 1 July 1997 for wind power plants with an output in excess of 200 kW. Before that date, grants of up to 35 % of the investment cost were available. The total generation cost varies between 30 and 36 öre/kWh without investment grant, depending on the wind conditions. With the investment support, the cost is between 26 and 31 öre/kWh. In addition to the investment grant, an operating grant of 16.2 öre/kWh is also allowed, which corresponds to the energy tax for households in southern Sweden.

The generation costs for oil-fired condensing plants, natural gas-fired combined cycle plants, and coal-fired condensing plants vary with the sizes of the various plants. Wood-chip fired condensing power plants are assumed to be small, i.e. of the order of 50 MW. The large volume of fuel needed and its handling restrict the plant size and result in higher costs. The revenue from heat generation reduces the electricity costs in combined heat and power plants, which is known as heat crediting. Crediting is calculated on fuel crediting and on power crediting. In this case too, the generation costs vary widely. The scatter depends on the plant size, the fuel used and the crediting selected.

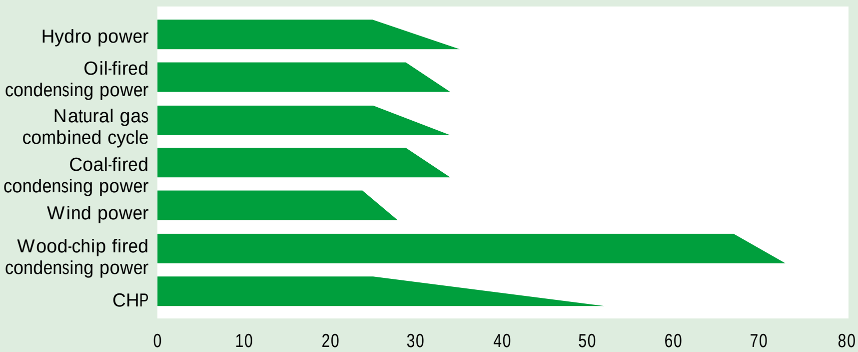
A state investment grant is payable to biofuel-fired combined heat and power generation plants that give a new contribution to electricity generation. A special operating grant of 9 öre/kWh for small-scale biofuel-fired plants (smaller than 1 500 kW_{el}) is payable during the period between November 1999 and December 2000.

Figure 9 • Variable generation costs in existing electricity generation systems, öre per kWh



Source: Information compiled and processed by the National Energy Administration and obtained from Kraftsam, Sydkraft and AB Ångpanneföreningen. Elforsk report 00:01, *"El från nya anläggningar"* (Electricity from new plants).

Figure 10 • Total electricity generation costs in new plants, öre per kWh



Source: Information compiled and processed by the National Energy Administration and obtained from Kraftsam, Sydkraft and AB Ångpanneföreningen. Elforsk report 00:01, *"El från nya anläggningar"* (Electricity from new plants).

The electricity prices charged vary between different customer categories, between urban and rural areas, and between individual Nordic countries. This is due to varying distribution costs, and differences in taxation, subsidies, state regulations and the structure of the electricity market.

The total price of electricity charged to the customer consists of:

- network tariff – price of the network service, i.e. for the transmission of electricity
- price of electrical energy
- charges and taxes
- the commercial mark-up made by every link in the sales chain.

The *network tariff* is designed as a "spot tariff". This means that the network tariff charged to consumers and generators is independent of the one with whom they trade in electricity. However, the network charge varies depending on the point in the network to which an electricity consumer or an electricity generator is connected. An electricity consumer thus pays the same network charge regardless of whether the electricity has been purchased from a neighbouring or remote electricity supplier. Electricity generators pay the same network charge regardless of the one to whom the electricity is sold. The spot tariff also means that payment is made for access to the entire transmission system. For customers who receive electricity on the local network, the regional and grid charges are included. The network tariffs are published and are monitored in Sweden by the National Energy Administration and in Norway by the Norwegian Water Resources and Energy Directorate (NVE). In Finland, a special supervisory authority – the Electricity Market Centre - has been formed for this task. Since 1 January 2000, Denmark also has a special supervisory authority for the network operations - "Energitilsynsudvalget" (Energy Supervisory Board). The latter replaces the two present boards, i.e. "Elprisudvalget" (Electricity Price Board) and "Gas- og Varmeprisudvalget" (Gas and Heat Price Board).

The thought behind the new electricity market is that *electricity should be purchased in competition.* When the network charge has been paid, the customer can trade freely on the network and can choose the supplier who is best suited to his needs. The market price is therefore determined by supply and demand. Trading takes place either through the electricity exchange or by bilateral contracts between two parties.

Spot and forward markets

The Nord Pool *electricity exchange* is an organized marketplace for trading in electricity. The benefit of trading on the exchange is that transaction costs are lower than those for bilateral trade agreements. More than 20 % of all electricity trade in the Nord Pool region now takes place through the electricity exchange.

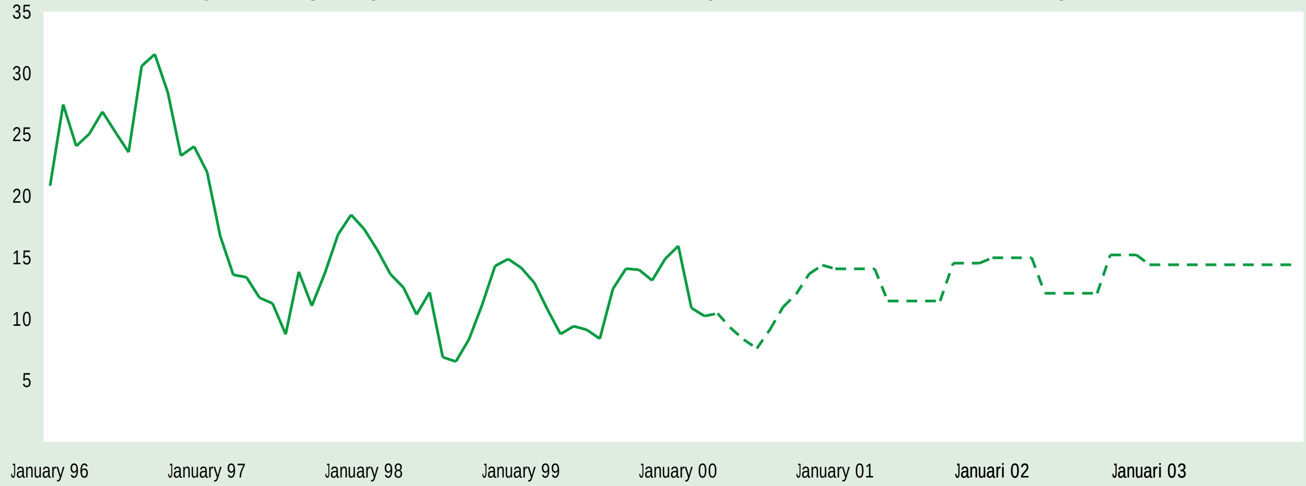
On the Nord Pool exchange, electricity is traded on the spot market and on the forward market. The spot market is a price reference for the Nord Pool forward market and for the remainder of the electricity market. Since 1 March 1999, electricity is also traded on the EL-EX balance adjustment market after the electricity exchange has closed.

The *spot market* is the Nord Pool market for physical deliveries of electric power. On this market, the players trade in hourly contracts for delivery in the next 24-hour period. Before 1200 hours, the players send in their bids for all hours of the next 24-hour period. The buyers state how much electricity they want to purchase hour by hour, and what they are prepared to pay for it. The sellers submit corresponding selling bids. The bids of the players are compiled into a supply curve (sales) and a demand curve (purchases). The price is determined as an equilibrium price at the point of intersection of the supply and demand curves.

In the event of network limitations, known as bottlenecks, the bidders must specify the part of the system in which electricity is to be purchased or sold, which is known as the notification area. The whole of Sweden and the whole of Finland each represent one notification area. Bottlenecks in the respective country are handled by means of so-called counter-purchases. Since 1 July 1999, Jutland and Funen are also a separate notification area. Norway has several notification areas and bottlenecks are handled by price areas and "capacity charges". The price mechanism is used for regulating the power flow in situations in which there are capacity limitations in the network. If the power flow between two areas should exceed the capacity, the price is reduced in the surplus area and is increased in the shortfall area until the transmission requirement has been reduced to the capacity limit. The spot market can therefore be regarded as a combined energy and capacity market.

There are different prices, depending on the pattern of power flow. The *system price* is calculated without taking into account any transmission limitations. If price calculations show that the power flow between two or more notification areas exceeds the capacity limit, two or more area prices will be calculated. The difference between the system and area prices is the capacity price in each area. If the capacity between the notification areas is not exceeded, there will be only

Figure 11 • System price on the 24-hour market for the period between 1996 and 2003, öre per kWh



Note: The dashed line shows the forward prices on 31 March 2000. Source: NordPool, ASA.

one price area. In this case the area price will be equal to the system price, and the capacity price will be zero.

The *forward market* is purely a financial market without physical deliveries and represents an organized market for price assurance and risk handling. The players on the forward market can use financial contracts to assure the prices of purchases and sales of power up to three years ahead in time. The result for the buyer will be a gain or a loss on the price difference between the price on the exchange at the delivery date and the price at the purchase date. The system price on the spot market serves as underlying reference for forward prices.

Lower exchange prices

The electricity prices in 1999 set out from a lower level than in 1998, and then continued to drop as a result of well-filled water reservoirs and a mild winter. Prices did not begin to rise until April, due to the colder and dryer weather and a slight downturn in the spring floods. At the same time, several nuclear power stations were shut down for the annual overhaul, which also pushed the prices up. In May, the prices dropped again, since the water inflow both in Norway and in Sweden was exceptionally high.

At the end of July, the spot prices bottomed at around 6 öre/kWh, which was followed by a substantial upsurge during the end of the summer to 14 öre/kWh. The appreciable rise was caused by reduced water inflow and the fact that five nuclear power stations and some hydro power stations were shut down for inspection or overhaul. In October, the prices began to drop again due to heavy precipitation and mild weather. At the end of the year, a cold spell caused a temporary increase in spot prices, but a quick return to milder weather led to prices dropping afresh. The average spot price during 1999 was 11.8 öre/kWh, compared to the average price of 12.3 öre/kWh in 1998.

The highest price level on the electricity exchange was recorded on 24 January 2000, when the Swedish, Danish and Finnish area prices rose to record levels. However, the price surge was temporary and affected only Sweden, Finland and Denmark. The situation occurred because the day was a cold winter day, and there is now serious anxiety that a power shortfall will occur in cold weather, since the installed power in Sweden has decreased. Moreover, on that particular occasion, the Baltic Cable link with Germany was out of operation. The reaction was an increase in electricity price, which then led to a drop in power consumption. But the mild and wet weather during February and March then caused the prices to decline again.

Due to the physical transmission limitations between Sweden and Norway, two different prices have periodically emerged on the spot markets of the two countries, i.e. a capacity charge arose. During 1999, the differences were highest during the summer, when prices in Sweden were higher than those in Norway. This was due to the large amount of precipitation in southern Norway, which led to a low area price. The price upsurge on 24 January 2000 also gave rise to wide differences between the two price areas. In Sweden and Finland, the prices rose to 408 öre/kWh during one particular hour (0800 - 0900), while the price in Oslo at the same time was 26.1 öre/kWh. As a result of the limited transmission capacities, the Oslo area became a surplus area with a low price on that particular occasion, while remaining parts of the Nord Pool region became a shortfall area with a very high price.

Total electricity price in Sweden

The prices on the exchange should not be compared with the prices that private customers are billed. The latter also include three other items, i.e. network charges, commercial mark-up, and also charges and taxes.

Table 17 shows the total electricity price when electricity is sold on a delivery con-

Table 17 • Total price of electricity on 1 January 1999 for the sale of electricity under a delivery concession to different customer types, öre/kWh, incl. taxes[1]

	Mean value	Upper quartile	Median	Lower quartile
Apartment	105.7	113.5	105.2	97.6
Single-family dwelling without electric heating	95.4	101.6	95.3	89.3
Single-family dwelling with electric heating	72.7	76.9	73.7	68.9
Agriculture or forestry	73.4	78.3	73.6	69.3
Commercial operations	38.1	41.1	38.0	35.6
Small industrial plant	37.5	40.9	37.1	34.4
Medium-sized industrial plant	-	-	-	-
Electricity-intensive industrial plant	-	-	-	-

[1] Industrial customers pay no electricity taxes.
- No information available
Source: *Priser på elenergi och nättjänst 1999* (Price of electrical energy and network service in 1999), E 17 SM 9901, Statistics Sweden

Table 18 • Total average price of electricity, including taxes, öre per kWh

	1995	1/1 1996	1/1 1997	1/1 1998	1/1 1999
Apartment	90.2	97.6	99.9	106.8	105.7
Single-family dwelling without electric heating	82.7	90.0	92.4	97.8	95.4
Single-family dwelling with electric heating	64.0	67.5	72.2	75.2	72.7

Source: Statistics Sweden.

Apartment	2 MWh/year, 16 A meter fuse rating
Single-family dwelling without electric heating	5 MWh/year, 16 A meter fuse rating
Single-family dwelling with electric heating	20 MWh/year, 20 A meter fuse rating
Agriculture or forestry	30 MWh/year, 35 A meter fuse rating
Commercial operations	100 MWh/year and 50 A meter fuse rating
Small industrial plant	350 MWh/year, 100 kW power demand or 160 A fuse
Medium-sized industrial plant	5 000 MWh/year, 1 MW power demand
Electricity-intensive industrial plant	140 GWh/year, 20 MW power demand
Large electricity-intensive industrial plant	500 GWh/year and 66 MW power demand

The *median* is the value of the variable for the centre company when the companies are arranged in the order of magnitude of the variable. Half the companies have a value which is lower than the median and half have a value which is higher than the median. In a corresponding manner, 25 % of the companies have a value which is lower than the *lower quartile*, and 25 % have a value which is higher than the *upper quartile*.

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Table 19 • Prices of network services on 1 January 2000 for different customer types, öre per kWh

	Mean value	Upper quartile	Median	Lower quartile
Apartment	42.3	48.0	42.2	34.6
Single-family dwelling without electric heating	37.2	43.4	36.9	31.3
Single-family dwelling with electric heating	20.8	23.5	20.6	18.1
Agriculture or forestry	21.9	24.6	21.5	18.8
Commercial operations	15.3	17.3	15.1	13.1
Small industrial plant	13.9	17.2	14.6	12.5
Medium-sized industrial plant	-	-	-	-
Electricity-intensive industrial plant	-	-	-	-

Source: National Energy Administration

cession to different typical customers in Sweden. The total price payable by customers living in apartments during 1999 fell on average by 1 % in actual monetary value compared to 1998, as shown in Table 18. For customers living in private houses without electric heating, the total price declined by 2.4 %, and for customers with electric heating, it dropped by an average of 3.3 %.

Demand for hourly metering abolished

On 1 November 1999, the hourly metering stipulation was withdrawn for customers in Sweden whose demand was 200 A or 135 kW. As a result, domestic customers can now change their electricity supplier without incurring costs. At the same time, the delivery concession system was discontinued. As a result of this change, the National Energy Administration no longer supervises the electricity trading prices.

At the same time as the demand for hourly metering was abolished, the profile-settlements of consumption was introduced. This means that every network area must have a standard curve for the electricity consumption which is not metered hourly.

Network tariffs in Sweden

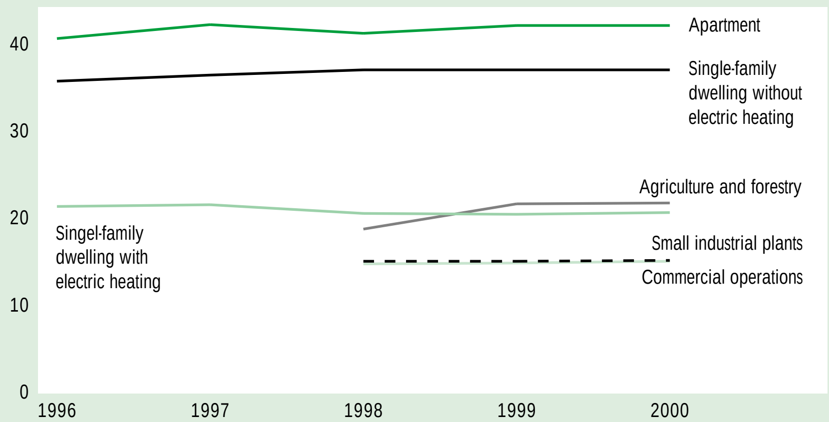
The term network tariff denotes the charges and other conditions for the transmission of electricity and for connecting to a power line or a power line network. The network tariffs must be reasonable and must be set on objective grounds. When the reasonableness of a network tariff is assessed, special consideration must be given to the interest of the consumers in low and stable prices. Moreover, consideration must be given to justifiable demands of the owners for a reasonable yield from the network operations. The tariffs, which must be based on costs that are related to the network operations, must be correctly costed. However, apart from a once-only charge for connection, the tariff must not be set differently depending on where in an area the customer is located. For practical and cost-saving reasons, network utilities are allowed to classify the network customers into categories of customer types. In each category, the tariffs must be the same for all customers. The Electricity Act does not specify whether the tariffs should consist of a fixed part and a variable part. In recent years, several of the network utilities have modified their tariffs so that the fixed charge is the larger part – around 80 % of the total tariff. Early in the year 2000, seven out of 210 companies had only a fixed charge. A summary of the prices for network services on 1 January 2000 for different typical customers is given in Table 19.

The way that network charges have developed for domestic customers between 1996 and 2000 is shown in Figure 12. Between 1996 and 2000, the network charge for customers living in apartments has increased by 3.8 % and for the category of customer living in a single-family dwelling without electric heating by 3.6 %. The biggest change in charges took place during the early years, and the charges subsequently remained relatively constant. For the category of customers living in single-family dwellings with electric heating, the charge during the same period dropped by 3.2 %. The tariffs for the category of small industrial plant customers have increased by 2.0 % during the period. The biggest change and increase in the tariff level was for the agriculture and forestry customer category. Since 1998, the level of tariffs has increased by 16 %.

The tariff levels within customer categories vary between companies. The scatter has decreased since 1996. It is mainly the highest charges that have fallen. On average, the network utilities that distribute electricity to sparsely populated areas have lowered their tariff levels for the category of customers living in apartments and single-family dwellings without electric heating, whereas network utilities with urban area distribution have raised their tariffs.

Taking into account the development of costs to society, the National Energy Administration considers that the price increases applied by the network utilities during 1999 were not reasonable. However, there are a few exceptions. Against this background, the National Energy Administration has directed a number of companies to lower their network charges during 1999. All except four of the companies have appealed to the County Administrative Court. The court has decided one case in favour of the Administration. However, the company has appealed to the Administrative Court of Appeal.

Figure 12 • Development of network charges between 1996 and 2000, average prices, öre per kWh



Source: National Energy Administration

Electricity prices in other Nordic countries

All customers in Norway and Finland can change their electricity suppliers free of charge. Just as in Sweden, electricity trading companies use a profile-settlements of consumption for small customers.

Although the demand for hourly metering was abolished in Finland in 1998, the delivery obligation remains. Delivery obligation covers customers who have not changed their electricity supplier and imposes the obligation on the electricity trading companies to sell electrical energy to such customers. The rules in the case of delivery obligation are different from those in a competitive situation. According to the law, the price of electrical energy shall be reasonable, and the electricity seller shall have a published price list of the electricity tariffs. The electricity prices to domestic customers and industrial customers in the Nordic countries are shown in Table 20.

Denmark has the highest electricity prices for all customer types. Danish domestic customers pay 2–3 times higher electricity prices than those in other Nordic countries. This is due to the high taxes on electricity consumption for domestic customers and to the Public Service Obligation (PSO) ordinance. According to the PSO ordinance, electricity distributors in Denmark are obliged to purchase a certain proportion of electricity generated by environment-friendly methods, and the additional cost is then recovered from the end user. This is not a tax, although it does affect the cost pattern, and the total price of electricity to domestic customers is thereby high. The electricity prices to industrial customers in Norway are lowest, whereas the prices to domestic customers in Finland are lowest.

Network tariffs in other Nordic countries

Monitoring of the network monopoly and the regulatory system does not differ significantly between the Nordic countries, except in Denmark. The task of the supervisory authorities is to ensure that the network utilities run their operations in such a manner that the cost effectiveness interests of the customers are met. The authorities must also ensure that the tariffs are reasonable and objectively set.

In Sweden, Norway and Finland, the network tariffs for the whole of the country are published at regular intervals. This system has not yet been set up in Denmark, since the electricity market reform has only just started and a new supervisory authority known as the Energy Supervisory Board was only formed on 1 January 2000.

The network tariffs for customers living in apartments are much lower in Finland than they are in Sweden. On the other hand, the network tariffs for the categories of commercial operations/agriculture and small industrial plants are appreciably higher in Finland. The network tariffs for the various customer categories in Norway are basically on a level with those in Sweden.

In Norway, the Norwegian Water Resources and Energy Directorate (NVE) has developed a new regulatory model for network operations, which is designed to contribute towards improved efficiency and cost reductions. As from 1997, the NVE has been setting up the framework for the magnitude of the total revenues which each individual network utility is entitled to draw from its transmission operations. The means that the

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Table 20 . Electricity prices to domestic customers and industrial customers, including taxes and VAT, on 1 January 1999, öre per kWh

Country	Small industrial plant[1]	Medium-sized Industrial plant[2]	Large Industrial plant[3]	Domestic customer 3 500 kWh	Domestic customer 20 000 kWh
Norway	37	27	20	94	55
Finland	45	40	29	81	49
Denmark	54	52	48	175	148

[1] 1.25 GWh annually, 0.5 MW, 2 500 hours.
[2] 10 GWh annually, 2.5 MW, 4 000 hours.
[3] 70 GWh annually, 10 MW, 7 000 hours.
Source: Unipede, Prices of Electricity as at 1 January 1999, SSB/Norway, Eurostat and National Energy Administration.

Table 21 • Electricity taxes in Denmark, Finland and Norway, öre per kWh[1]

	Denmark[2]	Finland	Norway	Sweden
Domestic	57	6	9	16
Industrial	0	4	0	0
VAT, percent	25	22	23	25

[1] The information from Finland relates to the situation in October 1999, and from Denmark, Sweden and Norway, to January 2000.
[2] In Denmark, carbon dioxide tax is payable at the rate of 12 öre per kWh by domestic customers, and 3 öre by industrial customers without an agreement/0.5 öre by those with an agreement.

Table 22 • Electricity taxes at consumer level, öre per kWh

	1995	1996		1997		1998	1999	2000
		1 Jan	1 Sept.	1 Jan	1 July	1 Jan	1 Jan	1 Jan
Northern Sweden								
Electricity, gas, heat and water supplies	3.7	4.3	5.3	7.4	8.2	9.6	9.5	10.6
Industrial operations, etc.	0	0	0	0	0	0	0	0
Other users	3.7	4.3	5.3	7.4	8.2	9.6	9.5	10.6
Remainder of Sweden								
Electricity, gas, heat and water supplies	6.8	7.5	9.1	10.7	11.5	12.9	12.8	13.9
Industrial operations, etc.	0	0	0	0	0	0	0	0
Other users	9.0	9.7	11.3	13.0	13.8	15.2	15.1	16.2

Source: Tax authorities.

network utilities can no longer adjust the network tariffs to cover their costs fully. The new rules also set the limits for the permissible profit and limits for minimum profit.

Taxation systems in the Nordic countries

Taxes on electricity at consumer level are levied in all Nordic countries. The taxes are differentiated for domestic and industrial customers. Industry pays lower taxes or, in Norway and Sweden, no taxes at all. Electricity at the generation stage is taxed in Norway and Sweden. On average, the generation tax is around 1.3 öre per kWh in Sweden and about 1.4 öre per kWh in Norway.

Sweden

Electrical energy is taxed both at consumer level and at the generation stage. Certain customer categories also pay Value Added Tax (VAT).

At consumer level

The consumption of electricity is taxed. For most users, electricity tax from 1 January 2000 is payable at the rate of 16.2 öre per kWh. The consumption of electricity in the supply of electricity, gas, heat or water attracts tax at the rate of 13.9 öre per kWh. Certain municipalities in northern Sweden have a lower tax rate of 10.6 öre per kWh. Since November 1998, electricity consumption for electric boiler plants with an installed power in excess of 2 MW has been taxed during the winter season (1/11–31/3). The tax rate is 12.9 öre per kWh in northern Sweden and 16.2 öre per kWh in the south. Since 1994, the electricity tax has been adjusted annually in line with the consumer price index. VAT on electrical energy is 25 % and is charged on the electricity price, including energy tax. The manufacturing industry, the mining industry and commercial greenhouse operators have been exempt from electricity tax since 1994. As from 1 July 2000, agriculture, forestry and aquaculture will also be exempt.

Generation stage

All fuels used for electricity generation are currently exempt from energy and carbon dioxide taxes. However, part of the fuel, namely 5 % in condensing power generation and 3 % in CHP generation, are considered to be own consumption and are taxed. In addition, all fuels used for electricity generation pay nitrogen oxide charges and, if applicable, sulphur tax.

Nitrogen oxide emissions are subject to an environmental charge amounting to SEK 40 per kg of nitrogen oxides from boilers, gas turbines and stationary combustion plants. The nitrogen oxide charge is levied on plants with an annual energy output of at least 25 GWh. The charge is neutral to state finances. The funds collected are returned to plants that have the lowest emissions in relation to their own energy generation, whereas plants with the highest emissions are net contributors.

The sulphur tax levied on coal and peat amounts to SEK 30 per kg of sulphur emission. For oil, the tax is SEK 27 per cubic metre for every tenth of one percent by weight of sulphur content in the oil. For fuel used for heat generation in CHP plants, half the energy tax is payable, and also the carbon dioxide and sulphur taxes.

Electrical energy generation in nuclear power plants is taxed at the rate of 2.7 öre per kWh. In addition, 0.15 öre per kWh is levied in accordance with the “Studsvik Act”, and an average of 1.0 öre per kWh in accordance with the law on financing future expenditure for spent nuclear fuel. In the past, hydro power was subjected to a special property tax, although this has now been abolished. From 1 January 1996, electricity generation plants have been paying a property tax amounting to 0.5 % of their taxable value.

All fuels used in Sweden for electricity generation are exempt from energy and carbon dioxide taxes. On the other hand, nitrogen dioxide charges and, if applicable, sulphur tax are payable.

Denmark

Taxes for domestic customers are particularly high in Denmark as shown in Table 21. These consist of carbon dioxide tax and electricity tax. Part of the revenue from taxation is used for financing grants for electricity generation systems that cause low emissions.

Several different tax levels are levied on industrial customers. Electricity tax is zero, but companies pay carbon dioxide tax. Taxes are differentiated depending on whether or not the plant is energy-intensive. In addition, certain industries have concluded agreements concerning carbon dioxide limiting measures and, in return, pay reduced carbon dioxide charges. The particulars in Table 21 concern energy-intensive industry with and without agreement. From the year 2000, a sulphur tax is levied on electricity generation. This amounts to 23 DKK per kg of sulphur emitted.

Finland

There are only two spot tax classes for electricity in Finland. One of these relates to electricity consumption in industry, while the other relates to all other consumption. In addition, a supply preparedness charge is levied at consumer level. Electricity generation and the power stations’ own consumption are not taxed. Financial support is given for electricity generation from certain renewable sources, such as wind power, small-scale hydro power, biofuel fired power and certain CHP stations. However, the financing of these grants has no direct link with electricity taxes.

Norway

Electricity tax is payable at consumer level. However, industry and commercial greenhouse operators are exempt from electricity tax. Electricity generation in Norway is dominated by hydro power. A natural resource tax is levied at production level, and this is transferred to hydro power municipalities and counties. In addition, an investment tax of 7 % is payable. Certain investments, such as wind power, bioenergy, district heating, etc. are exempt from the investment tax. In addition, a special grant for wind power has been introduced in 1999. ■

Electricity is transmitted from power stations to consumers by a network of power lines. The network is normally classified into three levels, i.e. the national grid, regional networks, and local networks. The national grid comprises 220 kV and 400 kV lines and most of the links with neighbouring countries. All of the Nordic countries have system operators that are responsible for their respective national grids and links with foreign countries.

Major power stations and regional networks are connected to the national grid and are entitled to use it for transmitting electricity. Balance providers and companies responsible for trade with foreign countries can also use the national grid.

The regional networks, which normally operate at voltages of 70–130 kV and, in certain cases, also at 220 kV, transmit electricity from the national grid to local networks and sometimes also to electricity users with a high consumption, such as major industrial plants and local network utilities.

From the local networks, normally at a maximum of 20 kV, electricity is transformed in the distribution areas to the normal domestic voltage of 380/220 volt.

Transmission of electricity and system responsibility in Sweden

Sweden has about 15 200 km of 220 kV and 400 kV transmission lines with stations, for which Svenska Kraftnät is responsible. Around 150 transformers and switching stations are provided for linking the networks together. At the present time, about 35 companies are connected to the national grid. One third of these companies are regional network owners and the remainder are power station owners.

Charges on the national grid

Svenska Kraftnät applies a spot tariff on the national grid. The charge consists of three parts, i.e. power charge, energy charge and investment contribution.

For the charge to reflect actual costs, it must be dependent on energy and power conditions at the connection point, and on the geographical location. Electricity is transmitted on the national grid mainly from the hydro power stations in northern Sweden to the consumption areas in central and southern Sweden. In northern Sweden, the infeed of electricity into the grid causes the load on the grid to increase, whereas outtake causes the load to decrease. The reverse applies in southern Sweden.

The power charge is based on the customer's annual subscribed power at each connection point and varies with the geographical location of the connection point. The charge is different for infeed and outtake at a given point. An infeed point in the north attracts a higher power charge than an infeed point in the south. The reverse applies to outtake points. In 1999, the charge was between 2 and 38 SEK/kW.

During 1998, a special power charge was levied on thermal power units, in order to contribute towards meeting the costs incurred by Svenska Kraftnät for maintaining a disturbance reserve. The charge was discontinued in 1999. The disturbance reserve is now financed directly by national grid charges.

The energy charge is designed to meet the cost of losses and is calculated as the product of the loss coefficient, energy price and energy infeed or outtake. Every point in the network is assigned a definite loss coefficient that corresponds to the calculated change in the energy losses at the point under normal operating conditions. A positive coefficient leads to debiting of the infeed of electricity and crediting of the outtake. The reverse applies to a negative coefficient. The energy price is determined in advance, one year at a time, and is based on the purchase price paid by Svenska Kraftnät to its energy suppliers for covering the grid losses. The average price of energy in the year 2000 is 18 öre per kWh.

If connection of a new customer plant to the national grid incurs costs that are not met by the ordinary charges, Svenska Kraftnät can demand an investment contribution from the customer.

During 2000, a temporary network charge of 0.2 öre/kWh is being levied to finance the state support for small-scale electricity generation.

System responsibility and balancing service

Svenska Kraftnät is responsible for maintaining the balance between electricity generation and consumption in the country. The task is managed by the operative balancing service which carries out short-term monitoring of the electricity balance and maintains the frequency in the grid at 50 Hz. Unbalance occurs if the planned electricity generation does not correspond to the actual consumption.

Svenska Kraftnät has concluded an agreement with somewhat less than 50 players who are known as balance providers. According to the agreement, these have accepted balancing responsibility for one or several electricity users or electricity suppliers. The agreement with Svenska Kraftnät regulates the handling of balancing power, i.e. the difference between a company's planned supply and consumption of electricity, and the actual utilization. Anyone who wishes to trade in electricity in Sweden must have his balance responsibility arranged either directly with Svenska Kraftnät or indirectly through one of the balance provider companies.

Balance providers create balance by planning their generation, if they do have generation, or by purchasing and selling electricity by trading with other balance providers and on the Nord Pool spot market. After the exchange has closed and up to 2 hours before the operating hour, the balance adjusting market of EL-EX, known as Elbas, can also be used. Elbas was set up in March 1999 and, in conjunction with this, the balance adjustment service of Svenska Kraftnät was wound up.

Frequency control

The balancing service employs primary and secondary regulation for handling unbalance during the operating hour itself. Primary regulation is used for fine adjustment of the physical balance. This takes place by a number of hydro power stations being automatically activated for raising or lowering the frequency. This power is purchased by balance provider companies that have offered this type of power interchange. According to a Nordic agreement, Sweden shall maintain a regulating capacity of 2500 MW per Hz for primary regulation.

Secondary regulation takes place manually on various regulating objects. No later than 30 minutes before the beginning of the operating hour, bids for secondary regulating power are submitted to the balancing service by suppliers who have the capacity to adjust their generation or consumption during the operating hour. The balancing service then places orders against such bids as required, in price order. The price of the regulating power for the hour will then be the highest accepted bid for upward regulation and the lowest accepted bid for downward regulation.

Charges for balancing service

The energy for the Svenska Kraftnät trade in balancing power and regulating power is priced and settled with the relevant balance provider company. The charges vary depending on the services that the balance provider companies use.

The balance providers pay a power charge and a volume charge for the balancing

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power, i.e. for adjustment during the operating hour. In addition, the balance providers pay an "additional price" for regulation. The additional price means that balance providers with unbalance "in the right direction" receive the most favourable price terms.

No charges are made for the balance regulation itself. Trade takes place against orders from the balancing service, which trades on the basis of the bids received.

Svenska Kraftnät has a settlement charge for trade with contracted power between the balance provider companies in Sweden and between balance providers and foreign players outside the spot market of the electricity exchange.

Transmission losses, cost development and reliability

Certain energy losses always occur in the transmission of electricity. Svenska Kraftnät purchases all of the energy necessary for covering the energy losses on the national grid. The total annual losses are estimated to be between 2 and 3 TWh, and the cost is estimated to be between SEK 500 and SEK 700 million annually, i.e. around 30 % of the operating costs of Svenska Kraftnät. The transmission losses vary with the power situation in the country. During years when a large proportion of the electricity is generated by hydro power, the transmission losses are higher due to the long distances to the consumers.

The infeed subscriptions have declined due to factors such as Barsebäck being decommissioned. The fact that the amount of infeed energy is lower than in 1998 is because electricity generation in the country has decreased. Reduced outtake is due to the fact that consumption and exports to foreign countries have declined somewhat.

The total transmission cost includes the costs of capital, operation and maintenance, administration, and the cost of transmission losses. A key factor that shows the cost development is the specific cost in öre per kWh, and this amounted to 1.28 öre per kWh in 1999. The corresponding figure in 1998 was 1.38. The reduction is due to factors such as lower costs of purchasing electricity for operation and maintenance. The calculation does not include costs incurred for the Svenska Kraftnät system responsibility, e.g. remuneration for disturbance reserve and purchase of regulation capacity, and neither does it include costs of a once-only nature.

A total of ten disturbances on the transmission network that led to supply interruption occurred in 1999. On 11 February 1999, four 400 kV lines in western Skåne were tripped during the course of one hour. The reason was that salty ice on the insulators caused flash-over when the ice melted. In addition, serious storms during the night between 3 and 4 December 1999 caused extensive blackouts in western and southern Sweden. However, the problems were concentrated to regional and local networks. During the storm, a cable between Sweden and Germany owned by Baltic Cable AB was damaged.

A measure of operating reliability is "energy not delivered". In 1999, this amounted to 96 MWh, which is an increase on the year before. Table 23 gives data for the national grid.

Table 23 • Data for the national grid between 1995 and 1999

	1995	1996	1997	1998	1999
Subscribed power, MW					
infeed point	22 059	21 539	21 927	21 338	20 416
outtake point	23 227	22 672	22 745	22 517	22 252
Maximum power taken out, GW	19.1	19.0	18.8	17.9	19.0
Energy fed in, TWh	115.4	114.3	114.6	118.9	116.6
Energy taken out, TWh	113.1	112.2	112.1	116.4	114.3
Energy losses, TWh	2.3	2.1	2.5	2.5	2.3
proportion of energy taken out, %	2.0	1.9	2.2	2.1	2.0
Maximum power losses, MW	635	660	610	658	658
proportion of maximum power taken out, %	3.3	3.5	3.2	3.7	3.5
Transmission costs, öre per kWh	1.53	1.55	1.70	1.38	1.28
Number of disturbances per year	196	162	291	207	228
Number of disturbances with blackout	5	7	9	8	10
Undelivered energy, MWh annually	6	133	279	84	96
Average interruption time, seconds per year	2	37	78	24	27

Source: Compilation of information from the Svenska Kraftnät Annual Report.

Power reserves and disturbance reserves

In recent years, several stand-by power plants have been decommissioned due to their inadequate profitability, which is a consequence of the electricity market reform. The National Energy Administration was instructed to study, in consultation with Svenska Kraftnät, the power balance situation in the country and the need for action by the Government. One of the conclusions reached in the report, which was submitted to the Government in January 1999, was that financial support for oil-fired condensing power plants was not justified.

Svenska Kraftnät is responsible for ensuring that adequate disturbance reserves are available in the network. For this purpose, Svenska Kraftnät has procured access to gas turbines in the country. In addition, an agreement has been concluded with a company that enables part of the generation capacity to be switched out, against financial compensation for the company.

National grids and system responsibility in other Nordic countries

Figure 13 shows the national grids in Northern Europe. The grid in the Nordic countries is well developed. The national grid in Norway is owned mainly by Statnett SF, although around 20 % is owned by other players. Statnett bears responsibility for the operation and expansion of the entire national grid. Statnett is also responsible for the links with foreign countries. The balance between generation and consumption is handled on the regulating power market, which is pursued within Statnett.

In Finland, joint system responsibility was established somewhat later than in Sweden and Norway. Today, Fingrid Abp bears the system responsibility and owns the national grid in Finland and the links with foreign countries. Fingrid also has balancing responsibility which is similar to the balancing responsibility in Sweden. Every party on the electricity market is responsible for electricity generation and electricity consumption being in balance at all times. Today, there are more than 20 balance provider companies. The conditions applicable to balance providers are determined by means of a balance agreement. After the electricity exchange has closed and up to two hours before the delivery time, scope is available for trading with balance power on the Elbas balance adjusting market. In the event of unbalance during the operating hour, Fingrid uses balance control.

Denmark has two system operators. These are Eltra, which is responsible for the national grid in Jutland and Funen, and the Elkraft system, which is the national grid company in Zealand. Just like other national grid companies, Eltra and Elkraft own the 400 kV network and the links with Sweden and Germany. The transmission line systems of Eltra and Elkraft are not currently interconnected with one another.

In addition to having the usual fields of responsibility of system operators, Eltra and Elkraft also have obligations concerning regulations on prioritized electricity generation. According to the Danish Electricity Act, all electricity consumers are obliged to purchase a certain proportion of their consumption as renewable electricity, known as prioritized generation. Renewable energy generators must submit particulars of the electricity they have generated and delivered to the system operator or to the network utility. In return, one "green certificate" is obtained per 100 kWh of delivered electricity from renewable energy sources. The system operators and the network companies have the obligation to meter and check the electricity delivered. The system operators transmit the information to a register of green certificates. In addition, the system operators must collect information on the electricity consumption of consumers who have a quota, in order to check that they have met the specified quotas.

Table 24 • Electricity trading links in Northern Europe

	Transmission capacity[1], MW	
Sweden–Norway	To Sweden	From Sweden
Northern Norway	1 350	1 350
Northern Norway	300	300
Central Norway	500	500
Southern Norway	1 800	1 650
Sweden–Finland	To Sweden	From Sweden
Northern Finland	900	1 500
Åland	35	35
Southern Finland	550	550
Sweden–Denmark	To Sweden	From Sweden
Jutland	640	670
Zealand	1 600	1 750
Bornholm	60	60
Denmark–Norway	To Denmark	From Denmark
Jutland–Southern Norway	1 040	1 040
Norway-Finland	To Norway	From Norway
Northern Finland	100	100
Links outside the Nordic countries	To Nordic countries	From Nordic countries
Sweden–Germany	600[2]	600[2]
Sweden–Poland	600	600
Norway–Russia	50	50
Finland–Russia	1 200	60
Denmark–Germany	1 400	1 800

1 According to the sizing rules, which specify the maximum permissible transmission

2 Due to the fact that the connected network in Germany is weak, the actual capacity is lower. Source: Nordel.

Links for foreign countries in Northern Europe

The links for electricity trade in Northern Europe are shown in Table 24.

Svenska Kraftnät owns all of the links with Norway, Finland and Jutland. Svenska Kraftnät and Sydkraft own the links with Zealand. A separate company, owned jointly by Sydkraft, Vattenfall and the German company PreussenElektra, owns the Baltic Cable. Due to limitations on the German network, the full capacity of the cable cannot be utilized yet, but the German network will be strengthen. The link between Sweden and Poland, known as the SwePol Link, is owned by a jointly owned company in which Svenska Kraftnät has a 51 % holding, Vattenfall has 48 %, and the Polish Grid Company has 1 %.

A new transmission link between Sweden and Åland with a transmission capacity of 80 MW, owned by Kraftnät Åland, is scheduled to be taken into operation in september 2000.

In addition to the direct links with the Continent, Sweden now has two further links with Germany, i.e. the link via Jutland, and the Kontek link between Zealand and Germany.

Planned links

It was decided in Denmark that a link would be built no later than in the year 2001 to join together the Elsam and Eltra networks. According to earlier plans, the cable would have a transmission capacity of 600 MW, but new technology enables the link to be expanded in stages.

Norway is planning two new links with the Continent. The Viking Cable, which is a DC cable with a transmission capacity of 600 MW, will be built between Norway and Germany. Statnett will own 50 % of the link and PreussenElektra will own the other 50 %, and the link is scheduled to be taken into operation in the year 2004. In addition, plans are afoot to build a link with a transmission capacity of 600 MW between Norway and the Netherlands, and this is expected to be completed by the year 2003. The cable will be owned by Statnett (50 %) and SEP (Samenwerkende elektriciteitsproduktiebedrievjen) (50 %). Plans for a third cable to Germany, known as the Euro Cable, have been shelved. A pilot study is in progress on the feasibility of laying a cable between Norway and Great Britain. The cable has no prospect of being profitable today, but some observers consider that the project may come to fruition within 5–10 years.

Rules and charges for foreign trade in Sweden

Svenska Kraftnät sells transmission services to links with the neighbouring Nordic countries. This service gives the customer the right to transmit power on the Swedish side of the foreign link, i.e. to or from the national border. The service also includes the right to feed power into or take power from the Swedish national grid. For transmission on the other side of the national border, the customer or his trading partner in the neighbouring country must conclude a transmission right agreement with the relevant grid owner.

In the same way as the national grid charge, the charge for foreign trade is geographically differentiated, in order to reflect the loading on the grid. This means that import and ex-

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port charges for a given country are different. The charge for a given country consists of a subscription charge and an energy charge per MWh according to the actual electricity traded. No network charge is payable between Norway and Sweden for spot transactions on the Nord Pool. The charge for Finland was discontinued in March 1999.

Annual subscriptions or hourly subscriptions apply only to Finland and Zealand. Annual subscriptions are intended for long-term power contracts, whereas hourly subscriptions are sold in 24-hour periods, if capacity is available.

After Svenska Kraftnät has been notified of planned trade on an annual subscription between Sweden and Finland, the remaining capacity available is put at the disposal principally of Nord Pool for spot trading. Hourly subscriptions are granted only after spot trading and Elbas trading have been decided.

Nord Pool established itself in Jutland in July 1999. At the same time, the possibility of concluding bilateral agreements with Jutland was discontinued. For trading with Jutland, a network charge of SEK 15 per MWh is taken for import and export. Nord Pool administers the charge and debits the players on the Jutland/Funen market.

Rules and charges in other Nordic countries

After the introduction of the common electricity market, no network charges are made for trading between Sweden, Norway and Finland.

In Norway, a “priority charge” is made for all power interchange that takes place against bilateral agreements, and the charge is determined on the basis of the trading volume. Fixed and variable charges are payable for trade with Denmark and Russia, and these charges are based on the same principle as the national charges.

Fingrid has a national grid charge for electricity delivered to or received from outside the Nordic electricity market area.

In addition to the network charge of SEK 15, Elkraft pays a further network charge of 25 SEK/MWh for trade with Sweden for the net electricity passing through Konti-Skan.

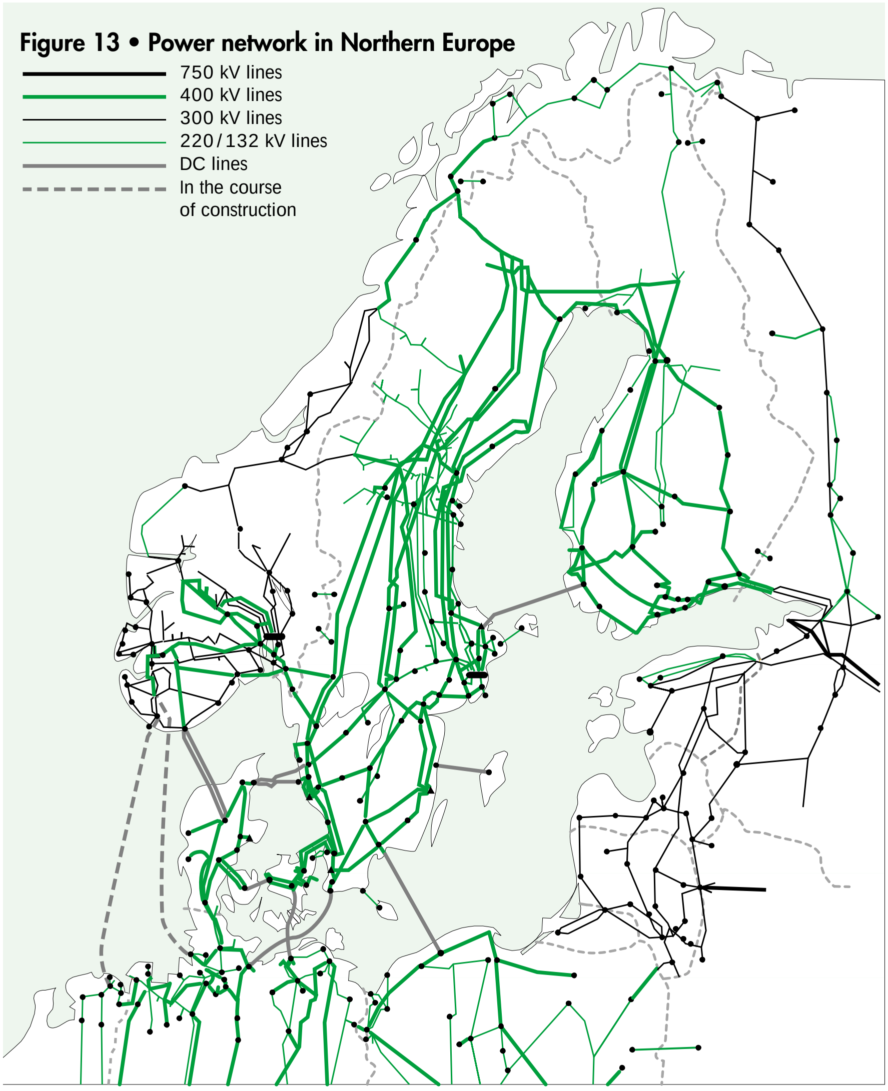
At the same time as Nord Pool was established in Jutland and Funen, Statkraft has opened the Skagerack link for spot trading. Available capacity can be used when the difference in area prices between Kristiansstad and Jutland/Fyn is at least 10 DKK/MWh over and above the loss and network charge.

Eltra has removed the tariffs for trading with foreign countries, although a take-out charge for trading with Norway remains, based on the amount of energy transmitted. Elkraft has special tariffs for imports and exports. For imported electricity consumed in the Elkraft region, a network tariff and a tariff for prioritized electricity generation are also payable. According to plans, Zealand, i.e. the area of responsibility of Elkraft, will also become its notification area in Nord Pool during the first half of 2000. In conjunction with this, the import and export charges will be removed.

Cooperation between system operators

The system operators in the Nordic countries have been cooperating for a long time. An agreement that regulates the cooperation between all system operators in the Nordic countries (excluding Iceland) was signed in February 2000. The purpose of the agreement was to put to use the benefits of interconnected operation of the Nordic power system. The parties will cooperate with the aim of maintaining coherent operation of the Nordic power system. Several of the provisions of the agreement are based on the recommendations made by Nordel, which is the Nordic organization for cooperation in the field of electricity. ■

Figure 13 • Power network in Northern Europe



Source: Nordel

In 1999, the six biggest power companies in the Nordic countries accounted for 241 TWh, which corresponds to about 64 % of the total electrical energy generated. Sweden accounted for 40 % and Norway for 33 % of the energy generated. By far the dominating company was Vattenfall, with a market share of about 20 %, followed by Fortum and Statkraft with 9 % each. Vattenfall and Sydkraft, Sweden's two biggest power generators, jointly accounted for around 71 % of the total electrical energy generated in the country, as shown in Table 25.

Structural changes in Swedish electricity generation

1999 was the fourth year of the reformed electricity markets in Sweden and Finland. In Norway, the electricity market was deregulated back in 1991. The competition on the electricity market has stiffened to a greater extent than in the previous three years, and great pressure was exerted on the companies to cut their costs. The availability of electricity continued to be good and the exchange prices were low. The ownership conditions in electricity generation in the Nordic countries have changed since deregulation. In September 1998, Gullspångs Kraft and Stockholms Energi merged to form Birka Energi, and Sweden thereby now has six players who dominate among electricity generators. On the other hand, there are more generation companies that compete on the joint Nordic electricity market. However, the big Nordic power companies make strategic investments, which causes a decrease in the market concentration in the Nordic countries. The Swedish Vattenfall, the Norwegian Statkraft, the Finnish Fortum and the German PreussenElektra all intend to compete on the future Northern European electricity market and are therefore investing in their neighbouring countries. Typical measures taken by the companies are take-overs, purchase of equity, alliances and the establishment of subsidiaries in other countries.

Foreign electricity companies increase their ownership in Sweden...

Figure 14 shows the current cross-ownership situation on the Nordic electricity market. Foreign companies have a 67 % holding in Sydkraft (percentage of share capital). The Norwegian Statkraft power company is now the biggest individual shareholder, and owns 30 % of the share capital. The German PreussenElektra has a 21 % holding of the share capital, and Hamburgische Electrizitätswerke (HEW) has 15.7 %. During 1999, foreign ownership increased by 16 percentage points after Statkraft increased its holding by 13 percentage points. PreussenElektra accounts for the remainder of the increase.

The Finnish Fortum energy utility is actively investing in Swedish power companies. During the 1996–1998 period, the company acquired all shares in Gullspångs Kraft, which thus became a wholly-owned subsidiary of Fortum. In September 1998, Gullspångs Kraft and Stockholms Energi then merged to form Birka Energi AB, in which Fortum has a 50 % holding. The remainder of the shares belong to the City of Stockholm Municipality. Early in the year 2000, Fortum concluded an agreement with Stora Enso to purchase most of its power assets. The purchase also includes the Stora Enso holding in the Finnish industry's power utility Pohjolan Voima (PVO). The transaction comprises a total generation capacity of around 6.7 TWh in a normal year. The deal is expected to be concluded during the spring.

The proportion of foreign ownership in Graninge rose marginally during 1999, when EdF increased its holding by 4 percentage points. EdF and the descendants of the Versteegh family that founded Graninge together have a voting majority in Graninge. They have jointly announced that they will not vote in important matters at Board meetings without first reaching agreement among themselves. The total proportion of foreign ownership in the beginning of the year 2000 was around 47 %.

...and Swedish electricity companies increase their ownership in neighbouring countries

As a result of the changes on the electricity markets in the Nordic countries, Swedish companies are also securing a broadening foothold in other countries. In 1999, it was Vattenfall that was the most active of the Swedish companies.

During the year, Vattenfall continued to increase its holdings in foreign power companies. The company is interested in further acquisitions in the Nordic countries and in Northern Europe, both in electricity generation and in network operations. The biggest investment during 1999 was the purchase of 25.1 % of the capital in the German HEW

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Table 25 • Largest Swedish electricity generators and the energy they generated between 1990 and 1999, TWh

	1990	1995	1996	1997	1998	1999	Installed power on 1 January 2000
Vattenfall AB	75.8	74.7	71.3	73.5	75.6	79.6	14 324
Sydkraft AB	23.2	27.0	24.7	28.2	30.4	27.5	5 878
Båkab Energi[1]	*5.6*						
Birka Energi[2]						21.0	4 399
Stockholm Energi AB	7.9	10.5	10.4	9.7	11.1		
Gullspångs Kraft	*4.3*	*8.9*	*9.8*	*10.5*	*11.3*		
Uddeholm Kraft[3]	4.1						
AB Skandinaviska Elverk[4]	2.2	1.9					
Stora Enso[5]	6.4	5.8	5.3	6.1	6.7	6.0	1 331
Skellefteå Kraft	2.4	2.5	2.2	2.5	2.7	3.0	598
Graninge	2.9	2.5	1.8	2.5	2.9	2.6	552
Sum	134.8	133.8	125.5	133.0	140.7	139.7	27 082
Total in Sweden	**142.2**	**143.3**	**136.4**	**144.9**	**154.2**	**150.5**	**30 885**

Note. The generation figures exclude minority shares. Contracted power is included in the companies that have the power at their disposal.

[1] Values in 1996. [2] The company was purchased by Sydkraft AB in 1997. [3] Purchased by Gullspång in 1992. [4] Purchased by Gullspång in 1996. [5] Name changed to Stora Enso in 1999.

Source: Swedish Power Association

from Hamburg City. The cost of the purchase was SEK 7.5 billion. After concluding an agreement with Hamburg City, Vattenfall will have commercial responsibility for the company. Sydkraft already had a holding of about 22 % of the capital in HEW, and PreussenElektra had a 15 % holding. HEW, which sells about 16.5 TWh of electricity and generates 12.6 TWh, also owns 16 % of the Sydkraft shares.

A further acquisition in 1999 was the Vattenfall purchase of 32 % of the capital in the Czech electricity distribution company Vychodoceska Energetica for around SEK 700 million. Vattenfall now has a holding of 42 %. The company has about 670 000 customers in the Czech Republic. In Poland, Vattenfall has invested in the Electrocieplownie Warszawskie (EW) company. The purchase comprises 55 % of the shares at a cost of just under SEK 2 billion. EW generates around 13 TWh of heat and 4 TWh of electricity.

In Finland, Vattenfall purchased the Revon Sähkö electricity company which has 43 000 customers in Finland and sales of 650 GWh. In addition, Vattenfall purchased Heinola Energia, which has around 22 000 customers. After these two purchases, Vattenfall has 240 000 customers in Finland through four electricity trading companies.

In Norway, Vattenfall purchased 49 % of the shares in Oslo Energi AS. The company has 315 000 customers and annual sales of around 10 TWh. In addition, Vattenfall acquired 100 % of the shares in Fredrikstad Energisalg which has about 33 000 customers.

Vattenfall AB

Vattenfall generates and delivers more than half the electricity consumed in Sweden. The company is the largest electricity generator in the Nordic countries and the fifth biggest in Europe. During 1999, Vattenfall generated 86.6 TWh. Vattenfall electricity sales in 1999 amounted to 86.9 TWh, of which 19.4 TWh was sold on the electricity exchange and the remainder to contracted customers.

The company's electricity generation is based principally on hydro and nuclear power. In 1999, hydro power generation accounted for 36.7 TWh of the electrical energy. The Ringhals and Forsmark nuclear power stations generated 49 TWh. In addition, other thermal power produced 0.9 TWh and wind power 0.04 TWh. The total installed power generation capacity at Vattenfall in the beginning of 1999 was 14 324 MW.

Sweden is still the dominating electricity market for Vattenfall, but sales in Finland and Norway are growing. In the Nordic countries, Vattenfall has a market share of about 20 %. Outside the Nordic countries, Vattenfall also has operations in countries such as the Netherlands, Germany, the Czech Republic, the Baltic States, Poland, South-East Asia and South America.

Sydkraft AB

Sydkraft is the second largest Swedish electricity generation utility. The total electricity generated in 1999, including minority shares and contracted-out power, amounted to 27.5 TWh, compared to 30.9 TWh in 1998. Hydro power accounted for 11.4 TWh. Nuclear power generation in Barsebäck and Oskarshamn amounted to 15.4 TWh. Other generation totalled 0.8 TWh.

Physical sales of electricity in 1999 amounted to 29.3 TWh. The 3.7 TWh reduction compared to 1998 was due to reduced availability of water and the long overhaul times in the nuclear power stations. On 1 January 1999, Sydkraft shut down two of the three units in the Karlshamn power station. The third unit was kept in operation due to a stand-by power agreement with Svenska Kraftnät. Barsebäck 1 was shut down at the end of the year. As compensation, Sydkraft receives replacement power from Vattenfall.

Birka Energi

Birka Energi was formed by the merger of Stockholm Energi and Gullspång Kraft in September 1998 and, with 842 000 customers, is now the largest power utility in Sweden in terms of number of customers. Birka Energi generates electricity in hydro power stations and in the Oskarshamn and Forsmark nuclear power stations. Hydro power and nuclear power account for around 90 % of the total electricity generated, which is equally distributed onto the two energy sources. Birka Energi also owns fossil fuel and biofuel fired CHP plants, which account for the remainder of the generation. The electrical energy generated in 1999 totalled 21.3 TWh, including minority shares and sub-contracted power. Electricity sales by Birka Energi totalled 24 TWh, and the electrical energy purchased through bilateral agreements and through the electricity exchange was 5.2 TWh. The total electricity turnover in the company was 26.5 TWh, including the energy used within the company.

Stora Enso Energy AB

Stora Kraft is a member of the STORA Group, which is now known as Stora Enso and is one of Europe's biggest forestry companies. In 1999, the electricity consumption of the Group in Sweden was about 12 TWh. The electricity was generated in hydro and nuclear power stations. The electricity generated by hydro power amounted to 4 TWh. Electricity generated by nuclear power from the company's shares in Oskarshamn and Forsmark amounted to 2 TWh. Total generation amounted to 6 TWh. In January 2000, Stora Enso concluded an agreement with

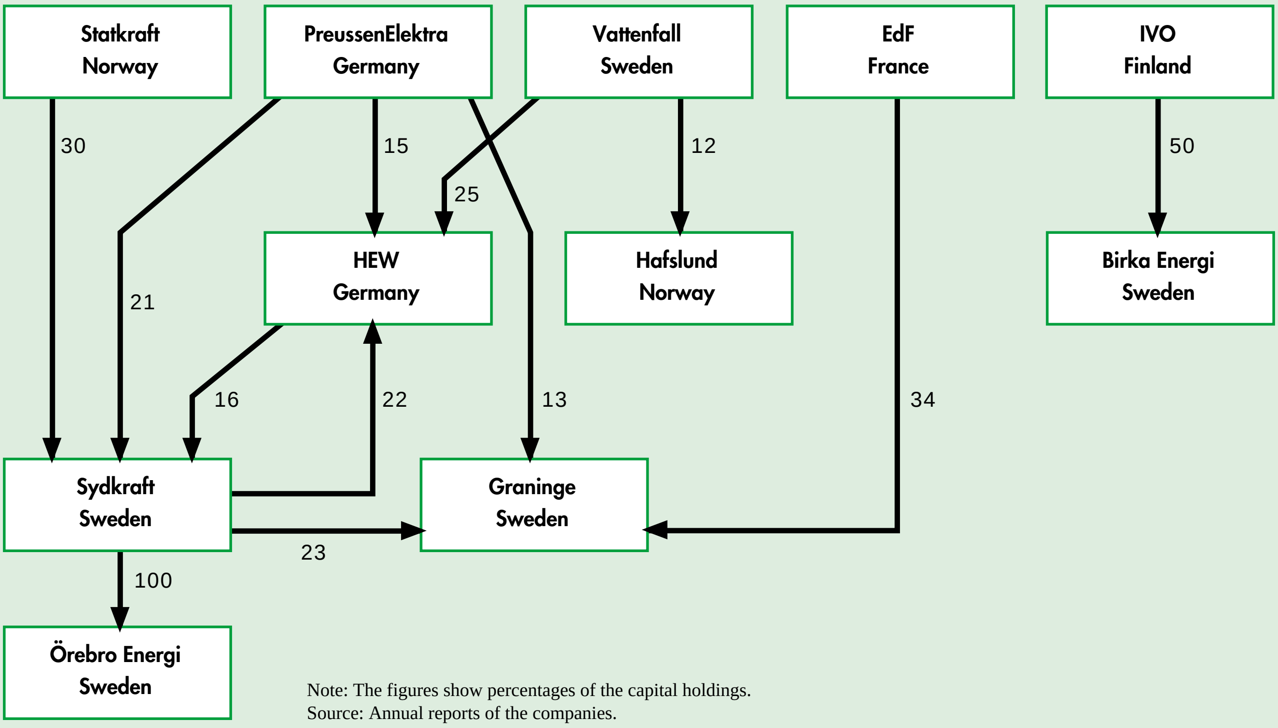
Table 26 • Largest Nordic electricity generators and the electrical energy they generated in 1999, TWh

Generators	Energy generated in 1999	Proportion in Nordic countries, %
Vattenfall	79.6	21
Sydkraft	27.5	7
Total for Sweden	**150.5**	**40**
Statkraft	33.5	9
Oslo Energi	8.1	2
Total for Norway	**122.9**	**33**
Fortum	35[1]	9
Pohjolan Voima Oy	20.3	5
Total for Finland	**66.8**	**18**
Elsam	22.8	6
Elkraft	14.2	4
Total for Denmark	**37.0**	**10**
Total for largest Nordic electricity generators	241	64
Total for the Nordic countries	**377.2**	**100**

[1] Including 50% of the energy generated by Birka Energi

Source: Swedish Power Association and contacts at the various companies

Figure 14 • Ownership conditions on the Nordic electricity market in the year 2000



Note: The figures show percentages of the capital holdings.
Source: Annual reports of the companies.

the Finnish Fortum energy company concerning the sale of a large proportion of the power generation capacity of Stora.

Graninge

The entire generation system of the company is based on hydro power. The energy generated in the company's own hydro power stations in 1999 amounted to 3.1 TWh. The electricity purchased by the company amounted to 1.9 TWh. Electricity sales by Graninge totalled 6.8 TWh. Early in the year 2000, the company began the process of breaking up the Group into one part for energy and one for forestry and timber.

Skellefteå Kraft

The power generation system of the company is based principally on hydro power. The company also has minor holdings in Forsmark. The total electrical energy generated in 1999 amounted to 3.1 TWh. Hydro power accounted for 2.6 TWh and nuclear power for 0.5 TWh.

Electricity generation in other Nordic countries

Electricity in Denmark is generated by more than ten companies. These are grouped into two big organizations, i.e. Elsam and Elkraft. The electricity companies in Jutland and Funen which actively participate in trading on Nord Pool are members of Elsam, while companies in Zealand and Bornholm are members of Elkraft. These two organization are responsible for electricity generation in Denmark.

Nuclear power station in Lovisa, Finland

Electricity in Norway is generated by more than 100 electricity generators, although around ten companies account for roughly 60 % of the production. Most of the companies are owned by the state or the municipalities and counties. By far the dominating player is the state-owned Statkraft, which is active on the reformed electricity market and will endeavour to compete on the future Northern European electricity market.

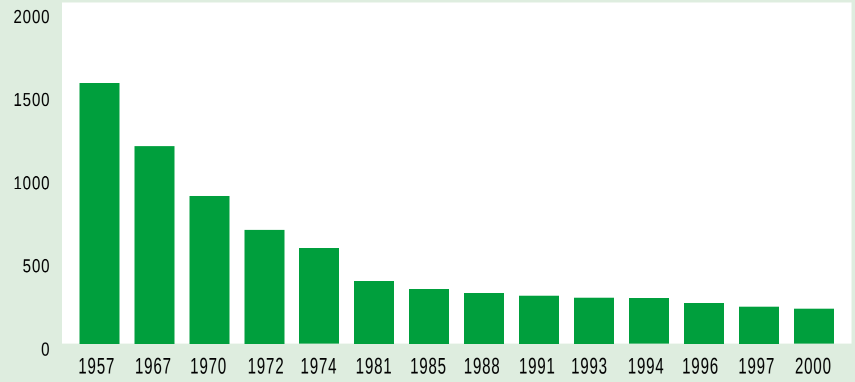
In Finland, Fortum is the biggest electricity generator. Industry is also a dominating player. The Pohjolan Voima Oy company accounts for around 50 % of the electricity generated in industry. ■

An important element in exposing electricity trading to competition in Sweden was the break-up of the traditional electricity utilities into network utilities and electricity trading companies. In Norway and Finland, demands are made only that a company must keep separate accounts for its network operations and for other operations. Electricity users in Sweden, Norway and Finland are now able to choose the electricity trading company from which they want to purchase their electricity, although they must purchase the network service from the network utility that has the monopoly in the area in which the electricity is to be distributed. In view of the different market conditions for the various operations, the structural changes may be different on the two markets. In all of the Scandinavian countries, many of the electricity trading companies are still members of groups that also have network operations. However, new players who are not involved in network operations or electricity generation will be entering the electricity trading market.

Network utilities and electricity trading companies in Sweden

About 210 network utilities were in operation in Sweden on 1 January 2000. There are no collective statistics on the number of electricity trading companies, but they are appreciably fewer. When the electricity market was reformed in 1996, there were as many network utilities as there were electricity trading companies. Since then, the number of companies has dropped, but the reduction was more rapid among electricity trading companies.

Figure 15 • Total number of electricity distribution utilities between 1957 and 1994, and network companies between 1996 and 2000



Source: Compilation of information from Detaljdistributörer av elkraft 1994 (Retail distributors of electric power in 1994), *Association of Swedish Electric Utilities, "Elnätföretag, 1996"* (Electricity network utilities in 1996), *Association of Swedish Electric Utilities, "Elnätföretag, 1997"* (Electricity network utilities in 1997), Swedish Electricity Distributors, and annual reports of the network utilities.

The trend towards fewer electricity distribution companies began in the 1950s, when there were around 1570 companies. When the electricity market was opened to competition in 1996, the total was down to about 250 companies. Mergers of municipalities are the main explanation for this development. Many of the electricity distribution companies were owned by municipalities, and they still are. When the municipalities merged, the electricity distribution companies also merged. In addition, the state has endeavoured to accelerate the development towards fewer companies by the work pursued in conjunction with the granting of concessions and by state support. After the break-up of the earlier electricity distribution companies into two parts, the drop in the number of companies has accelerated afresh.

Network utilities

A network utility owns the power line network within a geographical area and is responsible for the distribution of electricity to the end customers.

The task of the National Energy Administration is to ensure that electricity users will not pay a higher price than necessary for the network services, and that the network tariffs, the metering system and the settlement system are designed so that competition in electricity trading will be promoted.

Electricity trading companies

Electricity trading companies buy electricity from a number of different power generators, including Norwegian and Finnish companies, and also on the Swedish-Norwegian electricity exchange. Most of these companies have broken away from the original municipal electricity utilities. The number of electricity trading companies is lower than the number of network utilities. Some of the original municipal electricity utilities have sold their electricity trading operations or formed joint electricity trading companies with other companies, while retaining their network operations. Several of the newly formed joint companies are owned by municipal energy utilities. In some cases, industrial companies, oil companies and trade organizations have purchased holdings in the electricity trading companies. Other players have also begun selling electricity, such as the Statoil, Shell, OK-Q8 and Preem oil companies. Restructuring in the electricity trading sector is much more extensive than on the network side, since trading in electricity is open to competition, which forces the companies to rationalize their operations.

Table 27 • Number of electricity distribution utilities in 1957, 1970 and 1997

Number of subscriptions	1957	1970	1997[1]
50–99	200	54	-
100–199	285	86	2
200–499	500	181	1
500–999	251	164	4
1 000–1 999	154	121	16
2 000–4 999	82	136	46
5 000–9 999	51	70	40
10 000–19 999			54
20 000–49 999	46	70	39
50 000-		8	21
Total	**1 569**	**890**	**223**

After 1997, no statistics are available.

[1] Relates to conditions in October 1997.

Source: "Detaljdistributörer av elkraft" (Retail distributors of electric power) for the years 1991–1994, Association of Swedish Electric Utilities, and "Detaljdistributörer av elkraft, elnätföretag, 1996" (Retail distributors of electric power, electric network utilities, in 1996), Association of Swedish Electric Utilities, "Elnätföretag 1997" (Electricity network utilities in 1997), Swedish Electricity Distributors.

Take-overs of electricity trading and distribution companies

Growing numbers of municipal and smaller energy utilities are being taken over by other companies. Municipalities have several reasons for selling these operations. Many municipal energy utilities are too small to assert themselves on the new electricity market, trade on the electricity exchange and conclude favourable agreements with electricity suppliers. Moreover, many municipalities consider that operating on the competitive market is not a municipal task and that their influence on the electricity tariffs will disappear, since users can purchase electricity from other companies. Another reason for the municipalities selling these operations is to strengthen their strained finances, which is one of the explanations for the network operations of the municipalities being sold off.

A few examples of the acquisitions that have taken place in 1999 are given below:

- Sydkraft acquired 49 % of Norrköping Miljö & Energi for SEK 1350 million. The company has around 65 000 network customers and distributes approximately 1.2 TWh of electrical energy.
- Vattenfall purchased almost the whole of the Energibolaget i Botkyrka och Salem AB energy utility for SEK 770 million. The company has 39 000 network customers. Vattenfall acquired the network and electricity trading operations of the Ingarö Electricity Distribution Association for SEK 76.6 million. The company has 4800 customers.
- Birka Energi increased its holding in Ekerö Energi from 15 % to 39 % for SEK 76 million. The Group has both network and electricity sales operations serving around 11 500 customers. Birka Energi also took over Sigtuna Energi AB for SEK 345 million. The company owns and operates an electricity network with around 16 000 customers. The Group also includes Brista Kraft which generates and sells around 800 GWh of electrical energy to 34 000 customers. A further acquisition was Arvika Energi AB which Birka bought for SEK 33 million. The company has 10 000 customers and sales amounting to 100 GWh. Birka Energi increased its holding in Ockelbo Energi to more than 70 %. Ockelbo Energi has a turnover of 55 GWh. Katrineholms Energiförsäljning AB and Julita Energi AB with a total 19 000 customers were also taken over during 1999 for SEK 24.5 million.
- Lund Eastern, which is now known as Elbolaget i Norden AB, acquired 40 % of 7H Kraft which has 14 000 customers and electricity sales of around 270 GWh. In addition, Elbolaget i Norden acquired 67 % of Nynäshamns Energi AB for SEK 167 million. Nynäshamns Energi has 12 800 network customers and distributes around 200 GWh. The company also has electricity sales operations. A further acquisition by Elbolaget i Norden is 25 % of KraftRingen AB. KraftRingen has 40 000 customers and a turnover of 0.8 TWh.
- Falu Energi and Dalakraft are merging. Falun Municipality is buying about 29 % of the share capital in the company.

Network and electricity trading companies in other Nordic countries

Around 100 electricity trading companies operate in Finland. The biggest three are Fortum, Teollisuuden Sahkönmyynti and Vattenfall, the latter of which continues to capture market shares in Finland. The other electricity trading companies are mainly local and regional electricity utilities that have been on the market since before the electricity market reform. The distribution side has

somewhat more companies. In March 2000, there were 106 such companies, which is two less than in 1999.

Just like Sweden and Finland, Norway has a large number of electricity trading companies and network utilities. This is because many of the companies are owned locally by the counties. There are just under 200 network utilities, i.e. almost twice as many as in Finland. During the 1990s, an average of around eight mergers took place every year. Denmark has around 220 network utilities, but the statistics are uncertain.

It can generally be said that the number of players on the network and electricity trading sides of the electricity market is high, but that the trend is towards fewer players. This trend is most pronounced on the electricity trading side, where the competition is stiffest. ■

Electricity consumption

Electricity consumption comprises the use of electricity in the sectors of residential, commercial and services, industry and transport. To obtain an overall picture or facilitate comparisons, the concept of consumption should also include the generation plants' own consumption and also conversion and distribution losses. In 1997, Sweden was the world's fourth highest per capita consumer of electricity, after Norway, Iceland and Canada. The per capita electricity consumption in the United States was round 16 % lower than in Sweden. In some of the major European industrialized countries, such as Germany, France and Great Britain, the per capita electricity consumption was less than half that in Sweden. Compared to the average among OECD countries, Swedish electricity consumption was about twice as high, and the average for the EU member countries is 60 % below the Swedish electricity consumption.

Between 1993 and 1997, electricity consumption in EU member countries increased by just over 8 % from 2251 to 2432 TWh annually. During the same period, consumption in Sweden increased by 1%, while in the Nordic countries as a whole, for example, it increased by 4 %.

In many cases, countries that have a high per capita electricity consumption have access to inexpensive hydro power. The relatively colder climate in these countries leads to high electricity consumption for space heating. In the case of Sweden, other natural resources, such as forest and ore, also lead to industrial specialization in energy-intensive products. If the electricity-intensive industry is taken into account in the calculation of the electricity consumption per inhabitant in Sweden, i.e. if the electricity consumption in electricity-intensive industries is replaced by the average for industry, the per capita electricity consump-

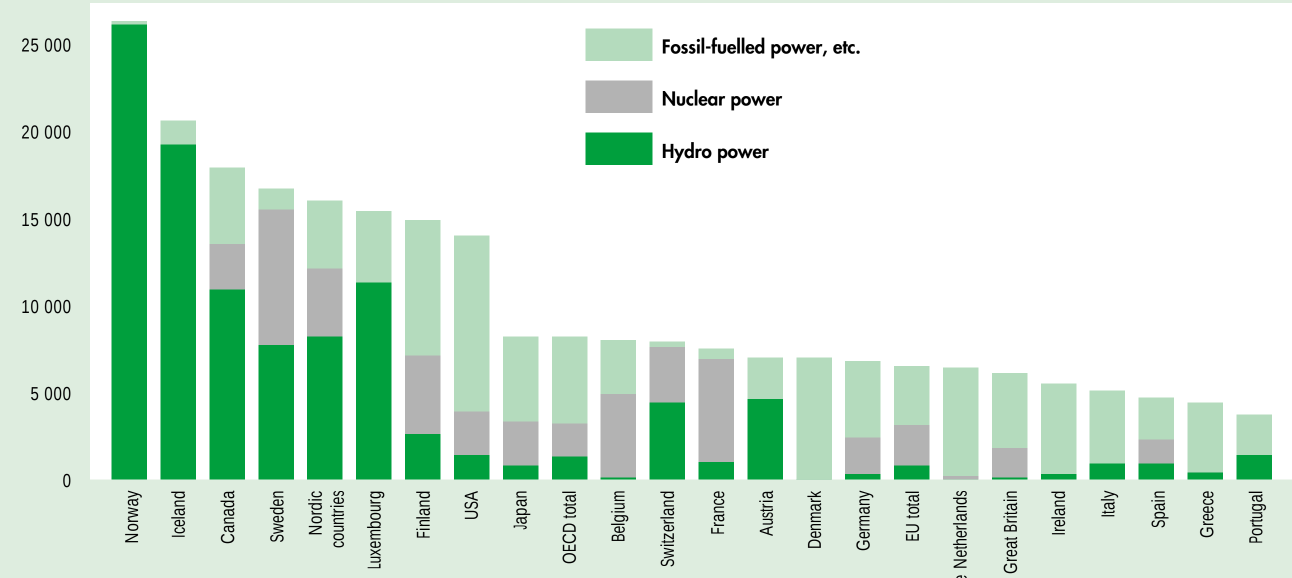
Table 28 • Gross electrical energy generation in 1997, TWh, and electricity consumption, kWh per inhabitant

	Hydro-power	Nuclear-power	Fossil-fired power etc.	Total generation	Imports–Exports	Elec. cons. per inhabitant, kWh
USA	358.5	666.4	2 674.1	3 699.0	38.4	14 009
Japan	100.4	319.1	620.6	1 040.1	0.0	8 244
Canada	351.2	82.5	141.4	575.1	-35.7	17 810
Norway	110.9	0.0	0.7	111.6	3.8	26 292
Switzerland	35.1	25.4	2.2	62.7	-6.8	7 902
Iceland	5.2	0.0	0.4	5.6	0.0	20 588
Belgium	1.3	47.4	30.4	79.0	3.3	8 084
Denmark	0.0	0.0	44.3	44.3	-7.2	7 002
Finland	12.2	20.9	36.0	69.2	7.6	14 942
France	67.5	395.5	41.2	504.2	-65.4	7 487
Greece	4.1	0.0	39.4	43.5	2.3	4 363
Ireland	0.9	0.0	19.0	20.0	0.0	5 436
Italy	46.6	0.0	204.9	251.5	38.8	5 105
Luxembourg	0.9	0.0	0.3	1.3	5.2	15 330
The Netherlands	0.1	2.4	84.2	86.7	12.6	6 362
Portugal	13.2	0.0	21.0	34.2	2.9	3 729
Spain	35.8	55.3	95.9	187.0	-3.1	4 677
Great Britain	5.6	98.2	241.6	345.3	16.6	6 133
Sweden	**69.1**	**69.9**	**10.5**	**149.5**	**-2.7**	**16 580**
Germany	20.9	170.3	360.3	551.5	-2.4	6 693
Austria	37.3	0.0	19.6	56.9	-0.8	6 950
Nordic countries	**192.2**	**90.8**	**91.5**	**374.6**	**1.5**	**15 888**
EU total	**315.5**	**859.9**	**1 248.5**	**2 423.9**	**7.7**	**6 510**
OECD total	**1 395.2**	**2 067.3**	**5 443.1**	**8 905.5**	**10.1**	**8 151**

Source: Compilation of information from OECD/IEA

Note. The consumption figures include the power stations' own consumption, and also conversion and distribution losses. The Nordic countries are Denmark, Finland, Norway and Sweden.

Figure 16 • Electricity consumption per inhabitant in 1997, with relative distribution per type of power, kWh



Source: Compilation by the National Energy Administration of information from the OECD/IEA.

Table 29 • Electrical energy from renewable sources and waste in 1997, GWh[1]

	Biomass[3]	Waste	Wind	Sun	Geothermal power/tidal power	Total	Proportion of tot. generation, %
USA	43 273	20 622	3 391	897	14 907	83 090	2.2
Japan	17 553	4 419	1	-	3 756	25 729	2.5
Canada[1]	4 019	-	62	3	32	4 116	0.7
Norway	215	50	8	-	-	273	0.2
Switzerland	140	987	2	8	-	1 137	1.8
Iceland	-	-	-	-	375	375	6.7
Belgium	105	993	8	-	-	1 106	1.4
Denmark	505	823	1 932	-	-	3 260	7.4
Finland	7 891	290	17	-	-	8 198	11.9
France[2]	714	1 381	20	-	570	2 685	0.5
Greece	-	113	36	-	-	149	0.3
Ireland	89	-	50	-	-	139	0.7
Italy	436	384	118	6	3 905	4 849	1.9
Luxembourg	1	46	3	3	-	53	4.2
The Netherlands	315	3 084	475	2	-	3 876	4.5
Portugal	1 037	-	38	1	51	1 127	3.3
Spain	1 098	541	742	13	-	2 394	1.3
Great Britain[4]	K	K	665	-	-	665	0.2
Sweden	**3 362**	**106**	**212**	**-**	**-**	**3 680**	**2.5**
Germany	326	7 013	3 000	34	-	10 373	1.9
Austria	1 508	111	-	-	-	1 619	2.8
Nordic countries	**11 973**	**1 269**	**2 169**	**-**	**-**	**15 411**	**4.1**
Eu total	**17 387**	**14 885**	**7 316**	**59**	**4 526**	**44 173**	**1.8**

[1] Hydro power and peat-fired generation are not included in this table. [2] Tidal water. [3] Biomass, solid (incl. black liquors) and liquid/gaseous.
[4] 5611 GWh of electrical energy are generated from unspecified renewable sources. K = confidential information.
Source: IEA/OECD, 1999.

tion in Sweden would be reduced by 15 %. Canada, Norway and Finland also have a high proportion of energy-intensive industry. All of these countries contribute towards international work distribution, since a large proportion of their electricity-intensive products is exported.

Electricity generation

The total electricity generated in the EU countries in 1997 was around two thirds of that generated in the U.S.A., while generation in the U.S.A. is just over 40 % of that in the OECD countries. Electricity generated in Sweden is less than 1.7 % of that in the OECD countries and just over 6 % of the generation in the EU. The total electricity generated in EU countries increased by more than 12 % between 1993 and 1997. In the same period, Swedish electricity generation increased by somewhat more than 2 %.

In the EU member states, more than half the electricity is generated from fossil fuels, 35 % from nuclear power and 13 % from hydro power. Sweden is among the world's countries that have a high proportion of hydro and nuclear power in its electricity generation system. The countries that have the highest proportions of hydro power are Norway, Iceland, Luxembourg, Austria and Canada. Norway and Iceland are the foremost in this area, since more than 90 % of the total electricity generated is from hydro power.

The use of renewable sources, excluding hydro power, for electricity generation is low. Finland, Denmark and Iceland are the countries that generate the highest proportion of electricity from renewable resources. The use of biomass is highest in Finland, where it accounts for 11.4 % of the total electricity generation. In Sweden, 2.2 % of the electricity generation is based on biomass. In Austria and Portugal, biomass-based electricity generation is also in excess of 2 %. Few countries have the conditions necessary for extracting geothermal heat. Italy and Iceland have the highest proportions at 1.9 % and 1.6 % respectively of the total electricity generated. Solar power accounts for less than 1 % of the renewable electricity. Information on tidal water generation is available only for France and Canada, and in both cases represents less than 1 % of the electricity from renewable sources.

A few countries, such as Luxembourg, the Netherlands, Denmark, Switzerland and Germany, generate relatively high amounts of electricity from waste incineration. In some countries, electricity generation from waste incineration makes a substantial contribution to the electricity produced from renewable sources and waste. Belgium and the Netherlands are in the forefront, with proportions in excess of 70 %. In relation to the total electricity generated, Luxembourg and the Netherlands have the highest proportions at almost 4 %. In other countries, the proportion of electricity from waste is less than 2 %.

Electricity prices

Electricity prices vary for different user categories, i.e. households and industry. In addition, prices differ widely between different countries. In the OECD region as a whole, the real electricity prices to both households and industry have steadily decreased during the 1990s. In most countries, domestic customers pay an energy tax, an environmental and/or value added tax, and a turnover tax. Industrial customers in more than 60 % of the countries listed in Table 30 have no such taxes. In addition, exemption regulations for industry are in force in several countries.

→

Table 30 • Electricity prices to domestic and industrial customers, including taxes and VAT, on 1 January 1999, öre per kWh

	Small industrial plants[1]	Medium-sized industrial plants[2]	Large industrial plants[3]	Domestic customers, 3 500 kWh	Domestic customers, 20 000 kWh
Australia, Sydney	36	27	20	59	28
Belgium	83	64	39	160	79
Denmark	54	52	48	175	148
Estonia	65	41	30	45	31
Finland	45	40	29	81	49
France	65	55	40	132	92
Greece	59	54	37	78	54
Ireland[4]	76	59	46	105	54
Italy	100	79	51	198	-
Japan, Tokyo	117	95	47	171	75
Canada, Montreal	45	30	21	53	36
Lithuania	36	28	24	36	27
Luxembourg	82	55	41	126	71
The Netherlands, Rotterdam	72	57	43	133	85
Norway	37	27	20	94	55
Poland	47	41	27	63	42
Portugal	69	61	41	126	79
Spain	67	58	48	125	70
Great Britain[5]	79	69	60	104	54
Sweden	40	29	23	87	75
Germany[6]	82	67	51	170	82
Hungary	50	43	37	77	47
Austria	96	75	55	138	95

Note. The prices quoted for industry exclude VAT.

Source: Eurostat and compilation of information from Unipede by the National Energy Administration. Prices of Electricity as at 1 January 1999, SSB/Norway

1 1.25 GWh per year, 0.5 MW, 2 500 hours
2 10 GWh per year, 2.5 MW, 4 000 hours
3 70 GWh per year, 10 MW, 7 000 hours
4 Domestic prices for Ireland relate to urban areas
5 Domestic prices relate to London
6 Domestic prices relate to Hamburg

Electricity market directive

The electricity industry is currently undergoing vast changes in many parts of the world. This is mainly due to new market conditions and stricter environmental demands. Northern Europe, and above all the Nordic countries, are in the forefront of this development through the restructuring of the electricity markets in Finland, Norway and Sweden.

Work is in progress in the EU for creating an internal market with increased competition and free pricing on a number of markets. An internal market for energy in the EU would contribute towards improved competitiveness of industry and increased welfare for the consumers. This will be achieved by measures such as higher efficiency, lower prices, reliable deliveries and a better environment.

On 19 December 1996, the EU issued a directive on "common rules for the internal market for electricity", known as the Electricity Market Directive. The aim of the Directive is to create common rules for the generation, transmission and distribution of electricity. According to the Directive, the market for electricity should be gradually opened to competition in both trading and the establishment of electricity generation plants on the EU electricity markets. On a market on which competition is fully established, electricity consumers should have free choice of electricity supplier. The market should be opened gradually to allow for the necessary adaptation and restructuring.

The Directive came into force on 1 January 1997 and allowed a two-year transition period, during which the national legislation of the member states would be harmonized with the Directive. According to the Directive, the national markets should be opened in three stages. The target for the year 1999 was that 26 % of the markets should be opened to competition, and by the year 2000, 28 % should be opened. In the third stage by the year 2003, 33 % of the market should be open to competition. The opening in the member states is taking place at different rates. Several countries have chosen to go beyond the provisions of the Directive. These include Sweden, Finland, Denmark, Germany and Great Britain.

Extensive restructuring is now in progress in the electricity industry. Restructuring of the electricity markets involves a transition from national monopolies with central planning to markets that are subject to competition. Electricity will become an energy raw material that can be traded and delivered across national borders. Free access to electricity networks is fundamental to the implementation of a free electricity market. This means that network operations should be separated, judicially or administratively, from other operations. At the same time, the power utilities are looking for new markets. The power utilities are being restructured towards bigger and more integrated energy companies, with operations in several countries. Strategic investments are being made by the bigger power utilities with the aim of increasing market shares on a future common electricity market. Mergers, take-overs and alliances are examples of measures adopted by companies, often across national borders.

In addition to increased competition between companies, markets and countries, restructuring of the electricity markets also contributes towards countries and regions being tied together by new trading links. The electricity markets in the Nordic countries are a typical example. Trade in electricity across cable links is increasing between the Nordic countries, and also between the Nordic countries and the Continent.

Natural Gas Directive

Other important parts of the internal energy market in the EU are the markets for natural gas and electricity generation from renewable sources. Restructuring of the various markets are linked together, and there are several parallels between the directives for the electricity market and the natural gas market.

On 22 June 1998, the EU issued a directive on “common rules for the internal market for natural gas”, known as the Natural Gas Directive.

The Directive came into force on 10 August 1998 and had a transition phase of two years, during which the national legislation of the member countries was to be harmonized with the Directive. On 10 August 2000, the Directive will be implemented in all member countries. Just like the electricity market, the national natural gas markets will be opened in a three-stage process. It is the electricity sector and industry that will be able to choose their natural gas suppliers, and the biggest consumers will be given access first.

In the Directive, the member states are given relatively wide freedom for the introduction, and a number of countries intend to go beyond the provisions of the Directive. As an example, the natural gas market in Great Britain is already fully restructured.

Electricity generation from renewable sources

An objective within the EU is to increase the proportion of energy generated from renewable sources, including large-scale hydro power, to 12 % by year 2010. However, limited scope is available within the EU for expanding the hydro power capacity. In many cases, the cost of electricity generation from renewable sources is high in relation to conventional power sources, and generation needs to be stimulated. At the same time, care is taken to avoid introducing distortion in the current restructuring of the electricity market. Work is now in progress in the EU on drawing up a directive for electricity generation from renewable sources.

While awaiting the directive, individual member states in the EU are endeavouring in various ways to support electricity generation from renewable sources. In Germany, a fixed price model and infeed obligation are employed, which has resulted in a substantial growth in wind power generation capacity. In several EU countries, a form of green certificate is in operation or is being considered as a value certificate for electricity generation from certain approved sources. Scope should be available for trading in the certificates, either together with or separately from trading in electricity, e.g. on an exchange. The thought is that trading will give a market value to the added value of electricity generated from renewable sources in relation to electricity from conventional sources. Such systems are in operation or are being considered in countries such as Denmark, the Netherlands, Great Britain, Italy, Belgium and Sweden. Such a system is also in operation in the U.S.A.

Climate issues

The climate issue and the work devoted to arresting the increase in greenhouse gas emissions have become increasingly important. The emissions of carbon dioxide originate to a predominant extent from energy consumption. Electricity accounts for 40 % of the energy consumption in the EU, and a substantial proportion of electricity generation in many countries is based on fossil fuels, as illustrated by Table 28, for instance.

Energy consumption, in turn, has a strong link with economic activity and growth. Between 1990 and 1995, the emissions of carbon dioxide in the industrialized world have declined as a result of the serious recession in the transitional economies since the end of the 1980s and the early 1990s. However, in most countries in the western world, the emissions have increased, and strict demands are being made for changes in the energy systems if the undertakings in accordance with the Kyoto protocol are to be achieved.

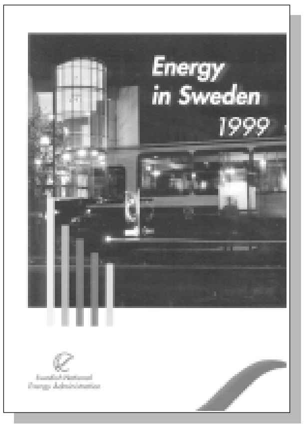
In Kyoto, the EU undertook to cut the emissions of greenhouse gases by 8% up to the years 2008–2012 in relation to the emissions in 1990. In several countries of the world, increased use of natural gas is an important element in the climatic strategy, since natural gas has the lowest environmental impact of the available fossil fuels. The carbon dioxide emissions from natural gas are 40–50 % lower than those from coal and around 25–35 % lower than those from oil. Investments are being made in the EU into measures such as changing over to natural gas, improving efficiency, adopting CHP generation, and generating electricity from renewable sources.

Taxes and new regulatory measures

For the electricity markets to perform well, joint rules and conditions must be established on the various markets. Harmonization of energy and environmental taxes is an example of one such condition which is important from the perspective of the Nordic countries. Several attempts have been made in the EU to harmonize the energy taxes. However, it has proved difficult to achieve unanimity in this area. Member countries are endeavouring instead to find different ways of achieving the environmental and climatic targets. In the Nordic countries, the carbon dioxide tax is an important measure. Another approach may be to conclude voluntary agreements, e.g. between the state and industry, whereby industry agrees to certain emission limitations and, in return, is relieved of having to face legislated limitations. The Kyoto protocol also regulates the “flexible mechanisms” that consist of International Emissions Trading (IET), Joint Implementation (JI) and Clean Development Mechanism (CDM). In March 2000, the EU Environmental Commissioner submitted a proposal, known as the “Green book”, for setting up trade in carbon dioxide emissions. The proposal relates to power stations, refineries and four industrial areas in which carbon dioxide emissions are high. Denmark is well to the fore, and trade in emission rights is expected to begin in 2001. Instead of cutting down various types of undesirable activities, efforts are made to promote what is considered to be desirable from the environmental aspect. This includes traditional investment support and grants but, as mentioned earlier, work is also in progress on new methods, such as “green certificates”. ■

Energy in Sweden 1999

ET 82:1999



The publication is annual and the issue for 1999 is the sixteenth in succession. This publication gives generalized and easily understandable information on the composition and development of the Swedish energy system. “Energy in Sweden” consists of an abundantly illustrated text version and a tabular appendix entitled “Energy in Sweden, facts and figures”. The tabular appendix contains numerical information for the figures in the text version, which are comprehensive time series from 1970 onwards. These include series of total energy consumption in Sweden, energy consumption distributed onto sectors and onto energy carriers, and also prices and taxes on different energy carriers and to different users.

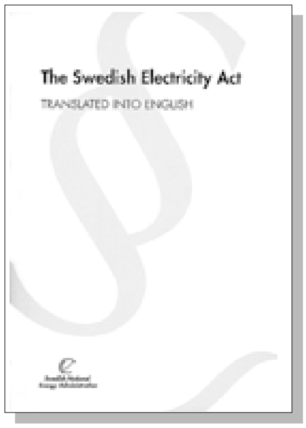
Climate report 1997

ER 2:1998

The report serves as a basis for Sweden’s second national report on climate changes, DS 1997:26. The analysis is focused on the contribution of the energy system to the Swedish carbon dioxide emissions. The report contains energy forecasts for the years 2000, 2005 and 2010, and this cover the initial stages of nuclear decommissioning.

The Swedish Electricity Act

An unauthorized translation into English of the Swedish Electricity Act has been made by the Swedish National Energy Administration. The text can be accessed on the home page of the Administration on www.stem.se.



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Fax: +46 16 544 22 59

EL-EX/Nord Pool, Finland
Phone: +358 9 6840 480

The *Electricity Market Authority* in Finland is a Government department which is responsible to the Finnish Ministry of Commerce and Industry. The main task of the Electricity Market Authority is to ensure that the Electricity Market Act is observed, and to promote the operations on the electricity market which is now based on competition.
Phone: +358 9 622 0360

The *Swedish National Electrical Safety Board* is responsible for the governmental electrical safety work, and issues regulations, participates in standardization and exercises supervision.
Phone: +46 8 519 11200

The Danish *Energy Agency* is engaged on matters related to the generation, distribution and use of energy, and is entrusted with the task of ensuring, on behalf of the Government, that energy development in Denmark will take place effectively from socio-economic, environmental and safety aspects.
Phone: +45 33 92 67 00

The *Swedish Competition Authority* is a central authority for competition matters, and its task is to promote effective competition in private and public operations, to the benefit of the consumers.
Phone: +46 8 700 1600

The *National Environmental Protection Agency* works towards reducing emissions in Sweden and other countries, and improving the environment by encouraging governmental authorities, various sector authorities, regional and local authorities, companies and the general public to take decisions and adopt measures that will lead to the targets that have been set up.
Phone: +46 8 698 10 00

Nordel is an organization that promotes Nordic electricity cooperation. The organization, which was founded in 1963, is a consultative and advisory body, the primary objective of which is to create and develop the conditions for an effective Nordic electricity market.
Phone: +358 9 85611

Nord Pool is the Nordic electricity exchange and organizes markets for spot trading and price assurance.
Phone: +46 8 555 166 00

The *Norwegian Water Resources and Energy Directorate* (NVE) is subordinate to the Norwegian Oil and Energy Department and is responsible for managing the Norwegian water and energy resources.
Phone: +47 22 959 595

Swedish Ministry of Industry and Trade
Phone: +46 8 405 10 00

The *Swedish Nuclear Power Inspectorate* (SKI) plays a supervisory role in ensuring that all nuclear engineering operations are pursued in a safe manner. Companies that have permits to pursue nuclear engineering operations also bear full responsibility for safety in the plants and for the safe handling and terminal storage of spent nuclear fuel.
Phone: +46 8 698 84 00

Statistics Sweden is responsible for public statistics, together with the relevant authorities.
Phone: +46 8 783 40 00

The *Swedish District Heating Association* is a trade organization for district heating companies and a cooperative body for Swedish heating plants and other companies that are interested in heat distribution, especially if combined with power generation.
Phone: +46 8 677 25 50

The *Swedish Association of Local Authorities* is entrusted with the task of supporting and developing municipal autonomy, advancing the interests of local authorities, promoting cooperation between local authorities, and assisting them in their operations.
Phone: +46 8 772 41 00

Svenska Kraftnät is entrusted with the task of managing, operating and developing in a businesslike manner a cost-effective, reliable and environmentally appropriate power transmission system, selling transmission capacity and otherwise pursuing operations linked to the power transmission system.
Phone: +46 8 739 78 00

The Swedish Power Association is a trade organization for the power generation utilities.
Phone: +46 8 677 25 60

Swedish Electricity Distributors is a trade organization for the country's network and local electricity trading companies, and has a wide range of services and products that support the operations and development of member companies.
Phone: +46 8 677 25 40

FACTS

The standard international unit for measuring energy is the joule (J). However, the watt hour (Wh) is often used in Sweden. 1 joule is equivalent to 1 watt second, and 1 watt hour is consequently 3600 J. The tonne oil equivalent (toe) unit is often used in international comparisons. 1 toe corresponds to the heat liberated in the combustion of 1 tonne of oil, which amounts to 11.6 million Wh. The joule, watt hour and even the tonne oil equivalent are impractically small units when large quantities of energy are considered. Multiples of the basic unit, such as thousands or millions of watt hours, are used instead, and these are abbreviated as shown below.

Multiple name	Symbol	Numerical value
kilo	k	10^3= 1 000
mega	M	10^6= 1 000 000
giga	G	10^9= 1 000 000 000
tera	T	10^{12}= 1 000 000 000 000
peta	P	10^{15}= 1 000 000 000 000 000

Power is measured in:
1 000 watt (W) = 1 kilowatt (kW)
1 000 kW = 1 megawatt (MW)
1 000 000 kW = 1 gigawatt (GW)

Energi is obtained by multiplying time by power. Energy is measured in:
1 000 kilowatt hours = 1 megawatt hour (MWh)
1 000 000 kWh = 1 gigawatt hour (GWh)
1 000 000 000 kWh = 1 terawatt hour (TWh)

In practical use
1 kWh is roughly the electricity used by an electric cooker plate in one hour.
1 MWh is roughly the electricity used by a household over a period of three months.
1 GWh is roughly the electricity used in one year by 50 electrically heated single-family houses of normal size.
1 TWh is roughly the electricity used by the whole of Sweden over a period of three days.

Swedish National Energy Administration

The Swedish National Energy Administration was formed on 1 January 1998 and is a central management authority for matters related to the use and supply of energy.

Our main task is to implement the energy policy programme passed by the Riksdag in the spring of 1997. The programme is aimed at creating an ecologically and economically sustainable energy system.

We are working to promote a safe, efficient and environment-friendly supply and use of energy. We are doing this by means such as supporting research into renewable energy sources, technical procurement of energy-efficient products, and providing investment support for promoting the development of renewable energy.

The Swedish National Energy Administration is also entrusted with the task of supervising the new electricity market. Our investigation operations are focused on analysing the relationship between energy, the environment and economic growth.

Swedish National Energy Administration

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