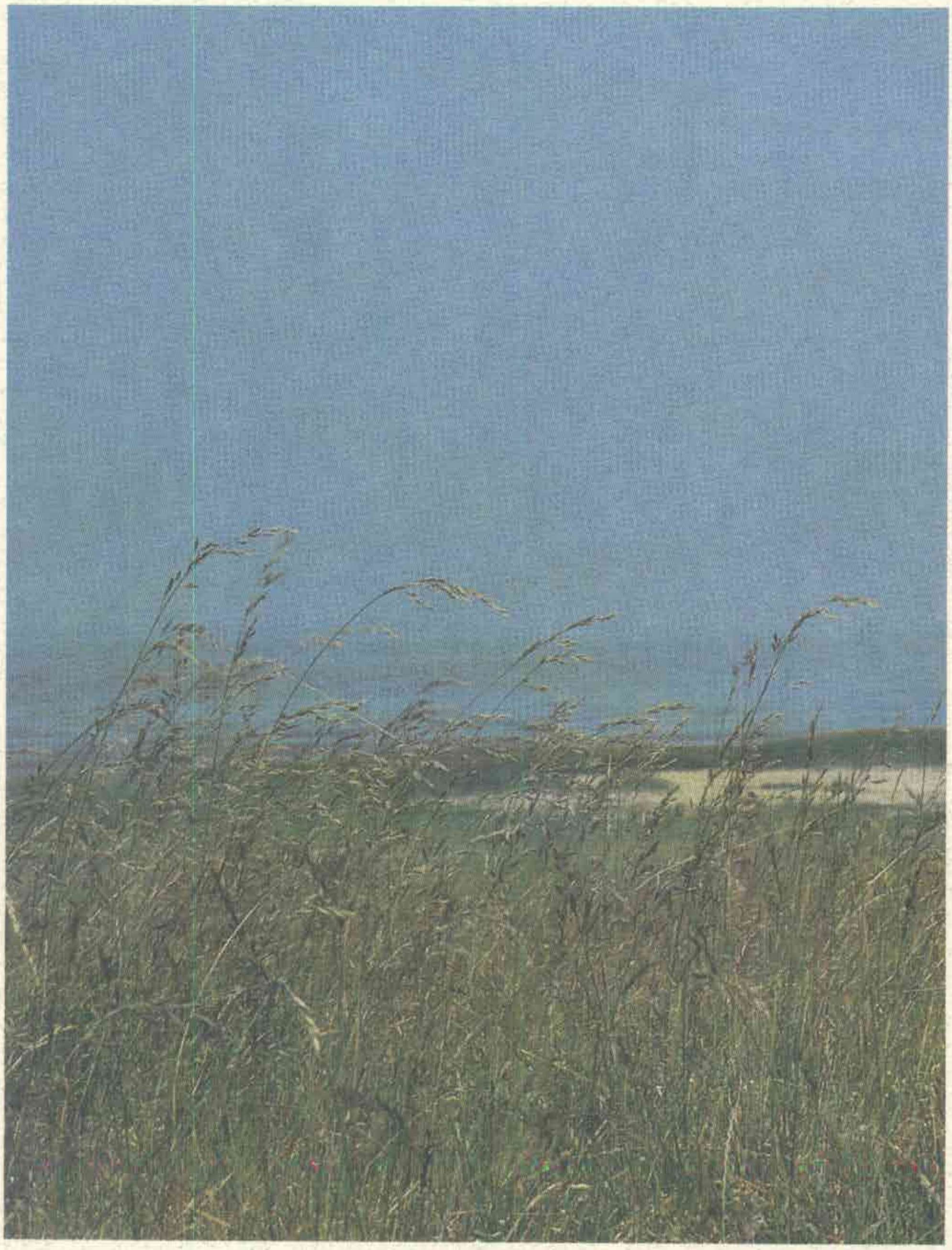
ANNUAL REPORT 1997



Nordel

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Nordel's Annual Meeting in 1997 was held in Middelfart, Funen, in Denmark. Photo: Højer/Kuvapörssi Oy.

NORDEL

Nordel is an association for electricity co-operation in the Nordic countries. Established in 1963, Nordel is an advisory and recommendatory body; its primary task is to create prerequisites for efficient utilisation of the Nordic electricity generation and transmission systems. Nordel has a non-commercial role in regard to electricity interchanges.

Nordel's tasks, which were revised together with the By-Laws in 1993, include:

- technical co-ordination of the Nordic electricity system;
- formulation of a technical framework for Nordic electricity co-operation;
- international co-operation;
- contacts with other players, organisations and authorities in the electricity sector.

Nordel is composed of leading individuals within the electricity generation and transmission sectors of Denmark, Finland, Iceland, Norway and Sweden. The chairman is elected for a three-year term, and the chairmanship rotates between the member countries. The chairman appoints Nordel's secretary and is responsible for the secretariat.

Nordel's executive body is the Executive Board, composed of one person from each of the Nordic countries. The Executive Board presents initiatives and makes decisions on current matters, and implements the decisions made at Nordel's Annual Meeting. The Board is also responsible for the association's external information activities.

A large proportion of Nordel's work is carried out by committees and working groups made up of specialists in both electricity generation and transmission sectors.

Key figures 1997		Nordel	Denmark	Finland	Iceland	Norway	Sweden
Population	mill.	**24.0**	5.3	5.1	0.3	4.4	8.9
Electricity consumption (excl. electric boilers)	TWh	**364.7**	34.5	73.5	5.2	111.4	140.1
Maximum load (measured 3rd Wednesday in January)	GW	**53.7**	5.4	10.1	0.6	16.2	21.4
Electricity generation	TWh	**370.1**	41.7	65.9	5.6	112.0	144.9
Breakdown of electricity generation:							
Hydropower	%	**53**	0	18	93	99	47
Nuclear power	%	**23**	.	30	.	.	46
Other thermal power	%	**23**	95	52	0	1	7
Other renewable power	%	**1**	5	0	7	0	0

· Data are nonexistent
0 Less than 0.5%

The Nordic electricity market continued to develop in 1997. The opportunities for actors to expand their operations outside the borders of individual countries improved, which further strengthened the unique market shared by these countries.

Roles and regulations with respect to system responsibility within the Nordel area were developed and specified during the year. Structural differences between the countries have been evened out. The bodies bearing system responsibility in each country have better prerequisites for closer co-operation; at the same time, the need for co-operation has increased. Against this background, Nordel's Executive Board has on several occasions discussed Nordel's composition and organisational structure in relation to the outside world. This issue came up at Nordel's Annual Meeting in Funen, Denmark, on 28 August 1997. It was concluded that the new situation makes it necessary to develop the organisation so that the new needs of enterprises bearing system responsibility pertaining to Nordic co-operation are taken into account. The Executive Board was urged to pursue the matter further so as to ensure that Nordel can both act as a co-operation body for enterprises with system responsibility and continue as a forum where both enterprises with system responsibility and other actors meet and work together. Questions concerning technical co-ordination of the Nordic electricity system will continue to make up the organisation's core activities, and the importance of carrying on the good traditions of co-operation were emphasised. The Executive Board appointed a working group to prepare a proposal for new By-Laws for Nordel. The goal is to discuss the proposal for new By-Laws at an extraordinary meeting during spring and to approve the By-Laws in their final form at the Annual Meeting in August 1998.

Besides the above issue, the Annual Meeting discussed the Annual Report for 1996, the Committees' reports and plans, and the current power situation in each Nordic country and collectively for all the Nordic countries during the next three years. Reports concerning the power balance and transmission capacity in the Nordel system in 2005 were approved.

The Annual Meeting was also informed of the work being carried out to create a joint Nordic electricity exchange. A management group monitors how the goals expressed in the report on the Nordic exchange in 1996 have been reached. It was noted, among other things, that efforts should be taken to abolish transmission fees between countries. It is also important to harmonise taxes and fees to ensure equal opportunities for all actors.

The trend towards more open electricity markets in Europe continued. Nordel's contacts with other organisations in the electricity sector have remained very good – a fact that was also confirmed during the annual meeting between the management bodies of UCPTE and Nordel.

Nordel's Chairman, Kalervo Nurmimäki, is CEO of Imatran Voima Oy. Photo: Keijo Westerberg.

ACTIVITIES OF THE SYSTEM COMMITTEE IN 1997

The System Committee is responsible for long-range issues related to technical systems. The Committee's work includes:

- Analyses of technical collaboration between generators and grid operators.
- Follow-up of the capacity situation within Nordel in both the generation and transmission sectors.
- Analyses of the capacity requirements for transmission between the different systems within Nordel and between Nordel and other countries.

A major proportion of the work is done by the two working groups subordinate to the System Committee: the Generating Group and the Grid Group.

In 1997, the System Committee introduced two major studies that will extend over several years:

- The first study deals with the importance of grid tariffs and bottlenecks for future market development in the Nordic countries and Northern Europe. The Generating Group has drawn up a proposal for a study programme. The designed Nordic Interconnection Model, which is maintained by EFI in Norway, will be used as an important tool for analysis in the study.
- The aim of the other study is to find out the consequences of the constantly increasing amount of electricity production that cannot be regulated (wind power and decentralised CHP production) in the Nordic system. The Grid Group has drawn up a study programme stretching out to the year 2000.

In addition to the above mentioned new study programmes, the two groups have operated as follows:

The Generating Group has completed a study on the power balance within the Nordel system in 2005. The results were reported at Nordel's Annual Meeting 1997 and documented in the report "Kraftbalans för Nordelsystemet år 2005" (Power balance within the Nordel system in 2005).

Calculations (the basic scenario) show that the power balance in the Nordic countries is fairly strong. The marginal production is usually coal and gas-fired condensing power. In years with normal precipitation, the Nordic system is a net importer of power. The connections with the Continent can basically even out the entire variation resulting from precipitation in the Nordic system. The exchange with the Continent varies by more than 70 TWh between extremely dry and wet years, which leads to better utilisation of the system. A harmonised CO_2 tax of NOK 136 per tonne

in the whole model area will mean that a considerable amount of coal-fired condensing power, above all on the Continent, will be replaced by production based on natural gas and oil. As a whole, CO_2 emissions will decrease by approximately 10%.

The Generating Group is updating the basic alternative for the year 2005. Among the major adjustments are: Poland will be included; the transmission capacity of new cables will be 600 MW instead of 800 MW; the Nordic power balance will be improved by 9 TWh. The Group is also considering the use of higher coal prices in Germany and Poland as a result of higher transportation costs and the introduction of a transmission fee between the model areas on the Continent.

The Grid Group has participated in a study on HVDC interconnections. The several new HVDC interconnections in the Nordic electricity transmission system create a number of new possibilities as well as new problems. In 1995, the System and Operations Committees appointed an ad hoc working group for studying these matters in more detail.

The results of the analyses were presented at Nordel's Annual Meeting in 1997. The main conclusion is:"No such faults that can make all the HVDC interconnection fail simultaneously were detected", and further "With a suitable control system designed by the manufacturer, it will in practice be possible to expand the number of HVDC interconnections according to the decisions already made without a need to further strengthen the AC network essentially". This means that the stable operation of the HVDC interconnections will not require any expensive solutions that would increase the strength of the AC network in addition to the measures already planned.

The Group will continue to analyse combinations of different types of faults, which influence the frequency directly, the emergency measures required and their distribution.

The Grid Group has also compiled a report, called "Overføringskapaciteter i Nordel-systemet, Stadium 2005" (Transmission capacities in the Nordel system in 2005), which describes the transmission capacities between the Nordel countries and between Nordel and other countries.

In addition, the Grid Group has analysed in more detail the requirements that the Nordic countries place on the reactive effect of power plants. It was found that even though the requirements may have been formulated in different manners, the generator sizes according to the requirements are with regard to system security considerations fairly consistent. During the process, the requirements of some of the participants were adjusted. No need for further harmonisation was, however, detected.

A corresponding detailed analysis of the dimensioned load situation and conductor dimension is being conducted.

Photo: IVO Photoarchive.

OBJECTIVES OF ACTIVITIES

The Operations Committee is responsible for technical system matters on a shorter term and for the technical framework of Nordic electric power interchange and day-to-day operation.

The primary objectives of the Committee are:

- To establish the preconditions for the optimum collective utilisation of the entire Nordic electric power system.
- To devote particular attention to the preconditions of electricity trading, including the establishment of framework conditions and administrative rules for the market contacts between the parties involved.
- To promote an open exchange of information between the parties in order both to ensure good reliability and to make it possible for the market to function efficiently.
- To serve as a forum for discussions about operational collaboration within the Nordic electric power system.
- To place high priority on environmental issues as an integral part of the activities, and to study the effects of operational collaboration on the environment.

Two permanent working groups have been set up under the Operations Committee:

- The working group for system operations (NOKSY) carries out analyses, prepares regulations and recommendations, and co-ordinates technical issues related to power system operation.
- The working group for information technology in power system operation (NORCON) promotes the effective utilisation of information technology in the operational management of power systems.

In its operations, the Committee strives to respect the energy policies and electricity market structures of the countries involved. The Nordel system will be connected to Europe more closely in the near future. Therefore, the Committee will closely follow the development of the electricity markets of the Nordic countries as well as developments in the EU.

POWER COLLABORATION

The Operations Committee has continuously dealt with issues concerning operational co-ordination, reliability, the power situation in the Nordic countries and the preconditions for electricity trading.

Whereas the year 1996 could be characterised as a dry year, the power situation in the Nordic countries returned to a normal level in 1997. This was due to lower consumption during the winter as a result of the difficult power situation at the beginning of the year, rainfall above the average during the entire period and heavy spring floods due to the extensive snow reservoir.

At the beginning of 1997, the reservoir situation in Norway and Sweden was clearly below the normal, whereas the reservoir levels in Finland were above the normal. As a result of the large snow reservoir in all the countries and the extensive rainfall, the reservoir situation improved considerably during spring and summer. In autumn, hydropower was exploited more strongly than usually in Sweden due to an increasing load and problems in the availability of nuclear power. This led to a lower reservoir level than normally at the year-end. In Finland, there was little rainfall in autumn, and at the end of the year the reservoir level was below normal. In Norway, the reservoir situation improved during the entire autumn, and extensive rainfall improved the reservoir situation to near normal by the year-end.

The difficult water situation in Norway and Sweden during the winter of 96/97 led to a considerably higher generation from fossil-fuel power than normally, which also led to greater emissions. In Finland, nuclear power functioned with good availability during the entire year, except for periods with reparation work. In Sweden, nuclear power functioned well during most of the year, but as a result of periodic problems during autumn, the availability during the entire year was poorer than normally.

The poor water situation at the beginning of 1997 led to large net imports to Norway and large net exports from Denmark during the first half-year. Sweden and Finland had net exports and imports, respectively, during the same period. During the second half of the year, the situation changed due to the altered water situation, but as a whole, there were net imports to Norway and continuous net exports from Sweden. Denmark had considerable net exports to both Norway and Sweden. Finland was a net importer with extensive imports from Russia.

The power situation in the Nordel system was difficult at the beginning of the year. This led to higher market prices and a high utilisation of reserve energy, primarily in the form of fossil-fuel power in the Nordic countries and as imports from Germany. The water situation improved markedly during the year, and market prices fell considerably during spring. The prices were low during the summer and autumn of 1997.

There was a strong reduction in the load during the first half of the year, but during the second half, the trend started to increase again considerably. The increase in per cent during the 12-month period was greater than the increase in generation.

The energy and power balances compiled by the Operations Committee for 1998 to 2000 show that the balance within Nordel is good but that there are great differences within the system. The energy balance for Norway shows that Norway is likely to be dependent on imports during both normal and dry years. From 1996 onwards, the balances have been compiled as pure balances per country, excluding both imports and exports. This is due to the new market structure in the Nordic region, which has a common market where agreements between generators and consumers in the different countries as well as between countries are confidential. The increasing competition between the parties will make it even more difficult to get information for such balances in the future.

UCPTE and the Operations Committee carried out a joint analysis of American grid failures in 1996. The analysis gave rise to a number of questions related to the reliability of operations and other technical considerations. It is important to study the reliability of the operations continuously. Carefully designed routines and plans as well as competent and experienced staff are important preconditions for maintaining good reliability. Lack of expertise can become a critical factor when faults occur in the system.

The Committee has studied questions related to information policy within Nordel. The main questions studied were, for example, the type of the information that is distributed, the frequency of the distribution, how detailed the information should be, and how the compilation and distribution of the information should be organised and supervised. The proposal stresses the use of information that is already available.

The interchange capacity of the AC interconnections between Sweden and Finland has increased, and the capacity is now 1,400 MW from Sweden to Finland and 900 MW from Finland to Sweden. The difference is due to the differently dimensioned fault in the two directions.

RELIABILITY

There were several serious operational disturbances in the Nordel system in 1997, but these did not lead to any interruptions in the system. On 1 January, a serious fault that was larger than the dimensioned fault occurred in Sweden. As a result of the fault, which was due to a fault in the grid, the nuclear power units Ringhals 1 and 2, totalling 1,700 MW were disconnected from the system, which in turn led to strong variations in the system, a major fall of frequency and the activation of emergency power measures. Several corrective measures were undertaken so that the situation could be better controlled in the future. For example, a grid protector was installed for the rapid shut-off of Kontiskan 2 when there are imports from Jutland if there is a breakdown on the line between Strömma and Stenkullen. Before installation of this protection system, the dimensioned fault in Sweden (and consequently in the Nordic region as well) was increased to 1,700 MW.

When the fault occurred, there were extensive exports from Jutland to Norway and Sweden. The Skagerak interconnection did not, however, function at full load when the fault occurred, and the system could have been exploited more effectively; in such situations, those responsible for operations could redistribute the power flow in the cables. Better utilisation of the cables would have an impact on reliability and on wastage in the system, and would help to reduce bottlenecks between the systems. Therefore, it should be possible to use the cables in an optimal manner without, however, exceeding the limits set by commercial agreements.

Photo: Compad-photodisc.

On 4 October, another fault that was larger than the dimensioned fault occurred. A 400 kV transformer exploded in Horred. The fault led to the disconnection of several important 400 kV lines, e.g. the lines to Ringhals 3 and 4, so that the nuclear power units also were disconnected from the system. This led to a major fall in frequency and activation of several emergency measures. Even though several faults that were larger than the dimensioned fault were detected in the system, it has not been regarded as necessary to increase the dimensioned fault permanently, which is the basis for the use of reserves.

Ring operations were tested in the Arctic area from the end of April. The experiences are good and no technical problems occurred. Ring operations will therefore continue when necessary. Grid tests show that the damping in the grid was better than expected on the basis of model simulations.

In the autumn of 1996, an ad hoc group started to study the preconditions of trade with regulating power and reserves and the possible forms of the trade. The group will issue its report during the first half of 1998.

The Operations Committee has started to work on questions related to the consequences of the year 2000. The beginning of the new millennium will place extensive requirements on the reliability of the system with regard to generation, transmission as well as utilisation.

The HVDC group, which represents co-operation between NOKSY and the Grid Group of the System Committee, has analysed the risks of multiple commutation faults in the interconnection when faults occur in the Nordel system, as well as the utilisation and co-ordination of frequency-steered emergency power.

The NOKSY working group has continued to study questions related to frequency quality. After the decreasing tendency of exceeding the frequency band of 50.1 - 49.9 during spring and summer, curves and histograms show an increasing tendency to exceed the level. Consequently, NOKSY investigated the possibilities of establishing a method for measuring the regulating power and continuously monitoring it.

NOKSY also continued with co-ordination of the operating criteria and grid dimensioning criteria. The work is based on previous analyses, which show that there are differences in the grid operating criteria and that the criteria are partly inconsistent with the new grid dimensioning regulations. NOKSY has also been asked by the Committee to focus on such tasks as:

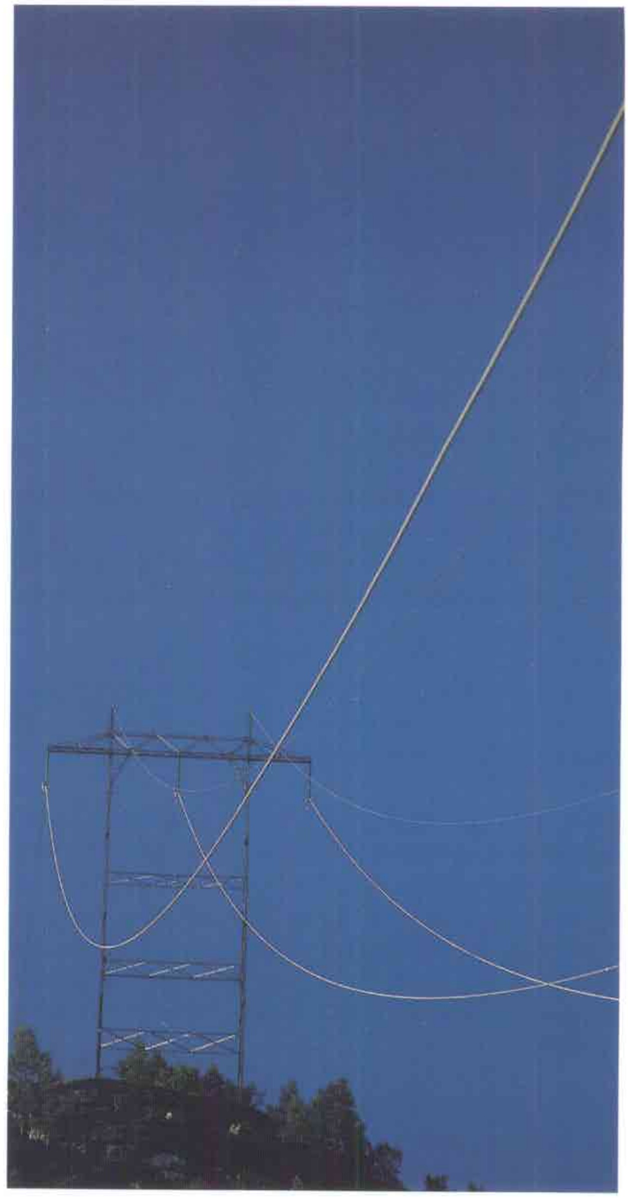


Photo: IVO Photoarchive.

- Comparing and assessing operational recommendations and rules applied by UCPTE and Nordel.
- Monitoring the frequency quality of the Nordel system and analysing the interaction between the requirements for frequency quality and regulating power and the routines for the control of generation.
- Establishing data for an operating grid for NOKSY's operational analyses.
- Defining and documenting the transmission capacity of the interconnections.
- Formulating an improved presentation of system operations with regard to frequency, utilisation of reserves, disturbances etc.
- Analysing disturbances in the Nordel system.

ELECTRICITY MARKET

Brisk development of the Nordic electricity market continued during 1997. An increasing number of actors expanded the scope of their operations to encompass other Nordic countries. Turnover rose on the joint Norwegian-Swedish electricity exchange Nord Pool and on the Finnish EL-EX exchange. The opportunities for power trading on the exchange between countries improved during the year, even though fees are still collected for transmission across borders other than the Norwegian-Swedish border.

Trading by means of financial agreements, which are mainly linked with the physical spot price on Nord Pool, increased rapidly. This trading is carried out both within the framework of the two electricity exchanges and bilaterally between enterprises, often through brokers. The year 1997 was also characterised by vigorous activity concerning acquisition of holdings in power companies and in energy facilities, both in the enterprises' own countries and in the other Nordic countries. Such transactions were carried out particularly in Sweden and Finland.

An increasing proportion of consumers had the opportunity to choose between competing suppliers. The terms and conditions applied to consumers were improved even if suppliers were not changed particularly often.

ECONOMY

Stable economic growth in the Nordic countries continued in 1997. Interest rates were low, and there is reason to believe that the favourable trend will continue. Uncertainty factors are mostly associated with the general trend in world economy and with questions pertaining to implementation of the European Monetary Union.

The *Danish* economy continued to experience a positive growth rate of nearly 3% in 1997, and it is expected that the same trend will persist for the next two years. The principal reason for this relatively high growth rate is the marked increase in domestic demand. Owing to steeply increased imports for this reason, the balance of payments has been under pressure but has remained positive. Unemployment decreased by about one percentage point, to 8%. Half of the new jobs were created in the public sector.

Finland, too, enjoyed a period of sound economic growth in all sectors for the whole year. The GDP grew by over 5%. Predictions for the near future are optimistic; the growth prognosis for 1998 is 3-4%. Inflation and interest rates are low, and so are inflation expectations. Unemployment decreased by 2-3 percentage points and is now under 15%. The principal reason for the hefty economic growth is the boom in the important forest industry sector. New capacity was introduced during the year, which together with the nearly maximum capacity utilisation rate led to rapid production growth.

The positive economic cycle continued in *Iceland*. The GDP grew by about 5%, which corresponds to the growth rate the year before. The real value of the country's main export sector, fishery products, fell by 1.2%. The growth in other sectors of industry was as high as 21%; export of aluminium accounted for the bulk of this. Investments increased by approximately 16% as against 23% in 1996. Unemployment fell somewhat and was on average around 4%. The consumer price index rose by 1.8%, compared to 2.3% in the previous year.

The *Norwegian* economy continues to be in a remarkably good shape. Mainly because of the oil and gas industries, the current account showed a surplus of as much as NOK 79 billion. The GDP grew by 4% and the rate of investment is high. Inflation in 1997 was about 2.5% and unemployment a little over 4%.

In *Sweden*, the GDP growth rate was 1.9%, as against 1.3% the year before. However, the growth rate within industry was considerably more rapid, around 10%. Exports increased from 6.1% to 10.9% in 1997. Inflation continues to be low, approximately 2%, and unemployment was somewhat under 7% in December 1997.

Total electricity consumption (excluding supply to electric boilers) for the five Nordel countries amounted to 365 TWh, or 1.1% more than in 1996. The differences were as follows: Denmark -0.8%, Finland +5.0%, Iceland +9.5%, Norway +0.6% and Sweden -0.2%.

Total electricity generation in the Nordel countries came to 370 TWh, or 2% more than in 1996.

- Hydropower was the biggest generation source, accounting for 197 TWh, or 53%, of the total electricity output. This represents an increase of about 15% because the year 1996 was unusually dry.

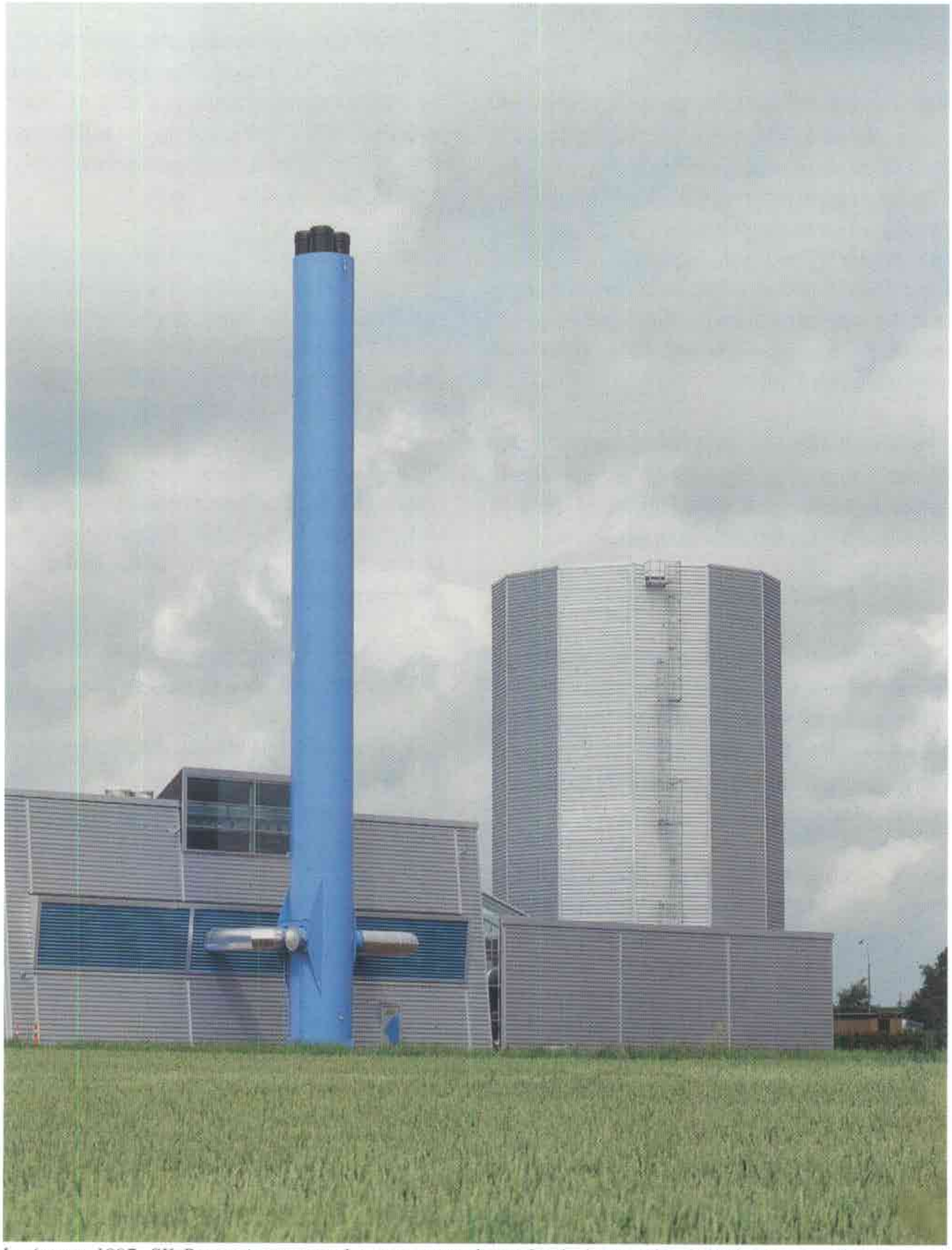
- Nuclear power was the second largest generation source, accounting for 87 TWh (24%) of the total output, or 3 TWh less than in 1996. The average availability rate of the nuclear power plant units was again on a high level by international comparison.

- Output by other thermal power plants stood at 84 TWh, accounting for 23% of the total. This was considerably less than in 1996, when the small output of hydropower was largely replaced by thermal power production, particularly in Denmark and Finland.

- Other energy sources, e.g. wind power and geothermal power, accounted for 2.5 TWh, or 0.7% of the total output.

Exchange of electricity between the five Nordel countries totalled 25 TWh. In addition, 10 TWh was interchanged with Germany and Russia. Denmark had the highest net exports of power (7.3 TWh), while Finland had the highest net imports (7.7 TWh).

Prices on the Norwegian-Swedish electricity exchange were lower than in 1996, but varied over a wide range during the year.



In August 1997, SK Power inaugurated a new natural gas-fired, decentralised CHP plant in Ringsted. Its capacity is 10.4 MW of electricity and 11.6 MJ/s of heat. Photo: Mogens Carrebye.

ENERGY POLICY

The new Danish Electricity Supply Act entered into force on 1 January 1998. One of the implications of the Act is that electricity distribution companies with annual sales of more than 100 GWh and users with an annual electricity consumption of at least 100 GWh per consumption point may enter into agreements for direct supply of electricity with Danish or foreign electricity suppliers. Electricity generators with an annual production of at least 100 GWh may also enter into agreements on direct sale of electricity with each other, with the above-mentioned categories of companies and with foreign parties. The Act also contains provisions concerning the transmission system operators and defines the scope of public service obligations as prioritisation of electricity from certain combined heat and power plants and from electricity production plants that use renewable fuels or renewable energy.

As a consequence of the new Danish Electricity Supply Act and the EU's market directive for electricity, ELSAM's competent assemblies decided in 1997 to separate all ELSAM's grid activities and transmission system operation, and to continue ELSAM as a commercial generator and electricity trading company. Western Denmark's 64 distribution companies, which regionally own the six Jutland and Funen power stations, decided in November 1997 to establish Eltra as the system operator in Jutland and on Funen. In the Articles of Association, it is stated that Eltra must perform its tasks neutrally and independently "of companies that produce, distribute, act as brokers for and sell electricity" . On 1 January 1998, Eltra took over ELSAM's former grid activities.

In the supply region for Eastern Denmark, a new structure is on the way, initially with temporary separation of the system operator at management level.

Those parts of the EU's market directive for electricity that are not covered by the new Danish Electricity Supply Act are being taken up in connection with the work on a reform of the legislation for the electricity, gas and heating sectors that commenced in 1996. In the reform, account must be taken of both the objectives of ENERGY 21, which is the Government's energy plan for sustainable energy development in Denmark, and the implementation of the EU's directive for an internal energy market. Proposals for revision of the rules for the electricity sector are expected in autumn 1998 and must be implemented before the time limit for implementation of the EU's market directive for electricity, which is 19 February 1999.

In February 1997, the Danish Parliament passed an Act on the Sale of Municipal and County Electric Utilities. If municipalities or county councils sell some or all of their shares or interests in electric utilities, an amount corresponding to the profit they gain from selling will be offset against their block grants. That will result in a saving for the Exchequer, and it is the Government's intention that any saving shall be placed in fund for the benefit of consumers and the electricity supply system.

On 1 July, a supplementary agreement to the biomass action plan from 1993 was entered into, resulting in changed flexibility with respect to choice of fuel. However, it does not look as though the generators will be able to comply with the time schedule for use of all the biomass they are required to use before the year 2000. That is due in part to delays in the official procedure for approval of new biomass plants, including Avedøre 2 in Elkraft's region, and rejection of ELSAM's application to build a development and demonstration plant in Århus; cf. the section on electricity production.

In 1997, the Minister for the Environment and Energy discussed plans for the development of offshore wind farms with the generators. In mid-February 1998, the Minister imposed a duty on ELSAM and Eltra (in Western Denmark) and Elkraft (in Eastern Denmark) to develop and establish five demonstration plants in the North Sea, the Kattegat and the Baltic Sea. Each of the farms will have a capacity of around 150 MW. In a later expansion, in which private investors will be invited to participate, the farms are expected to reach a total capacity of 4,000 MW.

A biomass boiler was commissioned at Ensted Power Plant, near Åbenrå, at the end of 1997. Photo: Jørgen Schytte.

Based on the experience gained, e.g. from the Vindeby windmill park, the Minister of Energy and Environment has introduced plans to establish large-scale sea mill parks. Photo: Mogens Carrebye.

At the end of 1996, the Danish Parliament reached agreement on a reduction of the special CO_2 subsidy for small-scale CHP plants, from 10 to 7 øre/kWh. As a result, industrial companies are showing far less interest in building their own CHP plants. Consideration is now being given to increasing the government grant available to companies for this purpose from 30 to 40% of the construction costs.

The new Danish Competition Act, which largely introduces the prohibition rules of EU's competition law, was passed in 1997 and became law on 1 January 1998. This Act also applies to the electricity sector, although not to areas that are regulated by other legislation, e.g. the Electricity Supply Act.

ELECTRICITY CONSUMPTION

In 1997, electricity consumption totalled 34.5 TWh, which is a small fall – 0.8% – in relation to 1996.

Industry, the residential sector and trade/service each accounted for about 30% of the total electricity consumption, while agriculture and other sectors accounted for the remaining 10%.

ELECTRICITY PRODUCTION

In 1997, production totalled 32.5 TWh at Denmark's primary power stations and CHP plants and 9.3 TWh at small-scale CHP plants and renewable energy installations. Total production was thus 41.8 TWh or about 17% lower than in 1996, when production was affected by extraordinarily large exports to the other Nordic countries because of the hydropower situation in that year. In 1997, more plentiful precipitation in Norway and Sweden brought production back to a more normal level. Of the total production of 41.8 TWh, 10.3 TWh was exported to the Nordic countries – partially traded on the Norwegian/Swedish electricity exchange Nord Pool. In the same period, imports amounted to 2.9 TWh.

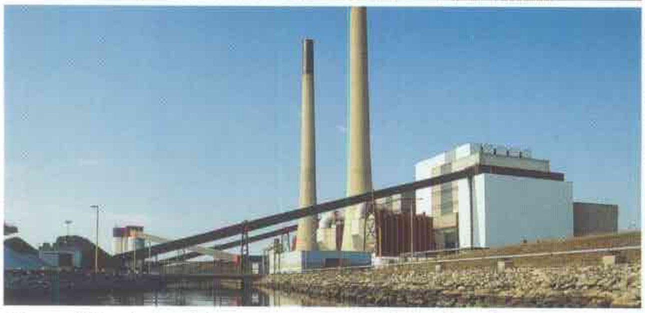
Coal is still the most commonly used type of fuel at Denmark's power stations, although with a declining share of fuel usage as a consequence of increased use of natural gas and biofuels and increased use of orimulsion by SK Power. In 1997, coal accounted for 71% of the total fuel usage, and orimulsion and oil for 16%, while natural gas, biofuels and wind energy together accounted for 13%.

In spring 1997, the Danish Government agreed to a de facto stop in the use of coal for new power stations. Thus, an application by ELSAM for permission to build an 88 MW small-scale CHP plant based on CFB technology with coal and biomass as the fuels was rejected. The grounds given for rejecting the project were lack of demand for electricity or heat, but a determining factor was the fact that the plant would be fuelled with coal. Owing to the rejection of its application, ELSAM must revise its biomass action plan because the planned CHP plant in Århus alone was intended to use about 320,000 tonnes of biomass a year – almost one quarter of the amount of biomass that politicians require the power generators to use from the year 2000.

On the other hand, a new application concerning Avedøre 2, which is to be built beside the existing Avedøre Power Station, was approved on 31 March, but only after the original concept, which was partially based on coal was changed, to a predominantly natural gas-fired plant combined with biomass. The advanced multifuel plant, which will have a capacity of 540-570 MW of electricity and 570-585 MJ/s of heat, is expected to go into operation in 2001.

On 11 March 1997, Princess Benedikte and Prince Richard inaugurated a new flue gas purification plant at Unit 3 of Ensted Power Plant. The purification plant had cost over DKK 1 billion. Like the power plant units, the purification plant was established by the Interest Group EV3, owned in equal shares by Sønderjyllands Højspændingsværk and PreussenElektra. The picture also shows SH's Managing Director Niels Bergh-Hansen and SH's Chairman, printing house manager Erling Bjerre. Photo: Hanne von Huth Smith/SH.

About 40% of electricity consumption in Jutland and Funen is today met by wind power and small gas-fired CHP plants, such as the above facility by a market garden in Funen. Photo: Jørgen Schytte.



SK Power is building a desulphurisation plant at Unit 2 of Stignæs Power Plant. The work will be completed at the end of 1999. Photo: Mogens Carrebye.

At the end of March 1997, the National Board of Energy approved SK Power's application for a multifuel CHP unit at Avedøre Power Plant. Photo: Mogens Carrebye.

A natural gas-fired CHP unit of 395 MW was commissioned at Skærbæk Power Plant. Photo: Jørgen Schytte.

In autumn, Skærbæk Power Station near Fredericia commissioned Denmark's largest natural gas-fired unit (395 MW electricity, 450 MJ/s heat). The unit, which has an electrical efficiency of 49.3% in condensing operation, will use 350-400 million m^3 gas a year.

In August, SK Power inaugurated a new natural gas-fired, small-scale CHP plant in Ringsted. The plant has a capacity of 10.4 MW of electricity and 11.6 MJ/s of heat. SK Power has also commenced the construction of a natural gas-fired small-scale CHP plant, with a capacity of 38 MW of electricity and 31 MJ/s of heat, at the Technical University of Denmark. The plant will replace an earlier coal dust-fired plant that has now been demolished.

THE MAIN TRANSMISSION GRID

1997 brought no solution to the technical bottleneck problems suffered by the main Jutland-Funen electricity system. The planned 400 kV line between Århus and Aalborg, which is recommended by the energy authorities, is still undergoing political and technical assessment in North Jutland and Århus County Councils.

The official procedure for approval of proposals to restructure the 40-year-old 400 kV line between the German-Danish border and Vejen and to establish a new 400 kV link between Vejen and Esbjerg has also come up against popular protest and major delays in Ribe County and South Jutland County.

The 20-year agreement between ELSAM and Vattenfall on use of the Kontiskan Link was renegotiated in 1997. This means that, from 1998, Kontiskan will be fully open to the market's players. The same is not the case with the Skagerak Link between Jutland and Norway. Here, Statkraft maintains that a 25-year exchange and transit agreement with ELSAM gives it a monopoly on the link.

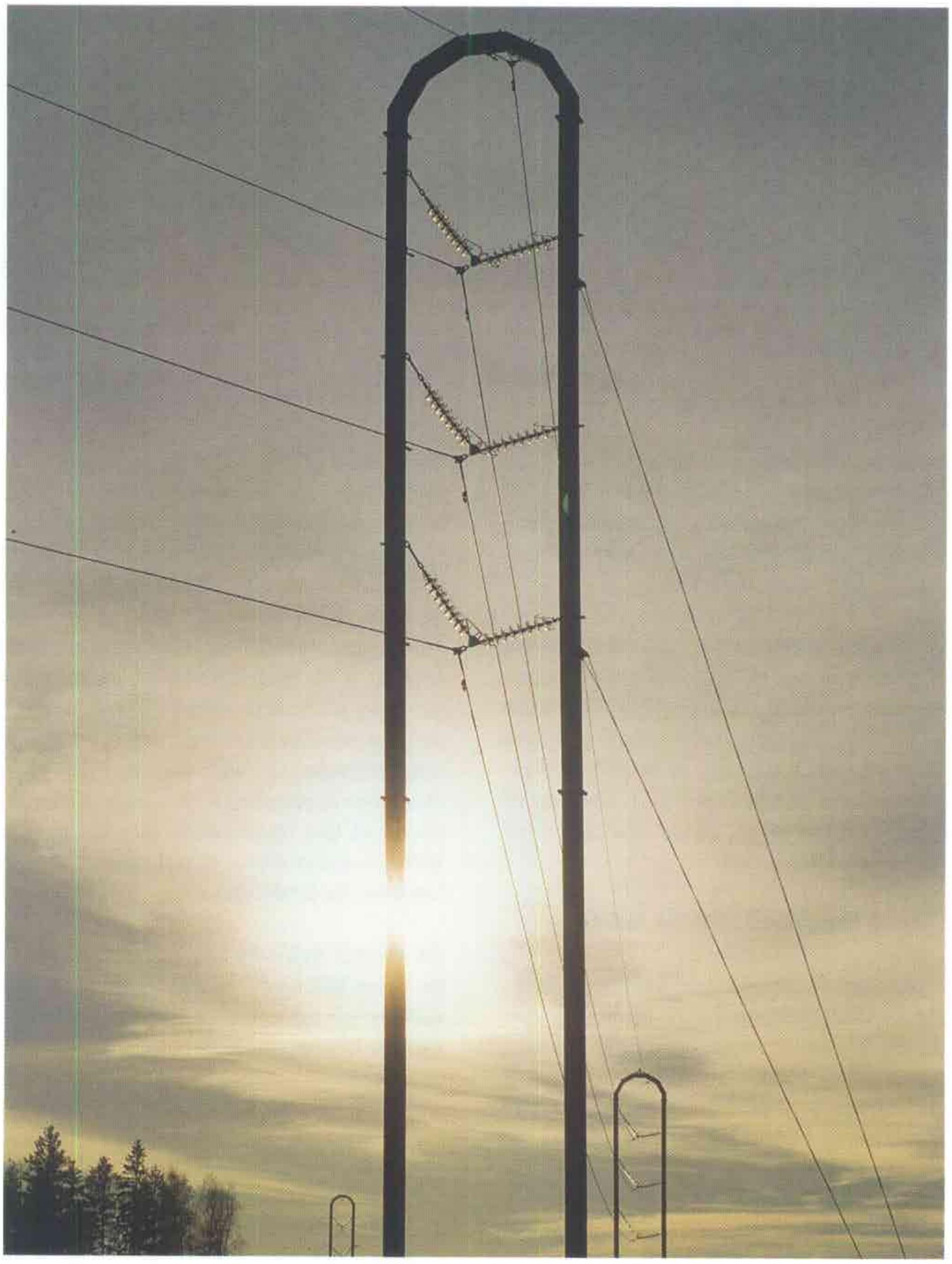
As the first phase of the Metropolitan project in Elkraft's region, the southern 400 kV cable from Ishøj transformer station via Avedøre switch station to H.C. Ørsted Power Station was commissioned in 1997. With a length of 22 km, the Danish-made cable is the longest PEX cable in the world. Work on the northern 400 kV link between Hovegård and Glentegård transformer stations is proceeding according to plan. When both links have been established, the principal criteria for dismantling a number of overhead lines in densely populated urban areas will be in place. Future planning in connection with the establishment of 400 kV ring structures is intended to include continued dismantling of overhead line installations as a means – in co-operation with the authorities – of reducing the impact of overhead lines on the landscape.

An electric link between Eastern and Western Denmark – the Great Belt Link – remains a planning assumption. Negotiations on the actual conditions for establishment of the link are in progress between the parties involved.

ELECTRICITY PRICES

Electricity prices, excluding taxes, rose by 2.3 to 4.2 øre/kWh from the beginning of 1997 to the beginning of 1998. The average consumer price, with an annual consumption of 3,500 kWh, is 50.66 øre/kWh. With taxes and VAT, that corresponds to a price of DKK 135.20 øre/kWh because the State has increased the tax for residential customers by 9.1 øre/kWh. With an annual consumption of 15,000 kWh, the corresponding consumer prices are 41.71 øre/kWh and 118.05 øre/kWh, respectively.

The average prices for an industrial customer with an annual consumption of 2.5 GWh are 38.56 øre/kWh, excluding taxes, and 44.46 øre/kWh, including taxes but excluding VAT.



A power line in Tuusula. Photo: Keijo Westerberg.

ENERGY POLICY

The Government submitted its report on the Finnish Energy Strategy to Parliament. The Government is committed to ensuring a sufficient supply of energy while preventing any deterioration of Finland's international competitiveness that would arise from one-sided economic means of steering within the energy sector.

Energy plays a central role in sustainable development, and decisions made in energy policy are of essential importance when combating the greenhouse effect. Since energy-intensive industries affect the state of the national economy, it is necessary to adapt the Finnish taxation policy to international developments.

The Energy Strategy strives to influence both energy generation and energy demand. The objective is to apply economic means of steering and market mechanisms to create conditions that support the economy and employment.

The Government also works actively to ensure that the emission limits required by the Climate Convention are defined for the contracting parties in international negotiations.

The basic structure of energy taxation will be maintained, and the competitiveness of Finnish businesses in relation to their major international competitors must not be impaired.

The Government contributes to the varied development and diversity of electricity supply now and in future, as concerns both fuels and production technology. No technically or economically feasible power generation alternatives are excluded if they help to achieve the environmental objectives set.

Maximum use is made of the potential for building more capacity for combined generation of electricity and heat by means of natural gas or indigenous fuels. The primary criterion with respect to other power plants is that they are based on low-emission alternatives.

In addition to national measures, the natural gas alternative requires decisions on the international scene and Finland's active contribution to the process. For energy economy to be based on natural gas to a much greater extent than now, sufficient supply of natural gas must be ensured in the coming years. Through all means available to it, the Government strives to ensure that the necessary investment decisions on Finland's connection to the European natural gas network will be made at the latest in 1999.

A hefty increase in the use of natural gas is an important prerequisite for Finland to be able to meet its international obligations under the Climate Convention, without jeopardising the goals set for economy or employment. In addition, other measures are needed as well.

Owing to compelling obligations, however, provision must be made for the eventuality that construction of additional nuclear power becomes topical, especially if the supply of natural gas is not sufficient to compensate for coal-fired capacity. Both Teollisuuden Voima Oy and Imatran Voima Oy have started preparations for the environmental impact assessment of new nuclear power capacity.

The Ministry of Trade and Industry will report on the results of studies to be conducted within the energy sector, and the reports can be used, e.g. in negotiations concerning the energy policy to be pursued by the new Government that will be appointed after the parliamentary election of 1999.

ENVIRONMENT

Preparations before the Kyoto Climate Convention dominated both energy policy and environmental policy in Finland. Finland's share of the EU's total emission quota is expected to be highly demanding.

The Acidification Committee has completed its technical and economic investigations. Because of a delay in international negotiations, the Committee's report will be restricted to the technical and economic possibilities. The Committee will not determine any national line of action with respect to further reduction of SO_2 and NO_x emissions.

A comprehensive reform of the Finnish environmental legislation and environmental permit system is being prepared on the basis of the reports issued by the Environmental Permits Committee and the Environmental Law Committee. According to plans, the working group will submit its proposal during spring 1998.

IVO's combined-cycle power plant next to Metsä-Serla's paper mill in Kirkniemi was inaugurated at the beginning of February 1998. The power plant, which is fired by natural gas and wood, generates 105 MW of electricity, 120 MW of steam and 15 MW of district heat. Photo: Juhani Eskelinen.

ELECTRICITY CONSUMPTION

Total consumption of electricity in Finland in 1997 amounted to 73.5 TWh, which included a statistical increase of as much as 5%. The corresponding real change, adjusted for temperature and the calendar, was 5.8%. Thus, after a couple of years of a sluggish growth rate, electricity consumption rose steeply in 1997, in step with the growth rate of the economy.

Demand for electricity by industry increased by 8.5%, mainly as a consequence of the upswing in the economic cycle and the higher production capacity within the forest industry. Electricity consumption within this sector, which accounts for about one third of the total consumption in Finland, was 13%. In total, industry accounted for 54% of all electricity consumption.

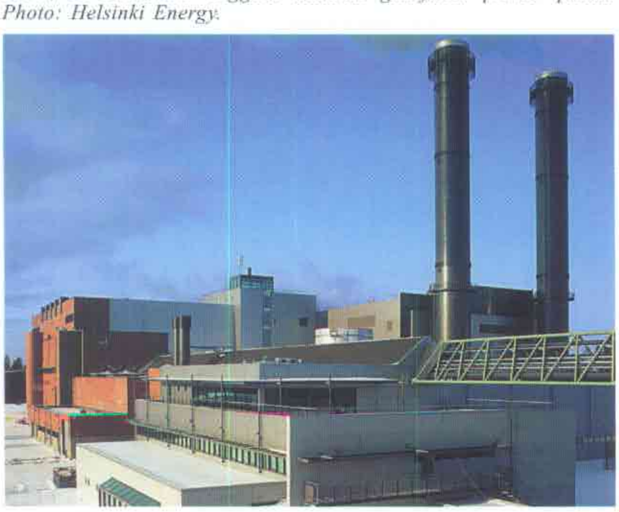
Activity increased in the building sector, and domestic demand in general picked up during 1997. Adjusted for temperature and the calendar, electricity consumption in the housing sector and in services rose by approximately 2.5%, which is one percentage point more than in the previous year.

The peak output for 1997 came to 11,100 MW; it was registered on 10 January when the temperature was -12°C. In 1996, the maximum loading had been about 100 MW higher.

ELECTRICITY PRODUCTION

The Finnish electricity supply amounted to 73.5 TWh. The measured, physical imports to Finland from the Nordel area came to 3.8 TWh, while 0.5 TWh was exported. Commercial exports and imports exceed the physical flow of electricity considerably. Owing to the improved hydropower situation in Norway and Sweden, the net exports of 1.0 TWh to the other Nordel countries in 1996 were changed to net imports of 3.4 TWh in 1997. In addition, 4.3 TWh, or 6% of the supply, was imported from Russia.

The Vuosaari Unit B co-generation plant, inaugurated in autumn 1997, is Finland's biggest natural gas-fired power plant. Photo: Helsinki Energy.



Hydropower generation was nearly 10% lower than the average. The annual energy figure amounted to 11.9 TWh, or to 16% of supply. A record-high output of 20.0 TWh was registered for nuclear power; this accounts for 27% of the total need for supply. The availability rates for the Loviisa reactor units were 94.3% and 94.7% and for the Olkiluoto units 94.0% and 94.3%, which are very good figures by international standards.

Generation of back-pressure power in built-up areas and in industrial facilities (22.9 TWh) was 3% higher than the year before. The need for separately generated condensing power (11.1 TWh) fell by approximately 20% on the previous year.

Generating capacity increased by a total of 868 MW during the year. The gas-fired co-generation plant in Vuosaari, Helsinki, accounts for more than half of this increase. The new capacity consists of hydropower, combined heat and power, industrial back-pressure power, and upgrading of the existing nuclear power plants. The power ratings of all four nuclear power plant units have been upgraded between 1996 and 1998; this will increase the total power output by roughly 10%.

At the end of 1997, a total of approximately 550 MW of new generating capacity was either under construction or at the stage where a decision on construction had been made. After the decommissioning of old power plants, the net increase is about 400 MW.

ELECTRICITY MARKET

The Electricity Market Act came into effect in June 1995. This opened up the possibility for free competition on the electricity market for the roughly two thousand biggest consumers of electricity in Finland. At first, the competition encompassed only the largest industrial and service companies and the largest public consumers, whose need for power exceeded 500 kW. This power limit was abolished at the beginning of 1997, when in principle all consumers gained access to the competitive market. In practice, all small-scale consumers of electricity are still excluded from competition, because the change of supplier would require expensive meters registering consumption by the hour. For this reason, it does not pay for households and other small-scale consumers to change their supplier. The Government has proposed an amendment to the Electricity Market Act so that a metering system based on type load curves, in accordance with the Norwegian model, can be introduced during autumn 1998.

According to estimates, there may now be over 30,000 electricity consumers in Finland who would benefit by requesting tenders from electricity companies and then comparing the savings achieved against the price of the metering device that is required. In principle, the Electricity Market Act also gives room for new, independent electricity sellers. As a result of the new market situation, there have already been mergers of electricity companies as well as changes in the ownership basis.

A new actor on the market is EL-EX, an electricity exchange that provides more varied opportunities for electricity supply. The members of the exchange are electricity producers, electricity companies, industrial enterprises and certain Swedish electricity companies. Only members may trade on the exchange. The new transmission grid company Fingrid purchased EL-EX in January 1998.

For the whole year, both Finnish and foreign actors expressed a great interest in restructuring the electricity company market through mergers and acquisitions, but relatively few deals were completed. At the end of 1997, Finland had 110 distribution companies, four less than the year before.

ELECTRICITY PRICES

In December 1997, the average consumer price of electricity, including the electricity and value-added taxes, was FIM 0.597 per kWh (of which the transmission price was FIM 0.312 per kWh) in blocks of flats, FIM 0.524 (FIM 0.264) in detached houses without electric heating, and FIM 0.396 (FIM 0.194) in detached houses with electric heating. The prices per kWh are roughly FIM 0.01 higher than the year before, but the main reason for the increase is the rise in energy taxes.

The price level for major consumers is now lower than a year ago. The average electricity price for medium-sized enterprises (2,000 MWh/a), which had been FIM 0.339 per kWH on 1 January 1997, was FIM 0.01 lower on 1 January 1998. The average transmission price for medium-sized industry, including the electricity and value-added taxes, was FIM 0.11 per kWh (December 1997). The price varied between 0.079 and FIM 0.181 per kWh. According to one study, the price level for large-scale industry has fallen even more.

MAIN GRID AND BALANCING

The new transmission grid company, Suomen Kantaverkko Oyj (Fingrid), began its operations on 1 September 1997, when it took over the grid operations of the IVO and PVO

The lighting of the transformer station in Virkkala was designed by Ekku Peltomäki. Photo: Fingrid.

Groups. The company owns virtually the entire high-voltage network in Finland, inlcuding all the major connections to and from abroad. At the same time, Fingrid was granted system responsibility in Finland. IVO and PVO each own 25% of the shares, while the government has a 12% holding and institutional investors 38%.

The new company intends to make its operations more efficient so that tariffs can be reduced by 15% during the first five years. The company is required to serve all actors on equal terms, and its task is to promote the functioning of the electricity market.

According to the Electricity Market Act, the transmission grid company Fingrid is responsible for ensuring that the Finnish electricity generation and transmission system is maintained and operated in a technically appropriate manner. For the electricity market to work as a whole, there must also be a well-functioning system for balance control and for settling of the balance. This is today ensured by Suomen Voimatase Oy, which began operations at the beginning of 1997. The company's operations include supply of sufficient regulating power in order to maintain the balance between consumption and production in the Finnish power system. The company also carries out regulation, settles any irregularities in the power balance, engages in trade in regulating and balancing power, and carries out other business operations aimed at ensuring the power system's functional capacity. Suomen Voimatase is owned by IVO, PVO and Fingrid.

In March 1998, the Finnish Parliament approved a proposal for amendment of the Electricity Market Act to introduce new rules for balancing and settling of the balance. Responsibility for the power balance on the national level would be included in the system responsibility vested in the transmission grid company. This will mean certain reorganisation of balancing on the national level. The amendment will come into effect in September 1998.

Fingrid has carried out environmental impact assessments (EIA) pertaining to the Rauma-Ulvila, Hikiä, Kymi-Länsisalmi and Yllikkälä-Huutokoski line projects.

About 84 km of 400 kV lines and 5 km of 220 kV lines were completed during the year, while 84 km of 400 kV lines and 24 km of 110 kV lines were under construction.

The transmission capacity of the two 400 kV lines linking the Swedish transmission grid with the Finnish grid in the north has increased by 300 MW, to approximately 1,200 MW of electrical power. This is because both of the lines crossing the border have been equipped with series capacitor stations. In autumn 1995, Svenska Kraftnät and Suomen Kantaverkko had decided to build series capacitor stations for both lines. The Isovaara station was completed in October 1997 and the Finnish station in Keminmaa became operable in November.

During the year, approx. 300 minor disturbances occurred in the main grid; 28 in 400 kV line, 43 in 220 kV lines and 217 in 110 kV lines.

Inside Skaftafell volcano. Quartz porphyry with intrusions in Kjós. Photo: Guðjón Jónsson.

ENERGY POLICY

The National Energy Authority was reorganised in 1997, when the public functions were separated from research activities. Both continue, however, to come under the responsibility of the Director General of the National Energy Authority.

In November, the Minister for Industry and Energy presented a proposal on liberalisation of Iceland's electricity sector. The proposal is based mainly on the reports filed by two Committees: the Energy Committee, which was appointed by the Minister in 1996 and which submitted its report in October of the same year; and the Owner Committee, which was appointed by the owners of the National Power Company (NPC) in order to study the power company's ownership relations, form of operation and objectives. The work of the Owner Committee gave rise to a new agreement between the owners of NPC.

As a result of the proposal, the Icelandic Parliament (the Altinget) has charged the Minister for Industry and Energy with the following tasks:

1. Compilation of a review on the forms of operation in all power companies in which the State has a holding, and estimation of their market value with regard to profitability and yield.
2. Launching of a study on the technical and financial preconditions for altering the structure of the primary transmission grid.
3. Initiation of discussion between power companies, on the basis of the study mentioned in item 2, with a view to establishing a new company for primary transmission.
4. Drawing up the terms and conditions governing the issuance of licences for power production, which would cover, e.g. the security and operational stability of the electricity system, environmental aspects and land use, the characteristics of hydropower and geothermal power as well as the technical and financial requirements placed on the applicant.
5. Examination of new ways of exploiting energy resources for the benefit of industry and trade and preparation of new agreements for power-intensive industries, on the basis of which more equity capital is used for the generation, transmission, distribution and sale of electricity.
6. Analysis of the technical, financial and environmental advantages and disadvantages of joining the Icelandic power system with the power systems in England or on the Continent of Europe.
7. Submission to the Altinget of a report on the development of the above matters every third year, the first report falling due on 1 December 2000.

The bed of the melt water river Gigjukvísl. Rebuilding a power line that was destroyed by violent flooding in Skaftá in 1996. Photo: Ragnar Axelsson.

Below is a rough schedule for these development efforts:

1997-1998:
- The production and transmission functions are separated from one another in the accounts of the National Power Company (NPC).
- Separation of the production, transmission, distribution and sales functions is begun in the accounts of the other power companies.
- A study on the technical and financial preconditions of altering the structure of primary transmission is initiated.
- New financial analyses of a sea cable to England or Europe are launched.
- Free competition in the production and sale of electricity to users consuming more than 50 GWh annually is introduced.
- A Bill for a new Electricity Act is introduced to the Altinget.

1999-2000:
- The form of operation of power companies is altered and a new yield policy is drawn up.
- Separation of the production, transmission, distribution and sales functions in the accounts is carried out.
- A report on the technical and financial preconditions of altering the structure of primary transmission is presented.

2001-2003:
- A report is presented on the results of the study on the technical, financial and environmental advantages and disadvantages of connecting the Icelandic power system with power systems in England or on the Continent. A decision on the future of the project is made on the basis of this report.
- A new company for primary transmission is established and the ownership agreement of NPC is revised.
- The power companies in which the State has a holding are reorganised into limited-liability companies.

Winter in Iceland. Photo: Jakob Skúlason.

2004-2006:

- Competition for meeting the increasing consumption of electricity is introduced before 2006.

2006-2009:

- A free electricity market is introduced by the year 2009.

ENVIRONMENTAL ISSUES

Owing to the expansion now taking place within the electricity sector, the importance of environmental aspects has increased. Reactions to new projects — above all, to new power lines — have been sharper than before. Thanks to environmental evaluations, however, agreements have been reached on most projects. Since external pressure has increased, the major power companies have paid more attention to environmental control and to discussions on environmental aspects.

As a result of global concern regarding pollution, use of foreign capital to exploit Icelandic hydropower and geothermal power for power-intensive industries has become a central topic of discussion. Exploitation of these power sources would make it possible to cut emissions by achieving a corresponding reduction in the use of power generated with gas or oil.

ELECTRICITY CONSUMPTION

The gross consumption of electricity in Iceland in 1997, including transmission and distribution losses and power plants' own consumption, amounted to 5,581 GWh, as compared with 5,113 GWh in 1996. The consumption increased by 9.2%. Firm power accounted for 4,329 GWh and non-guaranteed power for 1,252 GWh of the total consumption.

Power-intensive industries accounted for 53.0% of the total consumption, as compared with 50.1% in 1996. General consumption, without correction for the difference between the yearly temperature and a normal situation, increased by 2.7%. With this correction, the increase was 3.4%.

In 1996, the last year for which relevant data are available, electricity accounted for 20.3% of the total energy supply to end users.

A revised forecast of gross electricity consumption in Iceland up to 2025, excluding that of new power-intensive industries, was issued by the Energy Forecast Committee in December. The new forecast shows the consumption of both firm power and non-guaranteed power for the first time. The average consumption will increase by 2.0% annually, reaching 9,368 GWh in 2025.

ELECTRICITY PRODUCTION

Electricity production in Iceland equals the gross consumption mentioned above, as there are neither imports nor exports of electric power. Of the total production of 5,581 GWh, 5,203 GWh or 93.2% came from hydropower plants (93.2% in 1996 as well), 373 GWh or 6.7% from geothermal plants (6.7% in 1996 as well), and 3 GWh or 0.1% from fossil fuel (diesel) plants (0.1% in 1996 as well).

The total installed capacity of public power plants in Iceland amounted to 1,129 MW at the end of 1997, as compared with 1,049 MW at the end of 1996.

Modernisation of the Búrfell power plant continued. NPC has now changed four of the six turbine rotors, which has increased the capacity by a further 40 MW. The work will continue next year. The modernisation and renovation of Sogstationerne, which are the oldest plants used in the system, also proceeded and will continue during the following two years.

As a result of the rising consumption, NPC is expanding the power system by adding a new power plant, with a capacity of 120 MW, at Sultartangi by the Thjórsá river, north of the Búrfell power plant, and by building a new reservoir in Hágöngur by the Kaldakvísl river, which flows into the Thórisvatn reservoir. The facilities needed for leading water from the upper parts of the Thjórsá river to the Thórisvatn reservoir are completed.

NPC has now installed the second of the two 30 MW steam turbines to the Krafla geothermal plant in Northern Iceland, which gives a total capacity of 45 MW. Drillings, which will yield an additional 15 MW, will commence in 1998.

A romance from Borgarfjörður. Photo: Jakob Skúlason.

The Reykjavik District Heating Plant started building of a geothermal heat plant, having a capacity of 60 MW, at Nesjavellir, 30 km east of Reykjavik. The plant will be taken into use during the latter half of 1998. In conjunction with this project, the present geothermal heat plant will be modified into a CHP plant.

The Sudurnes District Heating Plant started building of a new 30 MW power unit, which will replace the oldest 2 MW unit of the existing geothermal CHP plant. Following this expansion, the installed capacity will be 45 MW.

ELECTRICITY PRICES AND TAXES

On 1 April 1997, the wholesale price of electricity supplied by the National Power Company (NPC) to distribution utilities rose by 3.2%. Partly as a result of this, the retail prices of the principal utilities increased between 1.7 and 3.2%.

No changes in electricity taxes were made in 1997. The only tax levied on electricity in Iceland is VAT, which generally stands at 24.5%, but is 14% on electricity used for the heating of apartments.

PRIMARY TRANSMISSION GRID

In the transmission system, NPC put capacitors into use in the 220/132 kV system around Reykjavik. Thanks to this increase, the 220 kV transmission capacity can now be fully utilised. A new power line across Sydlandet, from the hydropower plants in Thjórsá, is under construction. The Ministry for the Environment decided that NPC's plans to build the 400 kV line mean that the environmental consequences of the line must be evaluated in granting the permit. The required study was conducted during the last months of the year, and the authorities are currently evaluating the report. According to plans, the line should be taken into use in November 1998.

The Reykjavik Power Plant (Reykjavik Elverk) started construction of a 132 kV line from the CHP plant at Nesjavellir to Reykjavik. About half of the line will be built as an underground cable, mainly for environmental reasons.

MISCELLANEOUS

Extension of power-intensive industries
The capacity expansion of the smelter of the Alusuisse-Lonza Company at Straumsvík has advanced more rapidly than planned, and it is now in full operation. Construction of the new smelter for Columbia Ventures in Hvalfjödur, just north of Reykjavik — in accordance with a decision made in 1997 — advances according to plans, and half of its capacity is expected to be in use already in mid-summer 1998. Full operation will be introduced at the end of the year.

In 1997, a new power contract between Icelandic Alloys and NPC, pertaining to the 50% expansion of a ferrosilicon plant located in Grudartangi, was signed. The expanded plant will be taken into full operation during the second half of 1999.

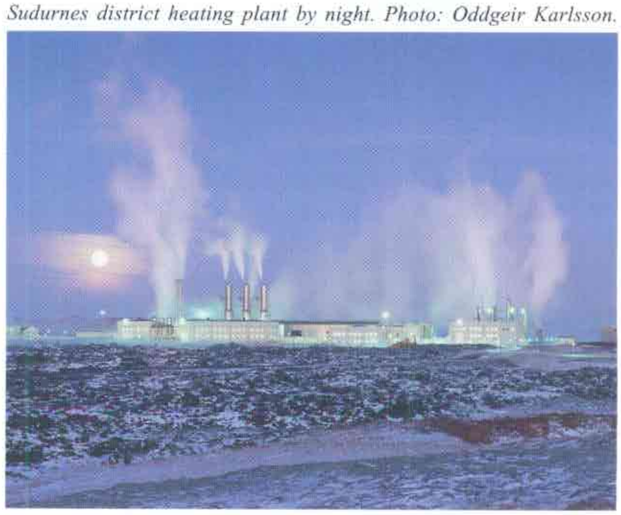
The Sudurnes District Heating Plant has the majority of shares in the Icelandic Magnesium Company. The aim of the company is to build up a magnesium production in the Sudurnes area, enabling a production of up to 53,000 tonnes of pure magnesium and magnesium compounds annually. A study on the profitability of production has come up with positive results, and the company has now entered into negotiations on marketing of the products and financing of the plant.

Power export
In 1997, the Icenet study group and parties concerned in the UK and Germany held talks on the possibilities of further studying a cable interconnection between Iceland and the Continent of Europe, either directly or through the British transmission system. It is considered to be necessary to establish co-operation with one or two foreign partners regarding the project. At a meeting held in November, it was also agreed that changes would be made in the Icelandic project organisation.

NPC will be responsible for the technical, financial and market analyses related to the project, whereas the Ministry for Industry and Energy will be responsible for co-ordination and for negotiations with authorities in other countries and the EU.

The main emphasis will be on investigating how the Icelandic system could benefit from the cable interconnection, e.g. by increasing security and flexibility and by improved utilisation of the power plants. Negotiations with authorities in the countries involved should also be introduced in order to ensure that Iceland, too, can benefit from reductions in CO_2 emissions and the export of power from Iceland, when concerning the fulfilment of its obligations under the decision reached by the UN. The aims of the study include an effort to anticipate the possible consequences of the Kyoto regulations on the power-intensive industries in Europe, which may improve the financial preconditions of the cable interconnection.

Sudurnes district heating plant by night. Photo: Oddgeir Karlsson.



Statnett carries out its biggest distribution project so far by constructing lines to span 30 Norwegian fjords. Lines were fixed and insulated on the power line across the Fjærland Fjord in autumn 1997. Photo: Einar Kr. Holtet.

ENERGY POLICY

The Norwegian Government has appointed a Committee charged with studying the balance of energy and power in Norway as projected to the year 2020. The energy balance will include the permanent energy consumption, i.e. not the transport sector. The Committee will review the central external circumstances influencing the balance of energy and power in Norway, on the basis of alternative versions, up to 2020. At least one of the versions must be based on a development scenario where renewable energy sources cover Norway's energy consumption during a normal year. The Committee will also study measures that can be applied in order to stabilise generation and to achieve a cut in consumption. The study will pay particular attention to the means of planning and organising the measures to be taken. The Committee is expected to submit its report within one year of its appointment (i.e. before 1 July 1998).

In its revised national budget for 1997, the Government took account of the power interchange with Sweden and Denmark and of the long-term power interchange agreements with Germany and the Netherlands. The report on these issues arose from an earlier study by the Norwegian Parliament (the Storting) on the organisation of power trade with Sweden (White Paper no. 11 1995-96) and from a decision, made in the autumn of 1996, concerning a review of the experiences derived from the new ELSAM agreement. The report in question was compiled on the basis of experiences gained during a year that involved considerably low water reserves in Norwegian hydropower plants.

The Government summarised the experiences derived from the power trade between Norway and Sweden in 1996 and 1997 by stating that restructuring of the Swedish electricity market and changes in the power trade between the countries have resulted in a more efficient and flexible interchange of power between the countries. The authorities are co-ordinating the framework conditions in order to prevent unwanted and unexpected effects on the parties involved. In Norway, co-ordination of the Norwegian and Swedish framework conditions is linked with the primary objective of utilising the Norwegian power resources as effectively as possible.

The Ministry of Oil and Energy has come to the conclusion that the cable agreements made are in accordance with the objectives set in Government proposal no. 46 (1992-93), and it sees no need for the Norwegian contracting parties to alter the agreements or licence terms. Neither has the Ministry any reason to believe that the ELSAM agreement or licence terms are not being fulfilled.

The Ministry of Oil and Energy has handled an appeal against a decision handed down by the Norwegian Water Resources and Energy Administration (NVE) that would grant a licence to Naturkraft AS for the building and operation of gas-fired power plants in Kollsnes (350 MW) and Kårstø (350 MW). The Ministry has confirmed the decision by NVE, with the following additional licence terms:

- Naturkraft shall build the plant in such a manner that enables later separation and storage of CO_2.
- Naturkraft shall see to it that the energy content in the condensation water from the power plants is put to use more efficiently.
- Naturkraft shall arrange the necessary checks by environmental authorities during the various stages of the building process.

Owing to these additional terms, the start of the construction project was initially postponed by more than six months, from May 1997, until the Norwegian Pollution Control Authority (Statens Forurensningstilsyn, SFT) had completed its evaluation of Naturkraft's application for an emission permit. The final emission permit is likely to be issued during 1998. At the same time, the Government is preparing a report on the follow-up of the results of the Kyoto Conference for the spring of 1998, to be presented to the Storting. This Government report may influence when building of the gas-fired power plants is begun.

At the end of November 1997, a preliminary plan for the building, at Skogn in Nord-Trøndelag, of a CHP plant based on natural gas from Haltenbanken was presented to the authorities. A new company, called Industrikraft Midt-Norge and owned by Norske Skog (40%), Elkem (40%) and Statoil (20%), has been established for the planning, building and operation of the CHP plant. The installed capacity will be 700 MW, divided between two plants. The annual electricity generation will be approximately 5.6 TWh, the annual exploitation of waste heat totalling about 750 GWh, with a total utilisation rate of roughly 66%. Plans are for construction to begin in 2000, the first plant going into operation in 2002 and the second in 2004. The application for a licence is likely to be filed in the summer of 1998.

ELECTRICITY CONSUMPTION

The total gross consumption in Norway was 116 TWh in 1997, representing an increase of 2.1 TWh (1.8%) on the previous year. The gross consumption in general distribution amounted to 78.4 TWh in 1997, which meant a decrease of 2.1 TWh (2.7%) from 1996. Adjusted for normal temperature conditions, the calculated general consump-

Working high in the air between fells. From the power line near Statnett's facility in Sunndalsøra. Photo: Einar Kr. Holtet.

tion was 80.2 TWh, an increase of 1.0 TWh (1.3%) on the previous year. Consumption in energy-intensive industries totalled 29.7 TWh, an increase of 1.3 TWh (4.7%) on 1996. The total consumption of power for electric boilers and pumped storage power was 6.3 TWh, an increase of 75% on 1996.

The consumption of light heating products (light fuel oils and paraffin) totalled 979 million litres. This represents a decrease of 215 million litres (18.1%) from 1996. The consumption of heavy fuel oils amounted to 383 million litres, which represents a decrease of 38 million litres (9.0%). NVE has estimated the net domestic final consumption of energy for permanent purposes in 1997 at 774 PJ. This represents an increase of 2 PJ (0.3%) on 1996. Electricity consumption accounted for 48.7% of this, which means an increase of 0.8 percentage points on 1996. Petroleum products accounted for 37.9% and solid fuels 12.8%. District heating amounted to about 0.6%.

The peak load occurring in domestic consumption, including electric boilers and pumped storage, was recorded on 4 December 1997 at 9 a.m., when it reached 19,528 MW. This represents a decrease of 1,719 MW from 1997, when the highest consumption ever in Norway was registered. At the peak-load hour, exports amounted to 629 MW.

ELECTRICITY PRODUCTION

The figure recorded for hydropower generation in 1997 was 111.3 TWh. With the addition of 0.7 TWh in thermal power, total generation amounted to 112.0 TWh. This is 7.1 TWh (6.9%) higher than generation during the previous year. The interchange of power with other countries resulted in net imports of 4.0 TWh. This represents a decrease from 1996, when net imports amounted to 9.1 TWh.

New net generating capacity in 1997 totalled 30 MW, with an average annual output of 158.9 GWh. The capacity is distributed between eight water bodies.

NVE estimated the average yearly output in the Norwegian hydropower system on 1 January 1998 as 112.9 TWh, based on data for the period extending from 1931 to 1990. In addition, Norway has thermal power plants with an average annual output of 0.8 TWh. The total power output in Norway in 1997 was consequently 0.7% lower than the calculated average annual figure. The installed capacity of hydropower plants on 1 January 1998 totalled 27,390 MW. The reservoir capacity on the same date was 84.4 TWh.

ELECTRICITY PRICES

The Norwegian Authority of Competition estimated the weighted average price for electricity paid by households on 1 January 1998 as NOK 0.305 per kWh, including electricity tax and VAT. The average weighted transmission price for households, excluding taxes, on 1 January 1997 was calculated as NOK 0.179 per kWh, the corresponding figure for 1 January 1998 being NOK 0.186 per kWh. Consequently, the increase in transmission prices during 1997 was 3.9%.

An electricity tax is levied on consumption. Manufacturing industries, mining, greenhouses and electric boilers have been exempt from this tax since 1995. Consumers in the counties of Nord-Troms and Finnmark are also exempt from the electricity tax. In 1997, the tax amounted to NOK 0.0562 per kWh; it rose to NOK 0.0575 per kWh in 1998. The generation tax levied on all electricity generated in 1997 was NOK 0.0139 per kWh. This tax was abolished in 1998, when a natural resource tax of 0.012 per kWh is being levied on hydropower production. The tax is calculated on the basis of the amount of power actually generated during the past seven years. As with other goods and services liable to VAT, electricity was subject to a value-added tax of 23% in 1997. The three northernmost counties are exempt from VAT.

MAIN GRID

There were some transmission limitations in the Norwegian main grid in 1997. Some were due to reparation work, but considerable regulation expenses have also arisen in the grid. There has, for example, been a full load in the interconnections from Sweden to the south of Norway and from central Norway to Sweden. Statnett and Svenska Kraftnät have expanded their co-operation on balance regulation so that the cheapest regulating resources in Norway and Sweden will always be used.

Otherwise, the year was rather uneventful with regard to the operation of the main grid. There were no considerable disturbances in operation concerning the Nordic joint use of the main grid during the year.

Plans for further expansion of the main grid are closely related to the three cable links decided upon between Norway and Germany and the Netherlands, and the planned gas-fired power plants in Norway.

NVE has granted Statnett a licence for building and operating a 420 kV line between Evje and Kristiansand. The need for a new line of 420 kV stems from the increased power interchange between Norway and Denmark as of 1998 and from an increase in the local consumption in the Kristiansand region.

The line will initially be operated with an operating voltage of 300 kV, but it will later be increased to 420 kV in connec-

Transport of transformers and other heavy machinery in the power business requires heavy-duty equipment. Statnett put to use a new, powerful trailer in 1997. The trailer was manufactured in France and it is the biggest of its kind in Norway. It is 57 metres long, has 96 wheels and weighs 119.5 tonnes. Photo: Einar Kr. Holtet.

tion with its extension to the Holen power plant. This is necessary in order to ensure southern Norway's transmission capacity to the new cable interconnections to Europe. An appeal against NVE's decision was lodged with the Ministry of Oil and Energy, which will make the final decision.

NVE has reached a decision concerning a dispute over the coverage of the central grid that stemmed from a decision made by Statnett's Board of Directors. Customers of the central grid, e.g. an association formed by customers and called Statnettkundenes Fellesorganisasjon (SFO), had complained against the decision made by Statnett, lodging an appeal with NVE. The central grid is characterised by a common national tariff area within the Norwegian main grid. The tariffs in the central grid in Norway correspond to the Swedish base grid tariffs in the joint power market of Norway and Sweden.

In its decision, NVE has defined the criteria for the lines and cables that are included in the central grid:

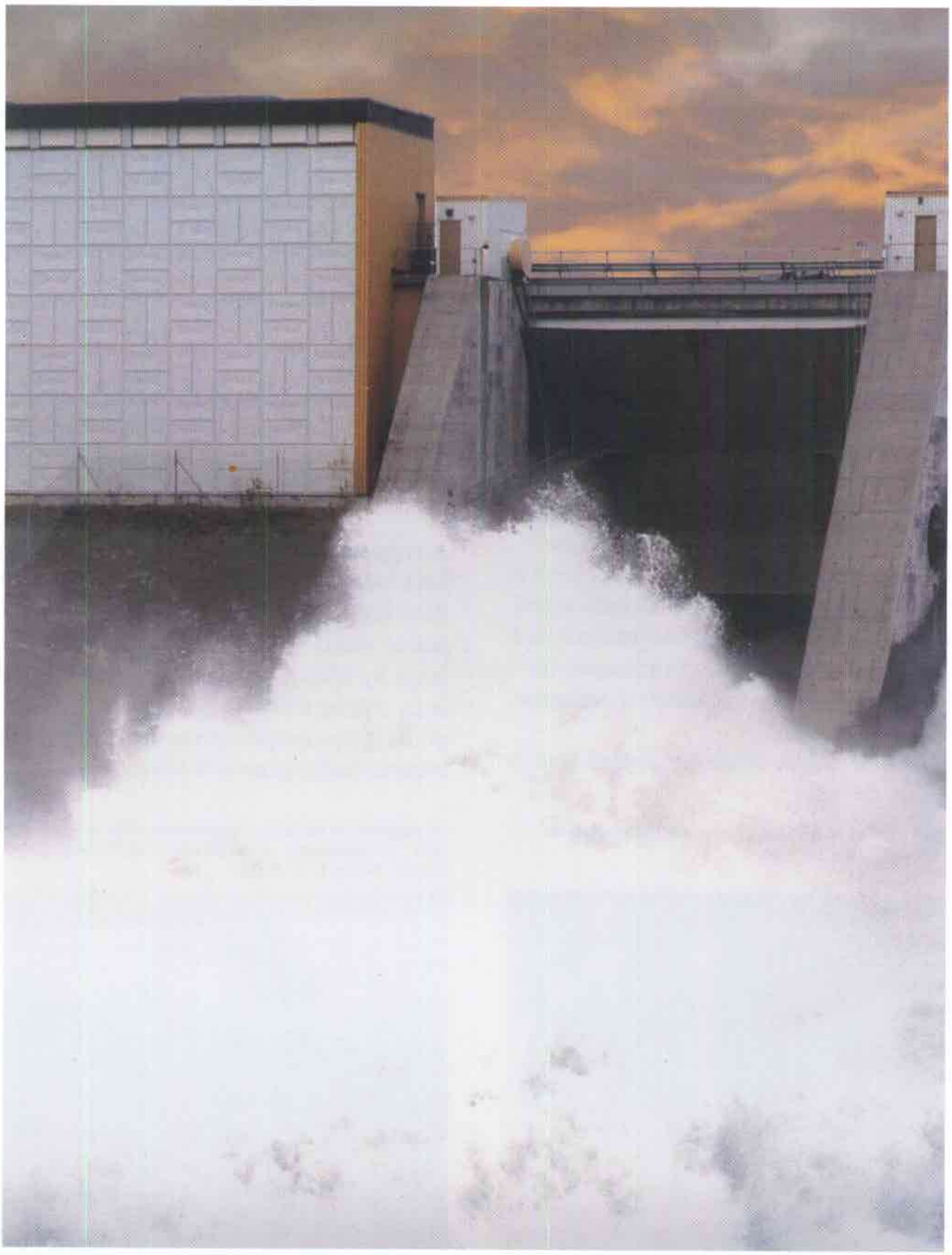
- The central grid shall cover all provinces and regions, and shall consist of lines and cables with the highest voltage in each county and region. The voltage levels of 300 kV and 420 kV are regarded as equal in regions where both exist. Lines with 132 kV are included in the central grid in areas having no 300 kV or 400 kV lines.
- Only the parallel grids with the highest voltage level in each county and region are included in the central grid.
- All interconnections with other countries are included. The lines from the central grid that are necessary for transporting energy to foreign interconnections are included in the central grid.
- Step-down transformation from the central grid is added to the regional grid.
- Production and industrial radial lines at the highest voltage level in each county and region can be included in the central grid, if this does not conflict with NVE's recommendations.

An appeal against the decision handed down by NVE was later lodged with the Ministry of Oil and Energy, and the final decision will be made by Statnett and several other power plants. The consequences of the decision handed down by NVE have been discussed widely in Norway. As costs will be transferred from the central grid to regional grids, the geographic price differences between different counties and regions will increase.

Circuit breakers at Kristiansand transformer station.
Photo: Tor Oddvar Hansen.

Two men in the mast. Working on the 132 kV line amidst the natural beauty of Nordmarka near Oslo.
Photo: Bjørn Brekken.

Installation by means of a helicopter. This technique is mastered by Statnett Entreprenør and Norsk Lufttransport in co-operation.
Photo: Svein Erik Dahl.



Porjus power plant. Photo: Hans Blomberg.

ENERGY POLICY

The issue of nuclear power continued to play the main role in Swedish energy policy during 1997. On 4 February, an agreement on the long-term objectives of energy policy was reached by three political parties represented in Parliament: the Left, the Centre Party, and the Social Democrats. The other four parties represented in Parliament had left the negotiations by that time.

On the basis of the agreement between the three political parties, the Government drew up a proposal on energy policy, which was approved by Parliament on 10 June. In brief, the decision by Parliament meant that 2010 was no longer specified as the year by which use of nuclear power will cease. One reactor in Barsebäck will be closed down at the latest on 1 July 1998 and the second reactor at the latest on 1 July 2001. Closing down of the second reactor is conditional; the reactor may not be closed down if it cannot be shown that reduced power consumption and new electricity generation capacity are able to cover the production capacity lost.

Together with Parliament's decision on energy policy, the administrative organisation of the energy sector was modified so that energy issues were removed from NUTEK (*Närings och teknikutvecklingsverket,* Institute for the Development of Business and Technology), and a separate energy authority was created. *Statens Energimyndighet* (State Energy Authority), located in Eskilstuna, is the central administrative authority in questions pertaining to energy use and supply. The duties of the authority include responsibility for the supervision of network operations. In its programme declaration, the authority stresses the importance of promoting a cost-effective and environmentally sound energy system.

Besides the decision on energy policy, Parliament reached a decision in December on introduction of a special law on cessation of operations, which entitles the Government to revoke the reactor owner's right to operate its nuclear power reactor.

Inauguration of the series capacitor station in Isovaara. From left: Uno Jonsson, project leader, Timo Toivonen, Fingrid, and Allan Lundberg, Svenska Kraftnät. Photo: Svenska Kraftnät.

The Government has decided that the right to operate Barsebäck 1 will cease at the end of June 1998.

Sydkraft AB has notified the European Commission of the decision, claiming that it is in conflict with the rules governing competition within the EU. Barsebäck Kraft AB has appealed to the Swedish Supreme Administrative Court, demanding that the decision should be annulled since it clashes with the Constitution, the Treaty on the European Union, and EU legislation. At the same time, the Government and Sydkraft have continued their dialogue on a voluntary agreement.

During the year, the Swedish energy tax legislation was under comprehensive scrutiny within the Government. In 1998, the Government intends to draw up proposals for an overhaul of the entire Swedish energy taxation system that would become effective as of the year 2000. The current energy tax system is considered to be too obscure, and the overall effects of the system on the energy sector are therefore unclear.

During the year, Parliament made a decision to replace the Electricity Act of 1902 and the Act on Electricity Trade of 1994 with a new, updated Electricity Act that would come into effect on 1 January 1998. In the main, the new Act has the same contents as the old Act. However, new and more comprehensive definitions of system responsibility and consumer protection have been added.

ELECTRICITY CONSUMPTION

Electricity consumption in 1997 amounted to 142.2 TWh, which is 0.3 TWh less than in 1996. Transmission losses accounted for 9.7 TWh of the total. Weather conditions during the past year were slightly above the normal in terms of temperature. Adjusted for temperature, electricity consumption is thus corrected by 0.7 TWh, to 143 TWh.

Industry's use of electricity increased by 3.5 per cent in 1997. Total consumption of electricity by industry came to 53.2 TWh. The food and timber processing industries used 2.4 and 2.0 TWh of electricity, respectively.

Series capacitor station in northern Finland. Photo: Svenska Kraftnät.

The pulp and paper industry, which is the most electricity-intensive industrial sector in Sweden, increased its consumption by 1.2 TWh, to 20.4 TWh. Consumption by the rail and tramway sector was 2.8 TWh, or the same as the year before. Consumption of electricity in the sector of housing, services, heating plants, etc. came to 73.8 TWh, or 2.6 TWh less than the year before.

The interchange of power with neighbouring countries rose during 1997. Sweden exported 12.9 TWh and imported 10.2 TWh, which gives a surplus of exports over imports amounting to 2.7 TWh, compared to a deficit of 6.1 TWh in the previous year.

ELECTRICITY SUPPLY

Electricity output totalled 144.9 TWh, or 8.9 TWh more than the year before. Hydropower plants generated 68.3 TWh, which is 4.6 TWh more than the mean annual output and 17.3 TWh more than in 1996. Availability of water was good after ample spring floods, whereas runoff volumes were more limited during autumn. Reservoirs were 51.0% full at the end of the year, equivalent to an energy value of 17.1 TWh.

Electricity generated by the nuclear power plants in 1997 came to 66.9 TWh, or 4.5 TWh less than the year before. The principal reason for the lower output by the Swedish nuclear power plants was the extended maintenance outage at Ringhals 1, but the longer outage at Forsmark 1 also contributed to the lower output.

The energy availability rate was 78.8%, which can be compared to the world average of 75.3% for light-water reactors in 1996 (the latest total figures available for the world – reactors in the former Soviet Union are not included in the weighted world figure). Of the Swedish reactors, Oskarshamn 3 recorded the highest availability rate at 90.9%, followed closely by Ringhals 2 at 90.3% and Forsmark 3 at 90.1%.

Back-pressure generation amounted to 9.1 TWh, or 0.9 TWh less than in 1996. Output from condensing power plants, gas turbines, etc. stood at 0.5 TWh, or 3.1 TWh less than the year before. Output by wind power increased to 0.2 TWh, compared to 0.145 TWh in 1996.

During the year, 83 MW of production capacity was installed: 29 MW of hydropower at Kvarnsveden, 41 MW of biofuel-fired capacity at Bristaverket and 13 MW of gas-fired capacity at Högsbo.

ENVIRONMENTAL ISSUES

By international comparison, the present-day Swedish electricity generation system takes environmental aspects into consideration very well. Enforcement of Parliament's decision on energy policy involves the risk that the burden on the environment caused by Swedish electricity consumption will increase. The cost structure in the Nordic system favours acquisition of additional electricity primarily from Danish coal-fired and Finnish natural gas-fired power plants. Compared to utilisation of the Barsebäck power plant unit, this shift in production will increase the emissions of harmful substances, such as carbon dioxide.

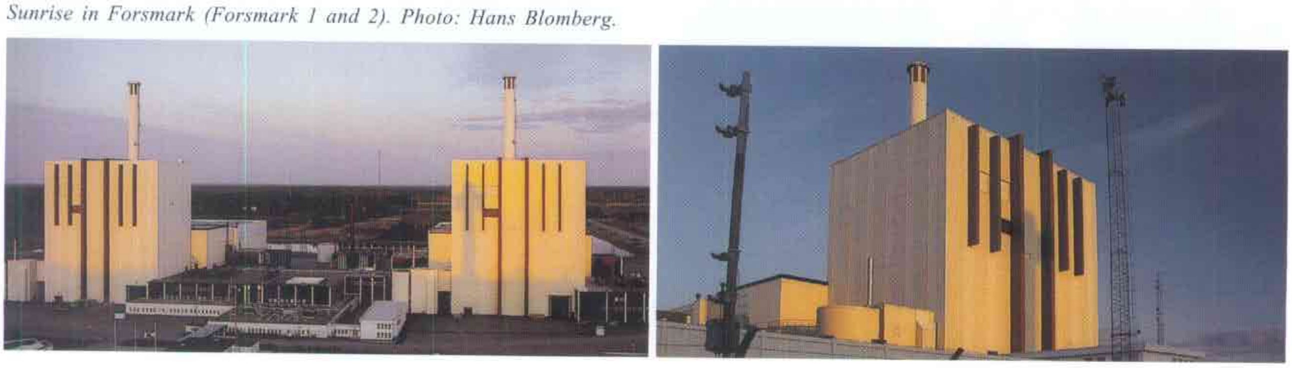
This trend appears problematic, not least against the background of the agreement on greenhouse gases that was concluded by 140 countries in Kyoto, Japan, on 10 December 1997. It is estimated that the compromise reached in Kyoto will help reduce emissions of atmospheric gases by a good five per cent between 1990 and 2008-2012. The EU Member States, which negotiated as a group, should cut their emissions by eight per cent.

It is not yet clear what consequences this agreement will have for Sweden in the end. Some indication may be obtained from the outcome of negotiations conducted earlier within the EU, where Sweden was given leeway for a 5% increase in its carbon dioxide emissions. The Kyoto agreement lies on a level which might involve a somewhat, but not essentially, higher emission level for Sweden if burden-sharing within the EU remains the same as before.

MAIN GRID AND INTERNATIONAL LINKS

A new series capacitor station, built on the 400 kV line between Svartbyn and Finland, increased transmission capacity by some 150 MW, providing more opportunities for electricity trading. The station was commissioned on 7 October. In Finland, a corresponding station has been built on the other 400 kV link. In total, transmission capacity has thus increased by 300 MW.

Sunrise in Forsmark (Forsmark 1 and 2). Photo: Hans Blomberg.



The control stations in Letsi and Rätan were rebuilt. The 220 kV line between Hällsjö and Söderala was upgraded.

A new 400 kV 150 Mvar reactor was installed at Vargfors and two existing reactors were removed from service. Optical-fibre links have been installed along existing lines between Malmö and Stockholm and along crosswise links, a total of 770 km.

ELECTRICITY PRICES

In its report on development of the electricity market, published in November, NUTEK concluded that electricity prices had risen among most consumer categories at the turn of the year 1996/97. The rise was between 2 and 7 per cent, depending on the consumer type. According to NUTEK, the price increase was principally the result of the rise in the production tax on electricity on 1 September 1996, which had repercussions on electricity prices in 1997. The shortage of hydropower in the latter half of 1997 is also deemed to have contributed to the price hike. The price range among suppliers has narrowed down in comparison to the previous year. The statistical basis with respect to major electricity consumers is very limited. It is estimated that electricity prices for this consumer category have fallen.

In 1997, the Swedish Parliament decided to raise the energy tax on electricity as of 1 January 1998 to two different levels, SEK 0.152 or SEK 0.096 per kWh. In 1997, these taxes were SEK 0.138 and SEK 0.082 per kWh, respectively. The lower tax is payable in some areas of Norrland, while the higher tax is levied elsewhere in the country. During the year, Parliament also decided to lower the tax on hydropower plant premises from 3.42 per cent to 2.21 per cent of the taxable value.

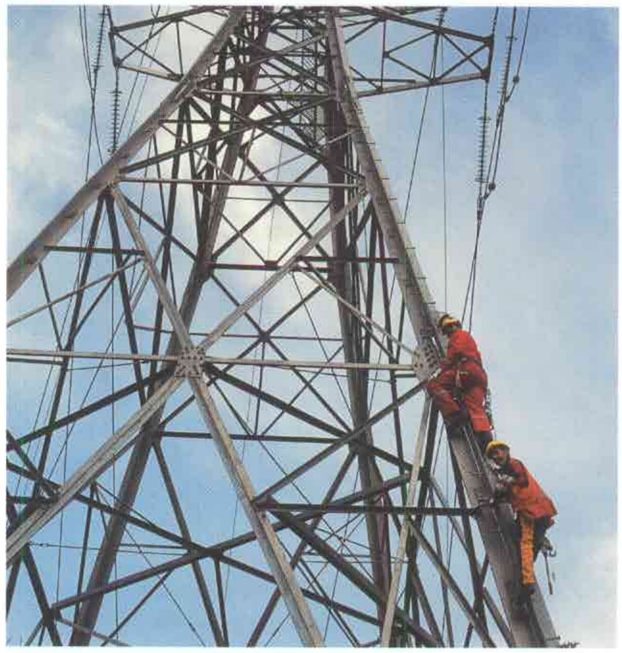


Photo: Kurt Pettersson/Tre fotografer.

In 1997, electricity generated by wind power increased by 36 per cent on the previous year, even though 1997 was less windy than the average. Photo: Perry Nordeng.

ELECTRICITY GENERATION IN THE NORDIC SYSTEM — ENVIRONMENTAL IMPACT FROM THE CRADLE TO THE GRAVE

INTRODUCTION

Within the Nordel region, electricity is generated by means of a number of different technologies, all of which have their own special characteristics. Together they form a stable system of reliable power supply; the system is cost-effective and also relatively benign to the environment.

The system is dominated by hydropower, which accounts for roughly 50% of the total output of electricity within Nordel. The percentage accounted for by hydropower varies from year to year, depending on rainfall. In some places, the system has reservoirs of a very high regulating capacity. Nuclear power accounts for about 25% of total output and provides for stable base-load power generation. The remaining 25% is generated by means of coal, oil and natural gas at co-generation plants or at condensing power plants. Co-generation of heat and electricity has a high total efficiency ratio since the heat produced together with electricity can also be put to use. However, this application has some limitations, too, because electricity may be needed at times when there is little demand for heat. In years when there is not much rain or when there are problems at nuclear power plants, the extra demand is largely met by fossil-fuelled power plants.

From the environmental perspective, the Nordel system is markedly better than the system that exists elsewhere in Europe (EU), at least with respect to the conventionally recorded emissions of CO_2, SO_2 and NO_X.

The traditional way of describing the environmental impact is to apply the "chimney perspective", i.e. to focus on emissions into air and into water during operation. By choosing a wider perspective, the examination encompasses the whole production cycle, from mining to decommissioning and waste management. This is the life cycle perspective. But this perspective, too, is limited because it generally concentrates only on normal operation. Malfunctions that are common and have a high frequency may sometimes be included, but major disasters – such as nuclear power plant accidents, breakdown of hydropower dams or large-scale fires at oil wells – are not considered.

THE NORDIC PRODUCTION SYSTEM

The Nordic electricity system is interconnected, but since the market is free and deregulated, it is the economic considerations of individual actors that principally determine how the system is operated. The various production technologies have different characteristics of supply, and a power system becomes more reliable and more robust when a mixture of different technologies is developed. The various technologies are not interchangeable as concerns power supply. Moreover, power generation technologies have widely different environmental characteristics, and the potential environmental effects are different and cannot always compared.

Hydropower
Hydropower has been utilised in the Nordic countries for over 100 years. Availability of water varies during the course of a year and does not coincide with electricity demand. For this reason, large reservoirs are needed for storing wa-

Emissions from Nordic and European power production

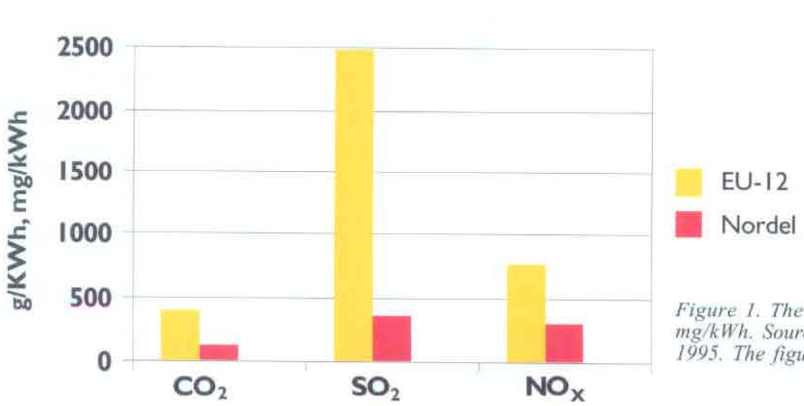


Figure 1. The unit for CO_2 is g/kWh and that for SO_2 and NO_X is mg/kWh. Source: IEA; Energy statistics and OECD countries. 1994-1995. The figures refer to the operating phases of systems.

ter. The reservoirs make it possible to regulate electricity production in quick response to consumers' demand.

The impact of hydropower on the environment is local and manifests itself differently in the different Nordic countries. However, a common feature in the Nordic countries is that methane emissions from water reservoirs are generally a very small problem, compared to the situation, e.g. in Canada and Brazil. The reason is that the large reservoirs here are situated in very hilly terrain, especially in Norway and Sweden, which means that the areas flooded by water are relatively small. In addition, soil layers are thin and biological activity is low.

As a rule, construction of reservoirs, dams and power plants brings about radical changes in the landscape. Water to and from the power plant is sometimes led in long tunnels, which means that flow volumes in the original riverbed are diminished drastically and sometimes the riverbed runs completely dry.

The rising and falling water level affects plants and animals living by the reservoir. Areas lying between the highest and lowest water level lose a considerable proportion of their biological diversity. Dam structures and power plants block the natural migration routes of migratory fish, particularly salmon. Generally, however, these regulated lakes constitute a large and continually exploited resource for professional and sport fishing. Other features may also be experienced as positive: there are fewer floods when rivers overflow in the spring, and new roads are constructed for use by the local population and tourists.

During the construction and operation of power plants, the manufacture of cement, steel and timber involves the greatest use of resources and results in emissions of CO_2, SO_2 and NO_X. Construction machinery also gives rise to emissions when earth and stones are moved. Utilisation of resources and emissions are considerably lower during the operation of hydropower plants than during their construction. Chemicals are used during operation, but their volumes are not particularly high.

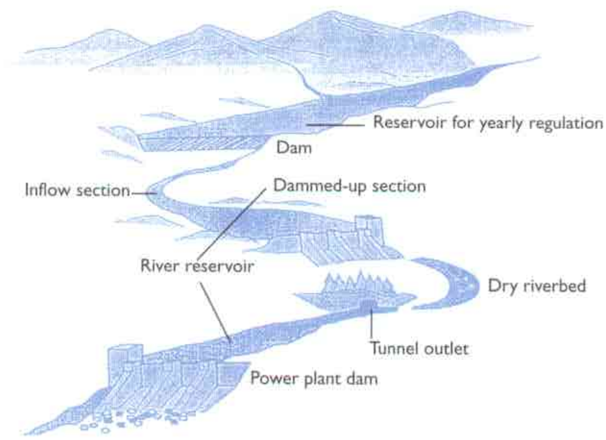


Figure 2. Various components that may be included in a hydropower plant system

Nuclear power

During normal operation, the greatest environmental impact of nuclear power comes from the manufacture of fuels and from the handling of waste material. Fuel production can be divided into uranium mining, conversion, enrichment and fuel manufacture. This chain involves a variety of transports.

Spent fuel is placed in interim storage and, in the Nordic countries, disposed of in a repository. Spent fuel may also be sent out for reprocessing. Resources for construction and transport are also needed during this part of the chain. According to plans, spent fuel from the Nordic power plants

Principal processes - nuclear power

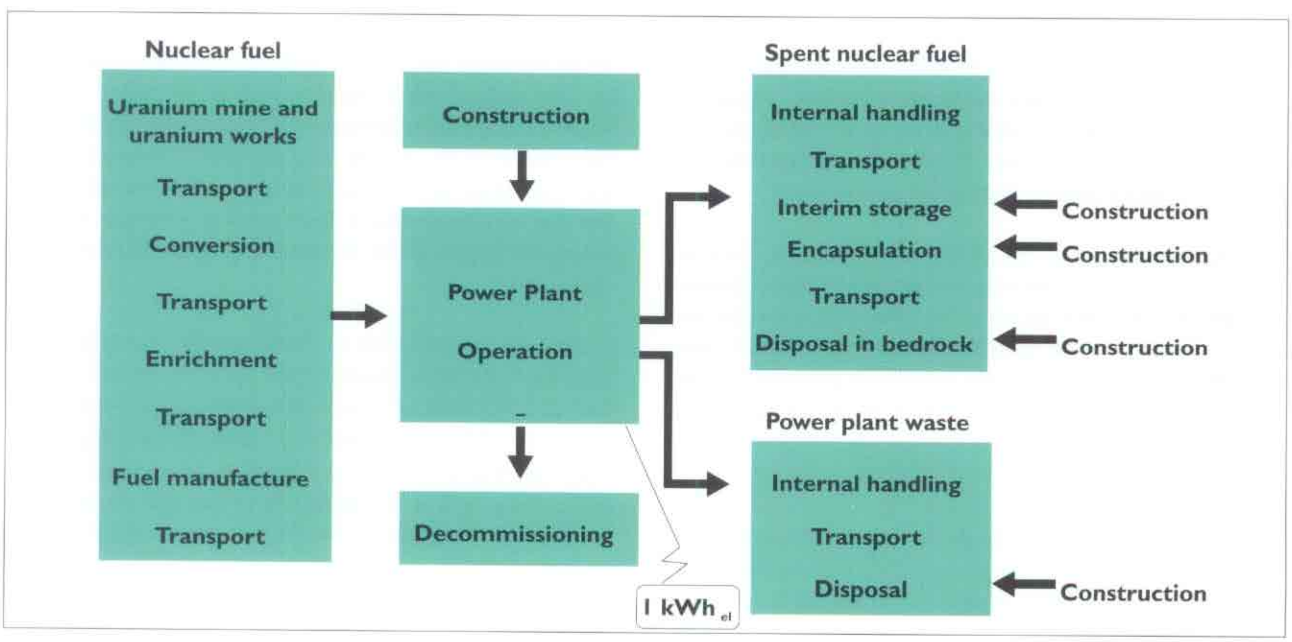


Figure 3. Principal processes during the life cycle of nuclear power

will be encapsulated in copper, steel and bentonite and placed in a repository in the bedrock. The metals used for the purpose will then be lost and cannot be recovered.

During the construction phase, the manufacture of construction material, such as cement, steel and timber, involves the most widespread use of resources and the greatest emissions into air. During the operation of nuclear power plants, emissions per kWh of electricity are of the same order of magnitude as during construction. Most emissions come from the manufacture of chemicals and from the transport of radioactive waste.

Releases of radioactive material during the manufacture of fuel, operation, and waste management remain below the limit values determined by the authorities in each country. Uranium mining, like any other mining, has a local impact on the environment.

Coal

Coal-fired power plants are used particularly in Denmark and Finland, which have fewer indigenous energy sources. Imported fuel can be utilised to the maximum when there is also an opportunity to make use of the heat generated; this is usually the case in Denmark and Finland. Finland also has some condensing power plants.

The environmental impact of coal-fired power is spread over the entire life cycle, but the dominating phase is the operation of the power plant. Generally, 90% of greenhouse gases during the life cycle stem from the operating phase. For acidifying substances, such as SO_2 and NO_X, emissions during transport and coal mining become gradually more important in relative terms. Some emissions of these substances into air and into water occur during operation. In order to reduce the emissions into air, many technical solutions are used, such as low-NO_X burners, electrostatic precipitators, desulphurisation plants and catalytic converters.

Coal is mined either in open cuts or in underground mines. Open-cast mining usually consumes less energy and involves fewer occupational accidents than work in underground mines. However, mining has a great number of other environmental effects, too. Most of the coal used within Nordel is transported by boat to the power plant.

Burning of coal gives rise to residual products, such as slag, fly ash and desulphurisation products. These residual products can often be used for other purposes; for instance, fly ash can be used in cement and concrete, and gypsum from desulphurisation is used for gypsum boards. Waste that cannot be utilised is placed in special repositories.

Natural gas

Natural gas is used increasingly for electricity generation in the Nordic countries. This is especially true for Denmark and Finland. The gas that is used in Norway and Denmark comes from the North Sea, whereas the gas used in Finland comes from Russia. Energy is needed for the drilling of gas, and some gas is emitted directly into the atmosphere during the process. Requirements at off-shore facilities are less strict than requirements on dry land, and NO_X emissions from natural gas production can therefore account for a considerable proportion of the total emissions.

Natural gas is transported in a pipeline from the source to the end user. Emissions from the Russian piping system are relatively high, but the major leaks occur most often in the local distribution network, not in the transmission pipeline. Because the gas leaked is methane, the leaks are also important from the point of view of the greenhouse effect; methane is 21 times more effective as a greenhouse gas than CO_2.

In the main, burning of natural gas gives off CO_2 and NO_X. As in the case of other fossil-fuelled power plants, energy consumption and atmospheric emissions during construction and decommissioning account only for a small percentage of the total.

Bioenergy

Bioenergy is an umbrella term for many different fuels and systems. It may involve specially cultivated products or by-products from forestry and agriculture. Peat is sometimes included in biofuels.

Biofuels are used to a relatively great extent for heat generation and at co-generation plants, but only rarely at condensing power plants for electricity generation.

Forest fuel consists of chipped logging waste, such as twigs, branches, treetops and small trees. Utilisation of logging waste means mineral losses for the forest system. If forest fuel is used extensively, ashes from the combustion must be returned to the forest in order to maintain the long-term production capacity of the soil. Humus reserves are an important factor.

In agriculture, straw is a residual product that is used, above all, in Denmark and for heat generation. Cultivation of willow for energy use is another way of obtaining biofuel. Willow fields can be harvested 3-7 years after planting, and harvesting can be repeated roughly half a dozen times before new planting becomes necessary. Cultivation of willow has environmental effects such as changes in landscape, the impact on the flora and fauna, and nutrient leakage.

During the construction of facilities, the manufacture of building material accounts for the major resource exploitation and the bulk of emissions. During operation, most emissions of SO_2, NO_X and CO_2 derive from fuel production, fuel transports and combustion. In view of the life cycle of biofuel, it is justified to ignore the emissions of carbon dioxide during combustion at power plants.

Wind power

Most wind power plants in the Nordic countries are located in Denmark, where about 2.5% of total electricity is generated by means of wind power. The most important effect that a wind power plant has on the environment is the impact on the landscape. To some extent, this impact can be described as an areal one since wind power needs a little more land area than many other energy types. However, much of the area can be used for agriculture. It is likely that wind power plants will be built increasingly at sea, in order to reduce the impact on the landscape.

Emissions to the ground and water stem mostly from the use of energy and resources during the construction of the power plants. Materials are needed for the machine house, the tower and turbine blades. The electricity that is needed for the construction and operation of a wind power plant corresponds to the output of 3-4 months at a corresponding plant.

Transmission

The electricity that is produced is transmitted via a network at different voltages to end users. The Nordic countries have a highly developed network that makes interconnected operation of the electricity system technically possible.

Electricity is transformed from the transmission network gradually down to lower voltages until it finally reaches the end users. The system includes overhead lines and pylons, underground cables, transformers and switch plants.

The environmental impact of transmission is mainly the result of transmission losses, which means that more electricity needs to be produced to supply the requested amount to the client.

The clearings needed for power lines in forests can promote biological diversity. The clearings create environments that are today becoming less and less common in farming areas, where land is allowed to become overgrown or is used for silviculture.

All electrical devices and power lines have electrical and magnetic fields around them. The research findings obtained so far have not given cause to set any limit values for low-frequency fields, but there is reason to apply precaution and to strive to reduce fields that differ sharply from what is considered normal in each environment. At present, it is difficult – if not impossible – to assess the effects of fields on the environment.

LCA

What is it?

The goal of a life cycle analysis, or LCA, is to obtain an overall picture of the environmental impact that a product, a process or an activity has from the cradle to the grave. An attempt is made to identify and quantify all factors that are important for the use of resources and for the environmental impact. All phases during the life cycle are analysed: from extraction and processing of raw materials and energy sources to manufacture, transport, use and disposal.

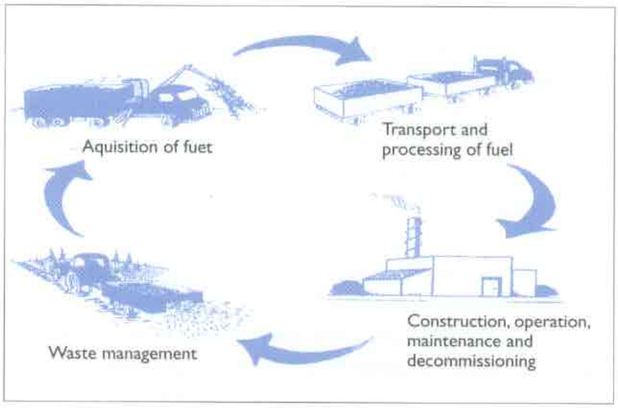


Figure 4. Steps in an LCA for biofuel. Basic principles

A general structure and methodology have been devised for carrying out life cycle analyses. The process is interactive; new needs may manifest themselves at the same time as data are gathered.

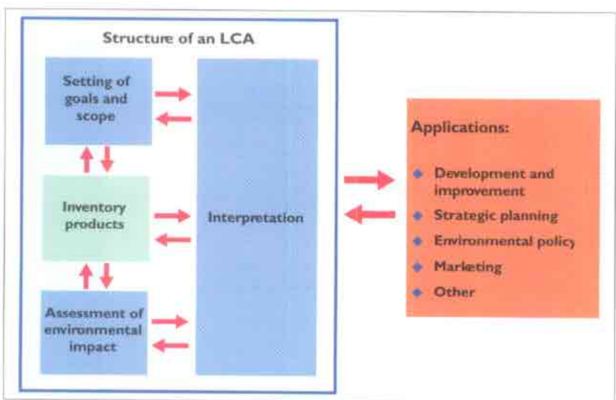


Figure 5. The overall structure for carrying out LCA work

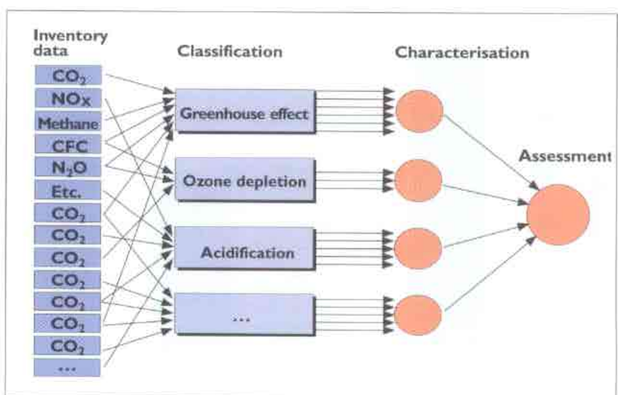


Figure 6. In assessment of the environmental impact, the inventory data can be combined step by step and weighed together to enable assessment of the potential environmental effects. The figure shows a schematic presentation of the various stages in a complete LCA.

The first phase, setting of goals and scope, determines the goals and purpose of studies. A very important part of this is definition of the functional unit, i.e. the benefit that is produced by the system and to which all data are related. For the energy sector, the functional unit can be kWh produced or supplied.

The goal of the **inventory** is to identify and quantify all material flows and energy flows into and out of the system under study.

The goal of the assessment of **environmental impact** is to describe the potential environmental effects that the life cycle may have.

Standard ISO 14040 contains a detailed description of LCA and its various steps.

Why is it done?

There are several reasons for conducting life cycle analyses covering a power company's electricity generation and distribution systems and other products and services. Pressure from clients is increasing. LCA is also a way of studying and verifying the work done by the company for constant improvement of the environment. Another reason is that, through an LCA, power producers obtain an overall view of the utilisation of resources and of environmental effects, and can compare different alternatives for new power production in the future.

Electricity is used in almost all manufacture. Many manufacturers conduct their own life cycle analyses and need a good basis for describing the role of electricity in the utilisation of resources and in the environmental impact of products. (The LCAs conducted so far in the energy sector have for the most part stopped at classification.)

Demand for reports on environmental effects is increasing, and these will probably be partly based on life cycle analyses. In Sweden, the Government has commissioned AB Svenska Miljöstyrningsrådet to administer a system of certified environmental reports. The certification applies to life-cycle-based information that is founded on scientific analyses and obtained through a standardised working method. Similar initiatives have been presented in the electricity sector in Finland.

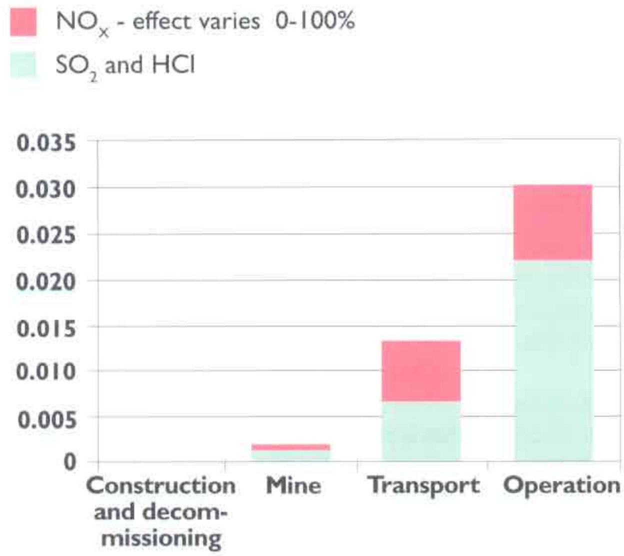
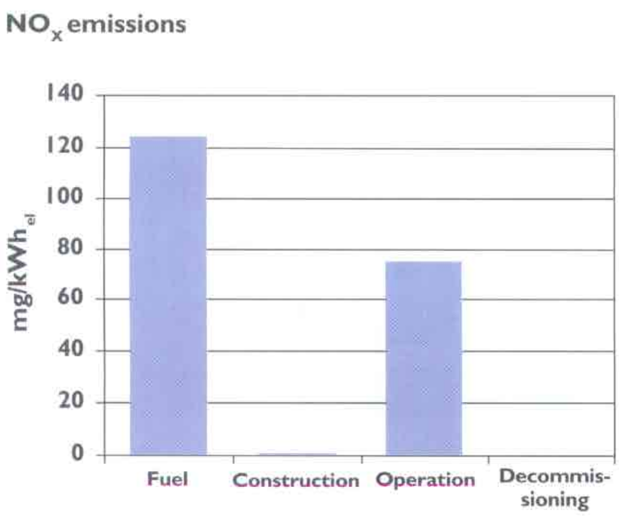


Figure 8. Acidification effects in the coal cycle.

EXAMPLES OF FINDINGS FROM VARIOUS STUDIES

An early analysis of a gas-fired combined-cycle plant, conducted by Vattenfall, showed that NO_x emissions from the power plant were surprisingly low when compared to NO_x from gas fields. The reason was the different, strict purification requirements. Thereafter, major efforts have been taken in order to improve the environment and to reduce emissions at gas fields.



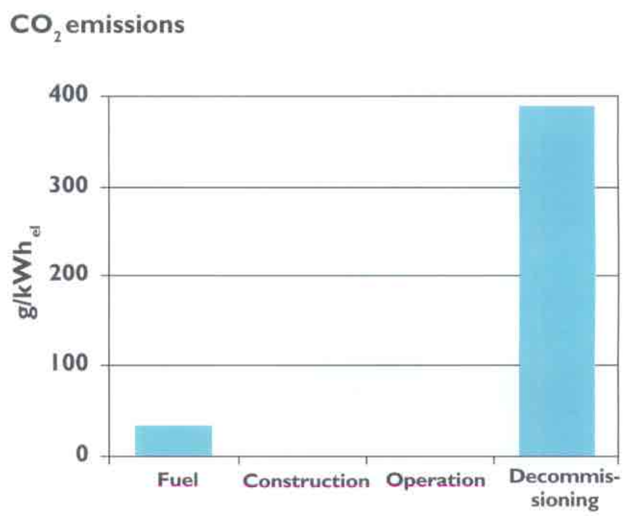


Figure 7. Emissions of CO_2 and NO_X in the various phases of the life cycle of natural gas used as fuel. (LCA by Vattenfall.)

Analyses show clearly that emissions of greenhouse gases and acidifying substances during the construction and decommissioning of facilities are very small in comparison to the combustion of fossil fuels in power plants.

Use of storage facilities partly depends on how material can be recovered. One example is use of iron and copper in the nuclear power cycle. The waste disposal methods that are studied for the Nordic nuclear power plants mean that the metals are lost as a result of their disposal in the bedrock. The copper in cables that can be recovered does not involve a particularly high load on the environment.

New large coal-fired power plants have effective sulphur and nitrogen removal systems, but even so, the emissions from operation are twice as high as from coal transports. The simplest way of reducing these emissions in the coal fuel chain may still be the use of low-sulphur fuels for transports, as well as low-NO_x engines in ships. However, acidifying emissions at sea may probably be less harmful than corresponding emissions on land.

ACTIVITIES WITHIN THE NORDIC COUNTRIES

In Denmark, extensive development of LCA has taken place within the past 5–10 years, above all through a programme supported by the National Board of the Environment and a number of major enterprises. ELSAM began life cycle work on coal in 1996. A co-operation project was launched in 1998 between ELKRAFT, Eltra and ELSAM to describe the life cycle per one kWh of electricity and district heat supplied to the end user.

In Sweden, there is an LCA competence centre at Chalmers (CPM). The centre is shared by *Närings och teknikutvecklingsverket* (Institute for the Development of Business and Technology), Chalmers and a number of major enterprises. *Institutet för Vatten och Luftvårdsforskning*, IVL, (Institute for Water and Air Research) has for a long time worked on LCA and on the development of methods for LCA. Many enterprises and university departments conduct analyses. The analyses carried out by Vattenfall on electricity production and distribution are described in brochures; for the analysis on production there is also a summary report. Sydkraft has conducted analyses on its production and describes these in a brochure.

In Norway, Statoil and Norsk Hydro have started an LCA, which includes production of oil and gas from the North Sea and electricity generation at natural gas-fired power plants. The work has just begun, and no concrete results are available yet.

In Finland, all the principal actors on the electricity market participated in an LCA project on energy production (SEEP). By means of questionnaires, SEEP gathered LCA data on fuel trading, transports, storage, energy conversion processes, transmission of electricity, emissions, by-products, and waste. Construction of the actual power plants and infrastructure was excluded. The resulting database can be used as basic data for the energy component of the life cycle analyses of various products. The electricity sector has recommended introduction of specifications on the environmental effects of products. Work to prepare a proposal on the contents of these specifications will begin in 1998.

SUMMARY AND CONCLUSIONS

The general conclusion on the environmental aspects of electricity within Nordel is that the situation is relatively good. At the same time, work aimed at finding and introducing improvements continues. Life cycle analysis has been a tool for expanding the perspective and for including environmental issues outside the power plant's gates in the discussion. As a result, companies will have arguments to justify the requirements they place on their suppliers.

The wider perspective will probably also serve to assist politicians who want to find the right signals to send to the market for steering developments in an optimal manner towards the desired goal of a "better environment", a goal that we all want to achieve. It may then be easier to determine where improvements in the environment can be made effectively and at the lowest costs.

References:

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- Livscykelanalyser för Vattenfalls Elproduktion, Sammanfattande rapport 1996
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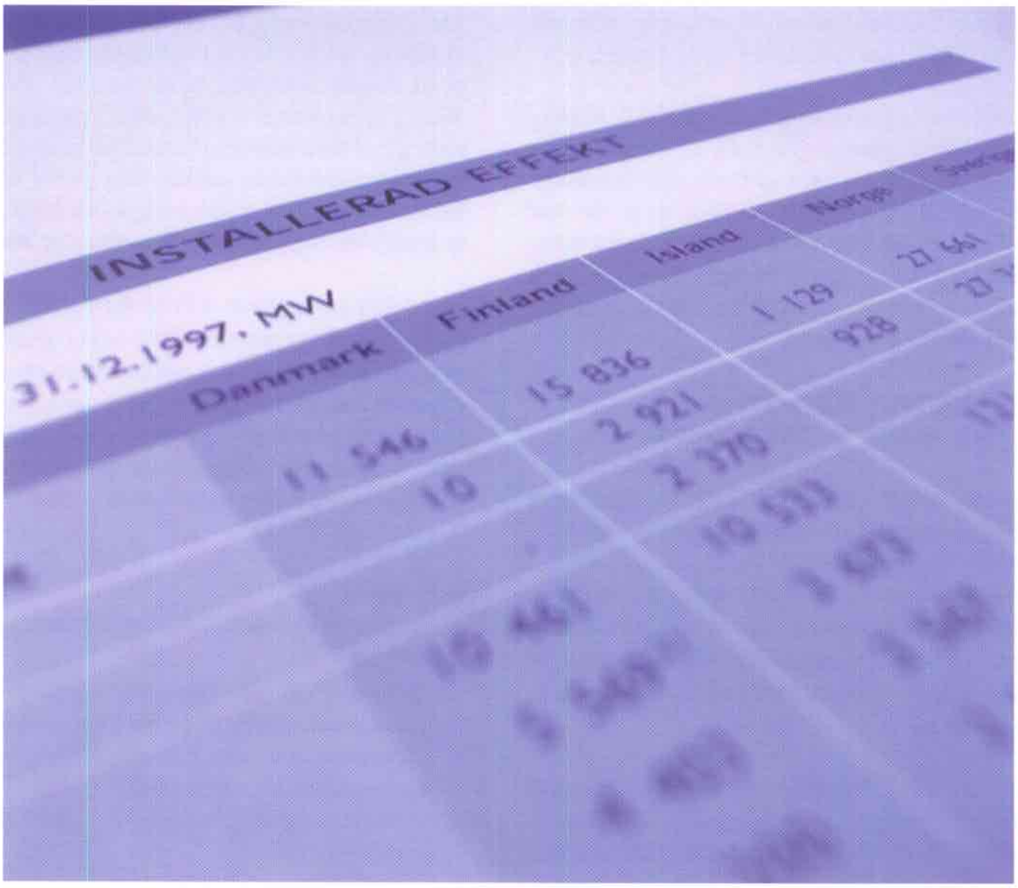
- Livscykelanalys, En inventering av miljöpåverkan från Sydkrafts elproduktion, Brochure 1998
- Smith Irene, 1997: Greenhouse gas emission factors for coal - the complete fuel cycle, IEA Coal Research/98
- ELSAMs miljøberetning 1995: Artikel om restprodukter
- Note No 16: The Energy Balance of Modern Wind Turbines. Danish Windpower Industry, December 1997

The article has been prepared by an ad hoc group under Nordel's System Committee.

STATISTICS


INSTALLERAD EFFEKT
31.12.1997, MW
Danmark
Finland
Island
Norge
11 546
15 836
1 129
928
2 921
10
2 370

DEFINITIONS, UNITS AND SYMBOLS

Installed capacity (net capacity):
The sum of the rated capacities of the individual power plant units (expressed in MW), excluding the power plant's own consumption of electricity.

Transmission capacity:
The power (in MW) that a high-voltage line can transmit under normal conditions, taking into account any limitations that may be imposed on the rated capacity.

Electricity generation (net generation):
The output of a power plant, excluding the plant's own consumption; usually expressed in GWh.

Generation of condensing power:
Generation at a conventional steam power plant where the energy of the steam is used solely for electricity generation and where the steam is condensed to water after the turbine.

Combined heat and power (CHP) generation:
Generation at a steam power plant where some of the energy of the steam is used for electricity generation and some for another purpose, e.g. for district heating or as process steam for industry. Previously known as back-pressure generation.

Imports/exports:
Since 1 January 1996, the monthly sums (in GWh) of the physically registered MWh values for each connection between the individual countries, per hour of exchange. Until 31 December 1995, imports and exports referred to the quantities of energy recorded as purchases and sales between the respective countries when accounts were settled. Net imports is the difference between imports and exports. The Norwegian share of Linnvasselv is recorded as imports to Norway and the German share of Enstedværket is recorded as exports to Germany.

Total consumption:
The sum of electricity generation and net imports, expressed in GWh.

Occasional power to electric boilers:
Expressed in GWh, this refers to the supply of electricity to electric boilers on special conditions for the generation of steam or hot water, which may alternatively be generated using oil or some other fuel. As of the reorganisation of its electricity market on 1 January 1996, Sweden can no longer determine monthly values for occasional power to electric boilers. The yearly statistics, too, only give the supply of power to electric boilers at district heating plants. Thus the values for gross and net consumption of electricity in Sweden also include the supply of power to electric boilers in industry.

Gross consumption:
The sum of domestic generation and imports minus exports and occasional power to electric boilers; usually expressed in GWh. For Sweden, the value for gross consumption of electricity also includes supply of power to certain electric boilers (see the definition under Occasional power to electric boilers).

Losses:
The difference between gross consumption and net consumption plus pumped storage power; usually expressed in GWh.

Pumped storage power:
The electricity used for pumping water up to a reservoir, for the generation of electricity on a later occasion; expressed in GWh.

Net consumption:
The sum of the energy used by consumers of electricity; usually expressed in GWh.

UNITS AND SYMBOLS

kW	kilowatt
MW	megawatt = 1,000 kW
GW	gigawatt = 1,000 MW
J	joule
kJ	kilojoule
PJ	petajoule = 10^{15} J
kWh	kilowatt-hour = 3,600 kJ
MWh	megawatt-hour = 1,000 kWh
GWh	gigawatt-hour = 1,000 MWh
TWh	terawatt-hour = 1,000 GWh
~	alternating current (AC)
=	direct current (DC)
.	Data are nonexistent
..	Data are too uncertain
0	Less than 0.5 of the unit given
-	No value

CALCULATION OF ELECTRICITY CONSUMPTION

Electricity generation
+ Imports
– Exports

= Total consumption
– Occasional power to electric boilers

= Gross consumption
– Losses, pumped storage power, etc.

= Net consumption

Responsible for statistical data on the individual countries:
Lisbeth Petersson - Association of Danish Electric Utilities, Denmark
Tapani Jylhä - Finnish Energy Industries Federation (Finergy), Finland
Ólafur Pálsson - Iceland Energy Agency, Iceland
Arne Hjelle - Nord Pool ASA, Norway
Jan Fredrik Foyn - Nord Pool ASA, Norway
Lars Nilsson - Swedish Power Association, Sweden
Lars Munter - Svenska Kraftnät, Sweden

Responsible for processing of the statistics:
Laura Karjalainen - Imatran Voima Oy, Finland

The present statistics were prepared before the 1997 official statistics for the individual countries had become available. Certain figures in the Annual Report may thus differ from the official statistics.

The statistical data and selected sections of the rest of the Annual Report can also be read on Nordel's Internet pages at www.nordel.org.

S1 INSTALLED CAPACITY ON 31 DEC. 1997, MW

	Denmark	Finland	Iceland	Norway	Sweden	Nordel
Installed capacity, total	11 546	15 836	1 129	27 661	34 044	**90 216**
Hydropower	10	2 921	928	27 364	16 246 [1]	**47 469**
Nuclear power	.	2 370	.	.	10 056	**12 426**
Other thermal power	10 461	10 533	121	293	7 620	**29 028**
- condensing power	5 569 [2]	3 673	.	73	2 777	**12 092**
- CHP, district heating	4 403	3 567	.	.	2 354	**10 324**
- CHP, industry	200	2 415	.	185	776	**3 576**
- gas turbines, etc.	289	878	121	35	1 713	**3 036**
Other renewable power	1 075	12	80	4	122	**1 293**
- wind power	1 075	12	.	4	122	**1 213**
- geothermal power	.	.	80	.	.	**80**
Commissioned in 1997	598	873	80	119	115	**1 785**
Decommissioned in 1997	44	0	0	89	229	**362**

[1] Includes the Norwegian share of Linnvasselv (25 MW)
[2] Includes the German share of Enstedværket (300 MW)

S2 AVERAGE-YEAR GENERATION OF HYDROPOWER IN 1997, GWH

	Denmark	Finland	Iceland	Norway	Sweden	Nordel
Average-year generation 1997	-	12 690	5 500	112 800	63 700	**194 690**
Average-year generation 1996	-	12 608	4 950	112 600	63 645	**193 803**
Change	-	82	550	200	55	**887**

S3 CHANGES IN INSTALLED CAPACITY IN 1997

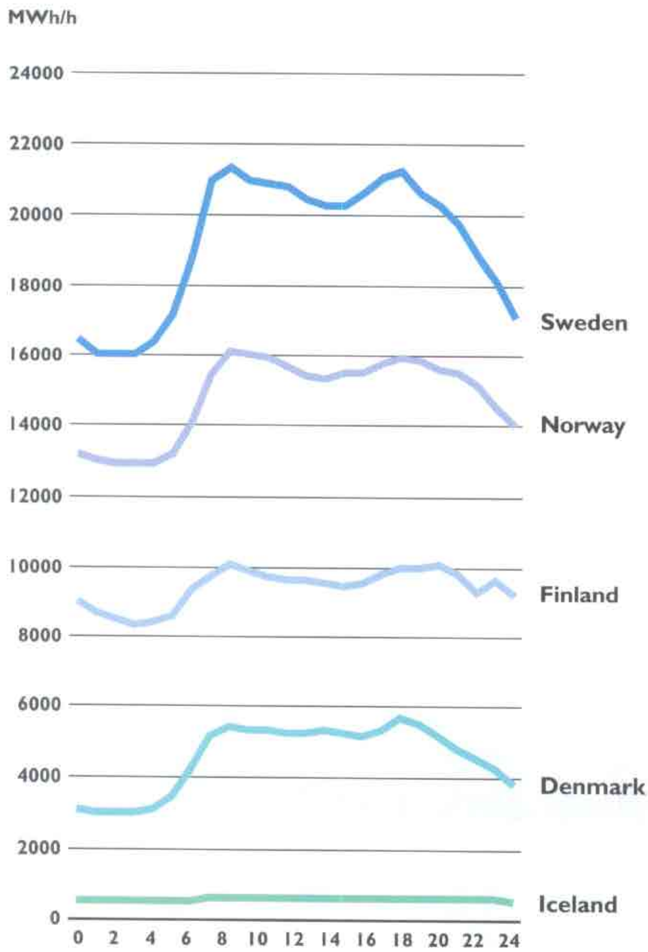
Power category	Power Plant	Commissioned	Decommissioned	Change in average-year generation (hydropower)	Type of fuel
		MW	MW	GWh	
Denmark					
CHP, district heating	Enstedværket	30			
	Skærbækværket	434			
	Others	75	44		
Wind power	Several small plants	59			
Finland					
Hydropower	Anjalankoski	3		25	
	Hämeenkyrö	12		15	
	Merikoski	2		9	
	Pamilo	27		1	
	Raasakka	20		25	
	Seitakorva II	6		5	
Nuclear power	Olkiluoto	20			
CHP, district heating	Ikaalinen	6			
	Kotka	47			
	Säkylä	5			
	Vuosaari B	472			
CHP, industry	Kirkniemi	75			
	Neste POVO	70			
	PVO Nokia	45			
	VTS/Oulu	57			
Iceland					
Hydropower	Burfell	50		380	
Geothermal power	Krafla	30			
Norway					
Hydropower	Skjerka	96		99	
	Svartisen	350	340	47	
	Others	13	89	13	
Sweden					
Hydropower	Kvarnsveden	29		55	
	flera små effektändringar	14		0	
Nuclear power	Ringhals	1			
Condensing power	Öresundsverket		65		
CHP, district heating	Brista	41			
	Högsbo	13			
	Sävenäs		10		
	Öresundsverket		154		
Wind power	Several small plants	17			

S4 POWER PLANTS (LARGER THAN 10 MW): DECISIONS TAKEN

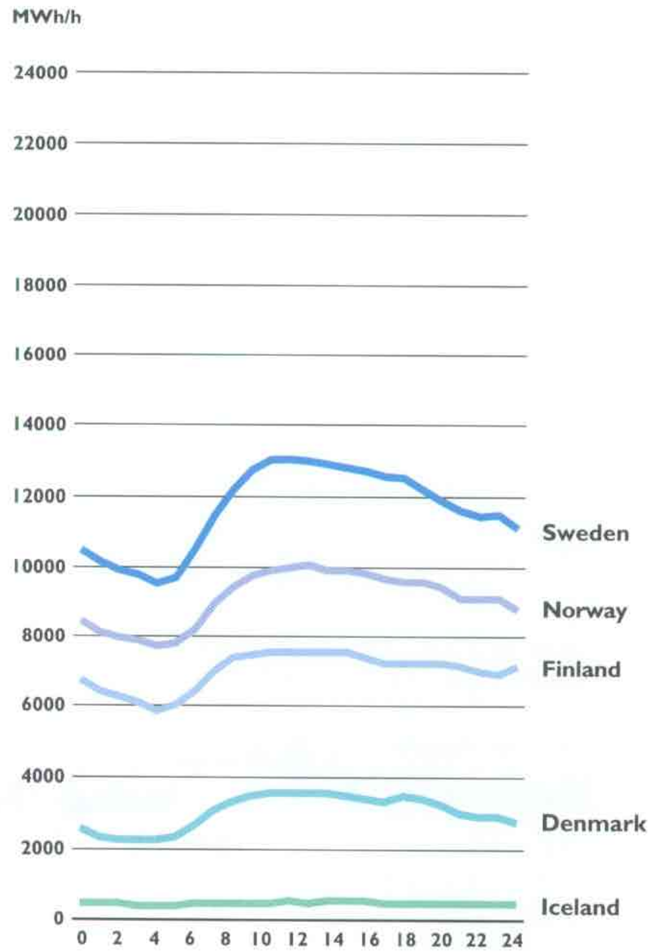
Power category	Power Plant	Capacity	Estimated start-up	Average-year generation (hydropower)	Type of fuel
		MW	Year	GWh	
Denmark					
CHP, district heating	DTU 2	38	1998		Natural gas
	Nordjyllandsværket 3	385	1998		Coal/Oil
	Maribo / Sakskøbing	10	2000		Biofuel
	Avedøreværket 2	540	2001		Natural gas/ Straw/ Wood chips/ (Oil)
Finland					
Hydropower	Taivalkoski I-III	15	1998	13	
Nuclear power	Loviisa	60	1998-2000		
	Olkiluoto	220	1998		
CHP, district heating	Vaasa	40	1998		Oil
CHP, industry	Joutseno	68	1998		Natural gas
Condensing power	Vaskiluoto	230	1998		Coal
Iceland					
Hydropower	Sultartangi	120	1999	880	
Geothermal power	Nesjavellir	60	1998		

S5 SYSTEM LOAD 3RD WEDNESDAY IN JANUARY AND 3RD WEDNESDAY IN JULY 1997

Average 24-hour load 3rd Wednesday in January (15-1-97)



Average 24-hour load 3rd Wednesday in July (16-7-97)



	Installed net capacity	Maximum system load	Minimum system load
	31 Dec. 1997 GW	3rd Wednesday in Jan. 1997 8:00-9:00 a.m. GWh/h	3rd Wednesday in July 1997, 4:00-5:00 a.m. GWh/h
Denmark	11.5	5.4	2.3
Finland	15.8	10.1	5.9
Iceland	1.1	0.6	0.4
Norway	27.7	16.2	7.8
Sweden	34.0	21.4	9.5
Nordel	**90.1**	**53.7**	**25.9**

All hours are local time

THE GRID SYSTEM IN THE NORDIC COUNTRIES

INTERCONNECTIONS

S6 EXISTING INTERCONNECTIONS BETWEEN THE NORDEL COUNTRIES

Countries Stations	Rated voltage	Transmission capacity as per design rules[1]		Total length of line	Of which cable
	kV	MW		km	km
Denmark - Norway		**From Denmark**	**To Denmark**		
Tjele-Kristiansand	250/350	1040	1040	240/pol	127/pol
Denmark - Sweden		**From Sweden**	**To Sweden**		
Teglstrupgård - Mörarp 1 and 2	132~	350 [2]	350 [2]	23	10
Hovegård - Söderåsen 1	400~	800 [2]	800 [2]	91	8
Hovegård - Söderåsen 2	400~	800 [2]	800 [2]	91	8
Vester Hassing - Göteborg	250=	290	270	176	88
Vester Hassing - Lindome	285=	380	360	149	87
Hasle (Bornholm) - Borrby	60~	60	60	48	43
Finland - Norway		**From Finland**	**To Finland**		
Ivalo - Varangerbotn	220~	70	70	228	.
Finland - Sweden		**From Sweden**	**To Sweden**		
Ossauskoski - Kalix	220~			93	.
Petäjäskoski - Letsi	400~	1300 [3]	700 [4]	230	.
Keminmaa - Svartbyn	400~			134	.
Hellesby (Åland) - Skattbol	70~	35	35	77	56
Raumo - Forsmark	400=	500	500	235	198
Norway - Sweden		**From Sweden**	**To Sweden**		
Sildvik - Tornehamn	132~	50	120	39	.
Ofoten - Ritsem	400~	1350	1350 [5]	58	.
Røssåga - Ajaure	220~	285 [6]	285 [5, 6]	117	.
Linnvasselv, transformer	220/66~	50	50	.	.
Nea - Järpströmmen	275~	450 [6]	450 [6]	100	.
Lutufallet - Höljes	132~	40	20	18	.
Eidskog - Charlottenberg	132~	100	100	13	.
Hasle - Borgvik	400~	1650 [6]	1800 [6, 7]	106	.
Halden - Skogssäter	400~			135	.

[1] Maximum permissible transmission.
[2] Thermal limit. The total transmission capacity is 1,600 MW to Denmark and 1,800 MW to Sweden.
[3] Further 100 MW for power balance deviation.
[4] 900 MW can be transmitted during reduced transmission in Finland.
[5] Thermal limit. Stability problems and generation in nearby power plants may lower the limit.
[6] The transmission capacity can in certain situations be lower, owing to bottlenecks in the Norwegian network.
[7] Requires a network protection system during operation (production disconnection).

S7 EXISTING INTERCONNECTIONS BETWEEN THE NORDEL COUNTRIES AND OTHER COUNTRIES

Countries Stations	Rated voltage	Transmission capacity		Total length of line	Of which cable
	kV	MW		km	km
Denmark - Germany		**From Nordel**	**To Nordel**		
Kassø - Audorf	2 x 400~			107	.
Kassø - Flensburg	220~	1400 [1]	1400 [1]	40	.
Ensted - Flensburg	220~			34	.
Bjæverskov - Rostock	400=	600	600	166	166
Finland - Russia		**From Nordel**	**To Nordel**		
Imatra - GES 10	110~	.	100	20	.
Yllikkälä - Viborg	±85=	.	1000	.	.
Nellimö - Kaitakoski	110~	60	60	20	.
Norway - Russia		**From Nordel**	**To Nordel**		
Kirkenes - Boris Gleb	154~	50	50	10	.
Sweden - Germany		**From Nordel**	**To Nordel**		
Västra Kärrstorp - Herrenwyk	450=	600 [2]	600 [2]	250	220

[1] Transmission capacity varies between 1,200 and 1,500 MW, depending on operating conditions.
[2] Owing to restrictions in the German network, transmission capacity is currently limited to 450 MW from Nordel and 400 MW to Nordel.

S8 INTERCONNECTIONS: DECISIONS TAKEN

Countries Stations	Rated voltage	Transmission capacity as per design rules	Total length of line	Of which cable	Estimated commis-sioning
	kV	MW	km	km	Year
Denmark - Denmark (Storebælt / The Great Belt) Elsam - Elkraft	400=	500 - 600	ca 70	ca 70	1)
Finland - Russia Yllikkälä - Viborg	±85=	300	43		1999
Norway - The Netherlands (NorNed Kabel) Feda - Eemshaven	400-600=	min 600	ca 550	ca 550	2001
Norway - Germany (Euro Cable) Øksendal (Tonstad) [2]- Brunsbüttel	400-600=	min 600	ca 600	ca 550	2002
Norway - Germany (Viking Cable) Øksendal (Tonstad) [2]- Brunsbüttel	400-600=	min 600	ca 600	ca 550	2003
Sweden - Poland (SwePol Link) Stärnö [3]- Slupsk	450=	600	252	237	1999

[1] According to plans, the Great Belt connection will be in operation in 2003. The Minister of the Environment and Energy has the authority to decide on the connection.
[2] Cable to Lista, overhead line to Tonstad.
[3] The valve room still needs a building permit.

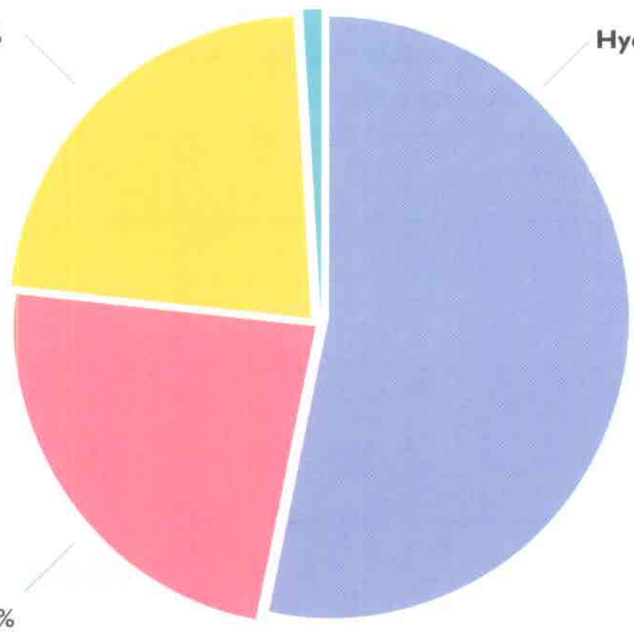
LINE LENGTHS

S9 TRANSMISSION LINES OF 110-400 KV IN SERVICE ON 31 DEC. 1997

	400 kV, AC and DC	220-300 kV, AC and DC	110, 132, 150 kV
	km	km	km
Denmark	1 313 [1]	453 [2]	3 964 [3]
Finland	3 905 [4]	2 665	14 900
Iceland	.	492	1 315
Norway	2 113	5 635 [2]	10 430
Sweden	10 807 [4]	4 602 [2]	15 000

[1] Of which 2 km in service with 150 kV and 46 km with 132 kV.
[2] Of which 80 km in Denmark and 96 km in Sweden (KontiSkan), 89 km in Denmark and 382 km in Norway (Skagerrak) in service with 250 kV DC, and 75 km in Denmark and 74 km in Sweden (KontiSkan 2) in service with 285 kV DC.
[3] Of which 13 km in service with 60 kV and 105 km with 50 kV.
[4] Consisting of submarine cable (DC), 99 km in Finland and 99 km in Sweden; and land cable (DC), 34 km in Finland and 2 km in Sweden (Fenno-Skan).

S10 TOTAL ELECTRICITY GENERATION WITHIN NORDEL 1997

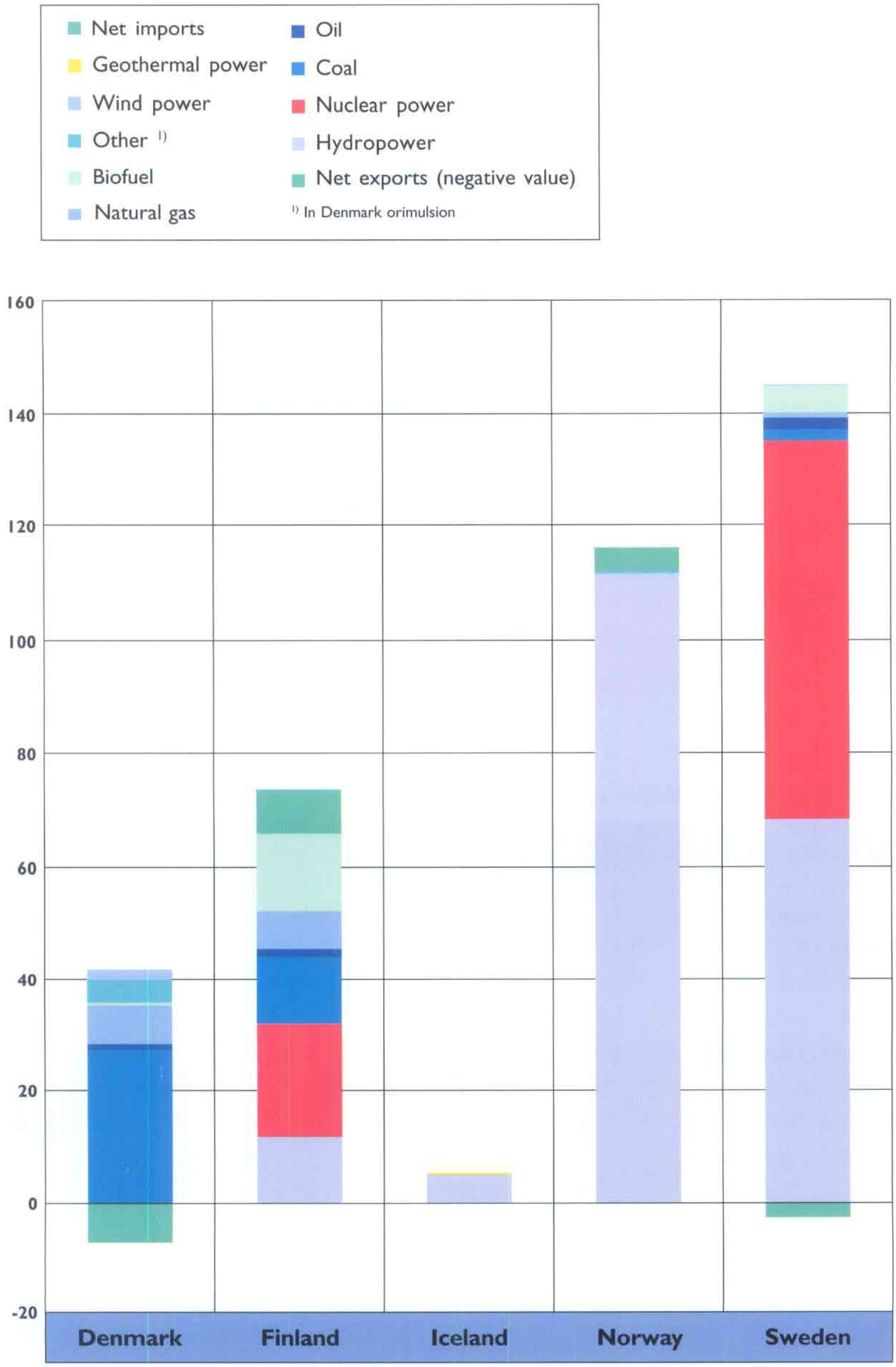


S11 ELECTRICITY GENERATION 1997, GWH

	Denmark	Finland	Iceland	Norway	Sweden	Nordel
Total generation	41 747	65 883	5 580	112 008	144 926	**370 144**
Hydropower	21	11 857	5 202	111 343	68 277	**196 700**
Nuclear power	.	20 035	.	.	66 912	**86 947**
Other thermal power	39 854	33 974	3	657	9 533	**84 021**
- condensing power	38 887 [1]	11 012	.	108	464	**50 471**
- CHP, district heating	..	12 090	.	.	4 772	**16 862**
- CHP, industry	967	10 834	.	314	4 291	**16 406**
- gas turbines, etc.	-	38	3	235	6	**282**
Other renewable power [2]	1 872	17	375	8	204	**2 476**
Total generation 1996	50 367	66 357	5 113	104 878	136 013	**362 728**
Change as against 1996	-17.1%	-0.7%	9.1%	6.8%	6.6%	**2.0%**

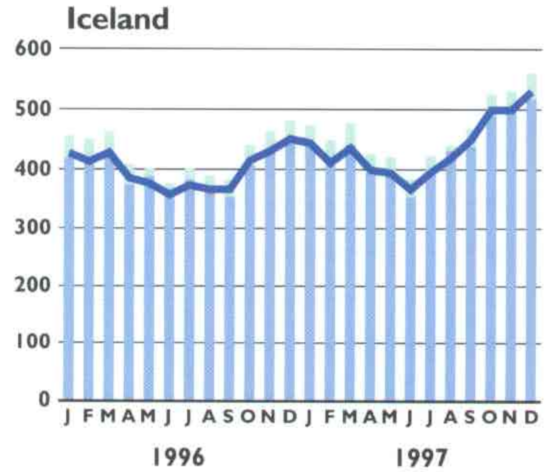
[1] Includes generation in combined heat and power stations
[2] Wind power and, for Iceland, geothermal power

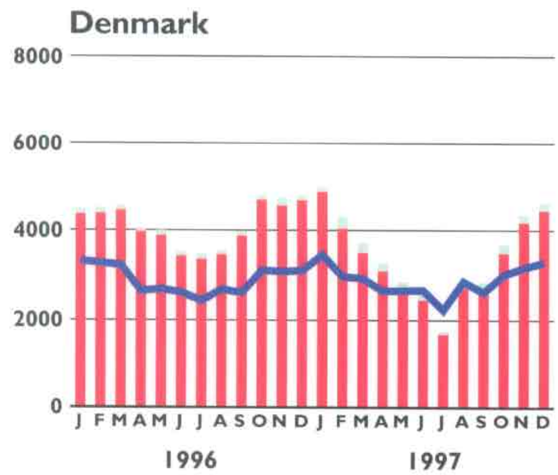
S12 TOTAL ELECTRICITY GENERATION
BY ENERGY SOURCE, AND NET IMPORTS AND EXPORTS 1997, TWH

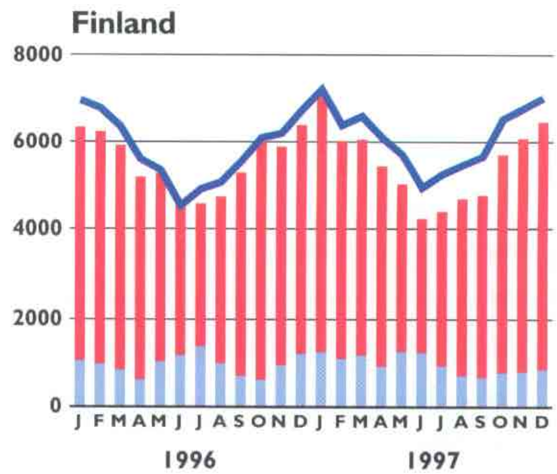


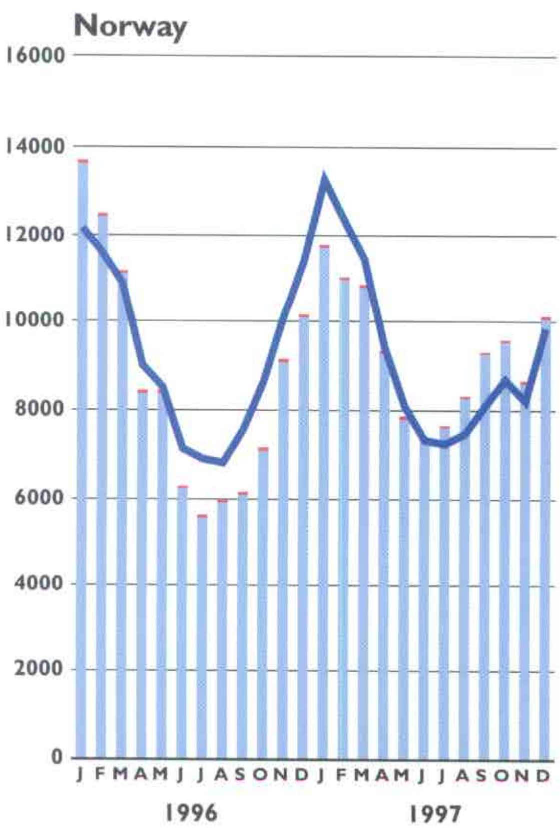
S13 MONTHLY GENERATION AND GROSS CONSUMPTION OF ELECTRICITY 1996-1997, GWH

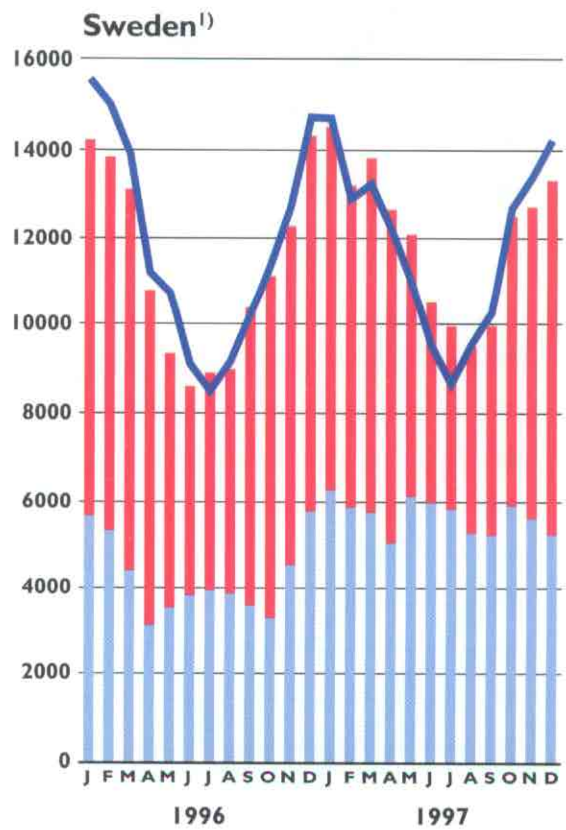
- Gross consumption
- Wind power or geothermal power
- Nuclear power and other thermal power
- Hydropower









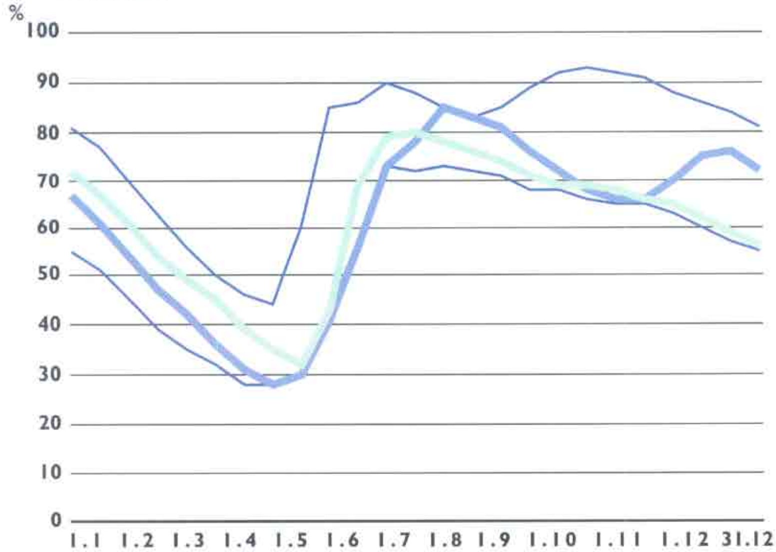


1) Consumption also includes supply to electric boilers

S14 WATER RESERVOIRS 1997

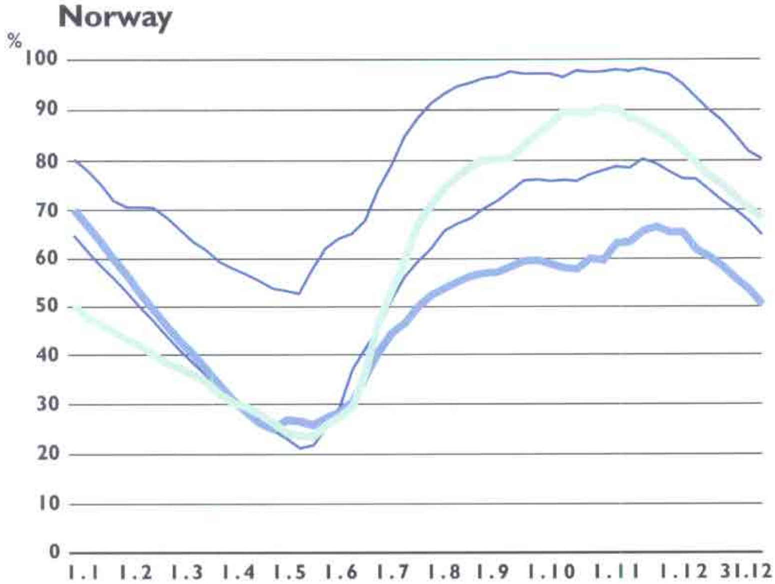
- **Water reservoirs 1997 expressed in %**
- **Water reservoirs 1996 expressed in %**
- **Minimum and maximum values in %**

Finland



Reservoir capacity 4 900 GWh
Minimum and maximum limits are based on values for the years 1987-1996

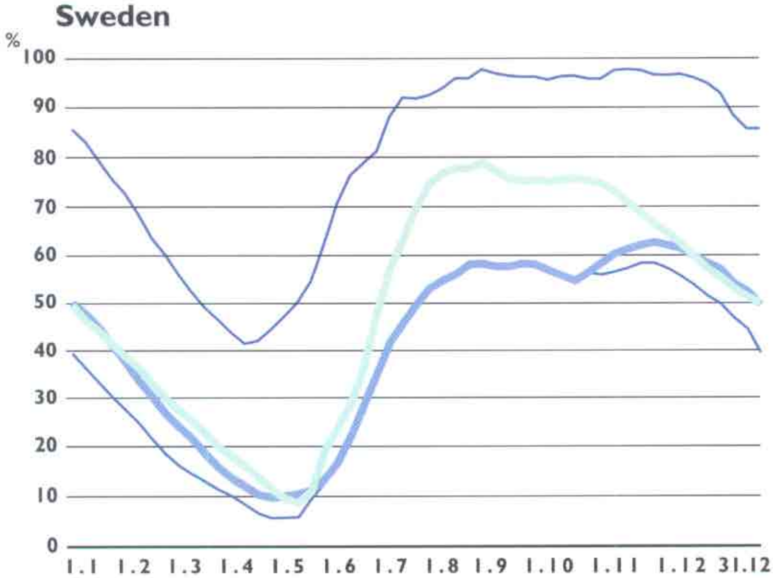
Norway



Reservoir capacity
1.1.1997 78 121 GWh
31.12.1997 80 356 GWh

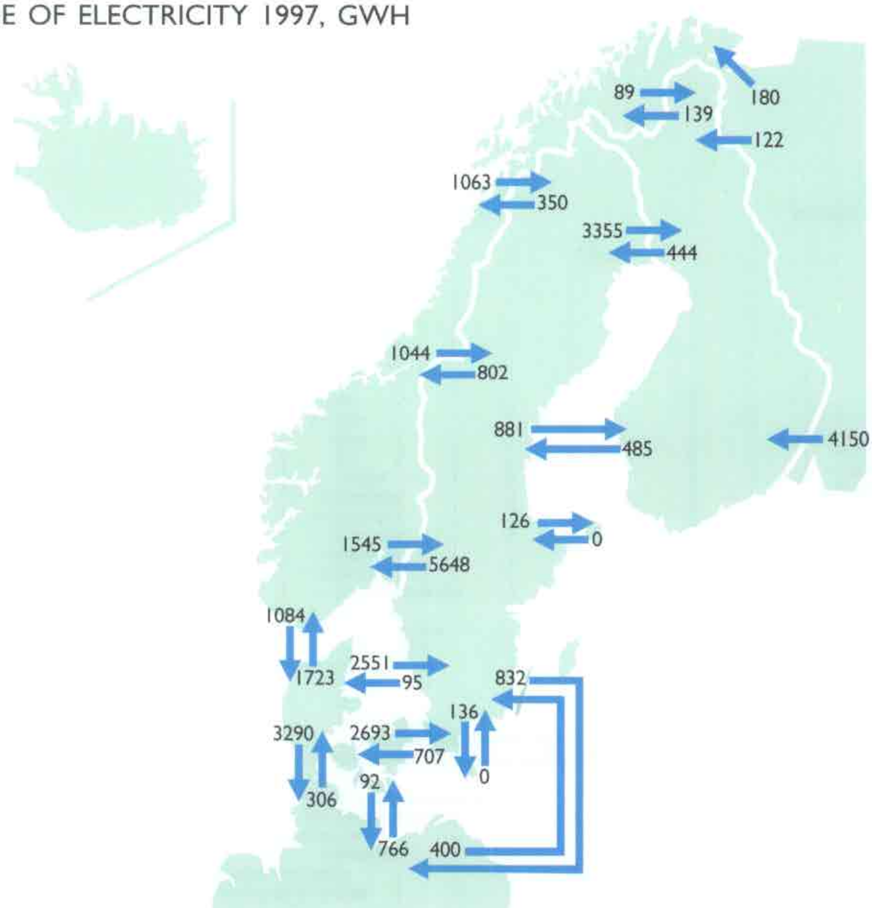
Minimum and maximum limits are based on values for the years 1982-1991

Sweden



Reservoir capacity 33 550 GWh
Minimum and maximum limits are based on values for the years 1950-1996

S15 EXCHANGE OF ELECTRICITY 1997, GWH



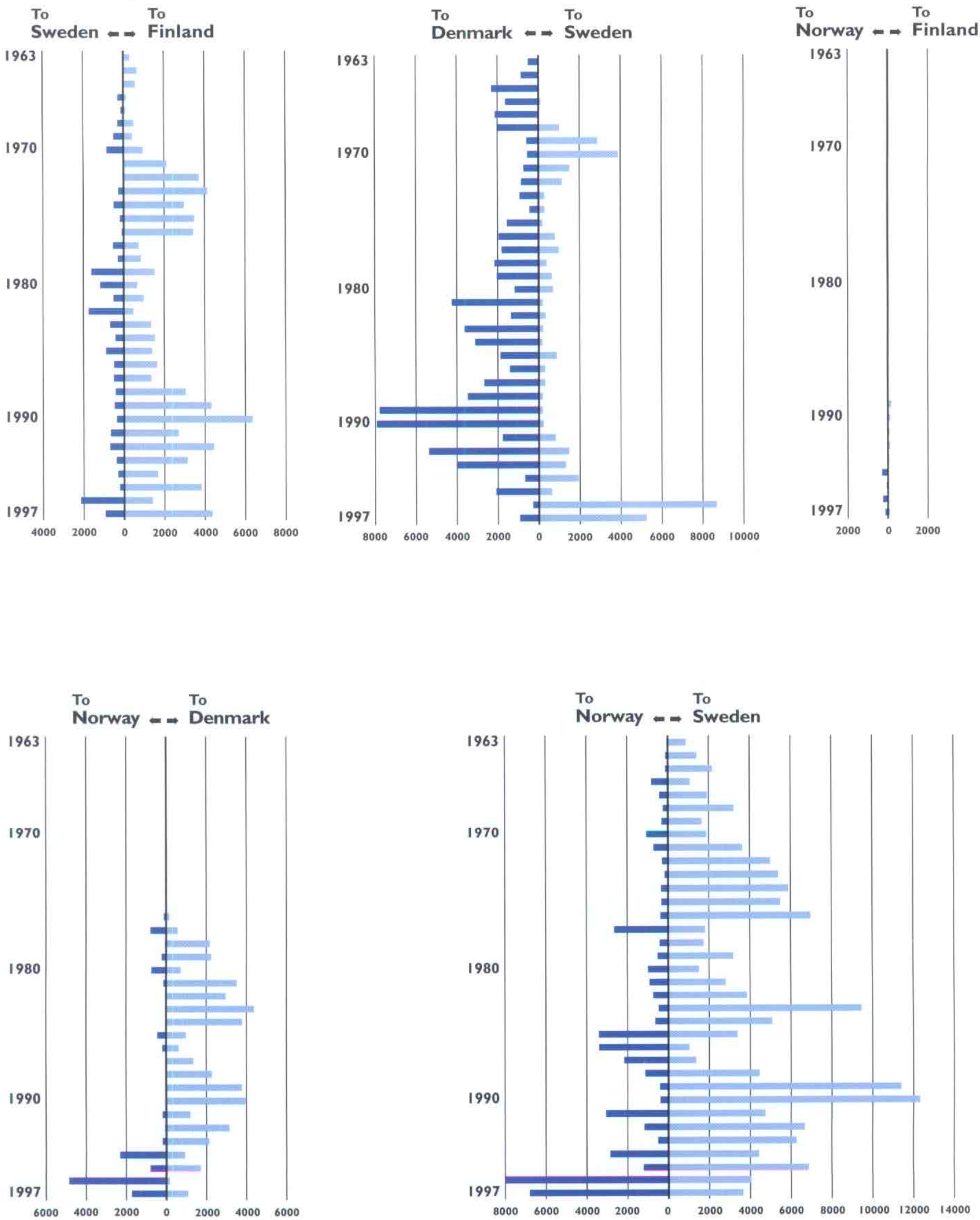
S16 IMPORTS AND EXPORTS 1997, GWH

	Imports to: Denmark	Finland	Norway	Sweden	Other countries[1]	Σ Exports
Exports from:						
Denmark	.	.	1 723	5 244	3 382	**10 349**
Finland	.	.	139	929	.	**1 068**
Norway	1 084	89	.	3 652	.	**4 825**
Sweden	938	4 362	6 800	.	832	**12 932**
Other countries [1]	1 072	4 272	180	400	.	**5 924**
Σ Imports	**3 094**	**8 723**	**8 842**	**10 225**	**4 214**	**35 098**

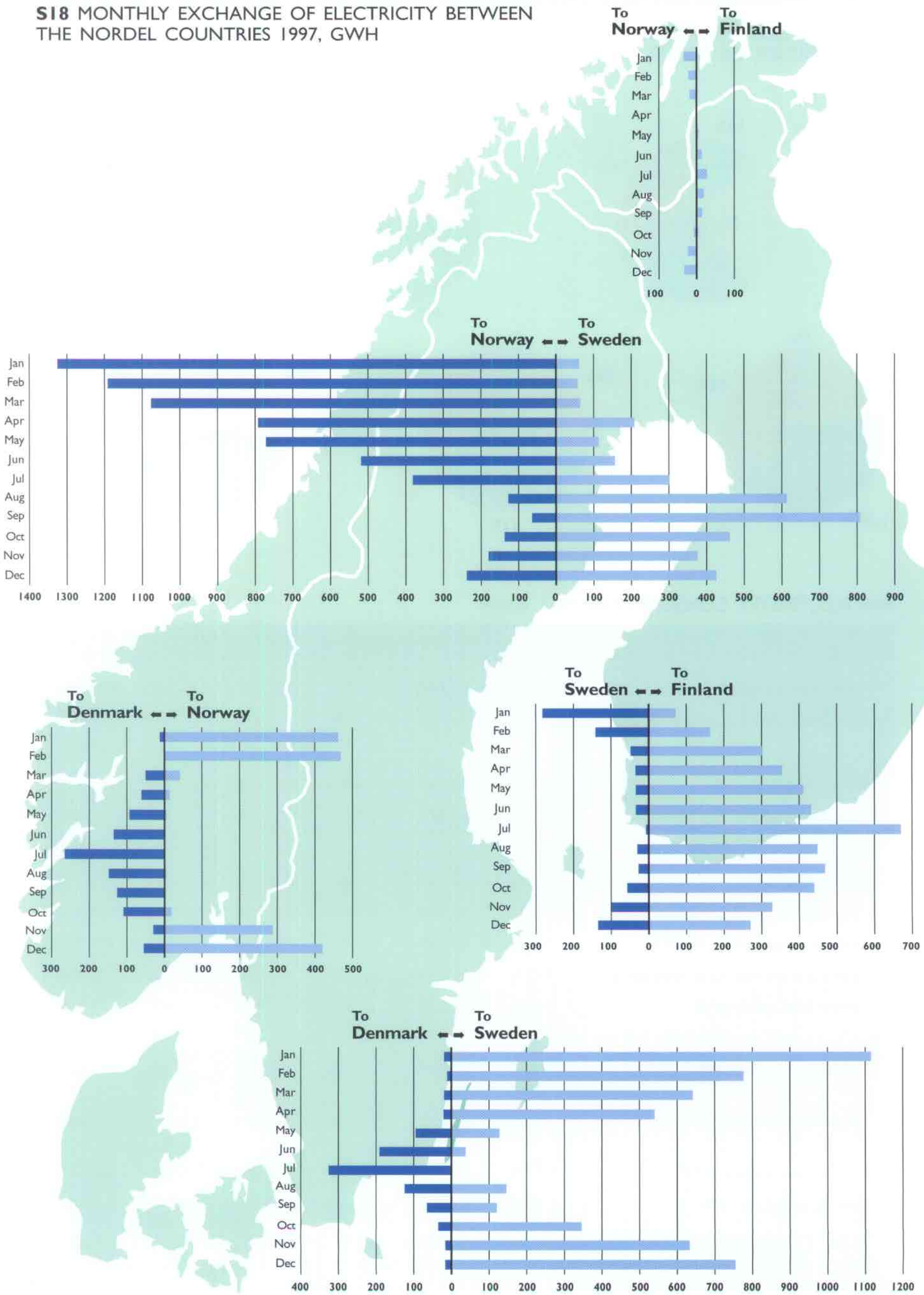
	Denmark	Finland	Norway	Sweden	Nordel
Total imports	3 094	8 723	8 842	10 225	**30 884**
Total exports	10 349	1 068	4 825	12 932	**29 174**
Net imports	-7 255	7 655	4 017	-2 707	**1 710**
Net imports / gross consumption	**-21.0%**	**10.4%**	**3.6%**	**-1.9%**	**0.5%**

[1] Germany and Russia

S17 EXCHANGE OF ELECTRICITY BETWEEN THE NORDEL COUNTRIES 1963 - 1997, GWH

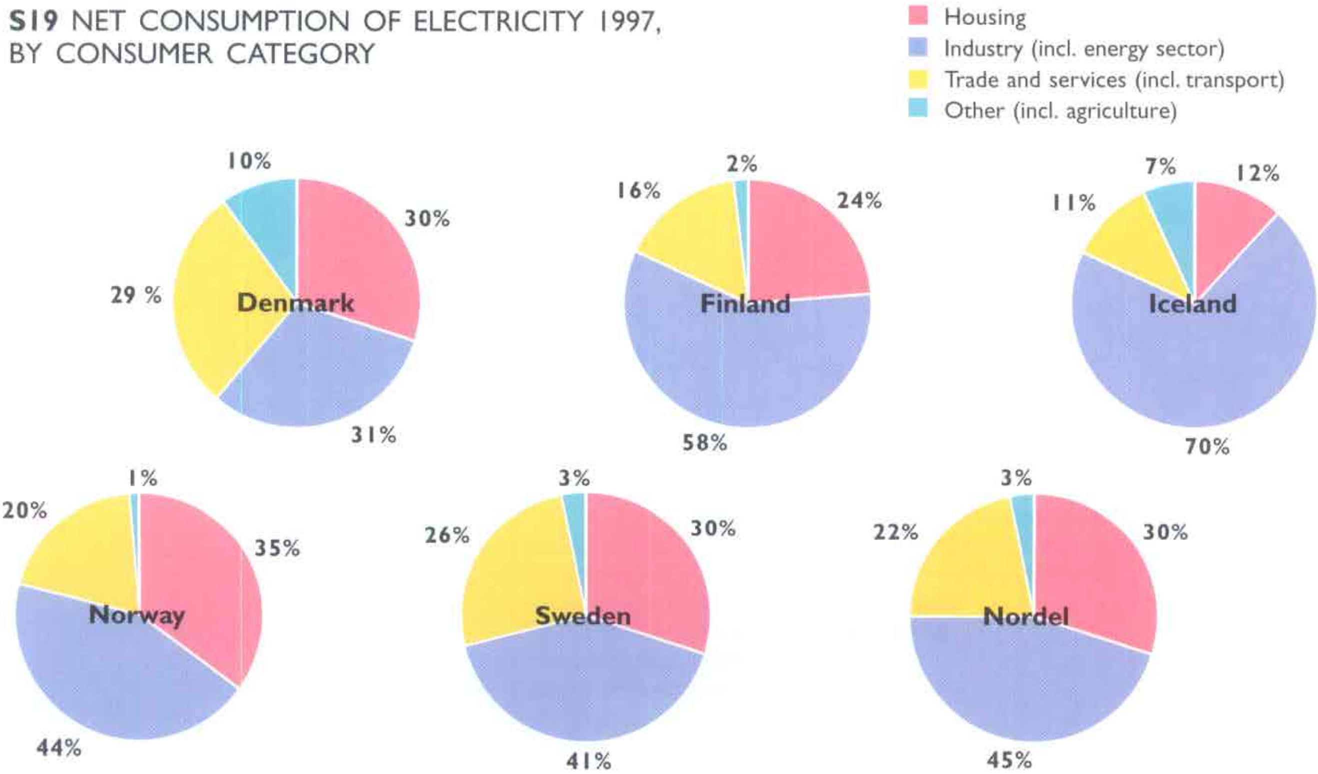


S18 MONTHLY EXCHANGE OF ELECTRICITY BETWEEN THE NORDEL COUNTRIES 1997, GWH



ELECTRICITY CONSUMPTION

S19 NET CONSUMPTION OF ELECTRICITY 1997, BY CONSUMER CATEGORY

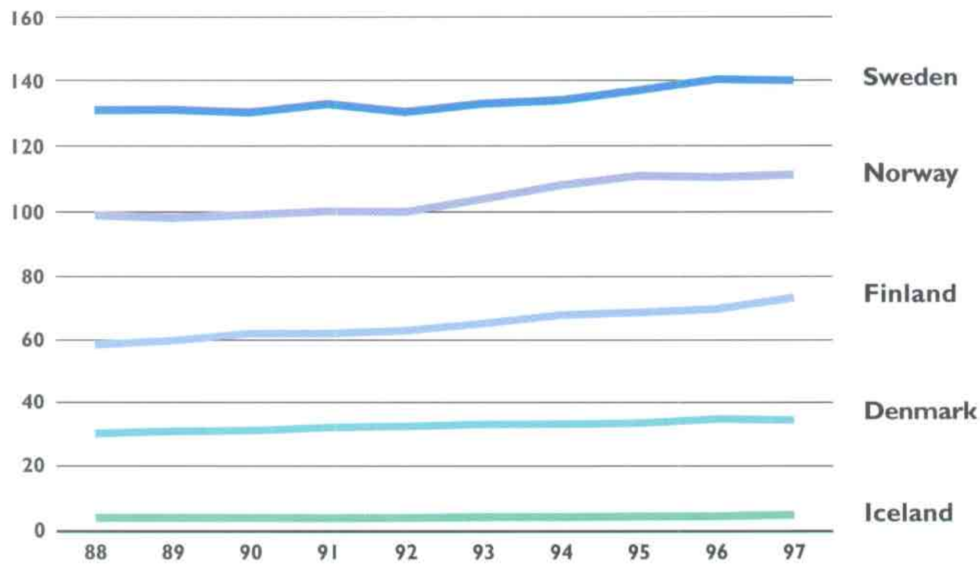


S20 ELECTRICITY CONSUMPTION 1997, GWH

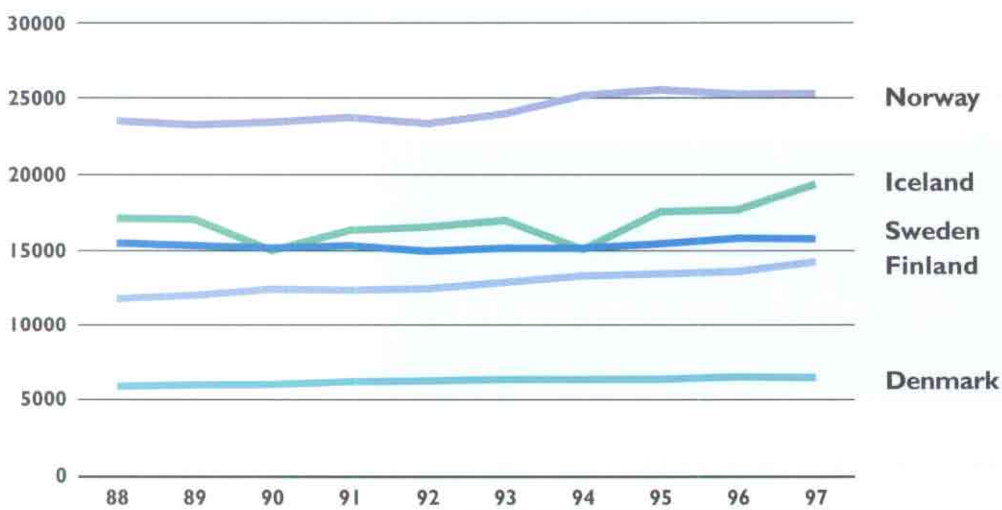
	Denmark	Finland	Iceland	Norway	Sweden	Nordel
Total consumption	34 492	73 538	5 580	116 025	142 219	**371 854**
Occasional power to electric boilers	.	71	338	4 610	2 100 [1]	**7 119**
Gross consumption	34 492	73 467	5 242	111 415	140 119	**364 735**
Losses, pumped storage power	2 352	2 801	353	10 685 [2]	9 719	**25 910**
Net consumption	32 140	70 666	4 889	100 730	130 400	**338 825**
- housing	9 710	17 404	580	35 250	39 500	**102 444**
- industry (incl. energy sector)	9 810	40 798	3 423	43 940	53 300	**151 271**
- trade and services (incl. transport)	9 330	11 094	524	19 940	34 200	**75 088**
- other (incl. agriculture)	3 290	1 370	362	1 600	3 400	**10 022**
Population (million)	5.3	5.1	0.3	4.4	8.9	**24.0**
Gross consumption per capita, kWh	6 508	14 293	19 415	25 299	15 831	**15 219**
Gross consumption 1996	34 783	69 955	4 788	110 697	140 438	**360 661**
Change as against 1996, %	-0.8%	5.0%	9.5%	0.6%	-0.2%	**1.1%**

[1] Only electric boilers at district heating plants shown
[2] Pumped storage power accounts for 1659 GWh

S21 GROSS CONSUMPTION 1988 - 1997, TWH



S22 GROSS CONSUMPTION PER CAPITA 1988 - 1997, KWH

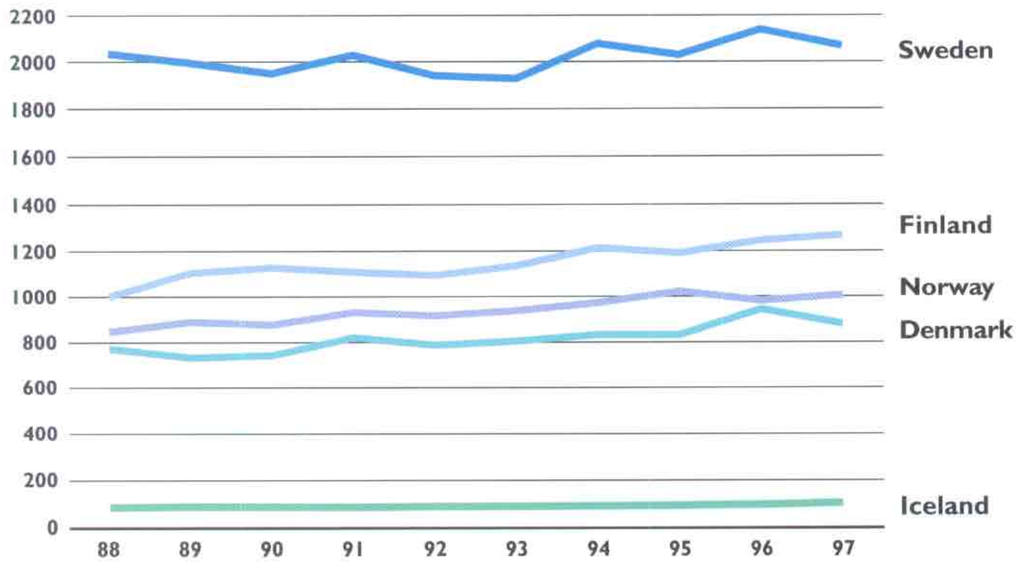


S23 TOTAL CONSUMPTION 1997, GWH

	Denmark	Finland	Iceland	Norway	Sweden	Nordel
Generation 1997	41 747	65 883	5 580	112 008	144 926	**370 144**
Net imports 1997	-7 255	7 655		4 017	-2 707	**1 710**
Total consumption 1997	34 492	73 538	5 580	116 025	142 219	**371 854**
Generation 1996	50 367	66 357	5 113	104 878	136 013	**362 728**
Net imports 1996	-15 584	3 656		9 041	6 127	**3 240**
Total consumption 1996	34 783	70 013	5 113	113 919	142 140	**365 968**

TOTAL ENERGY SUPPLY

S24 TOTAL ENERGY SUPPLY 1988 - 1997, PJ



N.B.
Energy supply is now recorded according to the international practice, which means that the figure for nuclear power includes energy conversion losses.

PROGNOSES

S25 GROSS CONSUMPTION OF ELECTRICITY 1997 AND PROGNOSES FOR 2000 AND 2005, TWH

Year	Denmark	Finland	Iceland	Norway	Sweden
1997	34	73	5,2	111	140
2000	35	78	7,3	117 [1]	146 [2]
2005	37	85	7,6	125 [1]	148 [2]

[1] Total consumption
[2] Prognoses based on the Climate Report issued by NUTEK

S26 PEAK LOAD DEMAND 1997 AND PROGNOSES FOR 2000 AND 2005, MW

Year	Denmark	Finland	Iceland	Norway [1]	Sweden
1997	7 260	12 700	877	22 650	25 000
2000	7 577	13 700 [1]	1 070	22 897	27 450 [2]
2005	7 854	15 000 [1]	1 125	24 999	27 890 [2]

[1] Excl. reserve requirements
[2] Prognoses based on the Climate Report issued by NUTEK

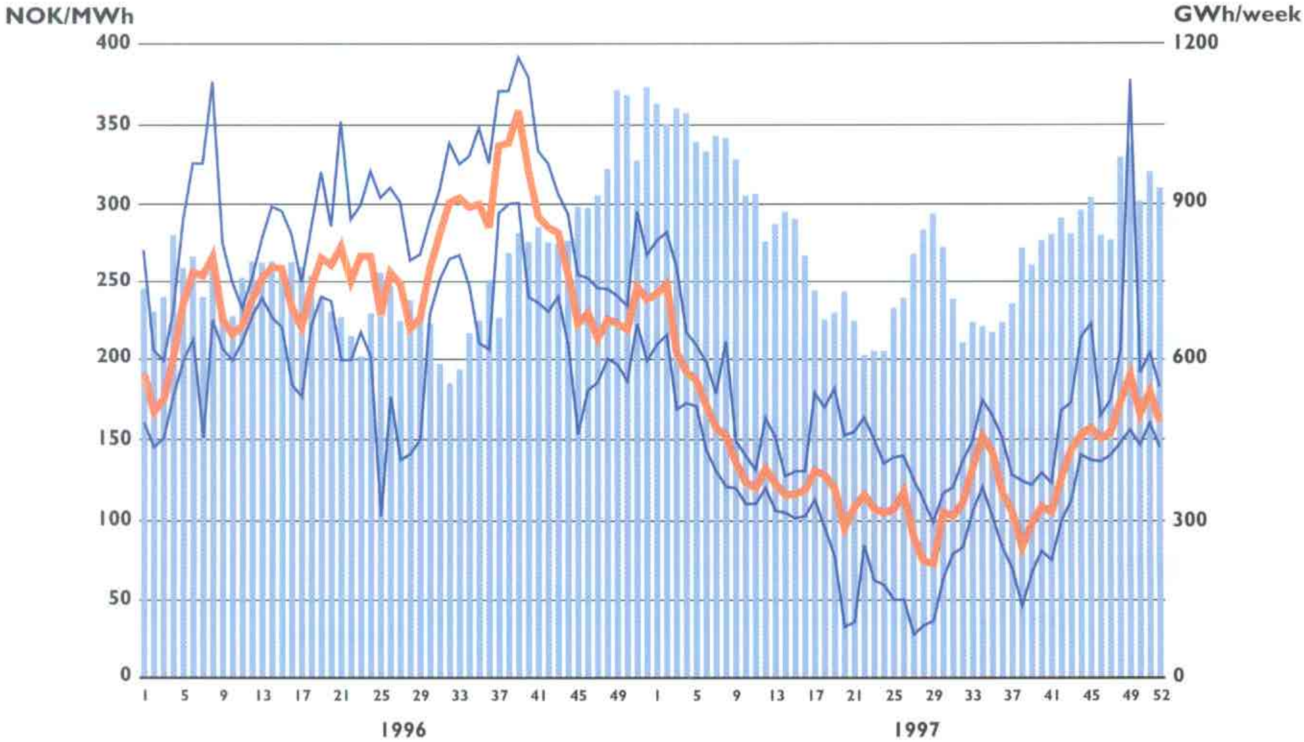
S27 INSTALLED CAPACITY 1997 AND PROGNOSES FOR 2000 AND 2005, MW

Year	Denmark	Finland	Iceland	Norway	Sweden
1997	11 546	15 836	1 129	27 661	34 044
2000	9 561 [1]	17 150	1 309	28 833	[2]
2005	9 024 [1]	[2]	1 309	30 533	[2]

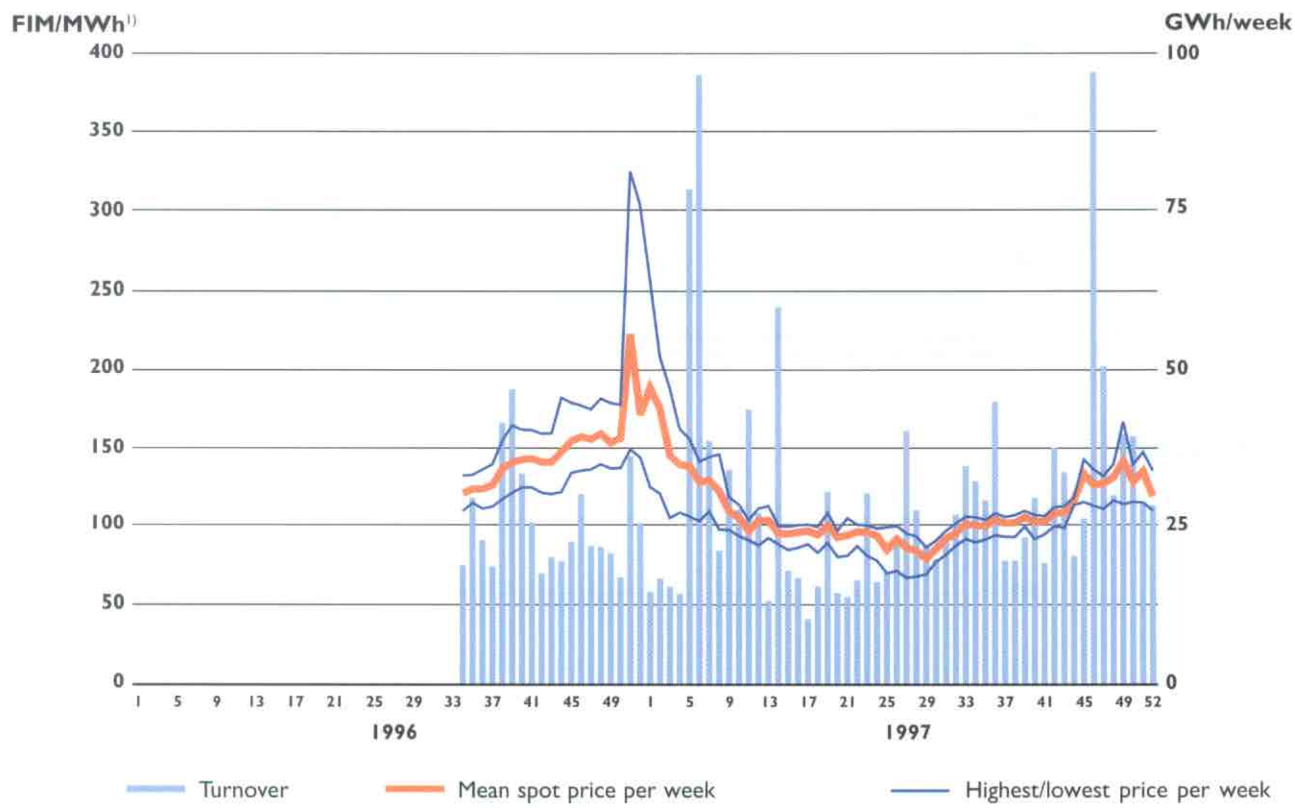
[1] Excl. capacity of autoproducers
[2] Prognoses not available

S28 SPOT PRICES AND TURNOVER ON THE NORDIC ELECTRICITY EXCHANGES 1996 - 1997

Nord Pool ASA's spot market: Mean price (system price) and turnover per week



EL-EX's spot market: Mean price and turnover[2] per week



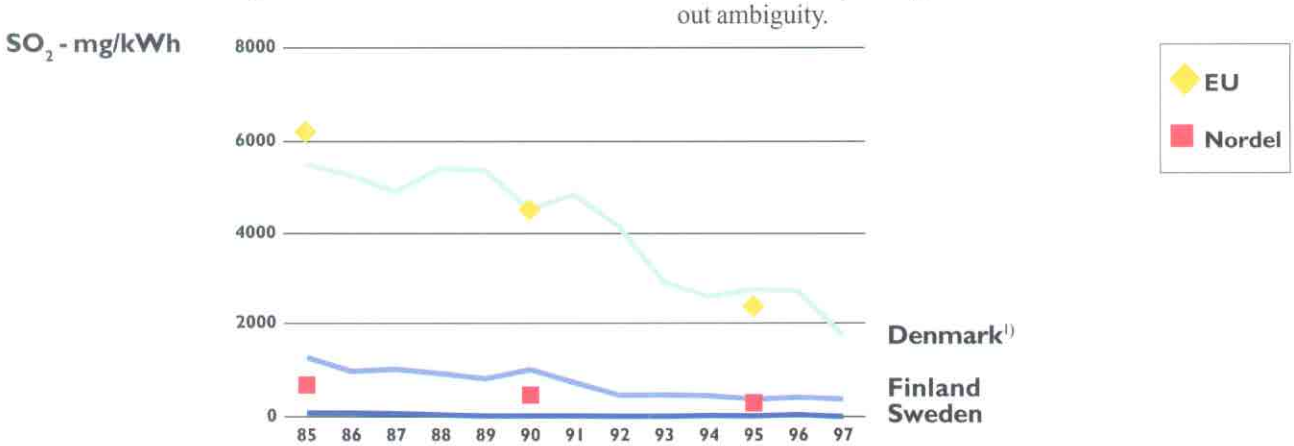
[1] The average NOK/FIM currency exchange rate was 0.7111 in 1996 and 0.7339 in 1997.
[2] Trading on EL-EX is based on the principle of continuous trading, which means that the turnover may be greater than the physical supply.

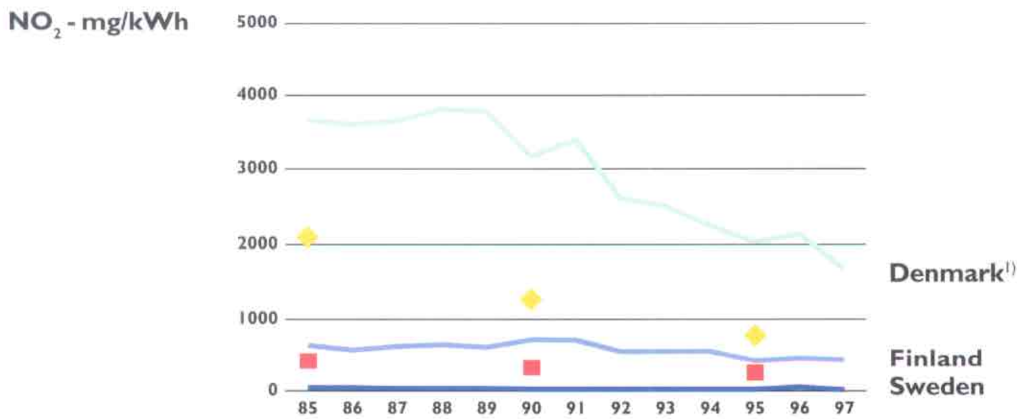
Environmental aspects play a central role in the electricity sector. The Nordic countries have taken long-range measures to reduce emissions from power generation, e.g. by utilising new combustion and purification techniques and by utilising combined heat and power plants of high efficiency. The active trade in power between the Nordel countries has also helped reduce environmental effects by ensuring that effective use has been made of the production resources.

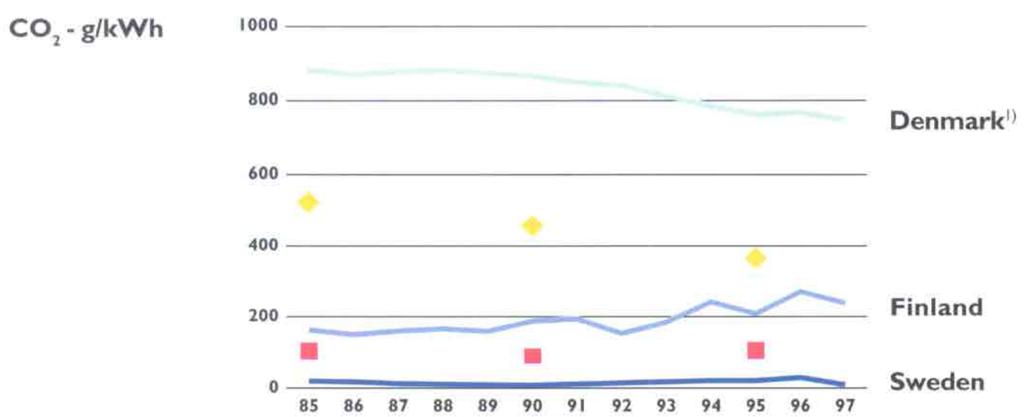
The diagrams below show the emissions of SO_2, NO_2 and CO_2 in relation to total electricity generation in each country. The high proportion of thermal power in the Danish and Finnish systems increases the emission figures in these countries. The Norwegian and Icelandic emissions are negligible because virtually all electricity generation is based on hydropower and geothermal power.

As a rule, the emissions show a steady downward trend in the long term. The year 1996 was an exception because the unusually dry year led to a sharp increase in the consumption of fossil fuels. However, the data for 1997 show that the general trend follows the previous pattern.

Average emissions within the EU and within Nordel are given for some reference years. Emissions from the Nordel countries are on a considerably lower level. The diagrams should merely be considered as indicating a trend because, for instance, the exact proportions of emissions from combined heat and power generation cannot be defined without ambiguity.







1) For Denmark, the figure shows only power production owned by power utilities, which represents about 90% of the total production.

ELECTRICITY TAXATION IN THE NORDIC COUNTRIES AS OF 1 JANUARY 1998

Taxation of electrical energy in the Nordic countries varies with respect to both structure and level. The taxes have been raised substantially in most countries during the '90s, and considerable structural changes have also been introduced.

Long-range planning in these questions is of great importance in the capital-intensive power industry, for instance, when companies make decisions about investments. If electricity taxes imposed on power generation vary from country to country within the same market area, a serious problem arises because enterprises in the individual countries are denied the opportunity to compete with each other on equal terms. In consequence, Nordel has called attention to this drawback and has recommended harmonisation of electricity taxes. The need for more uniform electricity taxation has also been stressed in connection with the development of a Nordic electricity exchange.

The table below shows the electricity taxes that have been imposed on power generation and consumption in the Nordic countries as of the beginning of 1998. When compared to 1997, the total tax burden has risen. The only major structural change has been implemented in Sweden, where some of the tax on hydropower generation has been shifted to the consumption sector.

To enable comparison between the countries, the taxes have also been converted to pennies/kWh. Some assumptions have been made, for instance, with respect to currency exchange rates and the characteristics of power plants; therefore the table should only be seen as indicative.

TAXES ON ELECTRICITY GENERATION & CONSUMPTION IN THE NORDIC COUNTRIES 1998

	Finland	Sweden	Norway	Denmark	Iceland
Generation					
Hydropower (pennies, öre/kWh)	0	0 [1)]	1.2 [4)]	-	0
Nuclear power (pennies, öre/kWh)	0	2.2	-	-	-
Coal (FIM, SEK, NOK, DKK/t)	0	0 [2)]	0	0	0
Gas (penni, öre/m³)	0	0 [2)]	0	0	0
Peat (pennies, öre/kWh, fuel)	0	0		-	-
Heavy fuel oil (pennies, öre/l, kg)	0	0 [2)]	0	0	0
Biofuel (pennies, öre/kWh)	0	0	-	0	0
Imports (pennies, öre/kWh)	0	0	0	0	-
Consumption					
Industry/Energy	2.02 / 3.3	0 / 12.9 (9.6)	0 / 0	1.2-7.9-57.5 / 1.2-7.9-57.5 [5)]	0 / 0 [3)]
Private elec. heating/Private (pennies, S/N/D öre/kWh)	3.3 / 3.3	15.2 (9.6) / 15.2 (9.6)	5.75 (0) / 5.75 (0)	51 / 57.5	0 / 0

The taxes on consumption have been divided into the following categories:
Finland: Industry / Other consumers
Sweden: Industry / Supply of electricity, gas, heat and water / Other consumers (Municipalities in Northern Sweden)
Norway: Industry / Other consumers (Consumers in Finnmark and Northern Tromssa are exempted from taxes)
Denmark: Industry and enterprises (heavy processes – light processes – heating) / Electric heating / Other consumers

1) The tax on hydropower was replaced by a tax on hydropower premises in 1997. In 1997, this tax amounted to 3.42% of the land value, but in 1998 it was lowered to 2.21%, which corresponds to ca. 2.9 öre/kWh.

2) Energy and CO_2 taxes are paid for the plant's own use of fuel, i.e. 3-5% of the total volume. For light fuel oil, the tax amounts to a little over 2 öre per kWh produced. In addition, an NO_x fee and an SO_2 tax are levied in proportion to the emissions.

3) The VAT in Iceland is determined so that the tax percentage is 24.5%, except for houses heated by electricity (14%) and power-intensive industry (0%).

4) A tax on natural resources, which can be deducted from the State's proportion of the tax on profits (20%).

5) Depending on the intended use and energy efficiency agreements, industrial enterprises and other VAT-registered companies may be entitled to a rebate on some of the fees. The figures show the fees after the rebate.

- Not applicable

TAXES ON ELECTRICITY GENERATION AND CONSUMPTION 1.1.1998, CONVERTED TO PENNIES/KWH

	Finland	Sweden	Norway	Denmark	Iceland
Generation					
Hydropower (pennies/kWh)	0	0	0.9	-	0
Nuclear power (pennies/kWh)	0	1.5	-	-	-
Coal (pennies/kWh)	0	1.5 [1)]	0	0	0
Gas (pennies/kWh)	0	0.8 [1)]	0	0	0
Peat (pennies/kWh)	0	0	-	-	-
Heavy fuel oil (pennies/kWh)	0	1.4 [1)]	0	0	0
Biofuel (pennies/kWh)	0	0	-	0	0
Imports (pennies, öre/kWh)	0	0	0	0	-
Consumption					
Industry/Energy	2.095 / 3.375	0 / 8.9 (6.6)	0 / 0	0.9-6.2-45.4 / 0.9-6.2-45.4	0 / 0
Private elec. heating/Private	3.375 / 3.375	10.5 (6.6) / 10.5 (6.6)	4.3 (0) / 4.3 (0)	40.3 / 45.4	0 / 0

Assumptions:

Currency exchange rates: 1 SEK = 0,69 FIM, 1 NOK = 0,74 FIM, 1 DKK = 0,79 FIM, 1 ISK = 0,07 FIM

Fuel	Energy	Efficiency
Coal	7.09 kWh/kg	0.38
Gas	10.00 kWh/m3	0.4
Peat	11.28 kWh/kg	0.38
Heavy fuel oil	10.77 kWh/l	0.36

Consumption taxes in Finland include a fee for supply security (0.075 pennies/kWh)

1) Excluding the NO_x fee and the SO_2 tax.

CURRENT NORDEL RECOMMENDATIONS

- **Availability Concepts for Thermal Power**
  September 1977
- **Localisation of System Oscillations Equipment**
  August 1992
- **Network Dimensioning Criteria**
  August 1992
- **Common Disturbance Reserve**
  August 1992
- **Operational Performance Specifications for Thermal Power Units Larger Than 100 MW**
  August 1995
- **Operational Performance Specifications for Small Thermal Power Units**
  August 1995
- **Standardised Communication Procedure**
  August 1995
- **Recommendations for Frequency, Time Deviation, Regulating Power and Reserves**
  August 1996

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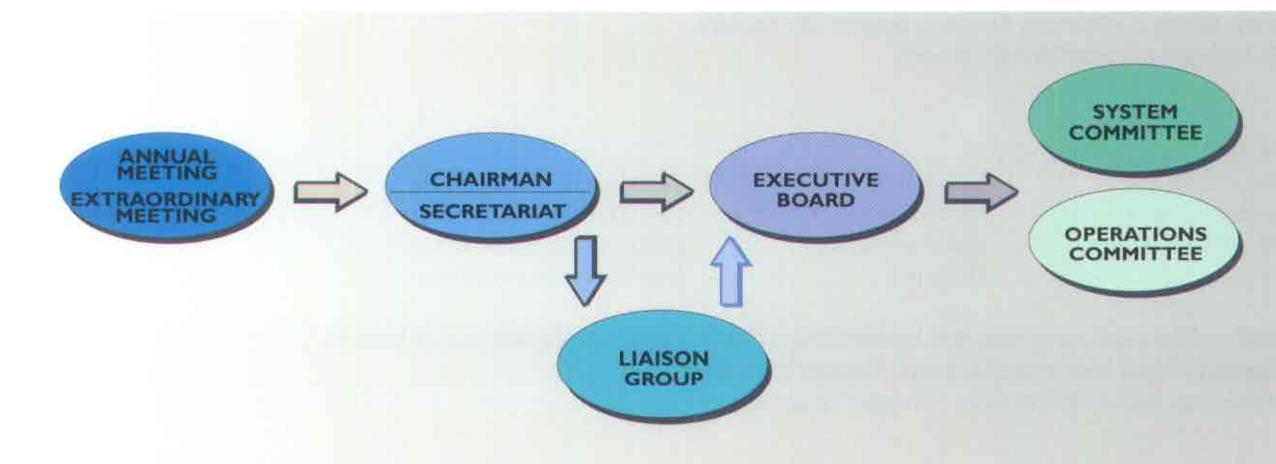

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