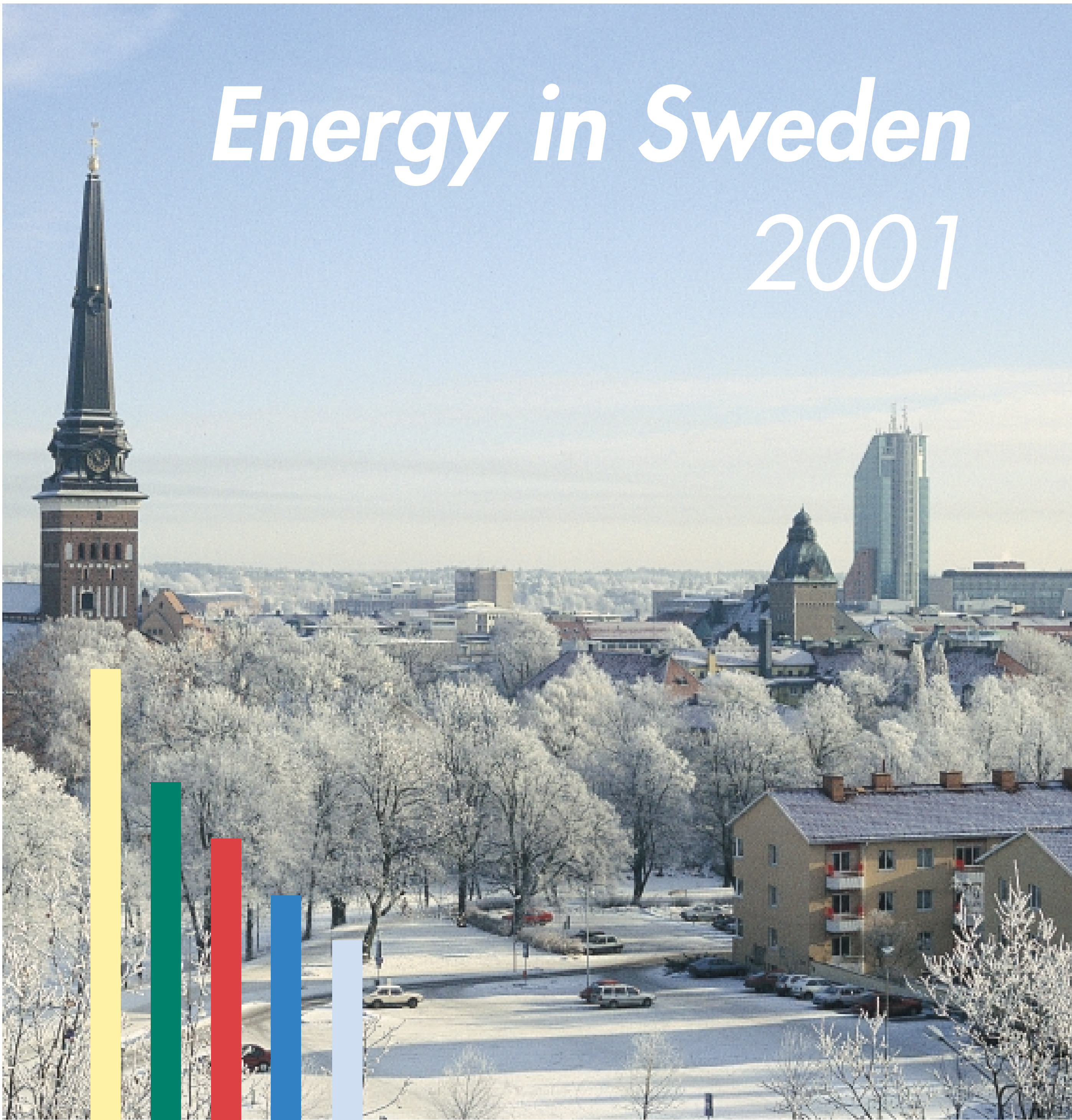
Energy in Sweden 2001



Swedish National
Energy Administration

Energy in Sweden is published annually, in Swedish and English, by the Swedish National Energy Administration. A special version, containing only the tabular data, is also available. In addition, the diagrams can be ordered from the Energy Administration in the form of a set of overhead pictures. Energy in Sweden, together with a number of other publications of current interest, can be ordered from the Energy Administration.

Further general information is available from the Energy Administration's External Communications Department.

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Preface

The energy markets are changing rapidly, partly as a result of changes in the direction of energy and environmental policy in Sweden and in other countries. *Energy in Sweden*, which is published annually by the National Energy Administration, is intended to provide decision-makers, journalists and the public with a single source of easily available information on conditions and developments in the *energy sector*.

In recent years, Swedish energy and environmental policy has increasingly concentrated on establishing or improving long-term conditions for effective energy markets. Reforming the Swedish electricity market, greater internationalisation and the effects of the energy system on the environment and on climate are important factors that influence this policy and thus the development of the energy markets.

An important event during 2001 was Sweden's presidency of the EU, which it took over from France at the beginning of the year. This has now passed to Belgium, which holds the presidency for the second half of 2001.

Sweden's energy policy, as decided by the Swedish Parliament in 1997, is to provide secure short-term and long-term supplies of electricity and other energy on competitive terms. The policy is intended to create the right conditions for efficient use and cost-efficient supply of energy, with minimum adverse effects on health, the environment or climate, while at the same time assisting the move towards an ecologically sustainable society.

An extensive energy policy programme has been started in order to facilitate restructuring and development of the energy system. The main thrust of this work is in the form of a substantial long-term concentration on research, development and demonstration of new energy technology. The National Energy Administration is responsible for implementing most of the energy policy programme, and for coordinating the work of restructuring the energy system. In order to ensure and encourage competition in the supply of electricity, the Administration monitors the performance and operation of the country's grid system. In addition, it is a central authority in respect of strategic planning for emergency situations, as well as for local authority energy planning.

The Administration is also responsible for monitoring developments in the energy and environmental fields, and for providing information on the current energy situation. This covers aspects such as developments in the structure and pattern of energy supply and use, energy prices and energy taxes, as well as the effects of the energy system on the environment.

The statistics in the diagrams in this year's edition of *Energy in Sweden* have been revised in comparison with those in previous editions. The revision covers the years 1983–2000, with the data for the last two years being based on preliminary statistics. The breakdown of data for certain fuels varies somewhat, depending on whether preliminary or definitive statistics have been used. ■

Stockholm, October 2001

Thomas Korsfeldt
Director-General

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Contents

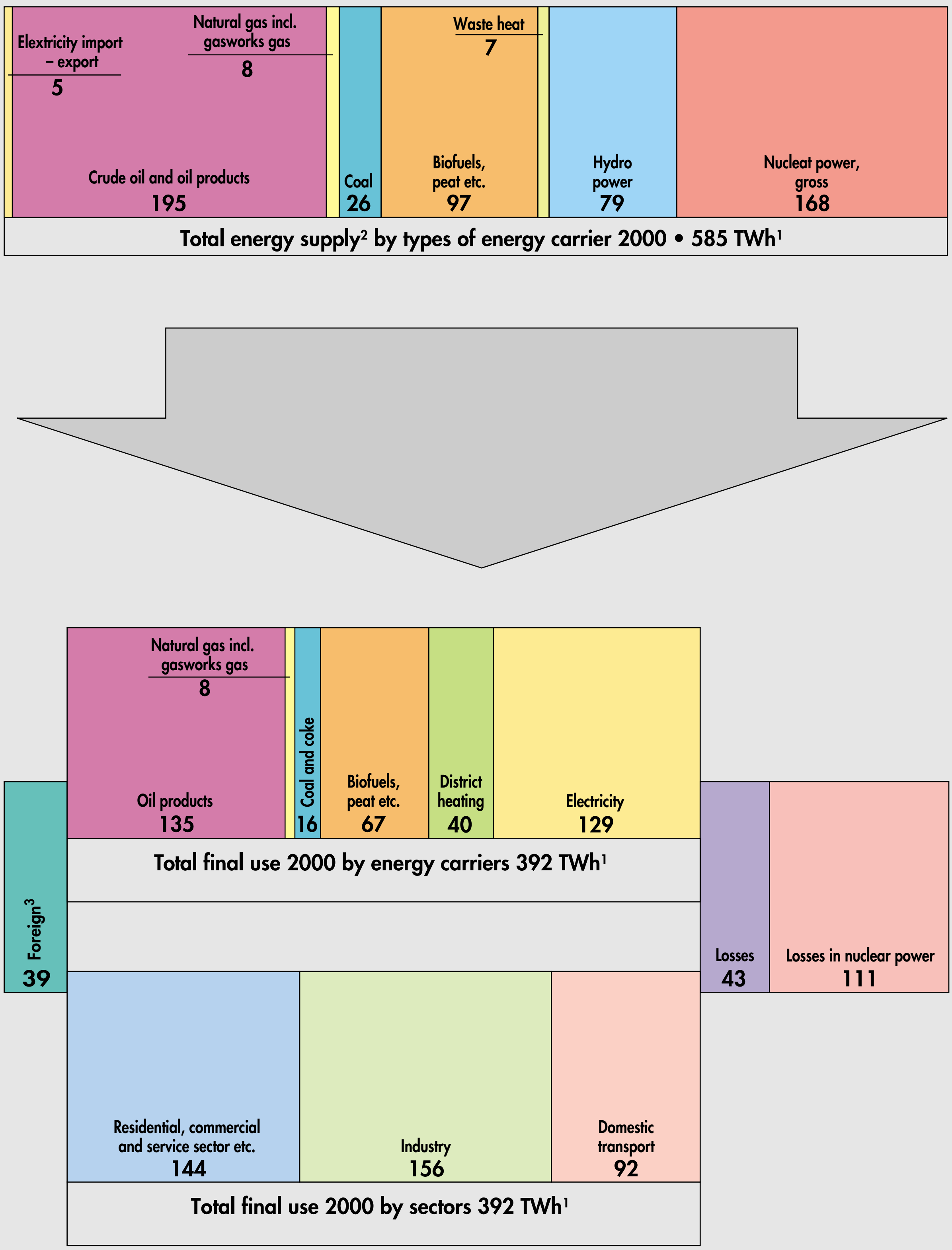
Information about statistics

Statistics in this year's edition of *Energy in Sweden* have been revised in comparison with those of previous editions. Although most of the changes are to figures relating to data for 1983–1999, entire series have been updated in some tables.

Much of the revision work has been carried out in conjunction with Statistics Sweden. Statistics for years up to and including 1998 are definitive, while those for the last two years are still preliminary. Breakdowns into certain types of fuels vary somewhat, depending on whether preliminary or definitive data has been used.

Figure 1 • Energy supply and use in Sweden 2000, TWh

The same diagram, expressed in PJ, can be found on page 44



[1] Preliminary figures. Due to rounding up or down of these figures, total figures may not always agree exactly with the sums.
[2] Including windpower, 0,44 TWh.
[3] Foreign maritime trade and energy for non-energy purposes.

This section concentrates on a number of areas of current interest in the energy, environmental and climate fields. The aim is to give a picture of some of the areas discussed elsewhere, and which can be relevant in connection with future energy, environmental or climate policies. It is not comprehensive, but describes only a selection of the matters discussed at national and international level.

National

The short-term and long-term objectives of Swedish energy policy are to ensure a supply of electricity and other forms of energy at competitive prices. Energy policy aims at creating the right conditions for the efficient use, and cost-efficient supply, of energy with minimum adverse effects on health, the environment or climate. Another important objective is to extent cooperation in the fields of energy, the environment and climate to other countries in the Baltic region.[1]

In the spring of 2001, the Government published a bill bringing together its proposals for stage objectives, necessary actions and strategies to achieve Sweden's environmental quality objectives. The Government's overall environmental policy objective is to hand over a society to the next generation in which Sweden's major environmental problems have been solved. The Bill covers 14 of the 15 environmental quality objectives that were agreed by Parliament in 1999. The objectives have been formulated on the basis of what the natural environment can stand, and define the Swedish environmental conditions towards which environmental work must aim.

The Government intends to put forward a bill in the autumn of 2001 covering the 15th environmental quality objective, that of limited effect on climate. The bill is expected to set out a strategy of how Swedish emissions of greenhouse gases can be limited or reduced.

The Goods Transport Commission presented its final report during the year. The report recommends a strategy for developing efficient, sustainable goods transport, based on both national and international measures, pointing out that such transport can be achieved only through international cooperation as a complement to national measures. A key aspect is therefore the introduction of proper cost accountability for goods transport. Among the Commission's recommendations are the introduction of a competitively neutral distance-based road tax and harmonisation of track access charges within the EU. In addition, the Commission proposes reform of navigation fees for shipping.

The Government published its Infrastructure Bill in October 2001. The Bill calls for the National Rail Administration and the National Road Administration to plan investments in new railways and roads, and to develop and modernise transport systems. In addition, it proposes to make available a total of SEK 364 x 10^9 between 2004 and 2015 for retention and maintenance of existing rail and road networks. Some of this money will be made available earlier, for work to be carried out during the period 2002–2004.

The Resource Efficiency Commission presented its report at the beginning of 2001. The Commission noted that, although the efficiency of use of materials and energy has improved considerably in recent decades, the improvement has still not been enough to prevent an increase in absolute terms. In the longer term, environmental policy will have to be tightened up in order, for example, to restrict environmentally hazardous and climate-affecting emissions. The Commission also notes that poor formulation of objectives, coupled with quantities based on summing of the use of natural resources in physical terms, do not provide any real help to the determination of policies aimed at sustainable development.

Energy policy objectives

- To ensure the supply of electricity and other forms of energy, on competitive terms that support good economic and social development in Sweden.
- To create the right conditions for efficient use of energy and a cost-efficient Swedish supply of energy having a low adverse effect on health, the environment and climate.
- To facilitate the changeover to an ecologically sustainable society.

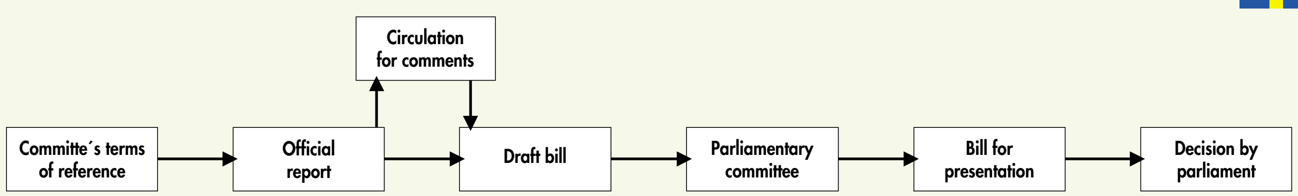
Transport policy objective

- To ensure a publicly economic and long-term sustainable transport system for industry and persons throughout the country.

An interdepartmental working party was appointed during the year in order to decide how more efficient use of energy can be encouraged, and is due to present its report by the end of October 2001.

A proposal for a new system for encouraging the production of electricity from renewable energy sources is to be presented by not later than the same date (Dir. 2000:56). The system, which is intended to be a model for support for renewable electricity production, will be based on trade in certificates. Its objectives include facilitating the construction of new plant for electricity production from renewable energy sources, stimulating technical development and cost efficiency and facilitating international harmonisation.

The Government has also taken the initiative to several new investigations during the year. One such is the appointment of a par-



When decisions must be made on various matters, the Government may appoint a committee. The starting point for the committee's work is set out in its terms of reference. The committee presents its conclusions and proposals in a report. Before deciding its views on the report, the Government circulates it to public authorities, organisations, local government etc. for comments. When the comments have been received, the Government prepares a bill for presentation to Parliament. The bill is then examined by the parliamentary committee responsible for the particular area. When this committee has put forward its proposals, Parliament makes the final decision.

The European Commission:

- Has the sole right to put forward draft legislation
- Is the EU's investigatory body
- Monitors to ensure that common regulations are being correctly applied.

The European Parliament:

- Is the elected body of the European Union
- Makes decisions, in conjunction with the Council of Ministers, on legislative matters in most areas.

The Council of Ministers:

- Makes decisions and legislates within the European Union.

The European Court:

- Interprets and adjudicates in disputes on how EU law is to be applied.

The Audit Committee:

- Monitors how money in the common EU budget is being used and accounted for.

Priority working areas of the European Commission Directorate-General for Energy and Transport for 2000–2005:

- Realisation of the single markets for energy and transport
- Combining development of transport and energy with environmental requirements
- Developing the major networks in Europe
- Space projects
- Improvement of safety
- Successful expansion
- The Mediterranean area
- Transatlantic links.

Read more at: http://europa.eu.int/comm/

liamentary committee to prepare a proposal for a Swedish system and regulatory framework for implementing the flexible mechanisms of the Kyoto Protocol, i.e. trade in emission rights, Common Implementation and Clean Development Mechanisms (Dir. 2001:56). The Commission is due to report its proposals for a regulatory framework by 31st December 2002, with the remaining work completed by 31st December 2004.

Another parliamentary committee has been appointed to review the present regulations for reduction of energy taxation in certain sectors (Dir. 2001:29). It is due to present its report by not later than 31st December 2002.

Parliament has to introduce new legislation, or modify existing legislation, to keep up with changes in the energy markets. A new Natural Gas Act was passed in June 2000, in order to bring Swedish legislation into line with the EU Electricity Market and Gas Market Directives. The main points of the Act are concerned with concessions, obligations of network owners, accounting and surveillance.

Several measures relating to energy policy were put forward in the Government's autumn 2001 Budget Bill. These include investment of a further SEK 75 million in expansion of wind power production during 2002. The Government will publish a bill on the electricity markets during the autumn of 2001, which will include suggestions for changes to the regulations governing surveillance of grid activities and changes to the Electricity Act as a result of the profile settlement reform. The Government has also submitted a special application for further review of the plans for closing Barsebäck 2, proposing that it should be closed as soon as the conditions set out by Parliament are fulfilled. The situation should be reviewed again in 2003.

Short-term energy policy actions, as included in the 1997 energy policy programme, are due to expire at the end of 2002, and so the Government is planning to present a new energy policy bill during the spring of 2002. This will include a proposal for green certificates aimed at encouraging electricity production from renewable energy sources. It will also include measures intended to encourage improving the efficiency of energy use, together with certain measures intended to improve operation of the electricity market.

EU level

Sweden held the presidency of the European Union during the first half of 2001. The main duties of the holding country are to provide a lead for EU work and to advance matters of common interest. A country holding the presidency also represents the Union in international contexts. The matters to which priority was given during Sweden's presidency were employment, the environment and expansion of the EU. For the second half of 2001, the presidency was taken over by Belgium, which will hand over to Spain at the end of the year. The environment and sustainable development are a couple of important working areas that Belgium will be pursuing during its presidency.[2]

The EU Directorate-General for Energy and Transport has set a number of political priorities for the period 2000-2005. Among them are establishment of the single market for energy and transport, and the question of how developments in the transport and energy sectors can be reconciled with sustainable development.

The objective of realising the single market for energy and transport is supported by other works such as the gas and electricity market directives. The Electricity Market Directive (96/92/EEC) was adopted in 1996, followed by the Gas Market Directive (98/30/EEC) in 1998. The objectives of these directives are gradually to open the respective markets, thus increasing competition and benefiting European consumers in the form of lower prices.

The electricity markets in the UK, Norway, Sweden, Finland and Germany are fully open to competition, i.e. all domestic and industrial customers are free to choose their electricity suppliers. Denmark, too, is well on the way to such a market: progress in other EU countries has been slower. In March 2001, the EU Commission presented proposals for modifications to the electricity and gas market directives.[3] The proposal considers aspects such as to what extent the electricity and gas markets should be liberalised, and obligations regarding grid access, consumer protection etc. The present directives include a timetable setting out the rate at which the markets should be deregulated. However, several countries (including Sweden) want to speed up this process. The Commission's proposal was discussed at the EU summit in Stockholm later that month but, as the ministers were unable to reach agreement on the new timetable, it will be taken up again in the spring of 2002.

The environment was one of the areas to which priority was given during the Swedish presidency. Prior to the EU summit in Gothenburg in June 2001, the Commission presented a status report on the progress of work on incorporating environmental consideration and sustainable development in the transport and energy field. This strategy is a continuation of the Cardiff Process that started in Cardiff in 1998, when the question of sustainable development was brought out. An important element of the Cardiff Process was to monitor the energy and transport markets, and to prepare status reports on which the necessary priorities on the path to sustainable development could be based.

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The proposals for strategies and measures included in the report were concentrated on such aspects as encouraging improvements in the efficiency of energy use and the use of renewable energy, as well as on reducing the demand for transport. The conditions must be created for fast, straightforward entry of efficient energy and transport technology onto the market.

The spotlight was turned onto security of energy supply in the EU at the end of 2000, when the Commission published a Green Paper on the subject.[4] The report draws three conclusions: 1) The EU is becoming increasingly dependent on external energy sources. It is expected that this dependence will increase from the present-day 50 % to 70 % in 2030. 2) The EU has very little scope for affecting its supplies of energy. Its energy reserves are limited, and insufficient to meet a growing demand for energy. The alternative that remains is to attempt to reduce the demand, primarily by encouraging improvements in the efficiency of energy use in buildings and for transport. 3) The EU is not on course at present to meet its obligations under the Kyoto Protocol in terms of reducing greenhouse gas emissions by 8 % between 1990 and 2008–2012. Further measures are needed in order to achieve this emission objective. On the basis of these conclusions, the Commission wants to start a discussion on certain key aspects, as set out in the Green Paper. Replies and views on the points can be submitted to the Commission up to 30th November 2001.

During the year, discussions were started between the EU and Russia on energy matters as part of the work of improving the security of energy supply. The objective is to establish a partnership for energy between the two regions. This partnership is largely a result of the fact that the EU and Russia are mutually dependent on each other in the energy sector: for example, 65 % of Russia's total exports to the EU consist of oil and natural gas. The objective of the partnership, which covers oil, natural gas and electricity, is to improve conditions for investing in the Russian energy sector. To do this, the EU needs Russia to implement comprehensive economic reforms and, in return, is undertaking to invest in the Russian energy sector, in such ways as through infrastructural improvements and assistance with the introduction of energy-efficient technology.

In September 2001, the Commission published a White Paper on the EU's common transport policy.[5] Overall guidelines call for policy to be concentrated on transferring freight transport from road to rail and ship, the elimination of bottlenecks in the transport system, the introduction of new principles for pricing infrastructure and transport, finding a balance between environmental consideration and the massive growth in air traffic, strengthening consumer rights and enhancing the position of the EU in international organisations.

Among the work of the Commission's Directorate General for the Environment is included climate problems. The European Climate Change Programme (ECCP) was concluded in June 2001. The purpose of the programme, which ran for a year, was to bring together the various parties concerned to discuss strategies and measures to reduce the emission of greenhouse gases, and is a preparation for ratification of the Kyoto Protocol. The areas that have been discussed are flexible mechanisms, energy supply, energy use, transport, industry and research. The programme's final report presents a number of possible measures, together with their expected effects and costs, intended to reduce greenhouse gas emissions.[6]

During the previous year, the Commission published a Green Paper on emission trading[7]. The objective of this was to initiate a discussion of trading in emission rights, including aspects such as how such a trading system might be constructed. The overall objective is that a trading system should have been established within the EU by not later than 2005. The ECCP work sees emission trading as an important means of reducing emissions, and so the Commission is therefore preparing more concrete proposals for the design of such a system. However, it is already clear to the Commission that any future trading system should be concentrated – at least initially – on carbon dioxide emissions, and should include a smaller number of emission sources that together account for a larger proportion of emissions.

In January 2001, the Commission published its sixth draft Environmental Action Programme.[8] The programme identifies four priority working areas: climate changes, nature and biodiversity, the environment and health, and natural resources and waste. The Commission claims that improvements can be achieved in these areas through better compliance with existing legislation, inclusion of environmental consideration in all relevant areas of policy, close cooperation between industrial organisations and consumers, more information to EU citizens on environmental matters and through the development of a more environmentally considerate approach to land use.

International

Climate negotiations as part of the UN Framework Convention on Climate Changes were restarted at the end of July 2001. These negotiations had stranded at Den Haag in the autumn of 2000, when the parties were unable to agree on how greenhouse gas emissions could be reduced by at least 5 % between 1990 and 2008–2012, as set out in the Kyoto Protocol. The new negotiations, held in Bonn in July 2001, dealt with four main aspects: financing and technology transfer to the least developed countries, opportunities for countries to carry out work aimed at reducing emissions in other countries and then being credited with the reductions (flexible mechanisms), carbon dioxide absorption by forests and the ground (carbon sinks), and sanctions against parties failing to meet their obligations. Despite major differences in views on such matters as the utilisation of carbon sinks, the parties did reach agreement on a final document, setting out agreements in principal on the above main points. However, much work remains before all details have been finalised. The negotiations will be continued during the Seventh Conference, to be held in Marrakesch in Morocco between 29th October and 9th November 2001.[9]

During the spring, President Bush presented a plan for ensuring energy supply in the USA, covering measures on both the user and the supply side.[10] The rate of increase in energy use is to be reduced, in such ways as through improving the efficiencies of vehicles and electrical equipment. Energy supply will be assured through increased exploitation of domestic oil and gas reserves, together with the encouragement of coal and nuclear power.[11] ■

Further information

1. Read more at http://www.regeringen.se (the Swedish Government's website).
2. Read more at http://www.eu2001.be/
3. Completing the internal energy market. *(COM 2001 125 final)*
4. Towards a European strategy for the security of energy supply. *(COM 2000 769 final)*
5. European Transport Policy for 2010: Time to Decide. *(COM 2001 370)*
6. European Climate Change Program. *(Report June 2001)*
7. Green Paper on greenhouse gas emissions trading within the European Union. *(COM 2000 87)*
8. Environment 2010: Our future – Our choice. *(COM 2001 31 final)*
9. Read more at http://www.unfccc.int
10. National Energy Policy. *Report on the National Energy Development Group, May 2001.*
11. Read more at http://whitehouse.gov or http://www.energy.gov

Sweden's energy supply has increased by 28 % between 1970 and 2000, from 457 TWh to 585 TWh in 1999.[1] Average energy supply has been 535 TWh/year.

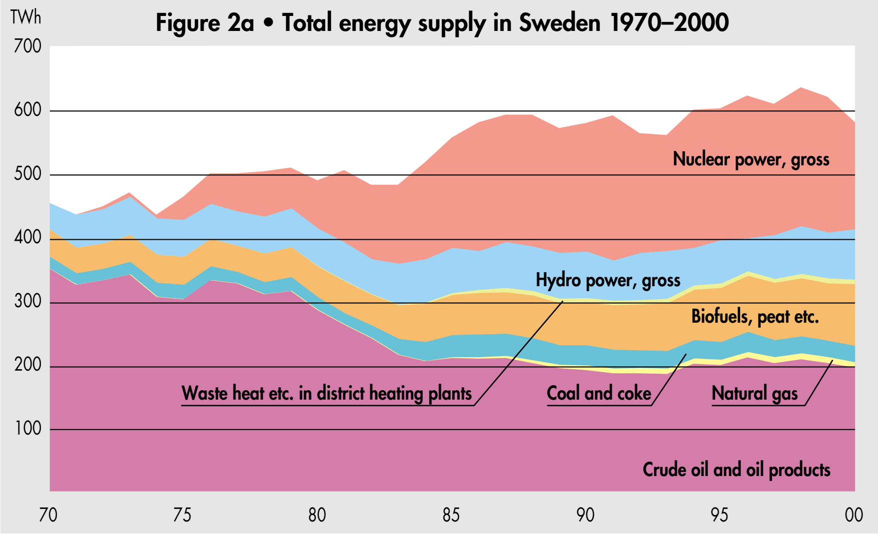
The constituents making up the total energy supply have changed considerably over this period. In 1970, crude oil and oil products accounted for 77 % of the total energy supply, but had fallen to 33 % by 2000. In 1970, most of the oil supply went to the residential and service sectors. Today, 54 % of oil supplies go to the transport sector. Over the last 30 years, much of the energy previously supplied by oil has been replaced by nuclear power and biofuels. Normal year production of hydro power, i.e. based on a mean value of precipitation statistics over the period 1950–1996, has increased. Today, nuclear power can provide about 206 TWh[1] (68 TWh of electricity) and hydro power can produce about 64 TWh under normal precipitation conditions. The total proportion of overall energy supply provided by hydro and nuclear power has increased from 9 % in 1970 to 42 % in 2000. In 2000, the proportion of energy supply represented by coal and coke was the same as in 1970, i.e. 4 %. However, biofuels and peat have increased their share of the supply from 9 % in 1970 to over 16 % in 2000. These fuels are supplied mainly to the industrial sector and district heating producers.

Total energy supply varies from one year to another due to a number of factors, including variations in temperature. Years that are warmer than statistically average result in a reduced need for energy supplies, while colder years increase the need. 2000 was warmer than an average year, and so energy supply was less than would otherwise have been the case.

In comparison with the international situation as a whole, Sweden obtains a relatively large proportion of its energy supplies from renewable energy sources, in the form of biofuels, hydro power and wind power. In 2000, these sources provided 30 % of the country's total energy supply. To increase their proportions, wind power and biofuelled CHP are subsidised by an investment grant, administered by the National Energy Administration.

The Administration's forecast for the period up to 2020 expects total energy supply to be 611 or 617 TWh respectively, with net imports of electricity amounting to 9 TWh and 10 TWh respectively.

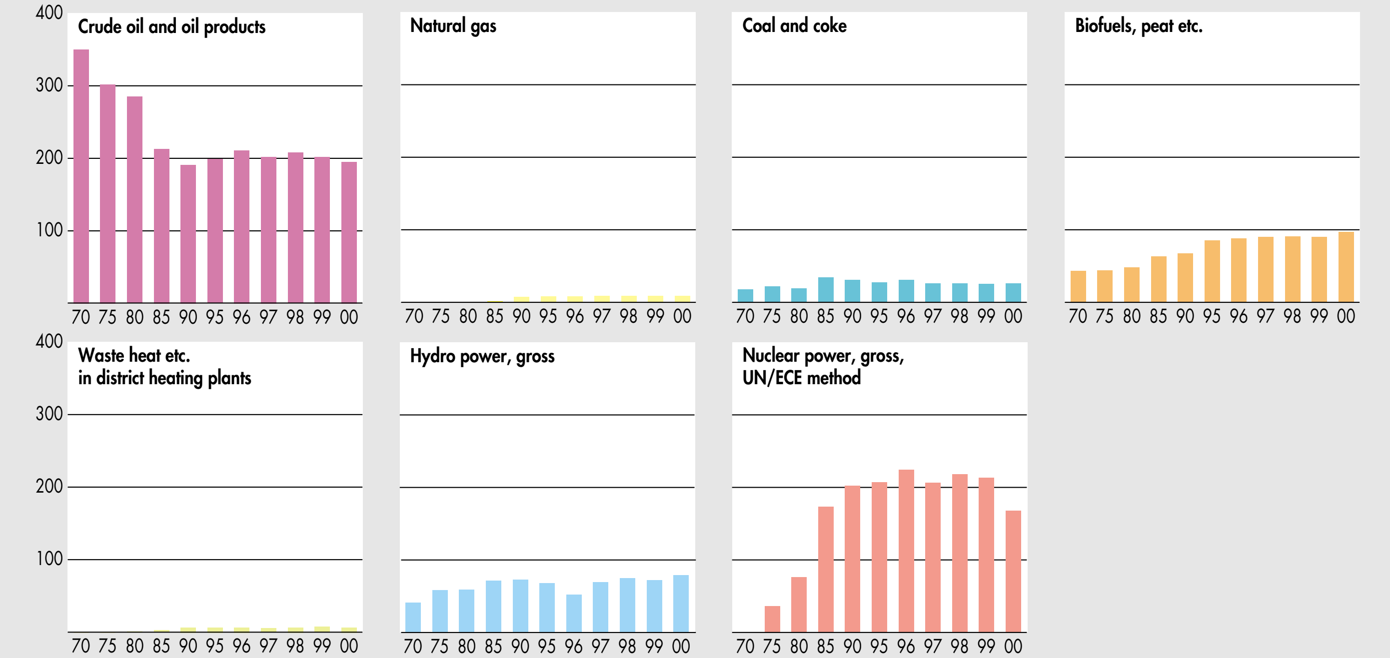
Figure 2a • Total energy supply in Sweden 1970–2000



[1] As calculated by the international method, which means that the energy conversion losses in nuclear power stations are included.

[2] Energy supply in Sweden, short-term forecast, 2001-02-26.

Figure 2b • Energy supply in Sweden by types of energy carriers



Total energy use can be divided up into three categories. First is what is known as the total final energy use, i.e. use within the three sectors of residential/services etc., industry and transport (excluding foreign maritime traffic). These three sectors account for the majority of all energy use. The second category comprises the losses in total energy use, by which are meant conversion losses in heat and electricity production (although the losses associated with hydro power production are not included), conversion losses in refineries and coking plants, the energy sector's own consumption and distribution losses associated with the supply of electricity, natural gas, town gas, blast furnace gas and district heating. The third category of energy use includes bunker oils for international shipping and coal and oil products used for non-energy purposes, such as raw materials and feedstocks for applications such as the plastics industry, lubricating oils and oil products used in the building and civil engineering sectors, e.g. asphalt, surface coatings etc.

The relative proportions of final energy use have gradually changed since 1970. The residential/service sector and the industry sector proportions have each fallen in relation to the amount of energy used by the transport sector. Industry's proportion has fallen from 41 % to 39 %, while the proportion of energy used by the residential/service sector has fallen from 44 % to 36 %. At the same time, the proportion of total final energy use by the transport sector, excluding that used by international shipping, has increased from 15 % to 23 %.

The variations in energy use from one year to another are due mainly to economic conditions and to climate conditions. The reduction in energy use in the residential/service sector at the end of the 1980s and during the beginning of the 1990s can be partly explained by the fact that this period was warmer than normal. 1996, however, was colder than normal, which explains the increase relative to the previous year. The years after 1996 were again warmer than normal, resulting in a fall in energy use in the sector.

Total final energy use in 2000 amounted to 392 TWh. To this must be added 39 TWh for international shipping etc., and 154 TWh for losses (of which the losses in nuclear power plants accounted for 111 TWh), giving a total energy use of 585 TWh for the year.

The Administration's forecast[3] for the period until 2002 expects final energy use to increase to 404 and 406 TWh/year respectively. ■

[3] Energy supply in Sweden, short-term forecast, 2001-02-26.

Figure 3a • Total energy use in Sweden 1970–2000

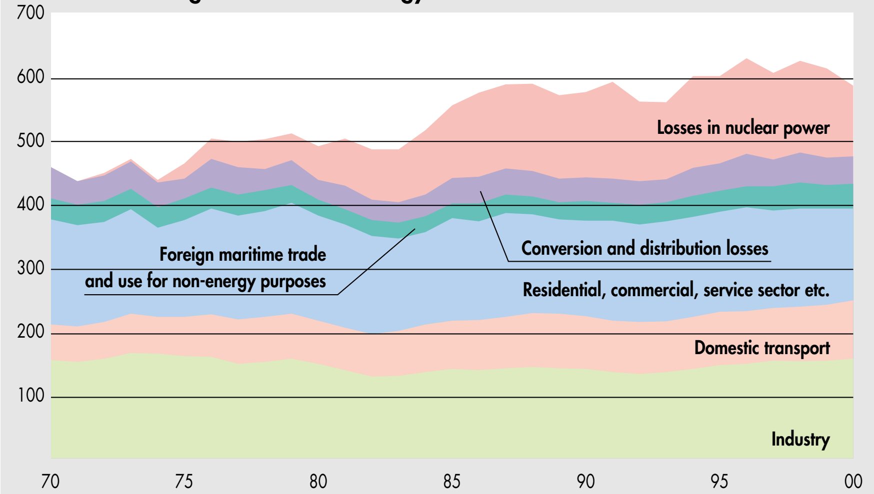
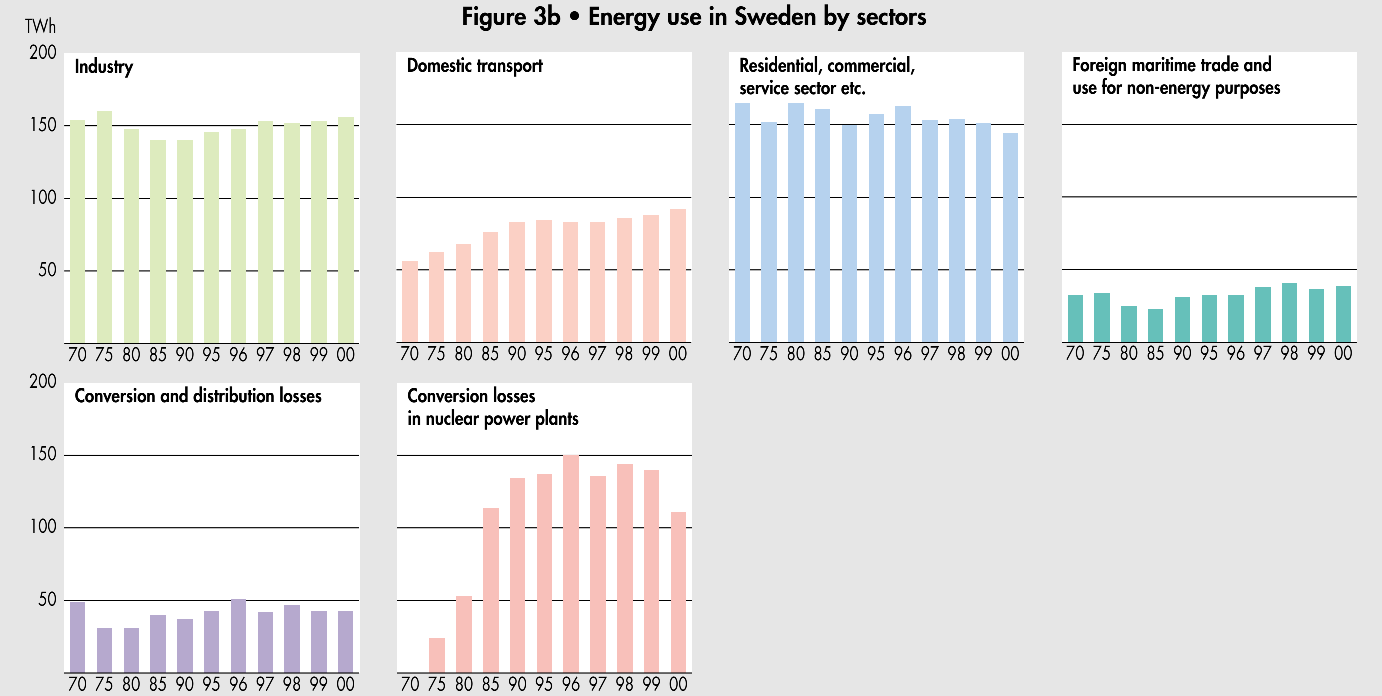


Figure 3b • Energy use in Sweden by sectors



2000 was the fifth year of the reformed electricity market in Sweden and Finland: Norway had reformed its electricity market in 1991, while Denmark had started work in 1999. Today, with the connection of Jutland and Zealand to NordPool in 1999 and 2000 respectively, all the Nordic countries except Iceland are trading on the Nordic electricity exchange.

Precipitation in 2000 was high, with record hydro power production in the Nordic countries, resulting in low prices on the exchange right up to the end of the year. Prices have started to rise again since then.

Electricity use

Over the period from 1970 to 1987, electricity use in Sweden increased by almost 5 % per annum. However, this rate of increase has eased off considerably since then, so that electricity use increased by only 0.5 % per annum from 1987 to 2000, when it amounted to almost 147 TWh/year. The greatest increase is to be found in the residential/service sector, although electricity use within the sector does vary with ambient temperature. However, most of the increase is due to a change from oil to electricity for heating, coupled with greater use of electricity for building services systems.

Electricity use in industry has increased on average by 1.8 % per annum since 1970. Industrial use is closely linked to conditions in a small number of important sectors: the pulp and paper industry, for example, uses about 40 % of all the electricity used in industry. Electricity use in the transport sector is relatively little, being used almost entirely for rail-borne transport. Total electricity use also includes the losses associated with the transmission of electricity and with its use in district heating plants, CHP plants and refineries.

Electricity production

Electricity is produced in Sweden by hydro power, nuclear power, wind power and conventional thermal power. This last category, of conventional thermal power, includes CHP plant, cold condensing plant and gas turbines. CHP plant, which produces electricity and heat simultaneously, is used in industry, where the heat is used for internal processes, and in district heating power stations, where the heat is generally supplied to a public district heating system.

At the beginning of the 1970s, most of Sweden's electricity was produced by hydro power and conventional thermal power. However, this was when construction of the country's nuclear power plants started, with the first commercial reactor, Oskarshamn 1, being commissioned in 1972. Since then, the proportion of electricity supplied by nuclear power has increased substantially, so that, since 1975, more electricity has been produced by nuclear power than by conventional power plant.

Today, most of the country's electricity is produced by hydro power and nuclear power, with conventional thermal power production accounting for only 6 %. Oil-fired cold condensing power stations and gas turbines are used primarily as reserve capacity during years with low precipitation and resulting low hydro power production. The reform of the electricity market has resulted in several reserve power stations being decommissioned for economic reasons.

As of August 2001, there were 541 wind power plants in the country. However, their

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Figure 4a • Use of electricity in Sweden 1970–2000

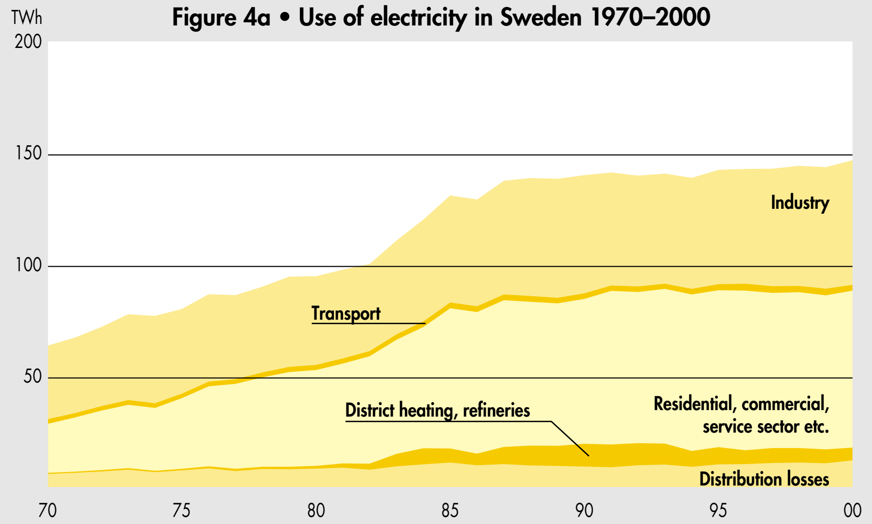
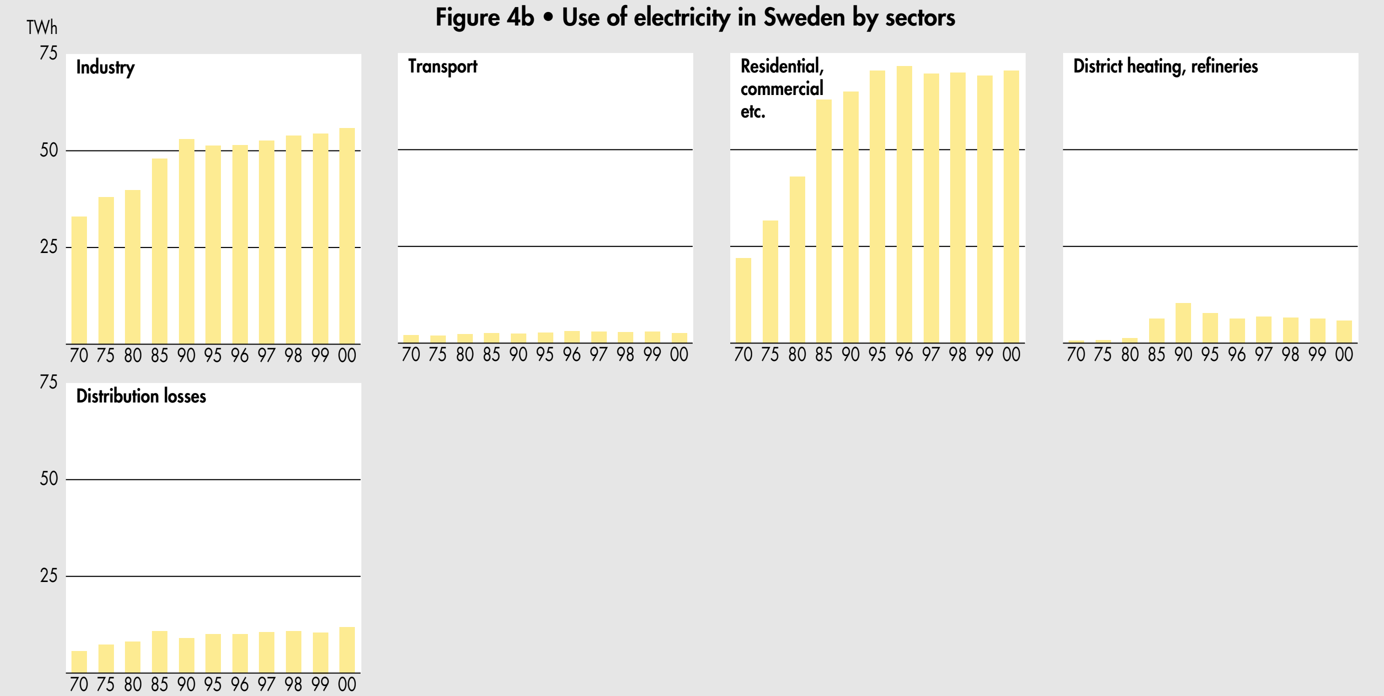


Figure 4b • Use of electricity in Sweden by sectors



contribution to total electricity production is still very small, amounting to 0.3 % during 2000.

The country's total installed capacity is somewhat over 30 000 MW. However, this total capacity can never be 100 % available, and there are also limits to the transmission capacity between northern and southern Sweden. Normal capacity allows 6 700–7 000 MW to be transmitted from northern to central Sweden, and 3 500–3 900 MW from central Sweden to southern Sweden.

In 2000, the electricity production amounted to 141.8 TWh, of which 55 % was from hydro power, 39 % from nuclear power and 6 % from fossil-fuelled and biofuelled production.

Transmission of electricity

A condition for proper operation of the electricity market is that all parties should have unrestricted access to the power grid. At the same time, there needs to be a system operator who, independently of other parties on the market, ensures that there is at all times a balance of power flows on the grid between power demand and power production. The Swedish system operator is Svenska Kraftnät, with responsibility for the country's grid and for most of the interconnections with the neighbouring Nordic countries. Interconnection capacities between the countries have been increased in recent years, and a cable link between Sweden and Poland was commissioned in 2000. In addition, steps have been taken to increase the capacity of links to Germany and Poland during 2001.

Trade in electricity

Prior to reform of the markets in the Nordic countries, electricity was traded between the countries under the terms of bilateral agreements between the large electricity producers. Today, there is also a joint power exchange, NordPool, where the price of electricity is settled on an hour-by-hour basis 24

Figure 5 • Wind power development 1982–2000

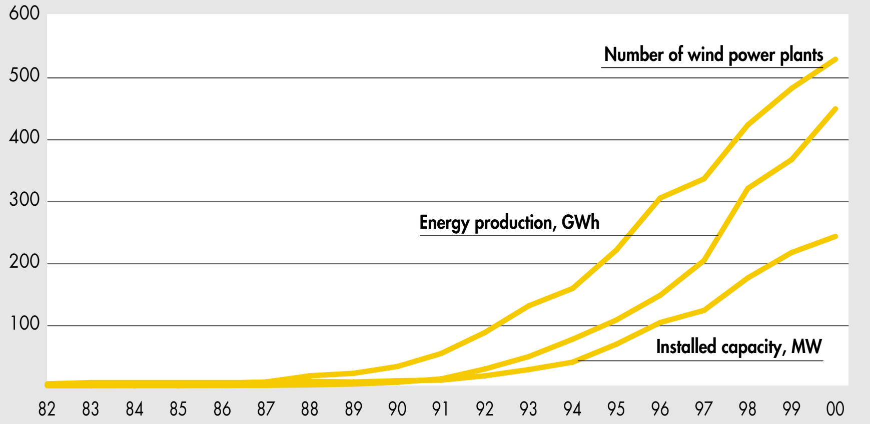
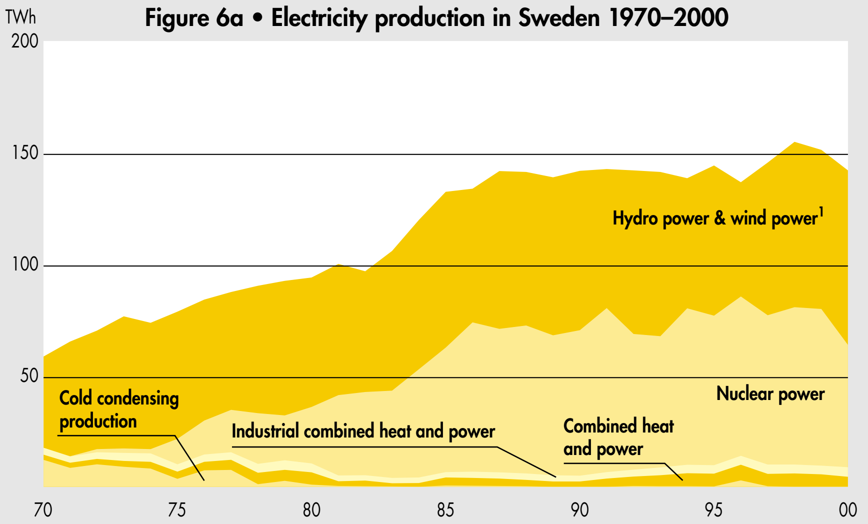
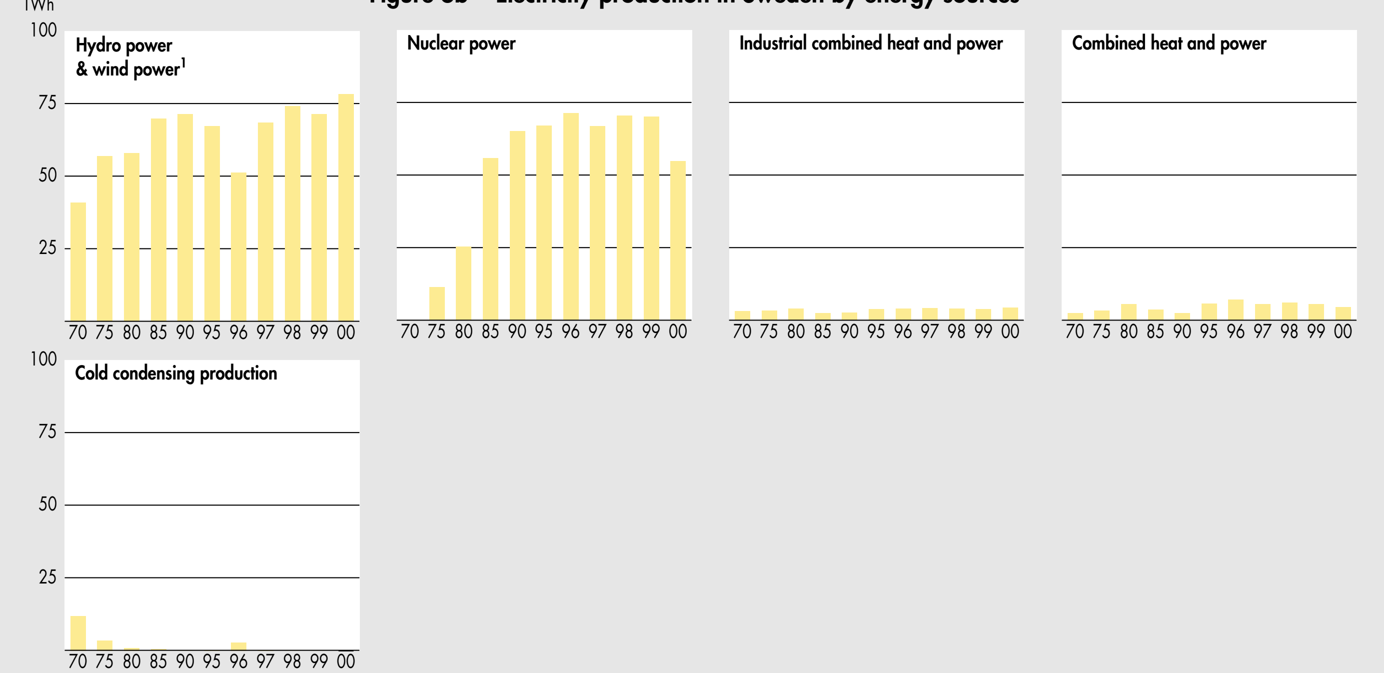


Figure 6a • Electricity production in Sweden 1970–2000



[1] Including wind power, 0.44 TWh.

Figure 6b • Electricity production in Sweden by energy sources



hours in advance. This has resulted in pricing on the Nordic market having become more efficient as a result of reduced transaction costs. In addition, the exchange price can be used as a reference for bilateral trade. Border tariffs have been removed between Norway, Sweden and Finland, which has also helped to encourage trade. Production plant with high production costs has been decommissioned due to not being profitable. Instead, the power utilities import power on the common Nordic market from neighbouring countries as necessary.

Today, as a result of the changes in the electricity markets in the four Nordic countries, Swedish producers can sell electricity directly to customers in Denmark, Norway and Finland. In the same way, Swedish customers can also purchase electricity from suppliers in other countries. Several Swedish electricity trading companies have long-term agreements with producers in the other Nordic countries for the import and export of electricity. Long-term agreements with customers in other countries are also becoming increasingly common.

Trade in electricity between the Nordic countries varies during the year and from year to year, depending on weather and economic conditions. However, the prime factor in determining power trading is annual precipitation to the Swedish, Norwegian and Finnish reservoirs, coupled with the marginal production costs of electricity. German, Russian and Polish utilities also trade electricity with the Nordic countries, despite not being allowed to trade via NordPool. However, as yet, the quantities of such trading are still relatively small.

Despite high availability of the country's nuclear power plants and an adequate inflow of water to the hydro power reservoirs, Sweden's trade in electricity during 2000 changed from having been a net exporter in previous years to a net importer, with most of the imported power coming from Norway. One explanation for this could be that the power companies have started to adjust their production to spot prices. During the spring and summer of 2000, for example, the price of electricity on NordPool was so low that it undercut the production costs from several forms of production, with the result that several nuclear power stations produced less electricity than normally. The direction of the power flows changed again in 2001, with imports being lower, and exports higher, than the corresponding periods during the previous year. During the summer, Sweden exported power primarily to Norway, although also with some to Denmark and Finland.

Price developments

The prices of electricity vary between customer categories, between urban and rural areas and between the Nordic countries. This is due to varying transmission costs across regional and local distribution systems, different taxation regimes, subsidies, national rules and the structure of the electricity market. The spot price of electricity on the power exchange is not the price that private customers see on their electricity bills. The final price of electricity to a customer consists of a grid tariff, a price for the electrical energy itself, various charges and taxes and, finally, the profit margin applied by each link in the chain. The spot price is determined on the basis of an equilibrium price, as indicated by the intersection of the supply and demand cost curves.

The first year of the reformed electricity market, 1996, was a dry year, which meant that the spot price rose until the end of the year. Since then, it fell substantially until the end of 2000, due partly to adequate precipitation and partly to increasing competition on the common electricity market. However, since the start of 2001, the price has risen substantially, due primarily to lower precipitation than usual in Norway during the first half of the year. During the summer, the spot price again fell, although it is still relatively high when compared with the spot prices of recent years.

The price also varies over the year: between 1998 and 2000, these variations followed a similar pattern, being higher during the winter and lower during the summer. The variations depend on the amount of precipitation, temperatures and available production and transmission capacities.

Due to physical limitations, primarily on the links between Sweden and Norway, different prices, known as area prices, have been applied on occasions. During 1999 and 2000, these differences were greatest during the summer, when prices in Sweden were higher than those in Norway. The greatest price differences during 2001 have so far occurred at the beginning of May, when the prices in Norway were higher than those in Sweden.

International development

The electricity market in many parts of the world is at present undergoing extensive

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Figure 7 • Sweden´s electricity imports January 2000–July 2001

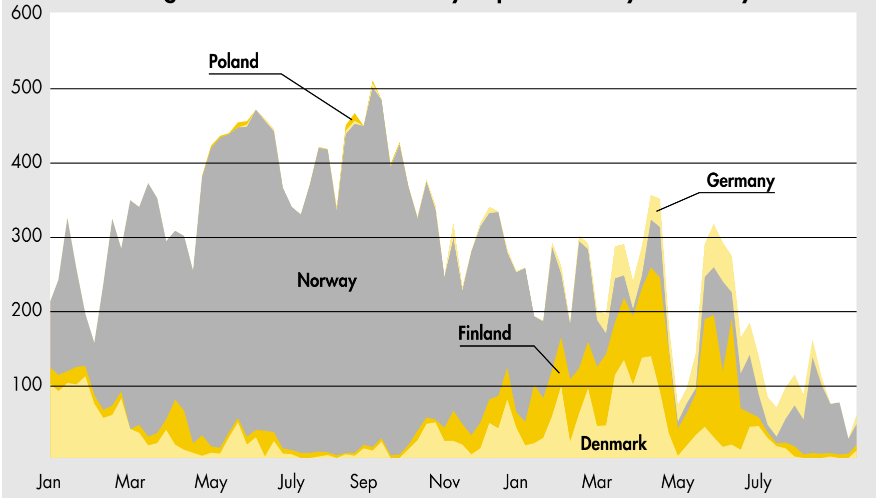
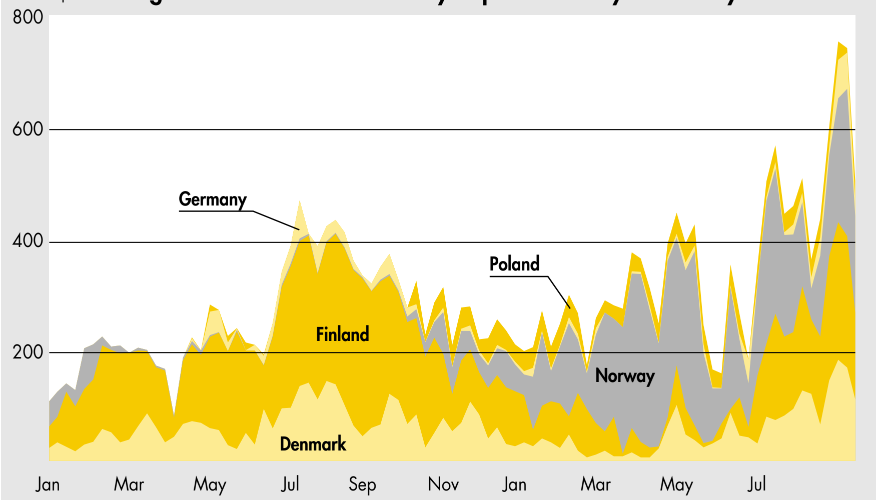


Figure 8 • Sweden´s electricity exports January 2000–July 2001

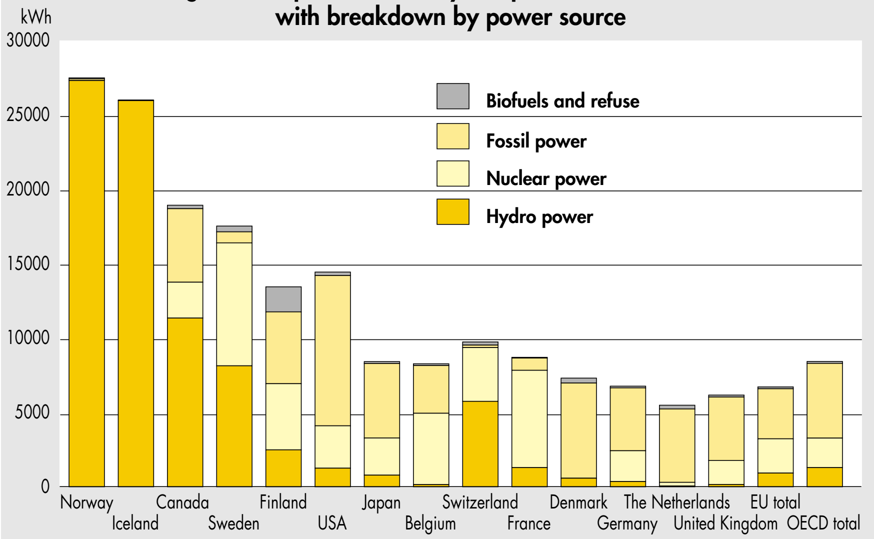


changes in terms of altered market conditions, new technology and greater environmental awareness. One of the effects of the EU Electricity Market Directive is that at least 23 % of the electricity markets in the EU states must be open for competition by 2003. Proposals to accelerate this process, so that all the electricity markets would be open to competition by 2005, were put forward in 2001, but have not yet been agreed by all the states. The degree of openness varies between states: the electricity markets in Sweden, Finland, the UK and Germany are fully open to competition, which means that all companies and households are free to choose their electricity suppliers. Austria (October 2001), Denmark (2003), Holland (2004) and Spain (2007) have decided to open their markets fully to competition, while other countries, such as France and Greece, have decided merely to fulfil the minimum requirements of the directive. The directive also affects other countries in Europe, and particularly those that have applied for EU membership.

Similar developments have occurred, or are occurring, in many parts of the world. In addition to the EU states, Norway, New Zealand, Argentina, Brazil and Chile have opened their electricity markets to competition, while reform has also started in Canada, Japan, the USA, Ukraine, Poland and Hungary. However, reform in California has largely failed, suffering from problems such as power cuts at times of high demand. As a result, the process has stopped for the time being in California and other American states.

Reform of the electricity markets involves a change from national monopolies, with central planning, to markets exposed to competition. Electricity becomes a form of energy raw material, which can be traded and supplied across borders. Today, there are electricity exchanges, i.e. organised markets for trading in electricity, in several countries, such as the Scandinavian countries, the UK, Holland (Amsterdam), Germany (Leipzig and Frankfurt), Spain and Poland. France and Italy are planning to open power exchanges in the near future. The power utilities are developing into larger and more integrated energy utilities, operating in several countries. The large, dominating companies on the Nordic electricity market – Swedish Vattenfall, Norwegian Statkraft and Finnish Fortum – have all bought into competing companies on the northern European market. PreussenElektra and EdF in France are also investing in the Nordic countries. With the extension of the activities of the larger companies across national borders, it becomes less relevant to talk of national electricity markets. Development will be towards a common market, with electricity being produced wherever it is physically and economically most appropriate.

Figure 9 • Specific electricity use per inhabitant, 1999, with breakdown by power source



Electricity production from renewable sources

Reform of the electricity markets and natural gas markets in Europe are important steps towards an internal energy market, with greater competition and lower prices. However, as a result of higher production costs, electricity from renewable sources may find it more difficult to break into the competitive markets. A directive aimed at encouraging the production of electricity from renewable sources was approved by the Council of Ministers in August 2001. It requires the production of electricity from renewable sources in the EU to be increased from somewhat less than 14 % to over 22 % by 2010. The necessary support for electricity producers using renewable energy sources can be provided by traditional investment support, by fixed price systems[1], by trading in certificates etc. The certificates would provide the producers of electricity from renewable sources with the necessary economic support in order to be able to meet current electricity prices and, at the same time, provide an incentive for cost-efficient production.

Electricity use varies between countries

In Sweden, per-capita electricity use is relatively high in comparison with that of other countries. In 1999, Sweden was in fourth place after Norway, Iceland and Canada. Electricity use per inhabitant in the USA was about one percentage point lower than in Sweden. Among the industrialised European countries, such as Germany, France and the UK, per-capita electricity use was less than half that in Sweden.

A feature common to the countries with high per-capita electricity use is that they have had plentiful supplies of cheap hydro power. In addition, the relatively cold climates in these countries has meant that there has been a substantial use of electricity for heating. In Sweden, it has been other natural resources, such as the forests and iron ore, that have resulted in industry specialising in energy-intensive products. If we remove the electricity demand of these electricity-intensive industries from the statistics, i.e. if we replace the electricity that they use by the amount of electricity that is average for industry as a whole, then the per-capita electricity use is reduced by about 15 %. Canada, Norway and Finland also have high proportions of energy-intensive industries, and each of them exports a high proportion of the products of theses industries.

Sweden is one of the world's countries that have a high proportion of hydro power and nuclear power in their electricity production. Only Iceland, Switzerland, Norway and Canada have higher proportions of hydro power, while only France and Belgium have higher proportions of nuclear power. Most of the world's electricity is produced by combustion of fossil fuels. In the USA, Germany, Holland and the UK, fossil fuels provide over 60 % of electricity production. Biofuels account for only a very small part of world electricity production, being not more than 1–2 % in many countries. Finland, however, is an exception, with 13 % of its electricity being produced by combustion of biofuels.

Over half of the EU's electricity production is based on fossil fuels, with somewhat over 30 % from nuclear power, 14 % from hydro power etc. and less than 2 % from biofuels and refuse. ■

[1] This guarantees a fixed price, agree in advance, to the supplier of electricity from a renewable source.

In 2000, the use of biofuels, peat etc. amounted to almost 97 TWh. These fuels are mainly indigenous, and consist of wood fuels (logs, bark, chips and energy forest), black liquors in pulp mills, peat (included in the concept of bioenergy), straw, energy grasses and waste.

These fuels are used mainly in the forest products industry, district heating plants, the detached house sector and for electricity production.

The forest products industry

For economic reasons, the forest products industry uses the by-products from various manufacturing processes for the production of heat and electricity. Black liquors remaining after chemical processing of wood to produce wood pulp are burnt to recover chemicals.

Black liquors are produced and used only within the pulp industry. In 2000, they provided over 39 TWh of energy (excluding electricity production). Wood fuels, in the form of raw materials residues, are used both in the pulp industry and in sawmills. They consist mainly of wood chips, bark and other waste products. Use is also made, although to a lesser extent, of wood fuels produced by on-site forest chipping of felled wood unsuitable for other commercial purposes.

In 2000, the pulp industry used a total of 6.9 TWh of wood fuels in the form of by-products for energy production, while sawmills and other woodworking industries used 10 TWh of wood fuels.

District heating plants

Over 25 TWh of biofuels, peat etc. were used for heat production in district heating plants in 2000. Of this, wood fuels accounted for 15 TWh, unrefined tall oil and black liquors for 1.5 TWh, refuse for 5.3 TWh, peat for 2.6 TWh and other fuels for 0.8 TWh.

The use of wood fuels by the district heating sector has more than quadrupled since 1990, amounting to 15 TWh in 2000. The main form of these fuels is felling wastes and by-products from the forest products industry. However, processed fuels, such as briquettes and pellets, together with unrefined tall oil, have also become increasingly used in recent years, amounting to a total of 4.1 TWh in 1999.

Refuse has been used for district heating production since the 1970s, and provided 5.3 TWh of energy in 2000. Improved sorting at source may reduce the potential quantity of domestic refuse available for use as fuel, although at present the supply of combustible waste exceeds capacity. Sweden is in process of making several changes to legislation relating to waste and waste disposal, that can affect the use of refuse for energy production. From 1st January 2002, combustible refuse must be separated from other refuse, coupled with a ban on disposing of unsorted combustible refuse to landfill. Landfill disposal has been discouraged since 1st January 2000 by a tax of SEK 250/tonne on refuse disposed of in this way. Refuse sent for combustion is exempted from the tax. The autumn's Budget Bill proposes that the landfill tax should be increased to SEK 288/tonne from 1st January 2002. The EU Refuse Incineration Directive[1] introduces stricter emission and monitoring requirements in respect of traditional refuse incineration and of its incineration with other fuels in conventional combustion plant. This directive must be implemented in national legislation by 28th December 2002, and can make the disposal of refuse by incineration more difficult in certain plants.

There is potential within the industrial sector for increasing the use of (primarily) salvaged wood fuels, which at present are not used for energy production. Some fuels of this type, such as refuse, salvaged timber etc., have been imported in recent years, but the quantity is difficult to estimate.

The use of peat has declined since 1995, amounting to 2.6 TWh in 2000, which is 0.2 TWh less than during the previous year.

Energy crops, such as energy plantations, straw etc., have been used since the beginning of the 1990s, although such use is still relatively limited. About 0.1 TWh of energy plantation fuels were used during the year, complemented by small quantities of straw and energy grass. Although there is considerable potential for greater use, the area planted with such crops has remained almost unchanged in recent years, amounting to about 14 300 hectares in 2000. The amount of land used for energy plantations depends largely on agricultural subsidy rules and the amount of the subsidy.

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[1] The European Parliament and Council Directive 2000/76/EEC of 4th December concerning incineration of refuse.

Figure 10a • Use of biofuels, peat etc. in industry 1980–2000

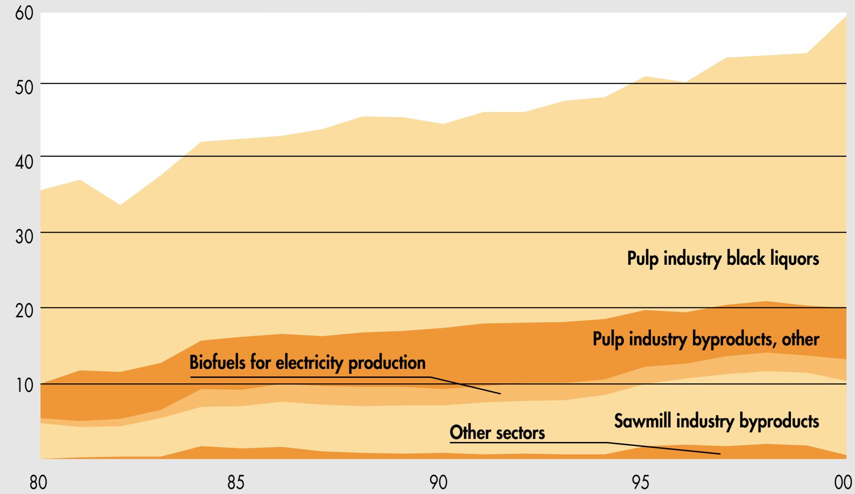
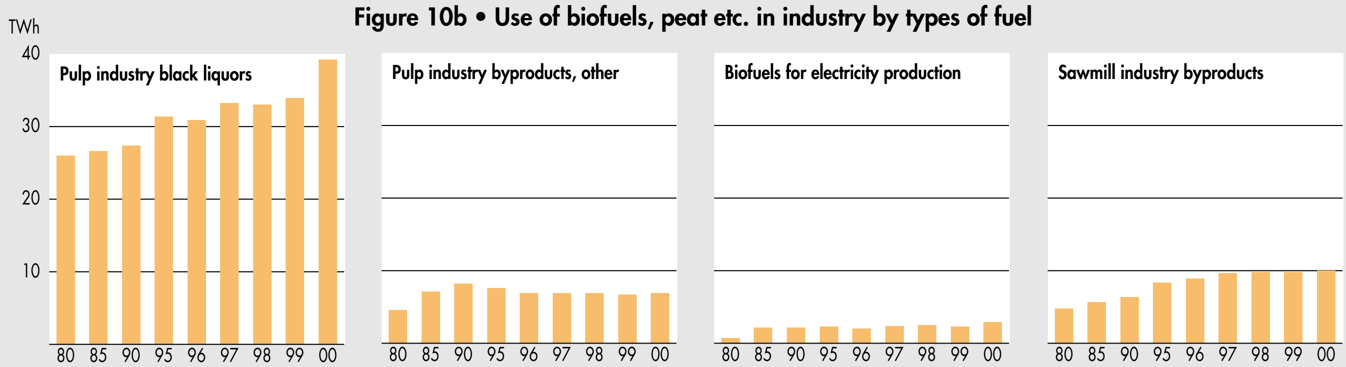


Figure 10b • Use of biofuels, peat etc. in industry by types of fuel



There has been relatively extensive commercial importation of biofuels during the year, in the form of materials such as wood fuels, salvaged wood, unrefined tall oil and peat. There are no official statistics of the imports, which makes the quantities difficult to estimate. However, quantities have increased in recent years, and were estimated in 1997 as amounting to about 7–9 TWh. Imports in that year accounted for about 35–40 % of the supply of biofuels for district heating plants, and nowadays constitute an important source of such fuels. They are imported at prices which are below those on the home market, which means that they exert a certain price press on indigenous fuels. For some individual heating plants, imported fuels can form a substantial part of their fuel supply. The supply of biofuels is good, and there is significant potential for their use in Sweden. For this reason, the trade in biomass fuels could become increasingly important in future.

The detached house sector

Over 6.7 TWh[2] of biofuels, peat etc., mainly in the form of logs, were used in detached houses for heating in 2000. Wood firing is commonest among property-owners with good access to forests, e.g. in agricultural or rural areas. The use of processed biofuels (pellets or briquettes) is still relatively modest in this sector, amounting to about 0.4 TWh in 2000.

[2] Figures for the use of biofuels for heating purposes in detached houses in 2000 are not wholly comparable with those for 1999. Statistics Sweden has changed its definitions, so that all permanently occupied detached houses/second homes are now included.

Electricity production

4.5 TWh of biofuels were used for electricity production during the year, which represents an increase of 1 TWh over 1999. About 1.6 TWh of fuels were used for the production of electricity in CHP plants. 2.9 TWh of electricity were produced from biofuels in industrial back-pressure plants, with black liquors and wood fuels accounting for virtually the entire electricity production. Other biofuels, such as agricultural waste, landfill gas, digester gas and peat, are sometimes used for electricity production, although such use is very limited.

An international context

Seen in a European perspective, Sweden acquits itself well in terms of its high proportion of biofuels, making up over 16 % of its energy supply. It is very difficult to find fully comparable details of biofuel use in other countries, although there are factors that have a considerable effect on their use: good availability of forests, a developed forest products industry and wide existence of district heating systems. This means that, of the European countries, it is Sweden and Finland that have the highest proportions of biofuels in their respective energy systems. Other countries with potentially high volumes of biofuels, but in which little use is made of them in their energy systems, are Germany, France, the UK, Romania and Austria.

In a global perspective, biofuels are the most important fuels for most of the third world's populations. ■

Figure 11a • Use of biofuels, peat etc. in district heating 1980–2000

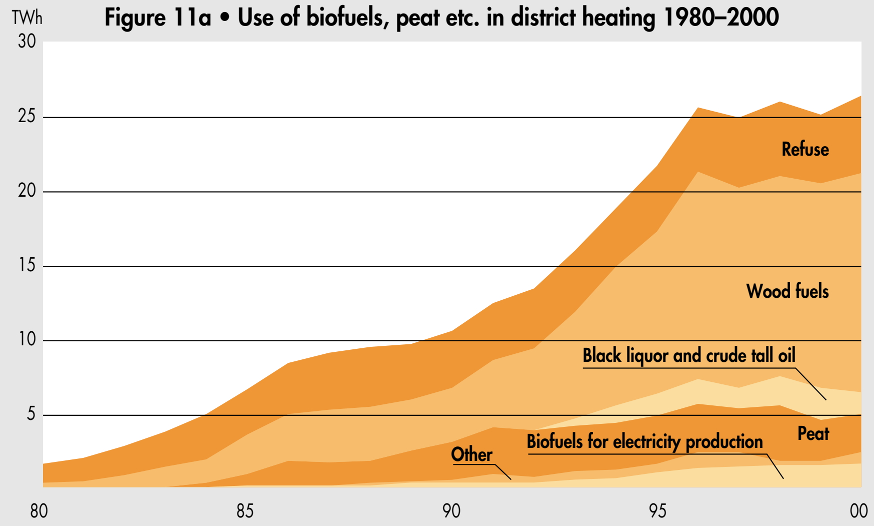
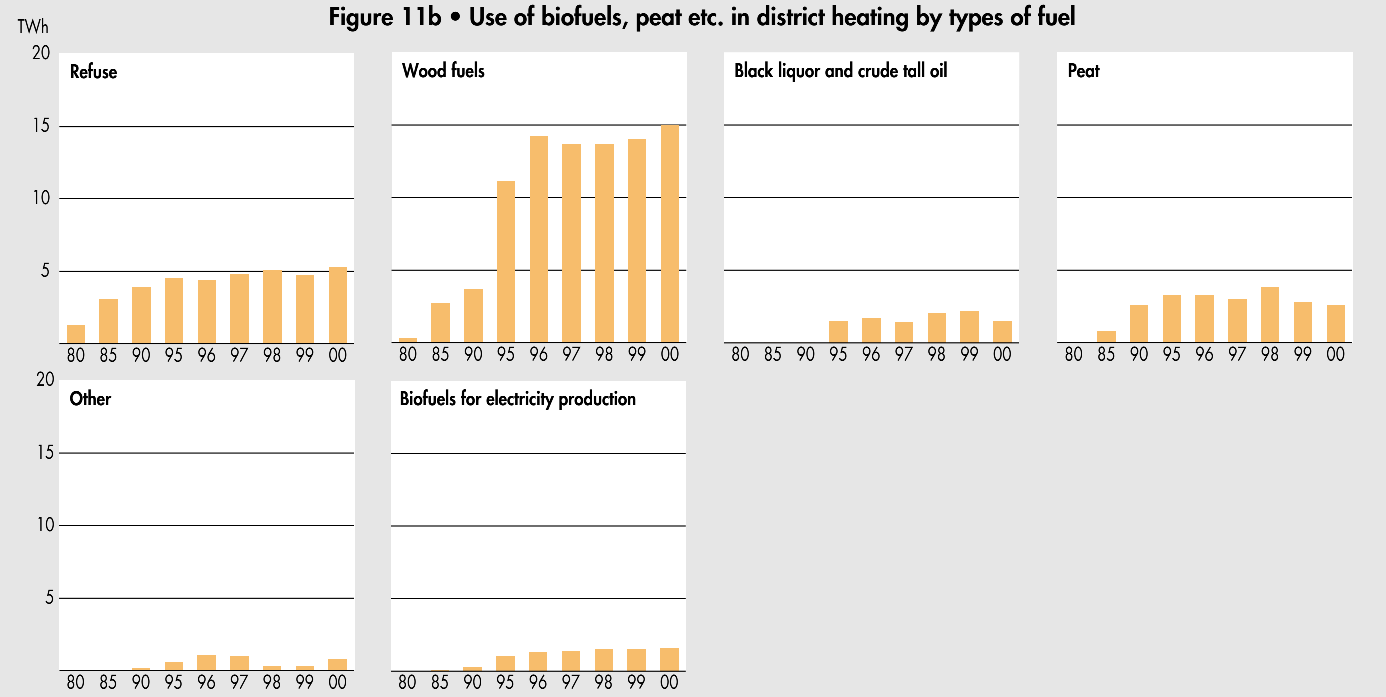


Figure 11b • Use of biofuels, peat etc. in district heating by types of fuel



District heating is often defined as a public heating system for the production and supply of heat in the form of hot water to buildings, under contractual arrangements between the supplier and user. It is produced in, and supplied from, hot water boiler plants or combined heat and power stations (CHP). There are also heating systems which supply heat to, for example, only a limited residential area, and these are known as group heating systems. They are generally smaller than district heating systems.

Local authorities began to look at district heating in the 1940s. Its use spread during the 1950s and 1960s as a result of the extensive investments in new housing and other buildings that were being made during that period, in conjunction with a substantial need for modernisation or replacement of boilers in the country's existing building stock. Group heating systems were gradually linked up to form larger systems, with a particularly substantial expansion of district heating over the period from 1975 to 1985.

Energy policy has favoured district heating through various forms of state support, e.g. grants for the extension of existing district heating systems and the connection of group heating systems and even individual buildings to existing systems. Replacing a multitude of small individual boilers by district heating enables the heat to be supplied from a much smaller number of larger boilers with high efficiency, reducing both fuel requirements and emissions. Today, investment support is available for biofuel-based CHP. The 1997 energy policy programme introduced grants for conversion and connection to district heating systems. However, take-up was poor, due to the fact that the costs for conversion were too high. The grants were withdrawn during 1999, but have since been reinstated.

District heating is most competitive in areas of high building density, which means that most systems tend to be found in areas where they are supplying apartment buildings and commercial premises. High capital costs for the mains network mean that it is difficult for systems to achieve viability in low-density detached house areas, where the ratio of mains length to kWh of heat supplied increases. Today, although about 40 % of the total heating requirement for residential buildings and commercial premises in Sweden is met by district heating, only about 7 % of the detached house heating load is met in this way.

At present, the country has about 11 200 km of distribution mains. 40 TWh of district heating were supplied in 2000. Of this, over 60 % was used for residential space heating, almost 30 % for heating commercial premises and 10 % by industry.

The fuels mix in district heating plants has changed considerably over the last 20 years. In 1980, over 90 % of the fuel input for district heating and CHP plants was in the form of oil. Nowadays, the fuel mix is more varied, with biofuels being the main energy source. The change to other energy sources can be partly explained by the carbon dioxide tax, which reduced the use of fossil fuels. Another reason has been the good availability of electricity for several years, favouring the use of heat pumps and electric boilers.

Total energy supply in 2000 was 45.6 TWh, of which biofuels accounted for 25.2 TWh, or somewhat over 50 % of the total energy carriers' input.

The use of electricity in the sector, with most of it being accounted for by electric boilers and heat pumps, has halved since 1990. Most of this reduction has been in the use of electric boilers, with the electrical energy input to heat pumps remaining relatively constant. This reduction is due primarily to the fact that tax exemption for interruptible supplies to electric boilers was withdrawn in 1991, and that the previous special contracts were terminated in connection with restructuring of the electricity market. Taxation on electric boilers during the winter was increased in 1998.

District heating losses have fallen since the 1980s. Today, distribution and conversion losses account for somewhat over 15 % of the total supply of district heating: during the 1980s, losses were about 20 %.

Until the beginning of the 1980s, most district heating systems were operated as local authority services. However, during the 1980s and 1990s, most have been restructured as limited companies owned by the local authorities. Today, there are about 220 companies supplying heat in Sweden: of them, about 170 are members of the Swed-

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Figure 12a • Use of district heating 1970–2000

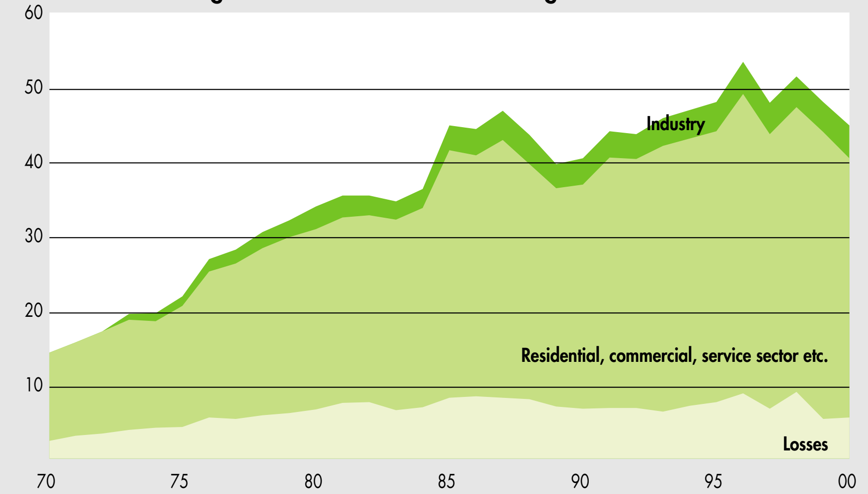
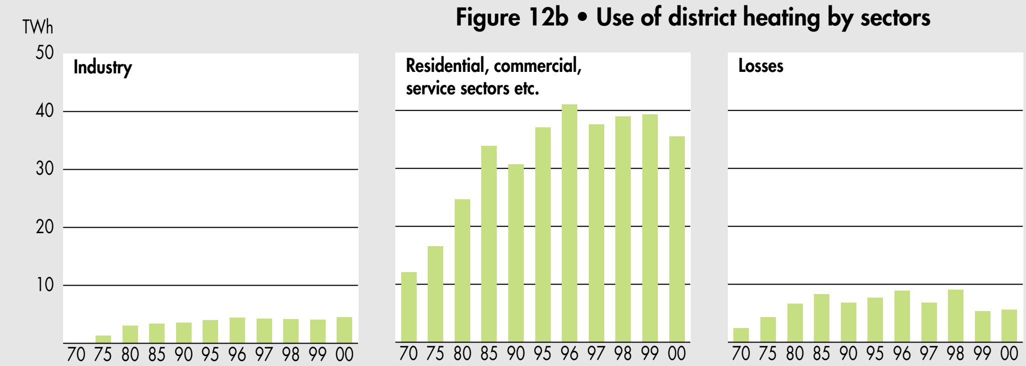


Figure 12b • Use of district heating by sectors



ish District Heating Association. 68 % of the companies are owned by local authorities, 20 % are privately owned, 8 % are owned by the state and 6 % are still operated as local authority services.

District cooling

District cooling is used primarily in offices and commercial premises, as well as for cooling of various industrial processes. Its principle is similar to that of district heating: cold water is produced in a large central plant and distributed through pipes to customers. There are several ways in which it can be produced: many district heating companies use waste heat as a heat source for their heat pumps to produce district heating. In this way, for every three units of district heat, two units of cold water can be produced for *district cooling*. Another way is to install absorption refrigerant plant, operating with a salt solution as the refrigerant, and powered by district heating. A further alternative is simply to use cold bottom water from the sea or a lake.

The country's first district cooling system was started up in Västerås in 1992. The market for district cooling has expanded strongly since its introduction, powered by such factors as new building regulations, the greater use of computers, more awareness of the importance of good working conditions, expansion of the distribution system and the entry of new suppliers to the market.

At the beginning of 2000, there were 21 district cooling systems in operation, supplying cooling through 85 km of mains. 337 GWh of district cooling were supplied. It is expected that deliveries will increase in coming years. ■

Figure 13 • District cooling supplied 1992–2000

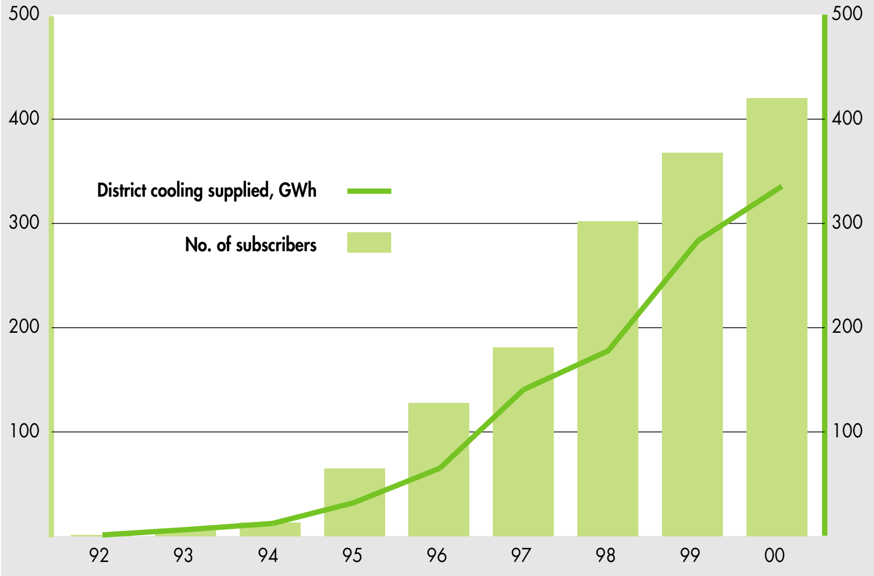


Figure 14a • Energy supplies to district heating 1970–2000

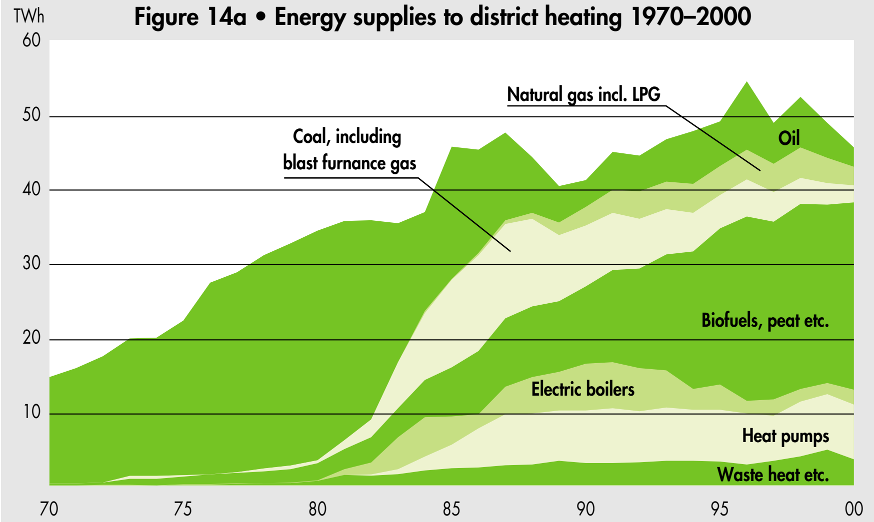
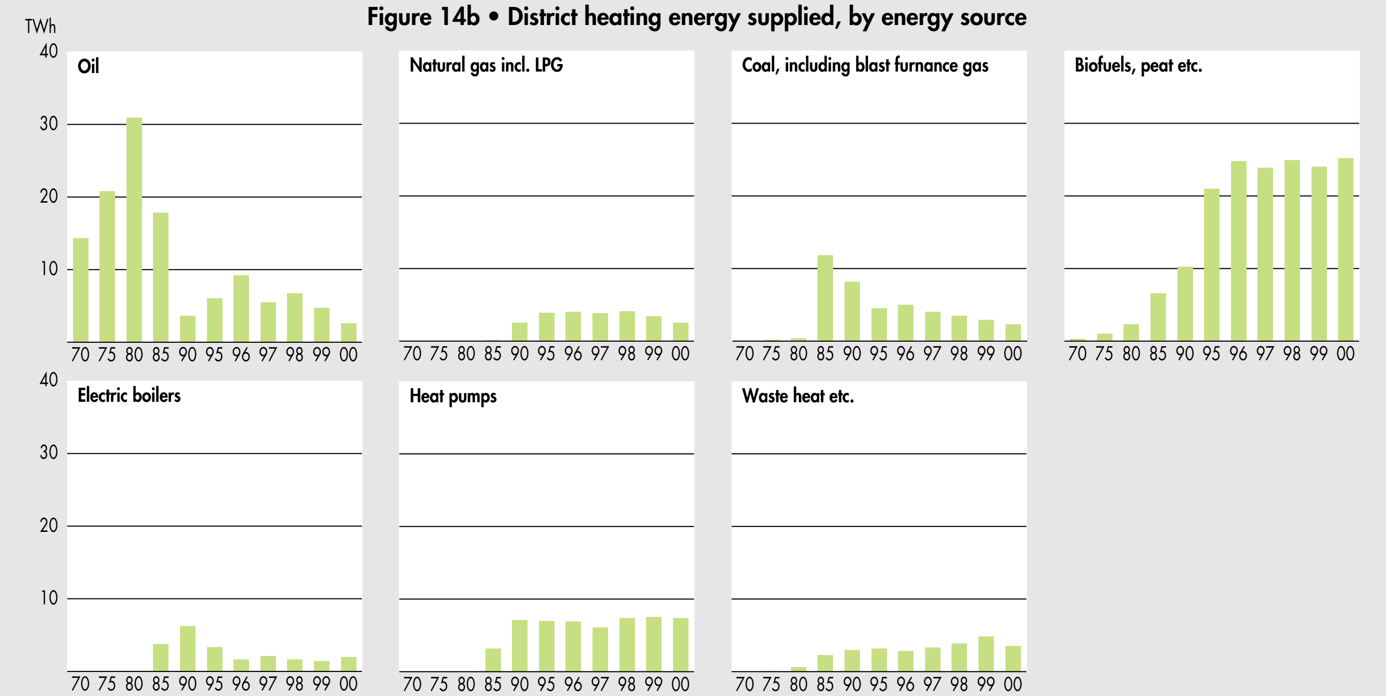


Figure 14b • District heating energy supplied, by energy source



In recent years, the international oil market has experienced major price changes. From the record low levels of 1998, the average prices of Brent crude rose by 40 % during 1999 to about USD 18 per barrel. Prices continued to rise by a further 60 % in 2000, reaching USD 29 per barrel. In the first two quarters of 2001, the one-month price has fluctuated between USD 24 and USD 29 per barrel.

The price rise started at the beginning of 1999, when the major OPEC oil-producing states agreed to reduce output in order to raise the low world market price. The price rose rapidly, so that it is today more than 200 % higher than it was before the production cutbacks started. However, this massive rise cannot be explained solely by the fact that the OPEC countries reduced output. During 1999, demand exceeded supply by about a million barrels/day. During 2000, on the other hand, the situation was more or less reversed, as the OPEC countries had again increased their output. In the first half of 2001, supply exceeded demand by about 0.9 million barrels/day. During 2000, and at the beginning of 2001, total production has been higher than it was in 1998: in other words, there is no shortage of oil at present. Nevertheless, prices have remained high. One explanation for this is that the market is still jittery, wondering whether the OPEC countries will maintain their high production and how large the stocks of oil in the USA and Asia are. Another important factor in explaining price changes on the oil market is that there are many psychological factors involved: expectations of a cold winter, for

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Figure 15 • Swedish imports of crude oil and petroleum products, 1972–2000 by country of origin (million tonnes, net)

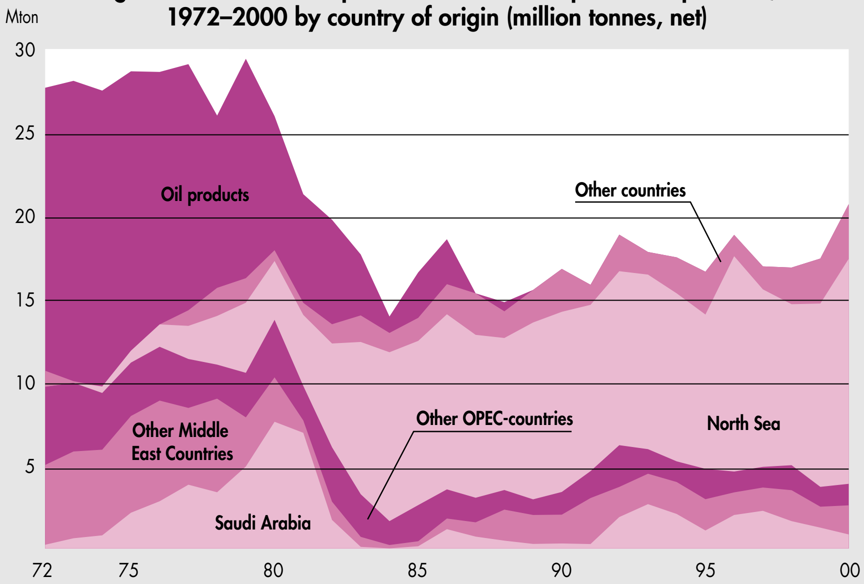


Figure 16a • Swedish use of oil products 1970–2000

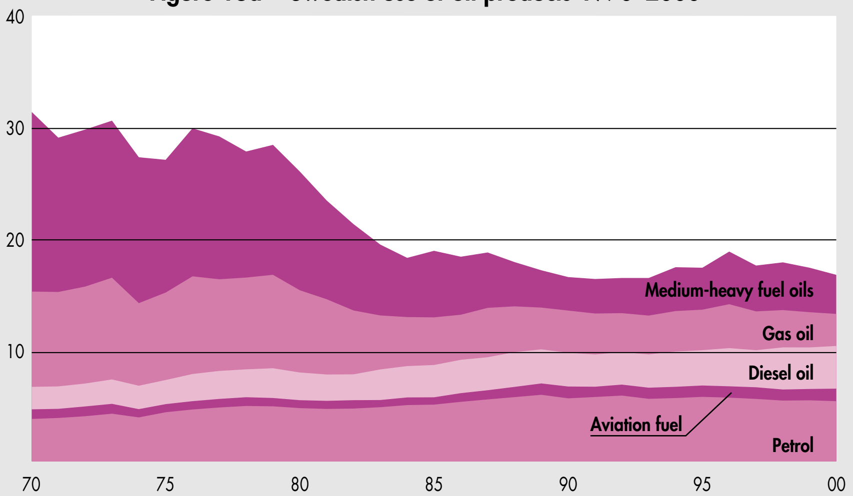
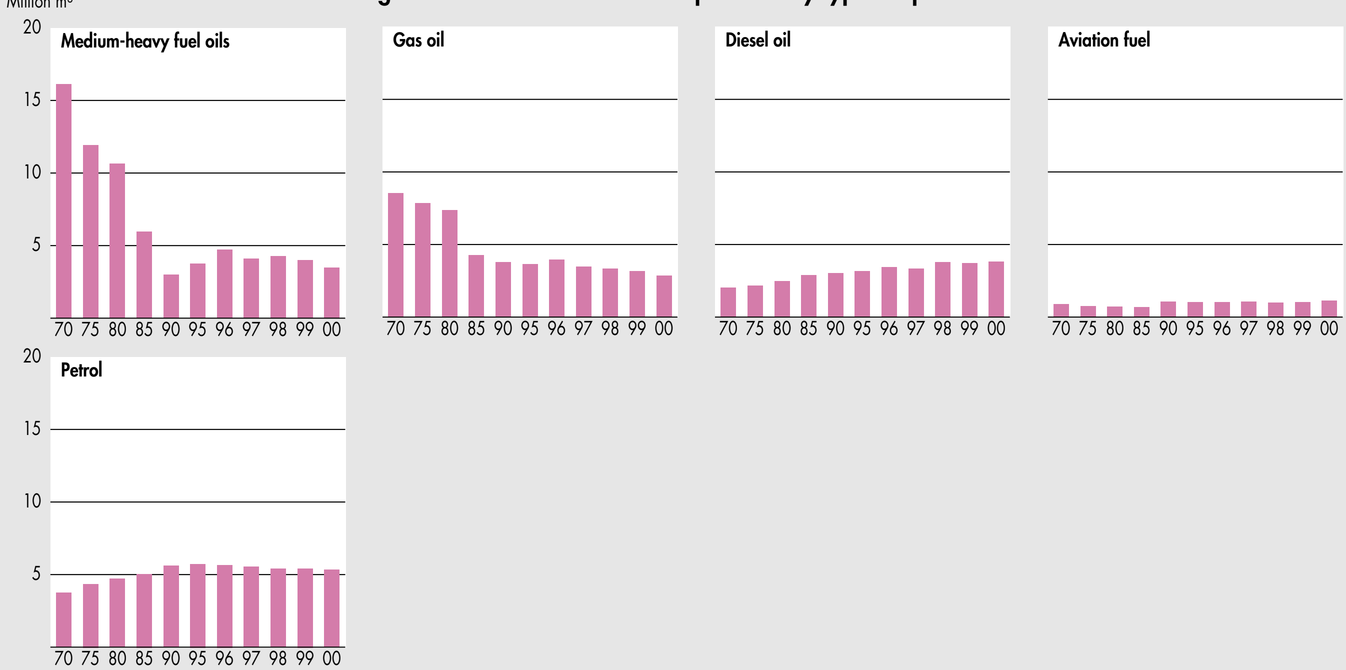


Figure 16b • Swedish use of oil products by types of products



example, as there has been a run of mild winters in recent years. The futures prices of oil were somewhat higher than spot prices in July 2001, which indicates that the market is expecting future price increases. This also creates signals to increase stocks in expectation of higher prices.

Oil production

Production methods for crude oil have become more efficient. Advanced computer methods have made it simpler to prospect for oil and to bring oil wells on line. New technology has also made it possible to extract more oil from each well. This has reduced the cost of recovering the oil, and thus improved the potential for lower future prices. However, this price reduction potential cannot operate as long as output is restricted.

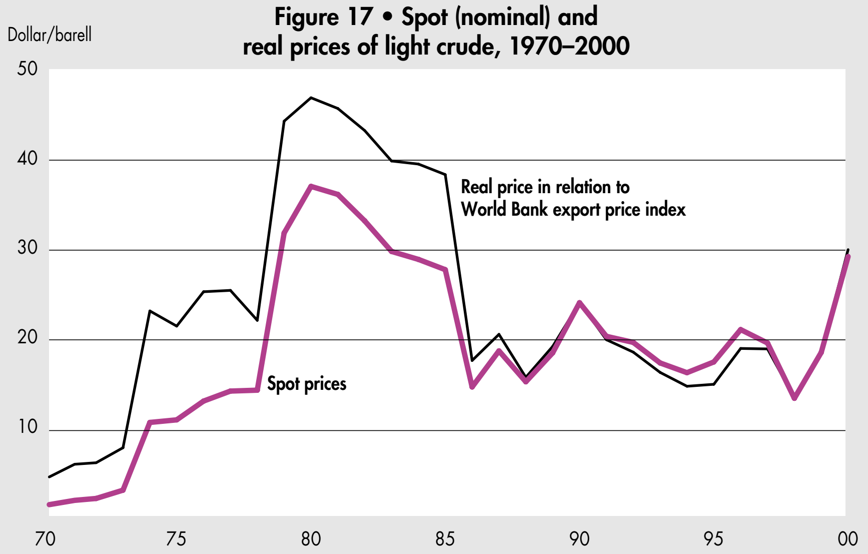
Between 1990 and 2000, world oil production increased by almost 14 %, amounting to 74.5 million barrels/day in 2000. OPEC's member states account for about 40 % of world oil production, and possess almost 78 % of its reserves, which thus gives them a considerable hold over the oil market. Other major oil producers are Norway, Mexico, Russia and the USA. Having failed in 1998 to reach agreement on production cutbacks in order to push up prices, OPEC did succeed in March 1999 in agreeing to reduce the agreed production quota by 1.7 million barrels/day, relative to earlier agreements. In addition, a number of non-OPEC oil-producing countries undertook to reduce their production by 0.4 million barrels/day. During 2000, the OPEC states agreed on four occasions to increase their production, resulting in a total increase of 3.7 million barrels/day. During 2001, on the other hand, the OPEC states' oil production has been reduced on three occasions, by a total of 3.5 million barrels/day. The latest reduction, of 1.0 million barrels/day, came into force on 1st September. OPEC's strategy is to maintain the price of oil at between USD 22 and USD 28/barrel.

The demand for oil

In 1999, the economic situation in Asia improved, resulting in the demand for oil approaching normal levels again. Total demand during that year was 74.8 million barrels/day, increasing to 75.6 million barrels/day in 2000. During the first quarter of 2001, total demand increased to 77 million barrels/day, only to fall to 75 million barrels/day during the second quarter. Supply exceeded demand throughout 2000 and during the first two quarters of 2001.

Future total demand for oil will depend largely on world economic developments. A forecast made in August 2001 expects total world demand in 2001 to rise by 0.7 %, followed by a further 1 % rise in 2002. During 2000, the greatest percentage increase in demand was shown by China, while North America showed the greatest increase in absolute volume terms. During 2001 and 2002, China and the Middle East are expected to be the areas showing the greatest increase in demand.

Figure 17 • Spot (nominal) and real prices of light crude, 1970–2000



Swedish oil supply

As with all other countries, Sweden is affected by the high world market prices of oil. However, as Swedish energy policy since the oil crises of the 1970s has been to reduce the country's oil consumption, use of oil has declined by over 50 % since 1970. It is, in particular, the use of oil for heating that has fallen: oil has been replaced by electricity and district heating for heating purposes, although the expansions of nuclear power production and the natural gas distribution network have also played their parts. Total use of oil in 2000 (including that for foreign maritime traffic) amounted to 16.7 million m^3, or 4 % less than during the previous year. About 70 % of all oil consumption was for transport. Although the low level of oil use in Sweden makes the country less sensitive to high oil prices, it also means that much of the viable conversion from oil to other forms of energy carriers has already been made.

Sweden's import trade in oil products is approximately twice as large as the country's actual use of the products. Almost 40 % of Sweden's total import of oil products comes from Norway, which also accounts for 46 % of the country's crude oil imports. A further 16 % of crude oil imports come from Denmark. Sweden's substantial import of oil is due to the fact that much of the oil is refined in the country and then re-exported. The export proportion has risen from 25 % of Sweden's production of oil products in 1986 to 54 % in 2000. ■

OPEC – Organisation of Petroleum Exporting Countries – was founded in 1960 as a counter to the power of the major oil companies and the resulting influence of their home countries on the world oil market. It has eleven members: Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela.

The coal industry has been suffering from surplus capacity since the middle of the 1980s, which has resulted in a fall in the price of coal until 1999. In 1998, for example, the price fell from USD 46 per tonne to USD 32 per tonne in northern Europe, in step with falling oil prices. The average price in 1999 was USD 28.8 per tonne. However, starting in 2000, prices have turned upwards again, primarily paralleling rising oil prices, so that the average price in 2000 was USD 36.0 per tonne. Prices continued to rise during 2001, reaching over USD 40 per tonne.

Coal is still a competitive fuel in many countries, due to the low costs of mining it. However, it is heavily taxed in Sweden due to its severe environmental impact, which has reduced its competitiveness. Several European countries, such as Germany, are now planning to close their coal-fired power stations and replace them with less polluting forms of power generation. Denmark, too, is attempting to reduce its use of coal. Work on trying to implement the climate gas reductions in the Kyoto Protocol, and the wish of many industrialised countries to reduce their climate gas emissions, is resulting in a declining use of coal in these countries. However, coal is still a competitive alternative in developing countries.

The largest producers of coal are China and the USA, which together account for over 50 % of world production. The four major exporting countries are Australia, South Africa, the USA and Indonesia, together accounting for over half of world trade in coal. Coal production in Europe is falling, while imports are increasing.

About half of all the coal that is mined is used as fuel, which means that it provides almost one-third of the world's energy supply. Black coal is a relatively high-value coal, while brown coal has a lower calorific value. Black coal is divided traditionally into two categories: coking or metallurgical coal, which is suitable for use in the iron and steel industry, and steam coal, which is sometimes also referred to as energy coal. Estimates put the amount of black coal and brown coal in the earth's crust at about 11 000 x 10^9 tonnes, although only a small fraction of this – about 1000 x 10^9 tonnes – can be recovered. If production continues at the present rate, proven and economically recoverable reserves would last for over 200 years. The largest accessible reserves of black coal are in Russia, the Ukraine, China and the USA, while the largest reserves of brown coal are in Russia, the USA, Eastern Europe and Australia.

Sweden's coal supply

Coal played an important part in Sweden's energy supply up to the 1950s, when it lost ground to the cheaper and more easily handled oil. The oil crises of the 1970s, with their steep rises in the price of oil, contributed to coal again becoming an interesting alternative fuel for reasons of price and security of supply. The increasingly stringent environmental standards imposed on coal firing, together with rising taxation of heat production in particular, have meant that the use of coal has stagnated, to the benefit of oil and biofuels, during the 1990s.

District heating and CHP production

About 40 % of the coal is used in the district heating sector, and the rest in industry. The use of coal for district heating has fallen considerably, particularly during the 1990s when the carbon dioxide and sulphur taxes were introduced. Plants that supply only heat have abandoned coal almost entirely as a fuel due to the high taxes. CHP plants, however, still use some coal, as coal used for electricity production is exempt from energy and carbon dioxide tax. The use of coal for electricity production is closely linked with hydro power production: during years with high hydro power production, less coal is used for electricity production. During extremely dry years, such as 1996, the use of coal for electricity production can be more than twice the normal amount.

The use of coal in industry

Industry uses energy coal, metallurgical coal, coke and smaller quantities of other coal products such as graphite and pitch. The use of energy coal in industry has fallen during the 1990s, as a result of the change primarily to oil and biofuels, which in turn has been partly caused by the introduction of the carbon dioxide tax in 1993. However, the cutback in industry has not been as great as in the district heating sector, due to the fact that the carbon dioxide tax is lower on industry.■

Figure 18a • Swedish use of energy coal 1985–2000

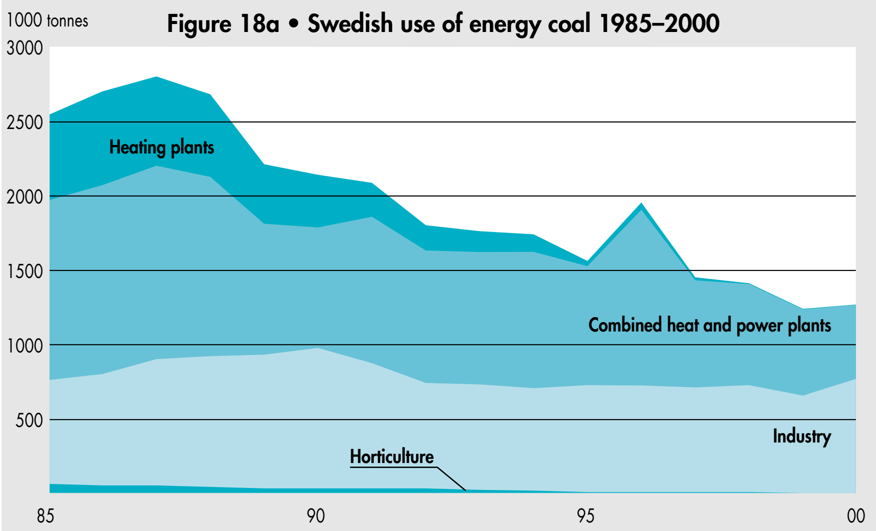
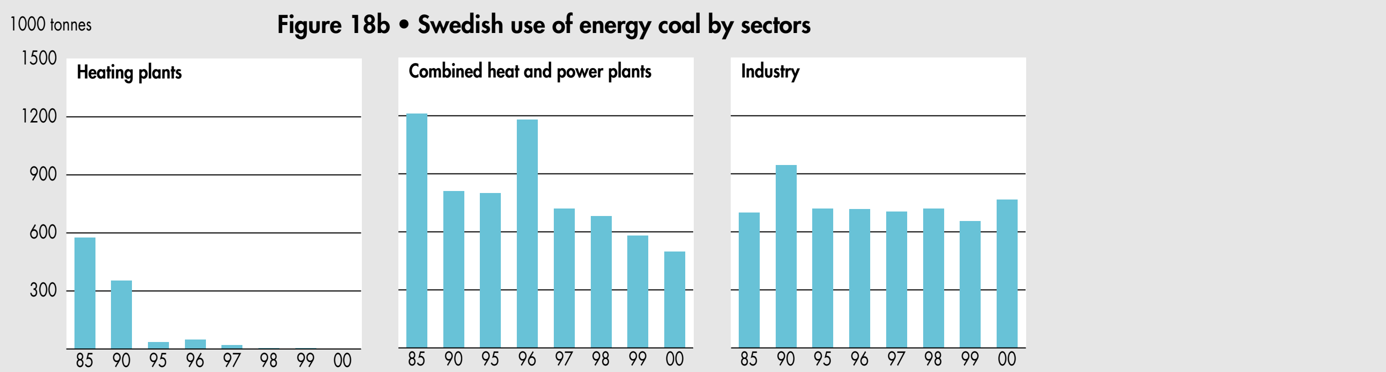


Figure 18b • Swedish use of energy coal by sectors



Natural gas

Natural gas was introduced to Sweden in 1985, since when use has gradually increased, stabilising at the present level in 1992. In 2000, imports amounted to 835 million m^3, equivalent to 8.1 TWh. Industry, on the one hand, and CHP and district heating plants on the other, each account for about 40 % of total use, with domestic consumers accounting for about 20 %. A small amount of natural gas is also used as motor fuel.

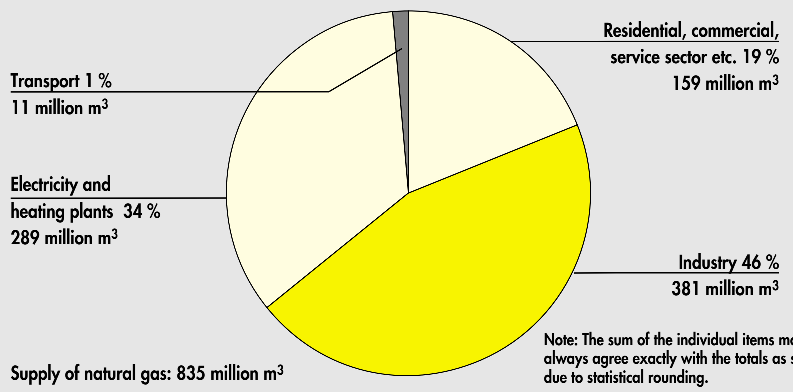
Natural gas is distributed at present to 26 towns, where it provides about 20 % of energy use. On the national scale, it supplies somewhat over 1 % of total energy use.

The gas is supplied exclusively from fields in the Danish sector of the North Sea. After transiting Denmark, a pipeline under Øresund brings the gas ashore at Klagshamn outside Malmö. A trunk main extends from Trelleborg in the south to Gothenburg, with a number of branches, including one to Hyltebruk in Småland. Vattenfall Naturgas AB owns, and is responsible for operation of, the trunk main, and for importation and transportation of the gas to other distribution companies. Sydgas AB is responsible for the branch mains in southern Sweden, and is at present planning an extension of the system from Hyltebruk to Gislaved.

Svensk Naturgas AB, which was established in 1999, is investigating extension of the system to Stockholm, the Mälar Valley and Bergslagen. If a favourable decision is reached, the company plans to start delivering natural gas to customers in these areas from 2007.

Natural gas is a combustible mixture of gaseous hydrocarbons, consisting mainly of methane and – unlike coal and oil – is almost completely free of sulphur and heavy metals. Combustion also produces no solid residues, such as ash or soot. The quantity of carbon dioxide produced by combustion is 25 % less than that produced by release of the same amount of thermal energy from oil, or 40 % less than from corresponding combustion of coal.

Figure 19 • Supply and use of natural gas by sectors in Sweden 2000



Note: The sum of the individual items may not always agree exactly with the totals as shown, due to statistical rounding.

LPG

Imports of LPG to Sweden in 2 000 amounted to 684 000 tonnes, while 293 000 tonnes were exported. 471 000 tonnes were supplied to the Swedish energy system, equivalent to 6.0 TWh. LPG is used mainly in industry, as well as in the restaurant trade and in agriculture. As LPG and oil and also, to some extent, biofuels are interchangeable fuels in these applications, the use of LPG is sensitive to changes in energy taxation or fuel prices. During 2000, 4.4 TWh of LPG were used in industry and 0.2 TWh in district heating.

LPG is a petroleum product, consisting of the hydrocarbons propane, propene and butane, or mixtures thereof. It is usually stored in liquid form in rock caverns at low temperature. Distribution is by rail tank car, road tanker or by direct pipelines. Its environmental characteristics are very similar to those of natural gas, with a very low sulphur content and a complete absence of heavy metals.

Biogas

Biogas consists of methane, formed by the breakdown of organic materials such as sewage sludge, refuse or industrial waste under anaerobic (oxygen-free) conditions. The process, known as digestion, occurs spontaneously in nature, e.g. in marshes. Today, Sweden has about 100 biogas plants in operation, most of them in sewage treatment plants or at landfill sites, producing digester gas and landfill gas respectively. Most biogas is used for electricity and heat production. In 1999, 33 GWh were used for electricity production and 447 GWh for heat production. Biogas can also be cleaned and distributed via the natural gas network as ‘green natural gas’. It is also used for powering vehicles: interest in the gas for this application has increased in recent years. Biogas is used primarily in local bus fleets and for urban distribution vehicles.

Town gas

Town gas is produced by cracking naphtha. SE Gas AB in Stockholm is the only producer of such gas in the country: the town gas used in Malmö and Gothenburg nowadays consists of natural gas mixed with a small proportion of air. It is used for heating detached houses, larger properties and industries, as well as for cooking in homes and restaurants. 0.5 TWh of town gas were used in 2000.

Hydrogen

Pure hydrogen does not occur naturally, but must be produced from sources such as methanol, LPG, natural gas or by electrolysis of water. Production of hydrogen is an energy-intensive process: to produce hydrogen with an energy content of 100 kWh requires about 125 kWh of electricity. Research is in progress, with the aim of improving production technology and developing effective means of storage. Hydrogen is used today primarily by the chemical industry, but can also be used as a fuel in fuel cells, where it is converted to electricity and heat.

Natural gas internationally

In Sweden, natural gas is a marginal energy source. In the Nordic countries as a whole, it supplies about 15 % of total energy use. In the EU countries and in the world as a whole, this proportion rises to somewhat over 20 %.

The world's natural gas reserves are substantial: at the end of 2000, commercially viable reserves amounted to 150 000 x 10^9 m^3, which would last for over 60 years at the present rate of use, with present technologies and present prices. Most of the reserves are to be found in the former Soviet Union (38 %) and in the Middle East (35 %). The world proportion of total energy supply met by gas has grown rapidly over the last decade, so that it nowadays the fastest growing primary energy source in the world.

Natural gas is included in the European Union's strategy for creating a single energy market. Over the last couple of decades, national natural gas systems have been expanded and linked, to form an extensive European natural gas network. The EU Natural Gas Directive was issued in February 1998, with the aim of increasing competition on the European natural gas market. In practice, however, restructuring of the natural gas markets in Europe is proceeding at different rates. The directive is due to be implemented in three stages, with at least 20 % of the market being open to competition in 2000. It is the largest users of gas, i.e. the electricity generation sector and industry, that will be given access to the deregulated market first.

In March, the EU Commission put forward a proposal intended to accelerate restructuring of the electricity and gas markets. It was discussed at the EU summit meeting in Stockholm later that month, but the delegates failed to reach agreement on a new timetable. Instead, it will be discussed again in the spring of 2002. The present Natural Gas Directive was incorporated in Swedish legislation on 1st August 2000, in the form of a new Natural Gas Act.

The EU sees a role for natural gas in its work of reducing environmentally hazardous emissions, primarily by replacing coal and oil and through the potential for efficient electricity production. The proportion of natural gas consumption accounted for by the electricity sector is therefore expected to increase substantially over the next ten years. Total use of natural gas is also expected to increase substantially, although with falling proportions for use in industry, housing and other sectors.

Only 3.5 % of the earth's natural gas reserves lie within the EU, even if this is also taken to include Norwegian natural gas and that in the former Eastern states. At the present rate of use, this would last for only 17 years. Over the last decade, natural gas supplies to the EU states have been increasingly based on production from the North Sea and imports from Russia and Algeria.

Figure 20a • World production of natural gas, 2000, billion m^3

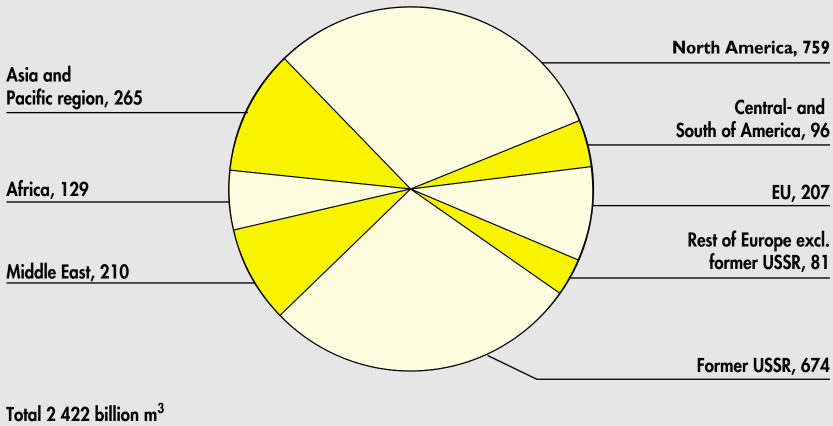
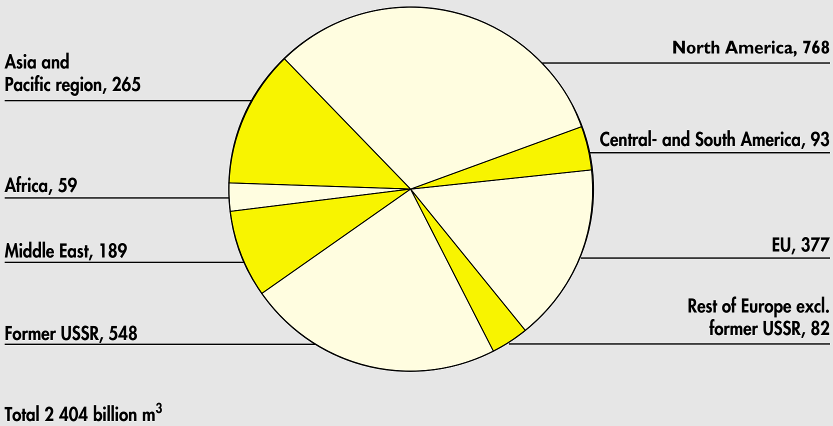


Figure 20b • World use of natural gas, 2000, billion m^3



In order to increase the security of supply, there is European interest in increasing the number of links between the Russian and Norwegian natural gas fields and the continent. At the sixth summit meeting between the EU and Russia in October 2000, agreement was reached between the chairman of the EU Commission and the Russian president on starting a dialogue on energy matters. The objectives include identification of joint working areas, e.g. investments in the energy sector.

In recent years, several investigations have been carried out into the commercial feasibility of extending the natural gas network in Europe.

The *North Transgas* project, which was carried out jointly by Finnish Fortum and Gazprom, looked at three routes for building a gas pipeline from Finland to Germany. One of the alternatives involved routing the pipe via Sweden: however, the Trade and Industry Committee decided (1998/99:NU8) that a large-scale introduction of natural gas, or a new natural gas pipeline through Sweden, is not of interest at present.

Since 1999, Sydgas AB, together with Verbundnetz Gas, Sjællandske Kraftværker and Norsk Hydro, have again been investigating the construction of a natural gas network between Germany, Denmark and Sweden, to be known as the *Baltic Gas Interconnector* (BGI). If permission is granted by the beginning of 2002, the project could be completed by 2004. ■

In 2000, energy use in this sector amounted to 144.5 TWh, which is 6.5 TWh less than during the previous year. It represented almost 37 % of Sweden's total final energy use.

About 87 % of the energy use in this sector is for space heating, domestic hot water production and the powering of domestic appliances. Energy used in land use applications accounts for about 5 % of total energy use in the sector, holiday homes account for another 1 % and other service applications for 7 %. These latter applications consist of energy use in the building sector, street lighting, waterworks, sewage treatment plants and electricity works.

Over 60 % of the energy use in the sector is used for space heating and domestic hot water production. As this is affected by temperature conditions, there can be considerable random variations in energy demand from one year to another. To enable proper comparisons to be made, it is necessary to correct for climatic conditions. 2000 was almost 20 % warmer than a statistically average year, which means that the amount of energy used for space heating was lower than normal. After applying such correction, energy use in the sector in 2000 amount to 154 TWh, a reduction of 1.8 % relative to 1999.

Reduced use of oil

The total temperature-corrected use of energy has remained relatively static between 1970 and 2000, although the relative proportions between the different energy carriers have changed. Oil crises, rising energy prices, changes in energy taxation and investment programmes have all affected the move from oil to other energy carriers. In 2000, total use of fossil fuels in the sector amounted to 26.1 TWh, as against 118.6 TWh in 1970. Much of this reduction is due to a shift from the use of oil for heating to electricity and district heating.

The number of dwelling units (single-family houses and apartments in apartment buildings) in the country increased by about 30 % between 1970 and 1999. However, the rate of new building during the 1990s has been very low, amounting on average to 14 300 dwelling units per year. This can partly explain why energy use in the sector has not increased in recent years. On the other hand, the number increased in 2000, with work starting on 18 000 dwelling units. Floor areas of commercial premises, however, have increased substantially since 1970, thus also affecting the demand for heating, domestic hot water and electricity for building services systems.

The use of electricity has grown continuously from 1970 until the middle of the 1990s, stabilising at about 70 TWh in recent years. It is used for heating, domestic electricity and building services systems.

Lower final energy use

Several factors have helped to offset increased energy use in the sector. On the heating front, there has been a change from oil to other energy carriers. In detached houses, the change has been mainly to the use of electric heating, while in apartment buildings it has been to district heating. Both these changes have resulted in a reduction in final energy use through reduced conversion losses in the end use processes. Different energy carriers exhibit differences in distribution and conversion losses in the process of final conversion to heat at the consumers' premises, which can be expressed in the form of mean annual efficiencies. These efficiencies allow for the aggregated effects of the combustion efficiency of the heating system, heat losses, distribution losses and shortcomings in control and adjustment of the heating system. The mean annual efficiencies of electric heating and district heating are, on average, higher than those for oil, which means that replacing oil by electric heating or district heating results in an overall reduction in final energy use.

The number of heat pumps in use has increased considerably in recent years, thus reducing the actual amount of energy used for space heating and domestic hot water production. Heat pumps abstract heat from rock, earth, air or water, and supply it to the building's heating system. Those abstracting heat from rock, the ground or lake water can supply 80–90 % of the annual space heating and domestic hot water requirements of a detached house, with the remaining 10–20 % usually being supplied by electric immersion heaters or an oil-fired boiler. Heat pumps normally supply 2–3 times as much thermal energy as they use in the form of electrical energy for driving them. This 'free' heat is not included in the statistics of the amount of energy used in the sector.

Figure 21a • Final energy use within the residential, commercial, service sector etc. 1970–2000

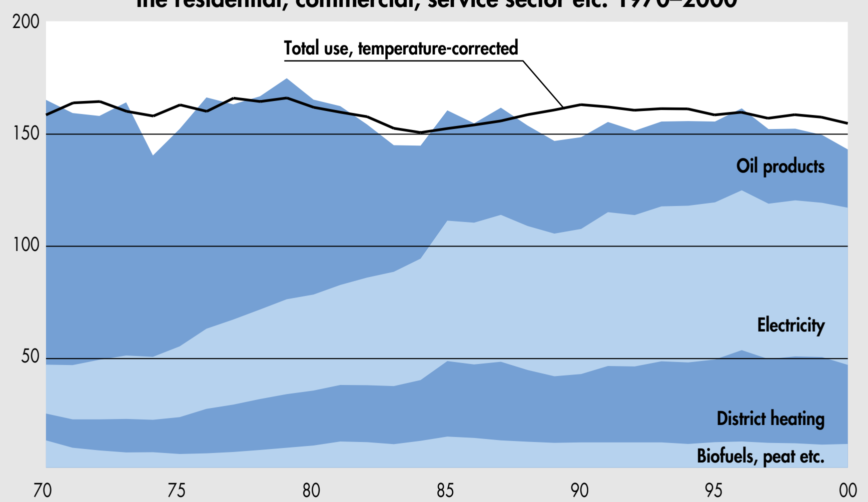
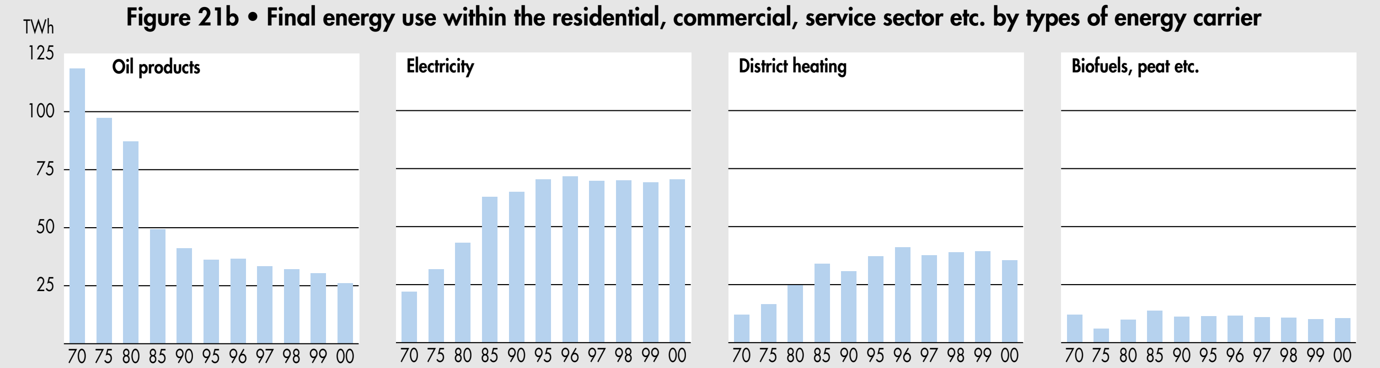


Figure 21b • Final energy use within the residential, commercial, service sector etc. by types of energy carrier



Other factors that have helped to prevent an increase in energy use for space heating and domestic hot water production in residential buildings and commercial premises include various types of energy conservation measures, such as retrofitting additional thermal insulation and upgrading windows in older buildings.

The rate of increase of use of electricity for domestic purposes and building services systems has been limited through greater use of equipment with higher energy efficiencies.

Heating

Of the 93 TWh that were used for space heating and domestic hot water production in 1999, it is estimated that about 44 % were used in detached houses, 31 % in apartment buildings and 25 % in commercial premises and public buildings.

Over a third of all detached houses in the country were heated by electricity alone in 2000. Approximately 18 % of detached houses have direct-acting electric heating, with 15 % having waterborne electric heating. About 13 % of detached houses are heated by oil alone, 8.5 % by district heating and 5.5 % by wood alone. The main reason for the high proportion of electric heating is that it is cheap to install and simple to run. The use of electric heating has increased substantially in the sector from 1970 to 1990, with the increase being greatest up to the first half of the 1980s. Conversion grants for changing from electric heating to some other form of heating were re-introduced on 1st June 2001. These grants are also available for partial conversions, with electric heating being combined with rock heat or a pellets-fired stove.

Another common heating system in detached houses is electricity in combination with wood and/or oil firing. The proportion of detached houses with such systems is almost 30 %. They are therefore relatively flexible in their choice of fuel, with the selection being largely determined by the relative price levels of the different energy carriers. Other households, not having this ability quickly to change their energy carriers, are more exposed to changes in the relative prices. The total use of electricity for space heating in detached houses and agricultural properties amounted to 13.7 TWh in 2000.

District heating is the commonest form of heating in apartment buildings, with about 75 % of apartments being heated by it, equivalent to a use of about 22 TWh. Oil is used as the sole or main heat source in 8 % of apartments, equivalent to 4 TWh of oil. The use of electric heating in apartment buildings is relatively low, amounting to 2 TWh in 1999.

The main source of heat in offices, commercial premises and public buildings is also district heating, with over 50 % of such buildings being supplied, equivalent to 15 TWh. The use of electricity for space heating and domestic hot water production in commercial premises amounted to 4 TWh, while 5 TWh of oil were also used for this purpose.

Domestic electricity

The use of electricity for domestic purposes more than doubled between 1970 and 1999, from 9.2 TWh to 18.5 TWh, due to an increase in the number of households and greater ownership of domestic appliances. However, continued improvement in the electrical efficiency of such appliances has tended to offset this increase, as old, worn-out appliances are replaced by new, more efficient ones. This has applied particularly to white goods.

Building services systems

The use of electricity for building services systems has increased substantially, from 8.4 TWh in 1970 to 29.1 TWh in 1999. The reasons for this development include rapid growth in this service sector and greater use of office machines. The high growth rate of private and public services has also resulted in a relatively substantial increase in the total floor area of offices and commercial premises.

Lighting and ventilation, which at the beginning of the 1990s accounted for about 70 % of the use of electricity in building services systems, have become more efficient as a result of improved light sources, more sophisticated operational control and correct sizing of systems at the time of installation. Nevertheless, the potential for further improvements in the efficiency of electricity use in offices and commercial premises is still regarded as considerable. Although companies constantly replace equipment, which becomes steadily more efficient, there is also a trend towards greater numbers of items and equipment. ■

Figure 22a • Electricity use in the residential, commercial, service sector etc. 1970–1999, corrected for climate variations

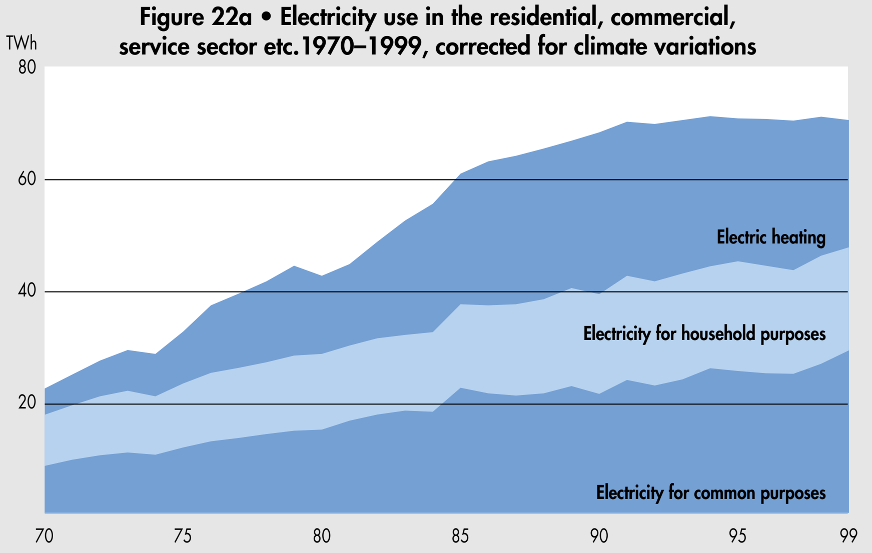
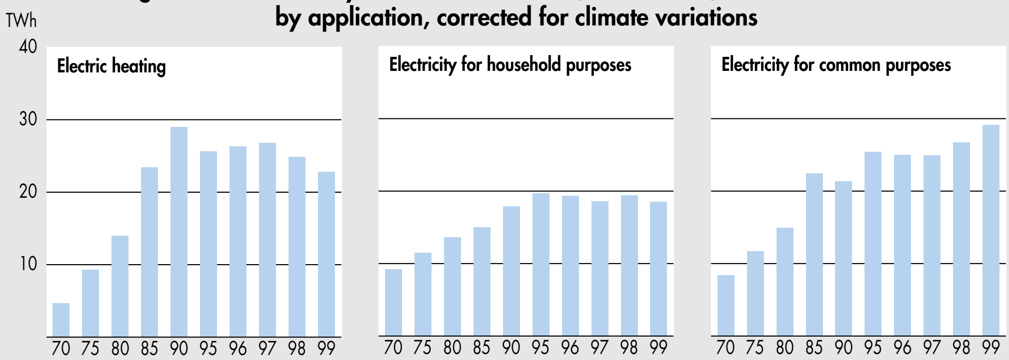


Figure 22b • Electricity use in the residential, commercial, service sector etc. by application, corrected for climate variations



In 2000, industry used 3.2 TWh more energy than during 1999, amounting to 156.1 TWh, or 40 % of the country's final energy use.

Classified by energy source/carrier, this consisted of 19.6 TWh of petroleum products, 15.8 TWh of coal and coke and 55.9 TWh of electricity. Use of natural gas amounted to 3.7 TWh, and that of district heating to 4.5 TWh. Supplies of biofuels, peat etc. amounted to 56.5 TWh: of this, amount 46 TWh were used in the pulp and paper industry, mainly in the form of black liquors. Final energy use in industry therefore consisted of 25 % of fossil energy and 36 % of biofuels, peat etc., with the remainder consisting of electricity and district heating.

In Sweden, a small number of sectors accounts for the bulk of energy use in industry. The pulp and paper industry uses about 49 %, the iron and steel industry about 14 % and the chemical industry about 7 %. Together, these three energy-intensive sectors account for over two-thirds of total energy use in industry. The engineering industry, although not regarded as energy-intensive, nevertheless accounts for almost 7 % of total energy use in industry, as a result of its high proportion of total industrial output in Sweden.

The relationship between output and energy use

In the short term, energy use in industry essentially follows variations in industrial output. In the longer term, it is affected also by such factors as changes in the types of goods produced, technical development, taxes and energy prices.

Between 1990 and 1992, industrial output fell by 6 %, which was reflected by a fall of almost 6 % in energy use. Electricity use in the sector also fell, but by somewhat more than 6 %, i.e. by more than the fall in total energy use, as the recession tended to hit the electricity-intensive sectors harder than other industrial sectors.

Industrial output increased again in 1993, and continued to rise substantially in 1994 and 1995. Output volume in 2000 was almost 70 % higher than in 1992, while energy use increased by 18 %. During the same period, the use of electricity increased by 6.2 TWh, or 12 %. When comparing the time period from 1975–1997 with that from 1990–1997, it can be seen that the response relationship between energy use and increased industrial output has fallen by about 40 %, due to such factors as technical development and structural changes in the sector.

Changes in oil and electricity use

Despite rising industrial output, the use of oil has fallen substantially since 1970, resulting from greater use of electricity and improvements in the efficiency of energy use. This trend started in connection with the oil crises of the 1970s, which resulted in both

Figure 23a • Final energy use in industry 1970–2000

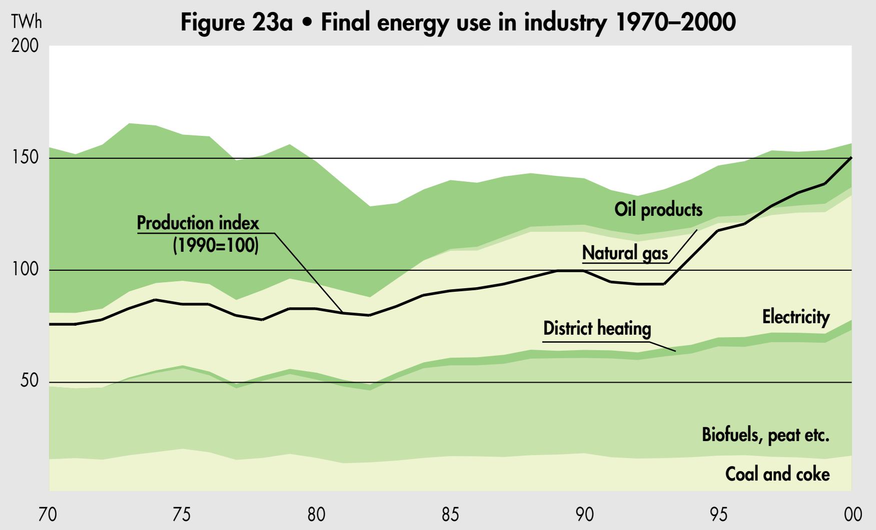
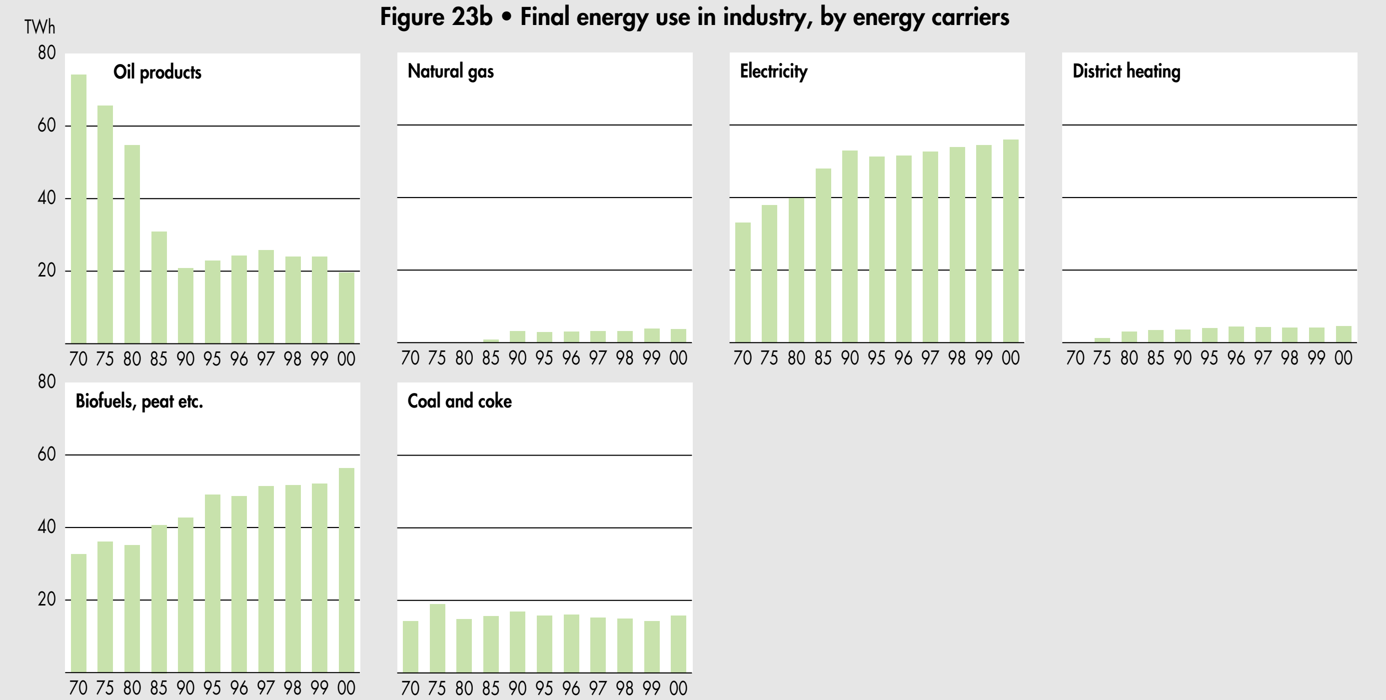


Figure 23b • Final energy use in industry, by energy carriers



State and business starting intensive work aimed at reducing the use of oil. In 1970, the use of electricity constituted only 21 % of industry's total energy use, which can be compared with the present proportion of 36 %. At the same time, the use of oil has fallen from 48 % to 13 % in terms of industry's energy use. Between 1970 and 2000, the proportion of biofuels, peat etc. has increased from 21 % to 36 % of total industrial energy use. However, the use of oil products increased by 2.2 TWh, or 13 %, over the period from 1992 to 2000. Among the factors contributing to this increase have been higher output, lower energy and carbon dioxide taxes and greater use of oil as a replacement for interruptible electric boilers.

Changes in specific energy use

Specific energy use, i.e. the amount of energy used per monetary unit of output of value, provides a measure of how efficiently the energy is being used. Since 1970, specific energy use in industry has fallen continuously: between 1970 and 2000, it fell by 50 %, showing a clear trend towards less energy-intensive products and production processes, together with structural changes in the sector. During this period, industrial output value has more than doubled.

The change from oil to other energy carriers, particularly electricity, is reflected in the specific use of oil and electricity per unit of output value. Specific use of oil fell by 80 % between 1970 and 1992, while specific use of electricity increased by 25 %.

The upturn in the economy during the 1990s, coupled with changes in the energy taxation of industry, is reflected in changes in specific energy use, which continues to fall. Between 1992 and 2000, it fell by 31 %, with specific use of oil falling by 35 % and that of electricity falling by almost 35 %. More generally, the reduction in specific energy use is due to the fact that production value has increased considerably more than has energy use.

For several reasons, we can expect a continued fall in specific energy use. Investigations are at present in progress, for example, into the feasibility of further reducing carbon dioxide emissions by industry through what are known as long-term agreements. Put simply, these agreements mean that industry undertakes to improve its efficiency of energy use and/or to replace the use of fossil fuels in exchange for, for example, a lessening of taxation or a promise of future unchanged taxation. ■

Figure 24a • Specific use of oil in industry 1970–2000, 1991 price level

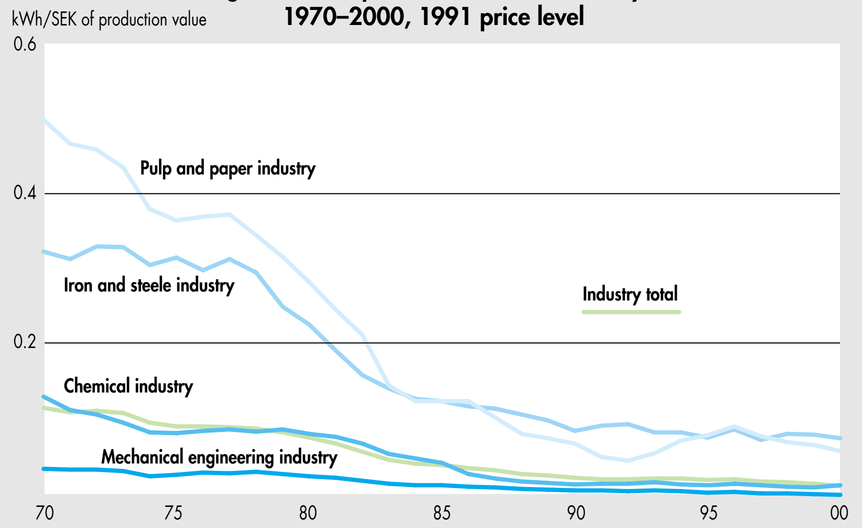


Figure 24b • Specific use of electricity in industry 1970–2000, 1991 price level

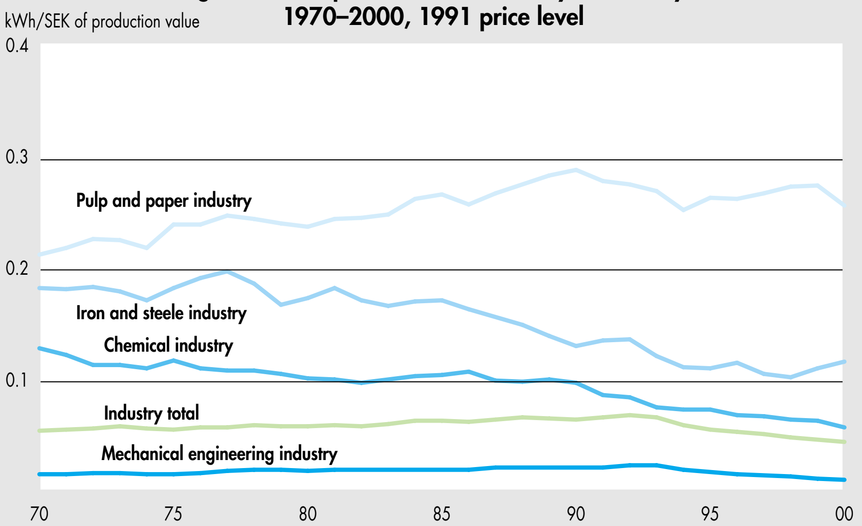
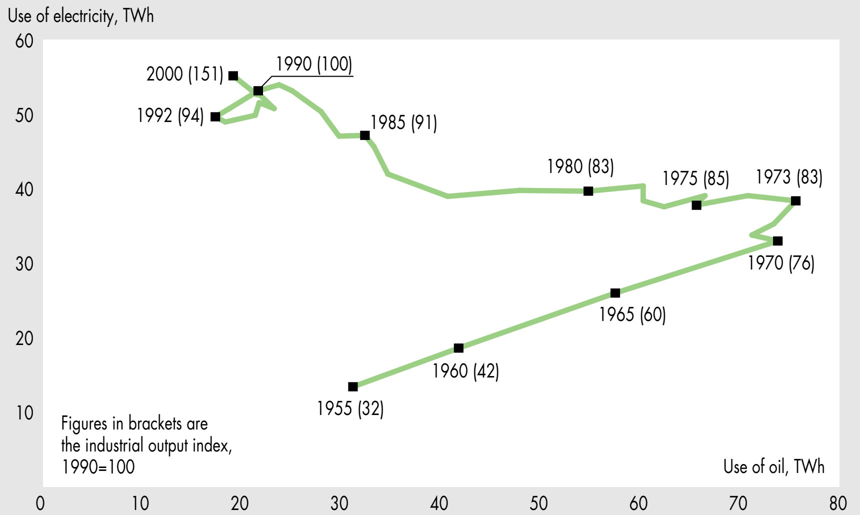


Figure 25 • Use of oil and electricity in industry 1955–2000



Energy use for transport (excluding foreign maritime traffic) in 2000 amounted to 91.6 TWh, or 23 % of the country's total final domestic energy use. Foreign maritime transport used about 17 TWh of bunker oils. Energy use in the transport sector consists almost entirely of oil products, primarily petrol and diesel fuel. In 2000, the use of these two fuels provided 83 % of the country's energy requirement for domestic transport. In recent years, the use of petrol has declined, while that of diesel fuel and aviation fuel has increased. Use is largely dependent on general economic conditions and technical development. The two main guide measures, intended to reduce the use of energy by the transport sector, are energy tax and carbon dioxide tax.

Alternative motor fuels

The use of alternative motor fuels, such as ethanol and biogas, is at present marginal: the costs of producing most of these fuels today are higher than the corresponding costs for petrol and diesel fuel. However, this cost differential is being eroded by technical developments and the introduction of environmental levies. Several research programmes are in progress, e.g. in the fields of production technology and vehicle technology. A new plant for the production of ethanol was brought on line in Norrköping in March 2001, with an expected output of 50 000 m^3/year.

Transport work

Domestic passenger and goods transport in 1999 amounted to 114 x 10^9 person-km and 59 x 10^9 tonne-km respectively. Private cars provide 73 % of passenger transport: bus travel provides 8 %, rail travel provides 4 % and air travel provides 3 %. 55 % of internal freight transport is by road, 32 % by rail and 13 % by water. In recent years, freight transport by road has increased at the expense of rail and water transport.

Environmental impact

All forms of transport produce emissions that are detrimental to the environment and to health. Although the introduction of catalysers has substantially reduced the emission of several hazardous substances, carbon dioxide emissions cannot be reduced in this way, which means that they have continued to increase in step with the greater use of fossil fuels. It has been found difficult to reach agreement on harmonised fuel taxes within the EU. However, the European automotive industry has entered into a voluntary agreement with the European Commission to reduce carbon dioxide emissions from new passenger cars by 25 % by 2008, relative to the 1995 levels. Corresponding agreements have also been reached during the year with Japanese and Korean vehicle manufacturers. During the summer, draft guidelines were presented for a comprehensive common transport policy within the EU, intended to concentrate on transferring freight transport from road to rail and water, eliminating bottlenecks in the transport system and introducing new principles for pricing infrastructure and transport. In addition, it is important to find a balance between environmental consideration and the substantial growth in air traffic, to strengthen the rights of consumers and to enhance the position of the European Union in international organisations. March 2001 saw the start of a programme under the name of Clean Air for Europe (CAFE), with the long-term aim of developing strategic principles to protect persons and the environment from air pollution. It will be incorporated, through technical analyses and political progress, in the Sixth Environmental Action Programme (6EAP) in 2004.

Technical development

Technology advances both through improvements in existing technology and in the form of completely new technologies. Of the latter, those that are closest to a commercial breakthrough within the next ten years are hybrid vehicles, ethanol-fuelled vehicles and flexible fuel vehicles (FFV). Hybrid vehicles have two alternative drive systems, e.g. both an electric motor and a combustion engine. FFVs can use different fuels simultaneously, e.g. ethanol and petrol. Several of the large vehicle manufacturers have already launched passenger cars with alternative drive systems, or will do so in the next few years. However, looking further ahead than ten years, the automotive industry is pinning considerable hopes on fuel cell technology. ■

Figure 26a • Final energy use in the transport sector 1970–2000

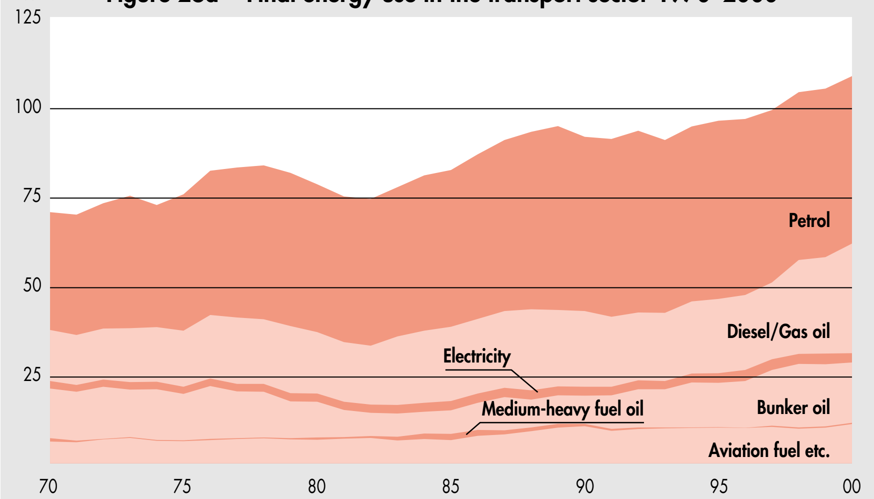
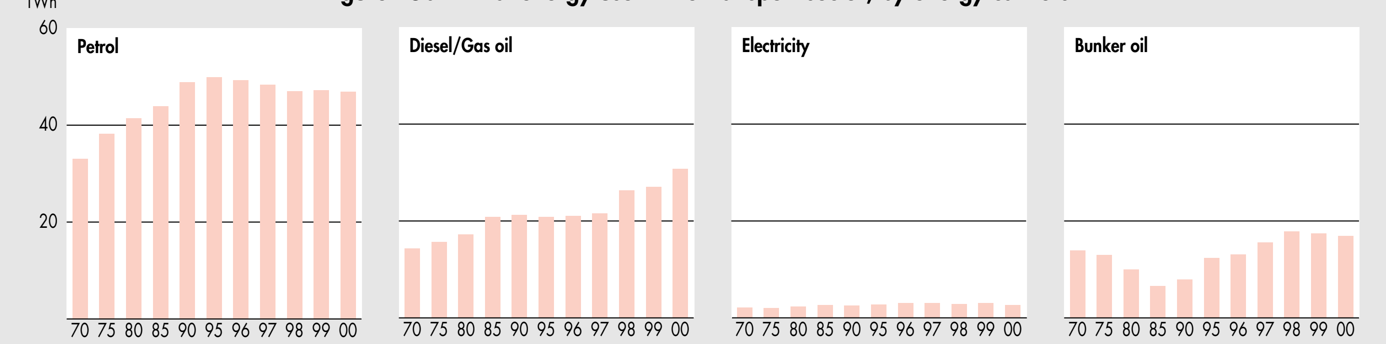


Figure 26b • Final energy use in the transport sector, by energy carriers



The foundation of the present European Union was laid shortly after the Second World War, when six Western European countries (Belgium, Germany, France, Italy, Luxembourg and Holland) cooperated in control and management of the coal and steel industries. The next step was the Treaty of Rome, which laid the basis for economic cooperation between the countries. In 1991, the Maastricht Treaty established the structure that is called the European Union, and which rests on three pillars: the single market, the agricultural and environmental policy and the common foreign and security policy, in conjunction with cooperation in legal and internal matters. The EU today consists of 15 member states.

A significant portion of world energy consumption

The European Union is one of the largest energy-consuming regions in the world: approximately 30 % of total OECD energy consumption, and about 15 % of world energy consumption, is accounted for by it. However, in recent decades, energy consumption in the EU has been rising more slowly than in the rest of the world.

Energy supply today and a look towards 2020

Oil is the dominating energy source in EU energy supply, and its use – particularly in the transport sector – is continuing to rise, so that it nowadays supplies over 46 % of final energy use. On the other hand, the use of coal has fallen considerably, to less than half of its 1985 level, so that it nowadays supplies less than 5 % of final energy use. The greatest reduction has occurred in Germany, although its use has also declined considerably in the UK. The use of natural gas continues to rise: since 1985, it has increased by 38 %, accounting for almost 24 % of final energy use in 1998. The European Commission forecast for developments up to 2020 expects the consumption of natural gas to increase by almost 50 % by 2010, after which it is expected to stabilise. The main reason is a continued increase in the use of natural gas for electricity production. The use of renewable energy sources has been relatively stable since 1985, although there has been an upturn in recent years. The use of wind power is expected to increase substantially by 2020.

Self-supply and dependence on imports

As a region, the EU is the world's largest importer of energy. Despite increased production, self-sufficiency in energy supply has fallen, as the demand for energy is increasing even more rapidly. From having been almost 60 % self-sufficient in energy supply in 1985, the EU was only 52 %

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Figure 27 • Total final energy use in the EU, 1985, 1990 and 1998

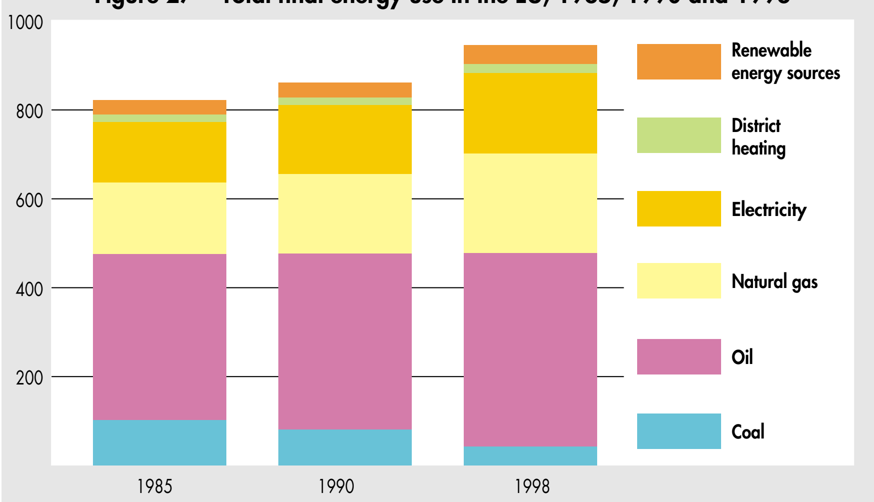
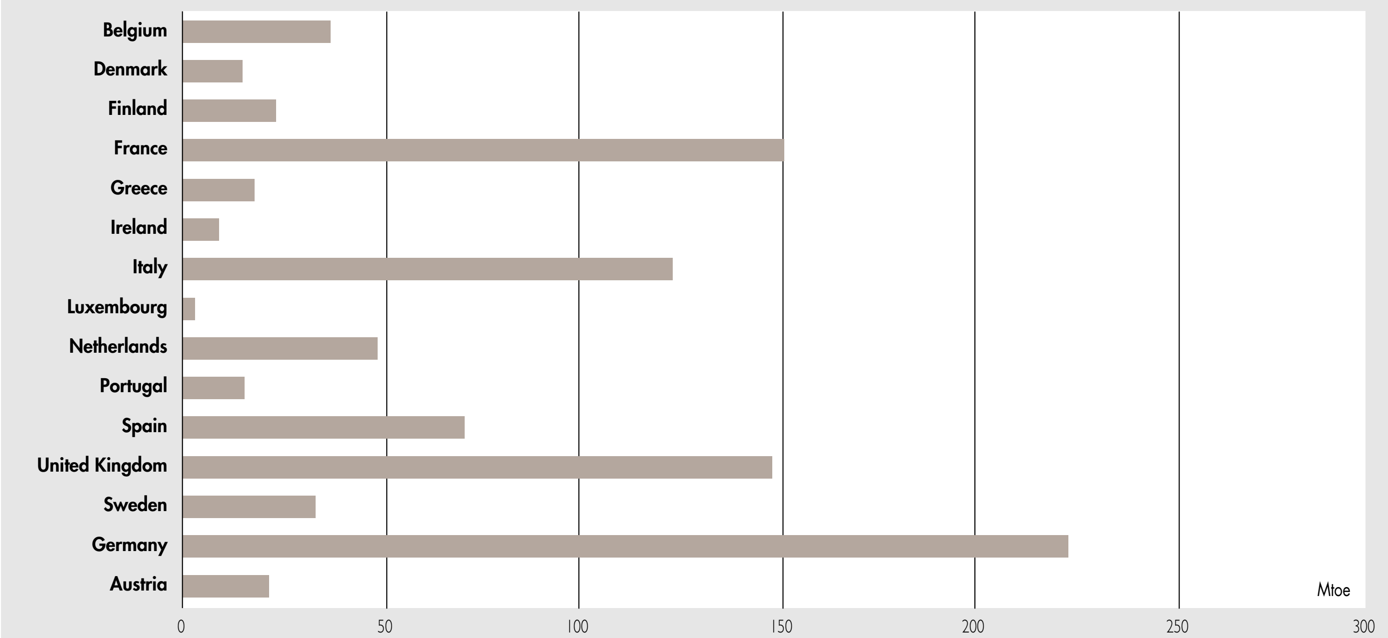


Figure 28 • Total final energy use, by EU member states, 1998



self-sufficient in 1998. It had, in other words to import 48 % of its energy requirements. Forecasts indicate that EU production of oil, gas and coal will all decline by 2020. The Commission's forecasts expect dependence on imports to have risen to about 65 % by 2020.

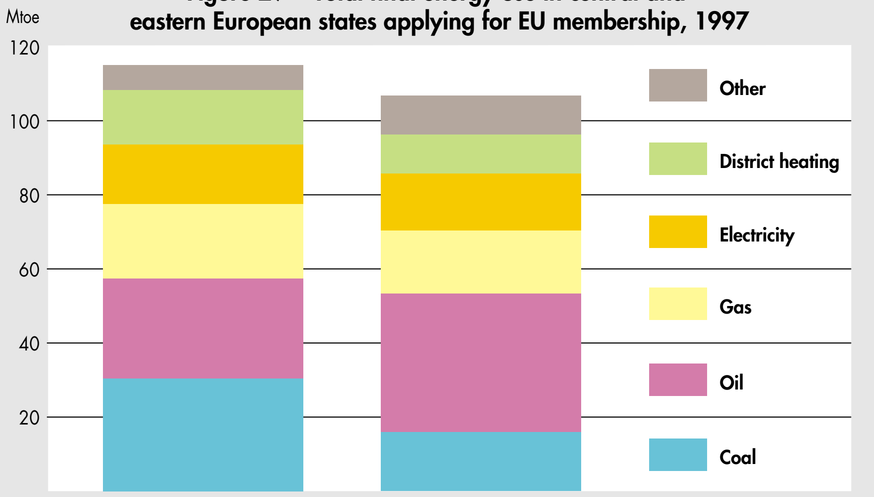
Fifteen states with different conditions

The EU consists of 15 member states with differing conditions. GNPs vary widely, with Germany, France, Italy and the UK having the highest values. Luxemburg has the lowest GNP, equivalent to 1 % of Germany's. Countries such as Portugal, Greece and Ireland have GNPs that are only 5–10 % of those of the large states. The climates also differ considerably, which has a considerable effect on energy requirements. Together Germany, France, Italy and the UK account for almost 70 % of total energy use, although this proportion changes somewhat when converted to per-capita energy use. Luxemburg has the highest per-capita energy use, due partly to the country's low motor fuels' prices, which mean that many vehicles on their way across Europe fill up with fuel there. As Sweden and Finland have a relatively high proportion of energy-intensive industries, together with a cold climate, they have relatively high per-capita energy uses. Belgium and Holland, too, have high per-capita energy use values. On the other hand, per-capita use is lower in the Mediterranean countries of Greece, Italy, Portugal and Spain.

Expansion of the European Union

The EU is in the process of preparing for a new expansion, this time towards Central and Eastern Europe, where a total of ten countries from the former Eastern European states – Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia – are candidates for membership. In addition, Cyprus, Malta and Turkey have also applied for membership. A first group of countries – Cyprus, Hungary, Poland, Estonia, the Czech Republic and Slovenia – has precedence in the negotiations. These negotiations take several years, and each country is judged on its own progress. Figure 29 shows energy use by different forms of energy carriers for the priority applicant countries and for the other applicant countries. ■

Figure 29 • Total final energy use in central and eastern European states applying for EU membership, 1997



[1] Of these countries, Poland accounts for over half of total final energy use.
[2] Except Cyprus, Malta and Turkey.

Figure 30 • Total energy use, by member states, by energy carriers, 1998

Globally, world energy supply is dominated by fossil fuels, which account for about 80 % of total energy supply. Oil is the most important energy source, meeting 37 % of demand, followed by coal at 23 % and natural gas at 20 %. Historical development from 1970 until today shows that, in relative terms, it is the use of natural gas that has increased more than that of either of the other fossil fuels. The use of coal increased until 1990, but has since remained relatively stable. Hydro and nuclear power account for about 2 % and 7 % of world energy supply respectively. According to the energy statistics prepared by IEA – the International Energy Agency – 11 % of world energy supply is met by biofuels.

Much of the world's energy requirements are still met by individual supplies of wood and other forms of biomass. This use is not included in the international statistics. One assessment is that, outside the OECD countries and the former Soviet Union, traditional energy sources such as wood, charcoal etc. are probably the world's largest individual energy source.

Resources and reserves

Proven resources of fossil fuels – primarily oil, coal and natural gas – are estimates of the quantities that can be viably extracted with present economic and technical conditions. Expressed in relation to present rates of consumption, they amounted at the end of 2000 to:

- 227 years' production of coal
- 40 years' production of oil
- 61 years' production of natural gas.

The proven resources consist of the known, discovered and developed fractions of the earth's total resources. They can be 'increased' by prospecting, or by rising prices making new and more expensive methods of recovery viable.

Energy supplies and international trade

Non-OECD countries hold a significant part of world energy supplies and reserves, and have been able to export their surpluses – primarily of oil – to the industrialised countries. The industrialised countries import over half of their oil requirements but, as a group, are almost self-sufficient in coal and gas. It is expected that their import requirements for oil will increase over the next 15 years. Production of oil in North America has been relatively stable over the last couple of decades, although consumption has increased significantly. In Europe, dependence upon imported oil supplies has fallen due to substantial increases in North Sea production. Both production and use of energy in the former Eastern bloc countries have fallen dramatically during the first half of the 1990s, although the situation is now starting to stabilise. Price controls in the former Soviet Union have been removed, with the result that domestic prices of crude oil, lighter products and natural gas have almost reached world market price levels. Exports to the industrialised countries have largely been maintained.

Energy use

During the 1990s, total world energy use has risen less rapidly than it did during the 1980s, when the average rate of increase was 2 % per annum. The average rate of increase during the 1990s was 0.8 %. Having been largely unchanged during the last years of the 1990s, the rate of increase of total energy →

Figure 31 • World oil reserves 2000 (billion barrels)

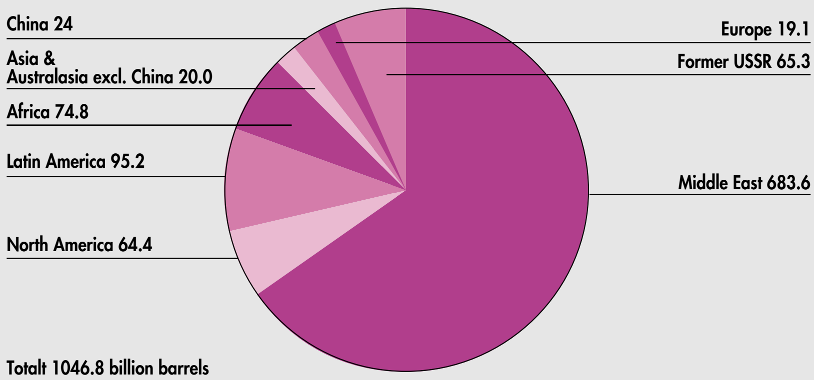
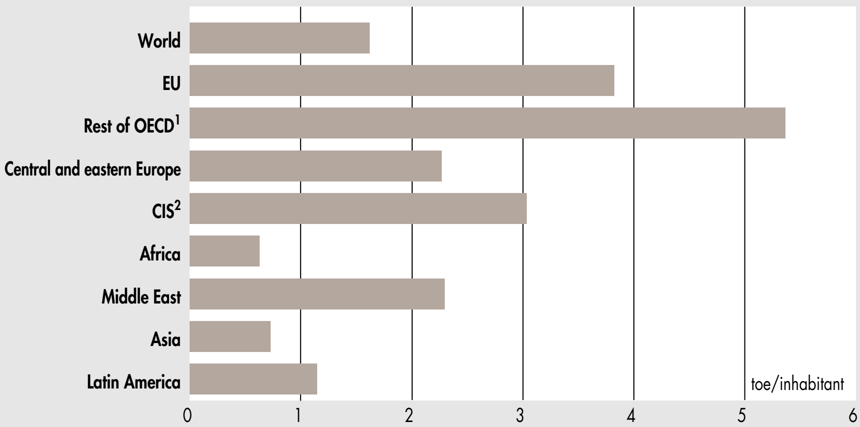
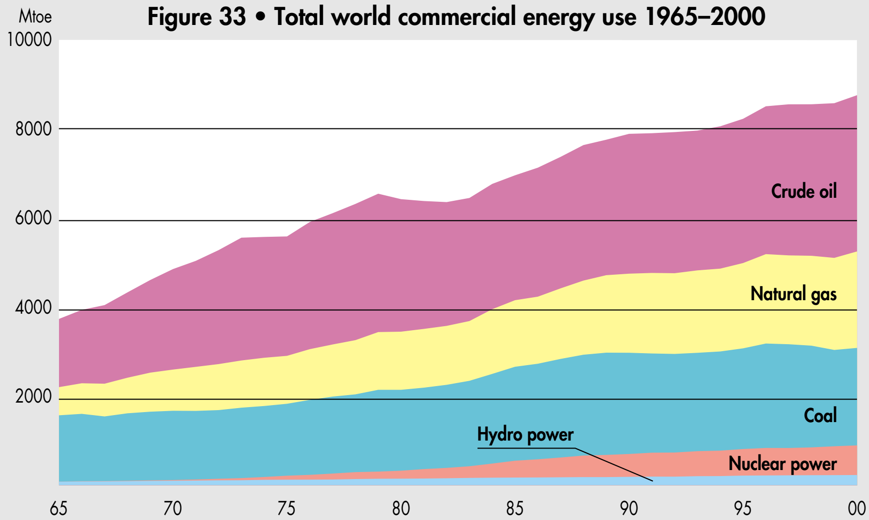


Figure 32 • Total energy use per inhabitant, 1998



[1] USA, Canada, Mexico, Norway, Switzerland, Iceland, Australia, Japan, New Zealand and Turkey.
[2] The Organisation of Independent States. Consists of twelve states, of which Russia and Ukraine are the largest. For statistical reasons, the Baltic states have been included.

Figure 33 • Total world commercial energy use 1965–2000



Note. Biofuels are not included, due to unreliable statistics.

use during the first years of the 2000s rose to over 2 %. A comparison between regions shows that energy use in most developing countries continues to rise steadily, due primarily to population growth, urbanisation and industrialisation. Energy use in the former Soviet Union fell dramatically during the first half of the 1990s, and continued to do so during the second half, but at a slower rate. Within the European Union, energy use increased slightly during the 1990s. North America and Japan showed higher increases up to 1997: in 1998, energy use in North America remained essentially unaltered, while that in Japan fell by 1.5 %.

World energy use varies considerably from one area to another. The differences are large: the OECD countries, for example, use 4–5 times as much energy per capita as is used in Africa, Asia or Latin America. In the group of 'other OECD countries', which includes the USA, no less than nine times as much energy is used per capita as is used in Africa.

Table 1 shows the energy intensity, i.e. the amount of energy used per unit of GNP produced, for a number of groups of countries, and thus gives an idea of the amount of energy used in relation to economic production.

Expressed in economic terms, over three times as much energy is used per unit of output in the central and eastern parts of Europe, in the former Soviet Union and in Asia, as is used in the OECD states. To some extent, the differences can be explained by the fact that the areas are at different stages of development: Asia, however, has shown a sharply reduced energy intensity during the 1990s. The countries in Eastern and Central Europe, too, have improved their efficiency of energy use. Energy intensity in the world as a whole has declined by somewhat over 1 % per annum over the last few decades.

Energy use in the former Soviet Union is highly inefficient. After the break-up of the Soviet Union, the economies are in a state of flux and problems are enormous, and this is reflected by greater use of energy per unit of output during the 1990s. However, the fact that energy prices today are now more or less up to world market prices should bring about improvements in the efficiency of energy use. It is assumed that improvements in efficiency will continue in China, Eastern Asia and Latin America.

Table 1 • Energy intensity (energy use/EUR), toe/million euro (1990)

	1980	1990	1998	1990/1980 % per year	1998/1990 % per year
The World	553	506	465	-0.9	-1.1
EU	291	248	235	-1.6	-0.6
Rest of OECD[1]	447	369	247	-1.9	-0.8
Central and Eastern Europe	1 625	1 470	1 231	-1.0	-2.2
OIS[2]	1 816	1 807	2 139	-0.2	-2.1
Africa	918	1 046	1 058	1.3	0.1
Middle East	358	688	828	6.8	2.3
Asia	1 777	1 346	1 053	-2.7	-3.0
Latin America	469	497	510	0.6	0.3

[1] USA, Canada, Mexico, Norway, Switzerland, Iceland, Australia, Japan, New Zealand and Turkey.
[2] The Organisation of Independent States. Consists of twelve states, of which Russia and the Ukraine are the largest. For statistical reasons, figures for the Baltic states have also been included in the table.

Note. Development in the Middle East is closely linked to revenues from oil production: between 1980 and 1990, GNP fell by 35 %. GNP in the OIS has fallen by over 45 % between 1990 and 1998.

Source: European Commission, '2000- Annual Energy Review'.

Forecasts

According to the most recent forecast from the International Energy Agency (IEA), world energy demand is expected to continue to rise steadily, rising at about 2 % per year until 2020, which can be compared with an annual 2.2 % rate of increase between 1971 and 1997. Much of the increase is expected to occur in the developing countries, with about 68 % of the increased demand originating from them, and 23 % of the increase from the OECD states. The scenario assumes an economic growth rate of 3 %/year, but a levelling-off of the population growth rate. Prices of fossil fuels are expected to be relatively stable until 2010, after which the prices of oil and gas are expected to rise.

Oil is still the world's major fuel, and it is expected that it will continue to provide approximately the same proportion of energy supply in 2020 as it does today. In the OECD states, it is the transport sector that is expected to account for the entire increase in demand. In other regions, the transport sector will account for the greatest increase, although here coupled with increases in other sectors such as the domestic sector, industry and for electricity production.

Of the fossil fuels, it is natural gas that increases the most in the scenario, replacing primarily the use of coal and nuclear power production. According to IEA, the world's natural gas reserves are more than sufficient to meet the substantial growth in use. However, as a result of the costs associated with extension of the necessary infrastructure, it is expected that the prices of gas will rise towards the end of the scenario period.

The use of coal is also expected to increase, although its proportion of total energy supply will decline between 1997 and 2020. China and India will account for two-thirds of the increase in use. Both countries have substantial reserves of coal, and are expected to experience considerable increases in the demand for electricity.

Production of electricity from nuclear power is expected to decline after 2010. Hydro power production is expected to increase by 50 %, mostly in the developing countries. Nevertheless, despite this increase, the proportion of total energy supply met by hydro power will fall during the scenario period.

Other renewable energy sources (solar energy, wind power, biofuels, refuse etc.) are expected to experience the greatest growth. However, despite the large percentage increase, these energy sources will provide only 3 % of total energy supply in 2020: today, their proportion is approximately 2 %. The greatest increase is expected to occur in the electricity production sector in the OECD states.

Forecasts for emissions of carbon dioxide

The IEA reference scenario expects a continued increase in carbon dioxide emissions, rising at over 2.1 %/year until 2020, with the fastest-growing developing countries making a significant contribution. China is expected to increase its emissions by 3.3 x 10^9 tonnes, which can be compared with the 2.8 x 10^9 tonnes increase in emissions from the OECD states. Global emissions of carbon dioxide are growing more rapidly than the demand for energy. The expected increase in the supply of energy from renewable sources is not sufficient to meet the extra demand: instead, the scenario foresees a continuing increase in the use of fossil fuels until 2020. Emissions from electricity production in the developing countries will account for almost a third of the total increase in emissions. The transport sector will remain a further major source, particularly in the OECD states. ■

The use of energy has been taxed in Sweden since the 1950s. The objectives have varied over the years: originally, the objective was to finance the State's public spending requirements, but in later years the emphasis changed to the need to control the production and use of energy in order to achieve various energy and environmental policy objectives. During the oil crises of the 1970s, there was a wish to reduce the use of oil and increase the use of electricity. Later, when Sweden joined the European Union, it was necessary to harmonise taxation with EU legislation. The environmental element of energy taxation was given greater importance at the beginning of the 1990s, and the green tax exchange continues in the budget for 2002.

The energy taxation system is complex. There are different taxes on electricity, energy, carbon dioxide, sulphur and NO_x, and they can vary, depending on whether the fuel is being used for heating or as a motor fuel, whether electricity is being used in northern Sweden or the rest of Sweden, whether it is being used by domestic consumers, industry or the energy sector, and so on. In 2000, revenues from energy and environmental spot taxes raised over SEK 52 400 million, or about 1.9 % of GNP. The energy taxation system has been under review for some years now.

The 2002 Budget Bill and green tax exchange

It was decided in the spring of 2000 that a total of about SEK 30 x 10^9 of taxation revenue should be transferred over a ten-year period. This is proposed to continue during 2002, amounting to about SEK 2 x 10^9 in higher energy taxes, which will be balanced by reduced taxes on labour.

Sweden's carbon dioxide emissions are to be cut, partly in accordance with the country's undertakings under the Kyoto Protocol. The 2002 Budget Bill proposes that the carbon dioxide tax on fuels should be raised by 15 % from 1st January 2002. This rise will increase the impact of carbon dioxide tax in relation to energy tax, and help to reduce carbon dioxide emissions. The energy tax on fuels, such as petrol and diesel fuel, will be reduced by an amount corresponding to the increase in the carbon dioxide tax, although there will be no rise in the tax on LPG, natural gas or methane when used as motor fuels. The proposed rise in carbon dioxide tax is intended to be such that the overall level of taxation on manufacturing industry, agriculture, forestry and fisheries etc. remains unchanged. This will be done by increasing the percentage carbon dioxide tax relief from 65 % to 70 %.

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Table 2 • General energy and environmental taxes from 1st January 2001, excluding value-added tax

		Energy tax	Carbon dioxide tax	Sulphur tax	Total tax	Tax, öre/kWh
Gas oil, SEK/m^3	(< 0.1 % sulphur)	688	1 527	-	2 215	22.4
Heavy fuel oil, SEK/m^3	(0.4 % sulphur)	688	1 527	108	2 323	21.5
Coal, SEK/tonne	(0.5 % sulphur)	293	1 329	150	1 772	23.4
LPG, SEK/tonne		134	1 606	-	1 740	13.6
Natural gas, SEK/1 000 m^3		223	1 144	-	1 367	14.1
Peat, SEK/tonne, 45 % moisture	(0.24 % sulphur)	-	-	40	40	1.5
Crude tall oil, SEK/m^3		2 215	-	-	2 215	22.1
Petrol, 95 octane, environmental class 1, SEK/l		3.26	1.24	-	4.50	51.6
Diesel, environmental class 1, SEK/l		1.51	1.53	-	3.04	31.1
Electricity, northern Sweden, öre/kWh		12.5	-	-	12.5	12.5
Electricity, rest of Sweden, öre/kWh		18.1	-	-	18.1	18.1
Electricity, gas, heat or hot water supply, öre/kWh						
Northern Sweden		12.5	-	-	12.5	12.5
Rest of Sweden		15.8	-	-	15.8	15.8
Electric boilers, > 2 MW, 1/11–31/3, öre/kWh						
Northern Sweden		14.8	-	-	14.8	14.8
Rest of Sweden		18.1	-	-	18.1	18.1

Note. Value-added tax at 25 % is additional to the above taxes. The energy and carbon dioxide tax for LPG used as a motor fuel is SEK 1 264 per tonne, and SEK 1 262 per 1 000 m^3 for natural gas.

Table 3 • Energy and environmental taxes for industry, agriculture, forestry and fisheries from 1st January 2001, excluding value-added tax

		Energy tax	Carbon dioxide tax	Sulphur tax	Total tax	Tax, öre/kWh
Gas oil, SEK/m^3	(< 0.1 % sulphur)	-	534	-	534	5.4
Heavy fuel oil, SEK/m^3	(0.4 %)	-	534	108	642	5.9
Coal, SEK/tonne	(0.5 % sulphur)	-	465	150	615	8.1
LPG, SEK/tonne		-	562	-	562	4.4
Natural gas, SEK/1 000 m^3	-	400	-	400	4.1	
Crude tall oil, SEK/m^3		534	-	-	534	5.2

Note. The tax administration and our own calculations.

Higher carbon dioxide taxes mean that electricity will become cheaper in relation to other forms of energy carriers, and so the tax on electricity will be raised by 1.2 öre/kWh.

The Budget Bill proposes that the boundary for exemption from the sulphur tax should be reduced from the present value of 0.1 % by weight to 0.05 % by weight.

Separately from the above, there will be increases in the tax rates applicable to all fuels, including motor fuels, due to indexing.

Types of tax

Energy tax is levied on most fuels, and is independent of their energy content. Carbon dioxide tax, which was introduced in 1991, is levied on the amount of carbon dioxide emitted by all fuels except biofuels and peat. It was raised from 37 öre/kg to 53 öre/kg with effect from 1st January 2001. A sulphur tax was introduced in 1991, and is charged at the rate of SEK 30 per kg of sulphur emission on coal and peat, and at SEK 27/m^3 for each tenth of a percent by weight of sulphur in oil. An environmental levy on the emission of NO_x was introduced in 1992, at the rate of SEK 40/kg of NO_x emissions from boilers, gas turbines and stationary combustion plant that supplies at least 25 GWh per annum However, it is intended to be neutral relative to the national budget, and is repaid to operators of plant in proportion to their energy production and in inverse proportion to their NO_x emissions, so that only those with the highest emissions are net payers. The electricity tax varies, depending on where, and for what purpose, the electricity is used.

Electricity and heat production

Fuels that are used for electricity production are exempt from energy and carbon dioxide tax, although they are subject to the NO_x levy and sulphur tax in certain cases. Until 1st July 2000, nuclear power plants were taxed on the basis of their electricity production, but since that date the tax is based on the gross thermal power output from their reactors[1]. In addition, there is a levy of 0.15 öre/kWh for decontamination and decommissioning of the country's previous nuclear facilities at the Studsvik research centre, and a further levy that amounts to about 1 öre/kWh for financing future storage facilities for spent nuclear fuel. Investment grants are provided for wind power, biofuelled CHP and small-scale hydro power. Wind power production receives an operating subsidy, known as the environmental bonus. In addition, there is also at present special support for small-scale power production, amounting to 9 öre/kWh, but this will be withdrawn at the end of 2002.

Fuels used for *heat production* pay energy tax, carbon dioxide tax and, in certain cases, sulphur tax, as well as the NO_x levy. In principle, biofuels and peat are tax-free for all users, although the use of peat attracts the sulphur tax. Special rules apply for simultaneous production of heat and electricity *(CHP)*: the fuel used for production of the electricity can receive a full rebate of energy and carbon dioxide tax. Some of the fuel, however, is regarded as having been used to meet internal power requirements, and is therefore taxed. The fuel used for the net beneficial heat pays only half the normal energy tax rate.

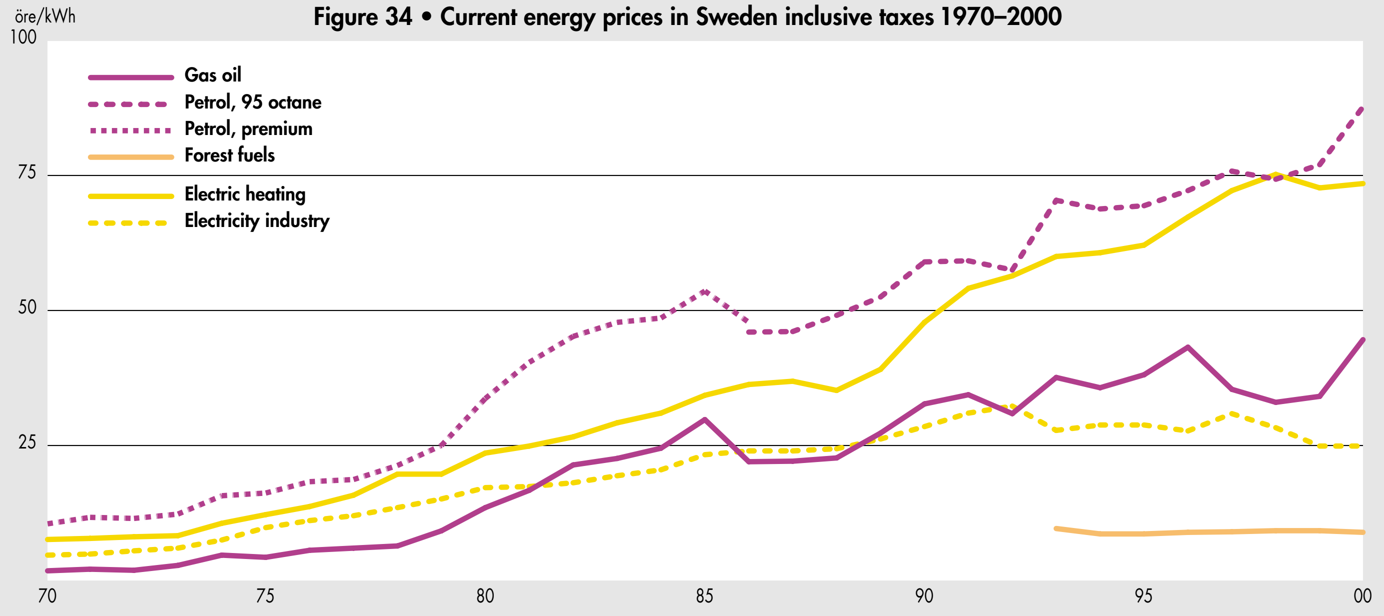
[1] Under a particular set of defined operating conditions, this tax raises the same revenue as the earlier tax rate of 2,7 öre/kWh.

Table 4 • Fuel prices and price of electric heating in Sweden, excluding taxes and value-added tax, actual prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
Crude oil, US $/fat	23.81	20.05	19.37	17.07	15.98	17.18	20.80	19.30	13.11	18.25	28.98
Gas oil, SEK/m^3	2 146	2 131	1 790	2 207	2 004	2 205	2 603	1 759	1 457	1 580	2 606
Med.-heavy fuel oil, SEK/m^3	1 702	1 535	1 316	1 652	1 525	1 525	1 526	1 014	853	997	1 850
Petrol, 95 octane, SEK/l	2.23	2.19	2,06	2.23	2.10	2.02	2.10	2.25	2.01	2.29	3.18
Coal, SEK/tonne	358	366	307	309	317	336	340	367	372	327	355
Forest chips, SEK/m^3				95.2	87.2	87.2	89.6	90.4	92.0	92.0	89.6
Electric heating, öre/kWh	31.5	36.1	37.9	40.0	39.7	40.7	43.60	45.2	45.0	43.0	42.2

Source: A table defining various environmental classes is included in the tables appendix, *Energy in Sweden; facts and figures*.

Figure 34 • Current energy prices in Sweden inclusive taxes 1970–2000



Taxation at the point of use

Domestic users pay different rates of electricity tax, depending on whether they live in the north of the country or the rest of the country. Manufacturing industry, horticulture and – since 1st July 2000 – agriculture, forestry and fisheries are exempt from energy tax, and pay only 35 % of the carbon dioxide tax. This means that, in principle, energy and carbon dioxide taxes on industry are the same as in 2000. There are special rules that rebate tax that exceeds 0.8 % of the sales value of the products manufactured.

There are various *transport tax* levels, depending on the environmental class of the fuel, and their effect has been to concentrate use on the least environmentally detrimental classes. Petrol tax has not been raised for 2001, apart from the increase due to indexing: the tax on diesel fuel, however, has been increased by 11.7 öre per litre. This has been offset by a reduction in the rate of value-added tax payable by public transport operators from 12 % to 6 %. No energy tax is payable on the use of diesel fuel or fuel oils used in commercial marine traffic, railbound traffic or aviation petrol or aviation paraffin.

Fuel prices

The price of crude oil rose steeply in 2000, reaching almost USD 29/barrel, as compared with somewhat over USD 18/barrel in 1999. The prices of processed oil products tracked the price of crude oil, and have had a substantial impact on consumer prices. The import price of coal rose somewhat in 2000, and continued to rise during 2001. The availability of forest chips is good, and the price continues to be stable.

The end prices paid by consumers depend to a considerable degree on taxation. In addition to the spot taxes (energy, environment and electricity), there is 25 % value-added tax. Industry does not pay value-added tax.

Of the total cost of heating a detached house with gas oil in 2000, 53 % was tax, which can be compared with 62 % in 1999. The proportion of the total price of petrol and diesel fuel made up of tax has also fallen: for petrol, from 73 % in 1999 to 64 % in 2000, while the tax proportion of diesel fuel fell from 64 % to 55 % over the same two years. The reason for this reduction in the proportion of the price made up of tax is that the underlying price of the oil itself has risen substantially.

The cost of electricity to a domestic consumer is made up of the price of the electricity itself, a cost element to the grid operator and taxes, including value-added tax. The price of the actual electricity makes up about 30 % of the total cost, and it is this that can be affected by the consumer by changing supplier. The grid charge accounts for about 28 % of the cost, with taxes accounting for the remaining 42 %. ■

Table 6 • Total fuel prices, including taxes and value-added tax, for industrial and domestic users, 2000

	Industry	Domestic
Gas oil, SEK/m³	3 135	5 509
öre/kWh	31.8	56.0
Heavy fuel oil, SEK/m³	2 487	
öre/kWh	23.0	
Diesel fuel[1], SEK/m³	2 938	
öre/kWh	29.7	
Coal, SEK/tonne	965	
öre/kWh	12.8	
Forest chips[2], SEK/tonne	269	336
öre/kWh	11.2	14

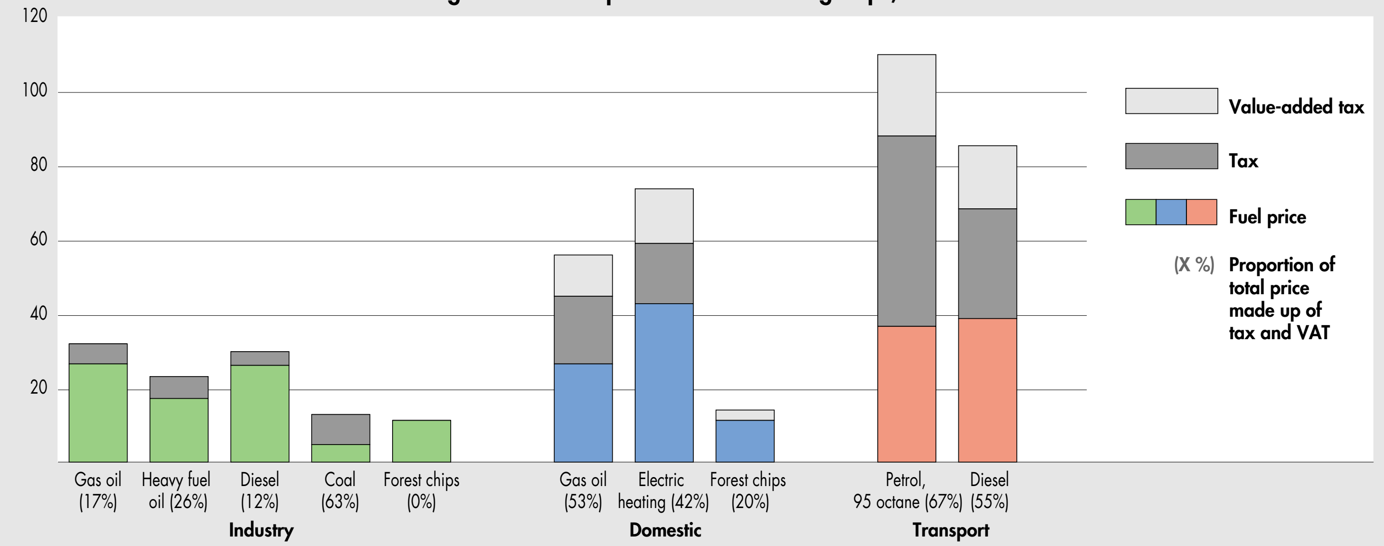
Source: Statistics Sweden, National Energy Administration and our own calculations.
[1] Per road tanker-load.
[2] 50 % moisture content.

Table 5 • Electricity prices and grid fees for various user categories, including taxes and value-added tax, öre/kWh

	Electrically intensive industries[1]	Small industries[2]	Detached houses with electric heating[3]	Detached houses without electric heating[4]
Total price, 1st Jan. 2000	25.4	35.6	73.5	96.0
Total price, 1st Jan. 2001	28.4	37	76.8	99.8

Source: Statistics Sweden, EN 17.
[1] Annual energy use, 140 000 MWh: power demand, 20 MW.
[2] Annual energy use, 350 MWh: power demand, 100 kW or 160 A.
[3] Annual energy use, 20 000 kWh: power demand, 20 A, supply fuse rating.
[4] Annual energy use, 5 000 kWh: power demand, 16 A, supply fuse rating.

Figure 35 • Fuel prices for three user groups, 2000



The production and use of energy are major sources of harm to the human and natural environment. Examples range from the ecological effects of the construction of hydro power schemes, through oil spills from tankers to vehicle exhaust emissions. Although Sweden has taken significant steps to counter these mechanisms, by such means as the imposition of statutory regulations, taxation and encouragement of the development of low-pollution technology, much still remains to be done.

The negative effects on the environment can be classified into three levels:

- local,
- regional, *or*
- global.

The boundaries between these levels are fluid, being determined not only by the type of emission, but also by how far it spreads.

Local environmental problems

Examples of local environmental problems include the fallout of dust from power stations or industrial processes, vehicle exhausts, smog, discharges of lead and the emission of carcinogenic substances. As problems of this type generally have an immediate effect on their surroundings and are easy to detect, it is natural that steps to deal with them can generally be taken at an early stage. Local environmental problems are regarded as being those that are restricted to the most immediate environment, such as that of the area of a medium-sized Swedish town and its surroundings.

Regional environmental problems

Regional environmental problems include acidification of the ground and water, and eutrophication. Problems of these types are akin to the fatigue of metals, as the damage that they cause becomes apparent only after a longer time. The emissions are spread over greater distances, and it can be difficult to locate the source(s). Environmental problems are regarded as being regional if they afflict large areas, countries or, in certain cases, continents.

Global environmental problems

"The solution to pollution is dissolution" was still regarded as a truth at the beginning of the 1960s. It was thought that the oceans and the atmosphere could absorb and dilute all our emissions to levels so low that they would not be noticed. Nowadays, we know that some of the emissions that we generate result in global environmental problems. This is clearly exemplified by the increase in greenhouse effect due to the emission of greenhouse gases and by destruction of the ozone layer. The extent of global environmental problems is such that they afflict the entire globe. They are therefore also the most difficult to tackle, as they require international coordination.

Acidification

Since the beginning of the 1970s, acidification has been one of the environmental problems in Scandinavia to which the most attention has been paid. As the ability of the ground and water to neutralise acidity is less in these countries than in most other parts of

Figure 36a • Emissions of sulphur dioxide (SO_2) in Sweden 1980–1999

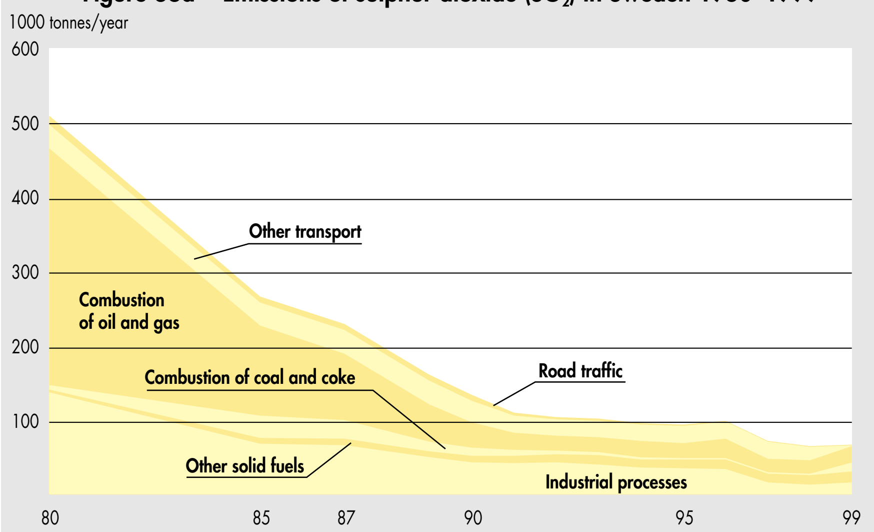
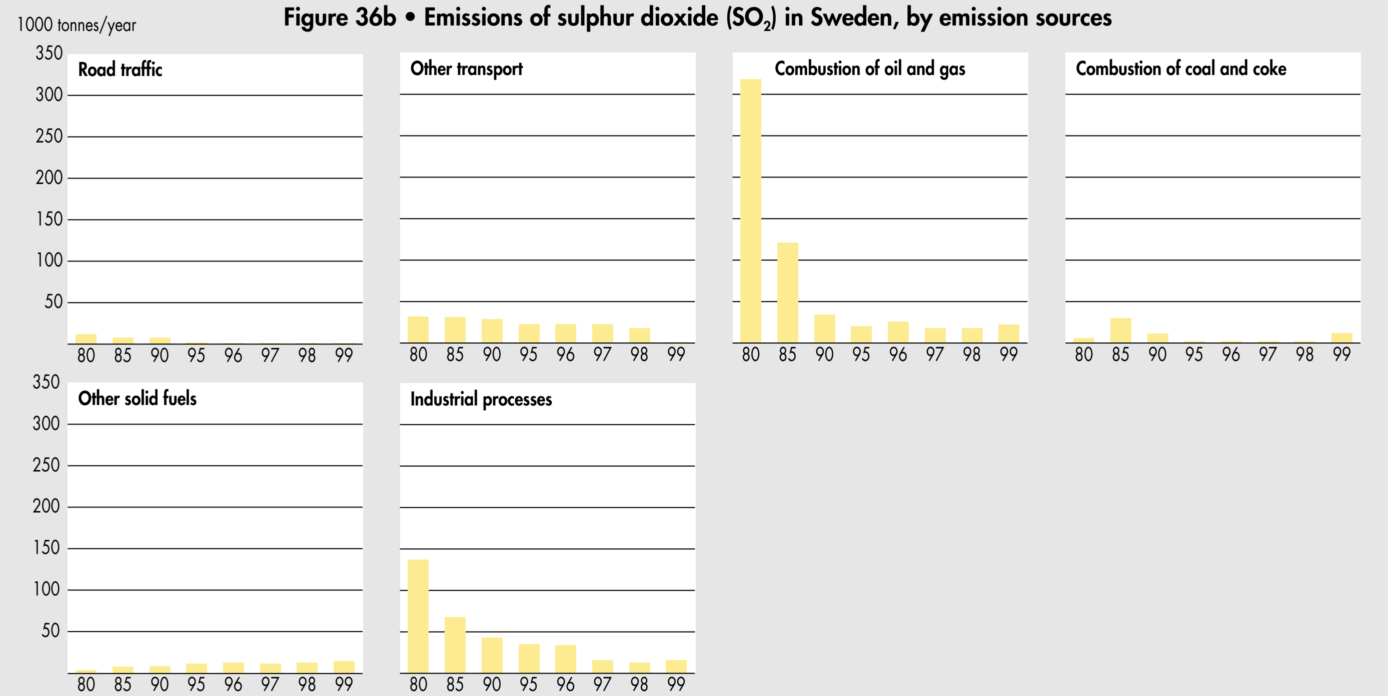


Figure 36b • Emissions of sulphur dioxide (SO_2) in Sweden, by emission sources



Europe, it was the Scandinavian countries in which the problem was first detected, with the result that it was long regarded as an essentially Scandinavian problem. One of the effects of acidification is the precipitation of metals in the ground and water, with the commonest example being aluminium. This results in the death of forests and to the disappearance of many sensitive species of plants and animals, both on land and in the water.

The main source of this acidification is the emission of sulphur in the form of sulphur dioxide. The sulphur dioxide is oxidised in the atmosphere to sulphuric acid, which is then brought down to the surface of the earth in precipitation, and thus referred to as 'wet deposition'. Sulphur emissions can also be deposited directly in the form of sulphur dioxide, known as 'dry deposition'. As the conversion process of sulphur dioxide in the atmosphere for wet deposition takes a few days – sometimes up to a week – it means that precipitation over Sweden originates primarily from sources in other countries. In 1980, over 17 % of sulphur precipitation in Sweden originated from domestic sources. By 1998, this figure had been reduced to somewhat over 7 %. As the prevailing winds over Sweden are westerly, the country is exposed to depressions and fronts from the west and north-west: large quantities of air pollutants are also carried over Sweden by southerly winds powered by high pressures over the continent. The countries from which over 30 % of today's precipitation in Sweden comes are primarily Germany, Poland and the UK. However, Sweden also exports air pollution to its neighbouring countries, primarily Russia, Finland, Norway, Poland and the Baltic states, although much of the pollution is precipitated in the sea. Swedish emissions come primarily from industrial processes, the combustion of oil and gas and from transport.

Reducing sulphur emissions

Emissions in both Sweden and the rest of Europe have fallen considerably since 1980. Sweden's Parliament committed the country to reducing its sulphur emissions to only 20 % of the 1980 levels by 2000. This reduction was, in fact, achieved in 1993, partly as a result of less use of oil and partly as a result of lower sulphur contents in the oil. An important international step in the work of reducing emissions was taken when a new sulphur protocol was produced by the UN Economic Commission for Europe (ECE) in 1994. Under the terms of the protocol, sev-

Table 7 • Changes in sulphur emissions in a number of European countries

Country	1998 emission relative to 1980, %
Austria	-88
Sweden	-90
Finland	-85
Norway	-78
Denmark	-83
Germany	-83
United Kingdom	-67
Poland	-54

Source: EMEP

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Figure 37a • Emissions of oxides of nitrogen (expressed as NO_2) in Sweden 1980–1999

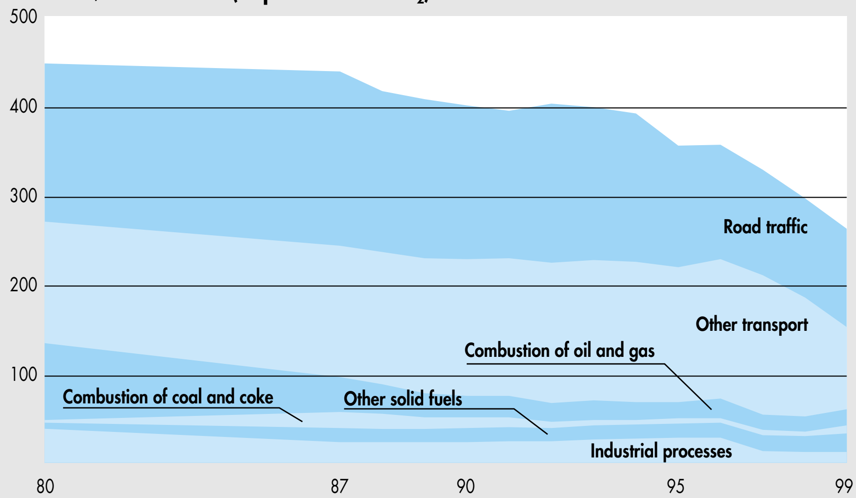
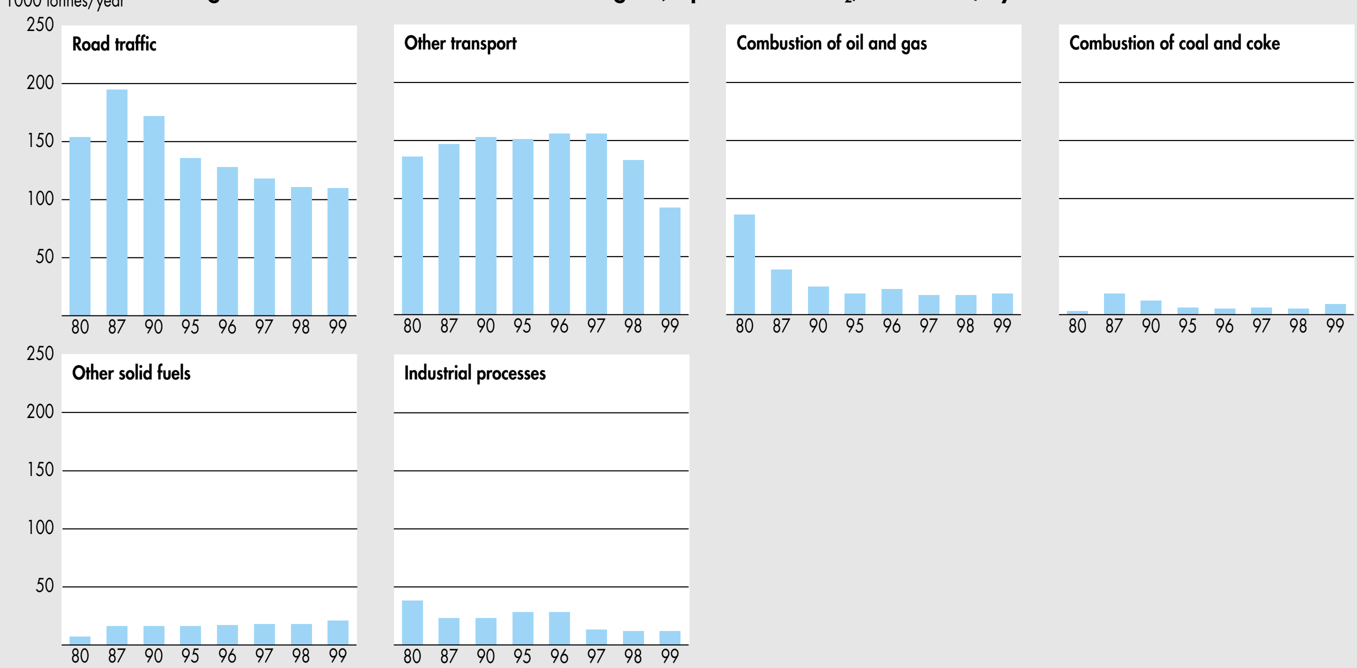


Figure 37b • Emissions of oxides of nitrogen (expressed as NO_2) in Sweden, by emission sources



eral European countries have undertaken to reduce their SO_2 emissions by between 30 % and 80 % by 2010, relative to the 1980 levels. The protocol came into force on 5th August 1998, and is legally binding, as it has been ratified by a sufficient number of states. Within the EU, the European Commission has succeeded in setting an emissions limit for the three key pollutants of sulphur dioxide, nitrogen dioxide and ammonia. These limits have been set such that the difference between the actual emission levels and the critical load limits, i.e. what the environment can stand, will be reduced by 50 % for each country.

In addition to sulphur dioxide, ammonia and nitrogen dioxide (reduced and oxidised nitrogen respectively) also contribute to acidification. However, due to the role of nitrogen as a macronutrient (i.e. an important nutrient that occurs in a relatively high concentration in biomass), these emissions make less contribution to acidification than does sulphur, although they make a considerable contribution instead to another major problem, eutrophication. It is only when nitrogen levels in the ground reach saturation that nitrogen contributes to acidification.

Eutrophication

Eutrophication, particularly of lakes and the sea, is largely due to emission of nitrogen. However, in the Gulf of Bothnia, it is not nitrogen that is the main cause of eutrophication, but phosphorus. However, as phosphorus emissions are not due to the use of energy, they will not be discussed further here. Nor, in fact, does the greater portion of nitrogen emissions originate from energy use, but rather from agriculture, although the contribution from the energy sector is sufficiently large to be significant.

Eutrophication is primarily a problem in water ecosystems. Forest eutrophication is rare, although forests in south-west Sweden do show signs of nitrogen saturation. However, eutrophication of other types of ground occurs, contributing in such cases to a substantial increase in the number of nitrogen-loving plants, such as wild chervil, sting-

Figure 38a • Deposition of oxides of sulphur in Sweden 1998 from various sources (%)

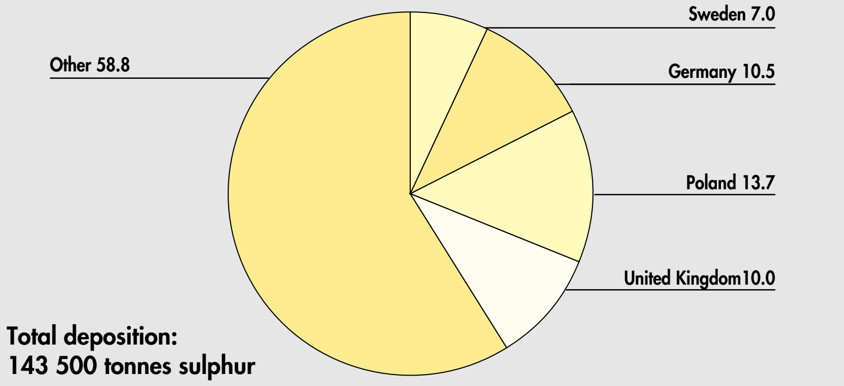


Figure 38b • Deposition of oxides of nitrogen in Sweden 1998 from various sources (%)

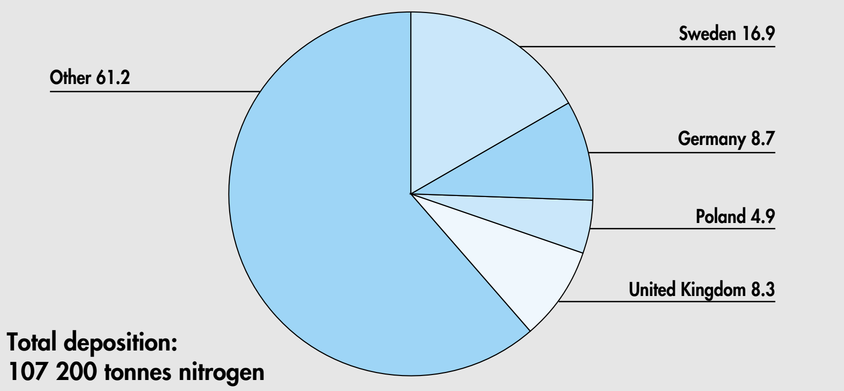


Figure 39a • Emissions of carbon dioxide (CO_2) in Sweden 1980, 1990–1999

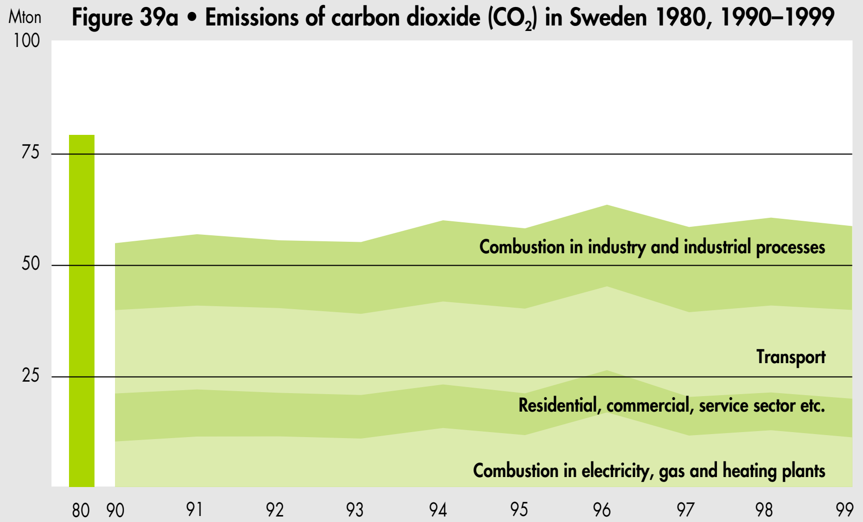
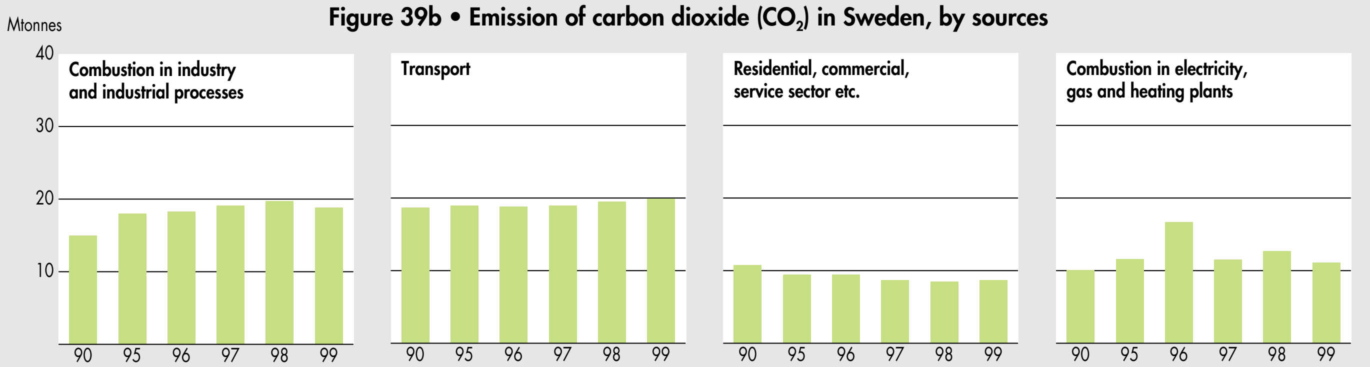


Figure 39b • Emission of carbon dioxide (CO_2) in Sweden, by sources



ing nettles and willow herb, at the expense of other species, such as mosses. Eutrophication of water ecosystems results in excessive growth of water plants, resulting in cloudiness of the water and reduced depth of visibility. In the longer term, there is a risk of lakes becoming totally clogged by plant growth and turning into marshland. Eutrophication also contributes to oxygen-free bottom environments through the increased demand for oxygen to break down dead plant growth. Oxygen-free bottom zones are a problem in a number of areas, including the Baltic. In fact, the Baltic is perhaps the biotope that has suffered most from nitrogen precipitation, resulting in algae blooms and oxygen-free bottoms. These oxygen-free bottoms make it difficult for cod to reproduce, and also contribute to a serious depletion of bottom fauna.

Catalytic exhaust cleaning has reduced emissions

Although emissions of nitrogen have not been reduced as much as emissions of sulphur, there has been an increase in the rate of reduction in recent years, due primarily to the introduction of catalytic exhaust cleaning on vehicles. By far the greatest proportion of the emissions comes from road traffic, although it is also here that the greatest reductions have been achieved. About 17 % of NO_x precipitation in Sweden originates from domestic sources. The largest contributors to NO_x precipitation from other countries are Germany, the UK and Denmark.

The greenhouse effect

Strictly, the greenhouse effect is not an environmental problem: it is, in fact, an essential factor for the existence for life on earth. Without carbon dioxide and water vapour in the atmosphere, the average temperature of the earth would be about 33 °C lower than it is today (i.e. about –18 °C), and the planet would be frozen. It is, however, the *increase* in the greenhouse effect, resulting from the emission of greenhouse gases, that presents an environmental problem. Over the last 150 years, anthropogenic activities have increased the concentration of carbon dioxide in the atmosphere by about 30 %: if the oceans were not also a major sink for carbon dioxide, this increase would have been closer to 60 %. The average temperature of the earth has risen by about 0.5 °C during the 20th century, but has accelerated particularly during the last 25 years.

The most important anthropogenic greenhouse gas is carbon dioxide. Other gases that contribute to the effect include water vapour, methane, nitrous oxide (laughing gas – N_2O) and ground-level ozone. These gases actually have a more powerful greenhouse effect but, due to their low concentrations in the atmosphere, they represent less of a problem than does carbon dioxide. The following text therefore concentrates primarily on carbon dioxide emissions.

The OECD countries emit over half of the total global carbon dioxide emissions, with the USA being responsible in turn for by far the greatest amount, of over 45 %. Other countries with high emissions include Japan, the UK and Germany. In terms of highest per-capita emissions, the USA is in

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Figure 40a • Emissions of sulphur dioxides (SO_2) in Europe 1980–1999

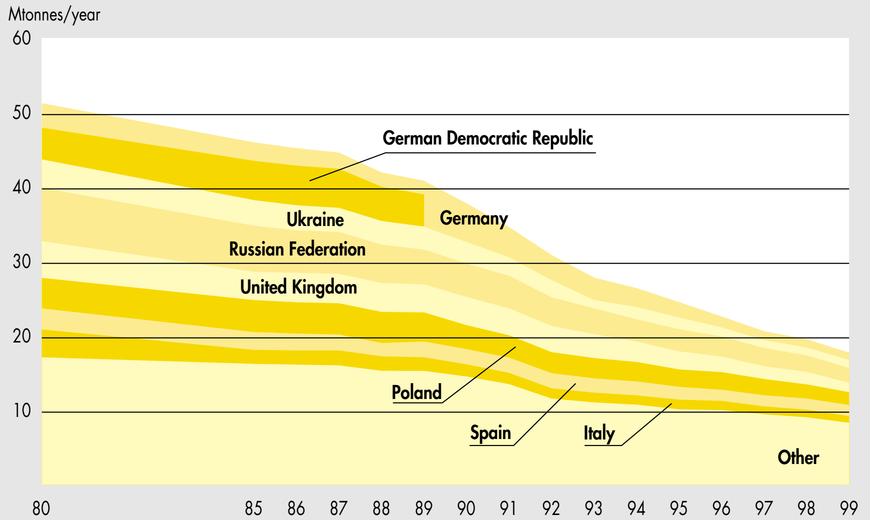
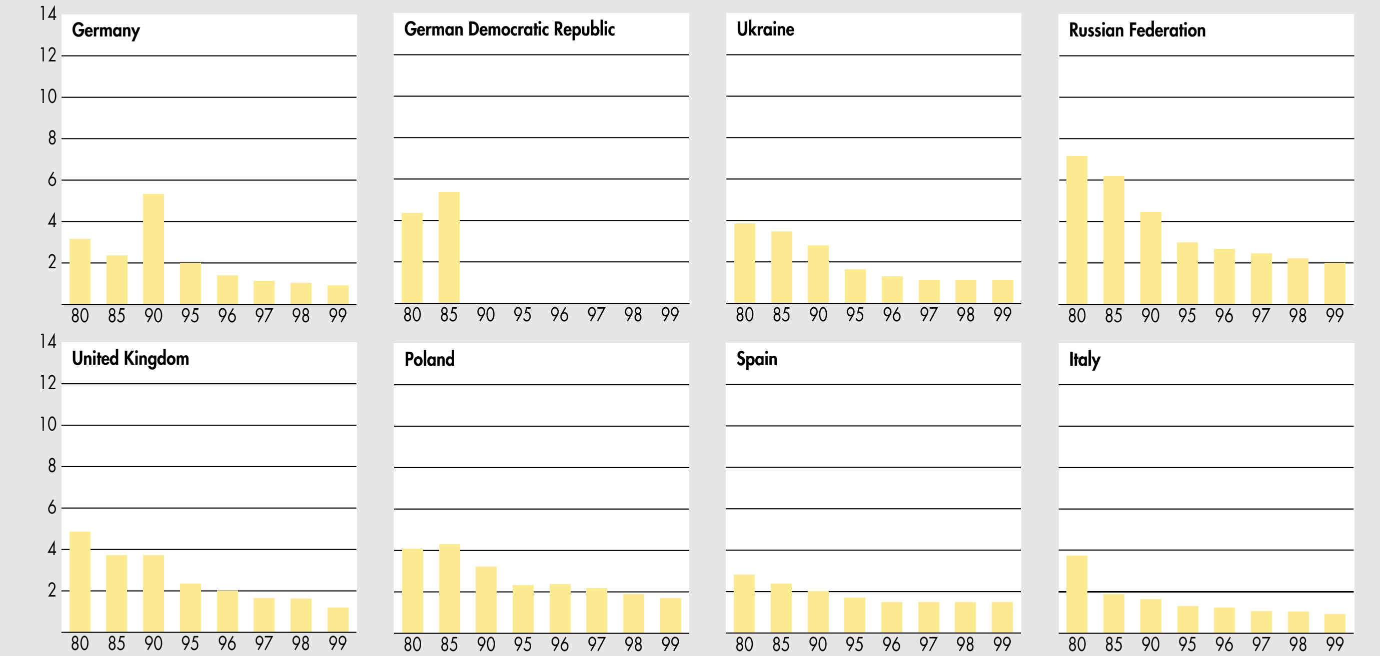


Figure 40b • Emissions of sulphur dioxide (SO_2) in Europe, by countries



top place, equal with Luxembourg, but with Australia and Canada following after. These countries also have relatively high emissions in relation to their GNPs, although the old Eastern European countries such as Poland and the Czech Republic have even higher values.

Sweden contributes a few parts per thousand to the world's carbon dioxide emissions, with per-capita emissions being below the average both for the OECD countries and for the EU. Carbon dioxide emissions have fallen by about 30 % between 1980 and 1999.

International climate cooperation

An outline convention on climate changes was signed at the 1992 UN Conference on the Environment and Development (UNCED) in Rio. It came into force in 1994, when it had been ratified by a sufficiently large number of countries. Sweden ratified the Convention in 1993, at which time it also adopted guidelines for Swedish climate policy. One of the contents of the Convention is that all industrial countries should take steps to reduce their emissions of greenhouse gases and to increase the uptake and storage of the gases. The countries must also regularly submit details of their progress and the steps that they have taken to the UN.

At the meeting of the parties in Berlin in 1995, it was noted that work to date was inadequate, and a process was started to produce a legally binding document. At the third meeting of the parties in Kyoto in 1997, agreement was reached on a document regulating emissions of carbon dioxide and five other greenhouse gases. The document sets out reductions for all Annex 1 countries, i.e. the OECD countries and the previous Eastern European states, for implementation by 2010. The reductions are expressed as an average to be achieved over the period 2008–2012, and are referred to the 1990 emission levels.

The EU, which negotiated as a single group, is required to reduce its emissions by 8 %. Subsequent agreement on the internal breakdown of this aggregate reduction, permitted Sweden in fact to increase its emissions by 4 %. 'Flexible mechanisms', in the form of emission trading and joint implementation, are included in the Kyoto protocol in order to facilitate more cost-efficient reductions.

Emission trading involves the trading of emission rights. Countries that have emitted less than their permitted proportion can sell their remaining portion to another country that wants to emit more. Joint implementation involves effecting some improvement in another country and being credited with the resulting reduction in emission. A third mechanism is that of clean development, which involves essentially the same as joint implementation, except that the improvements are carried out in a non-Annex 1 country.

Bonn 2001

During the third meeting of the parties in Kyoto in 1997, the parties negotiated quotas for the sizes of the emission reductions that each country undertook to effect between 1990 and 2008–2012, known as the Kyoto Protocol. Since then, further negotiations have decided how these emission reduction are to be achieved in practice. The objective

Figure 41a • Emissions of oxides of nitrogen (expressed as NO_2) in Europe 1980–1999

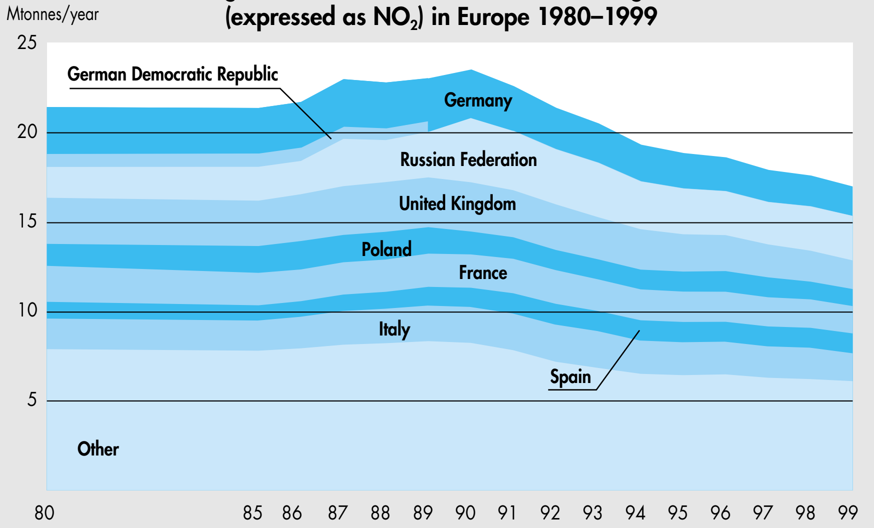
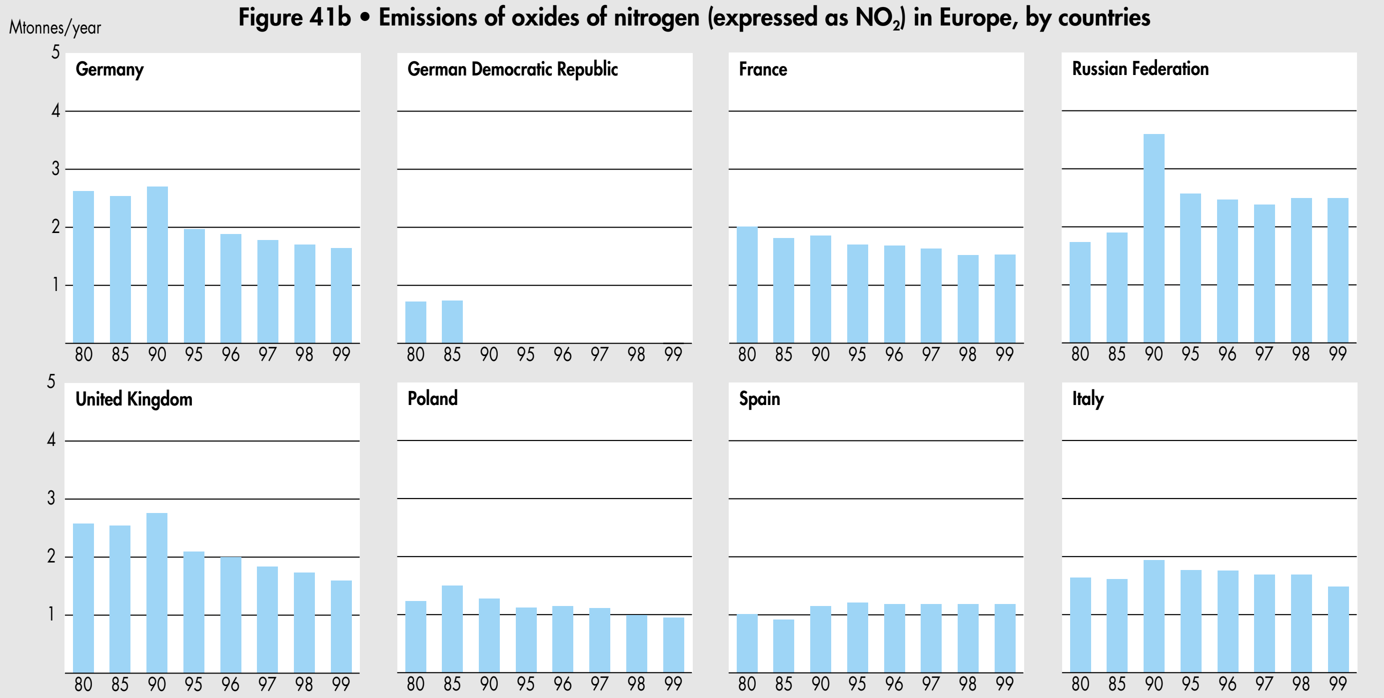


Figure 41b • Emissions of oxides of nitrogen (expressed as NO_2) in Europe, by countries



of the sixth meeting in Den Haag was to resolve the final outstanding points. However, agreement was not reached, and it was decided that the parties should meet again during the first half of 2001 in order to continue the negotiations. This resulted in a further meeting in Bonn at the end of July.

The Bonn negotiations were concerned with four main questions: financing and technology transfer to the least developed countries, arrangements for reducing emissions in second party countries, with the resulting reductions credited to the first party country (flexible mechanisms), carbon dioxide absorption in forests and the ground (carbon sinks) and sanctions against countries failing to fulfil their obligations. Despite major differences in views on such aspects as the utilisation of carbon sinks, the parties did reach agreement on a final document, setting out rules for the above main points. However, much work remains to be done before all the rules are ratified. Negotiations will continue during the conference in Marrakesch between 29th October and 9th November 2001. ■

Figure 42a • Emissions of carbon dioxide (CO_2) per inhabitant and GNP 1998 in EU and OECD-countries

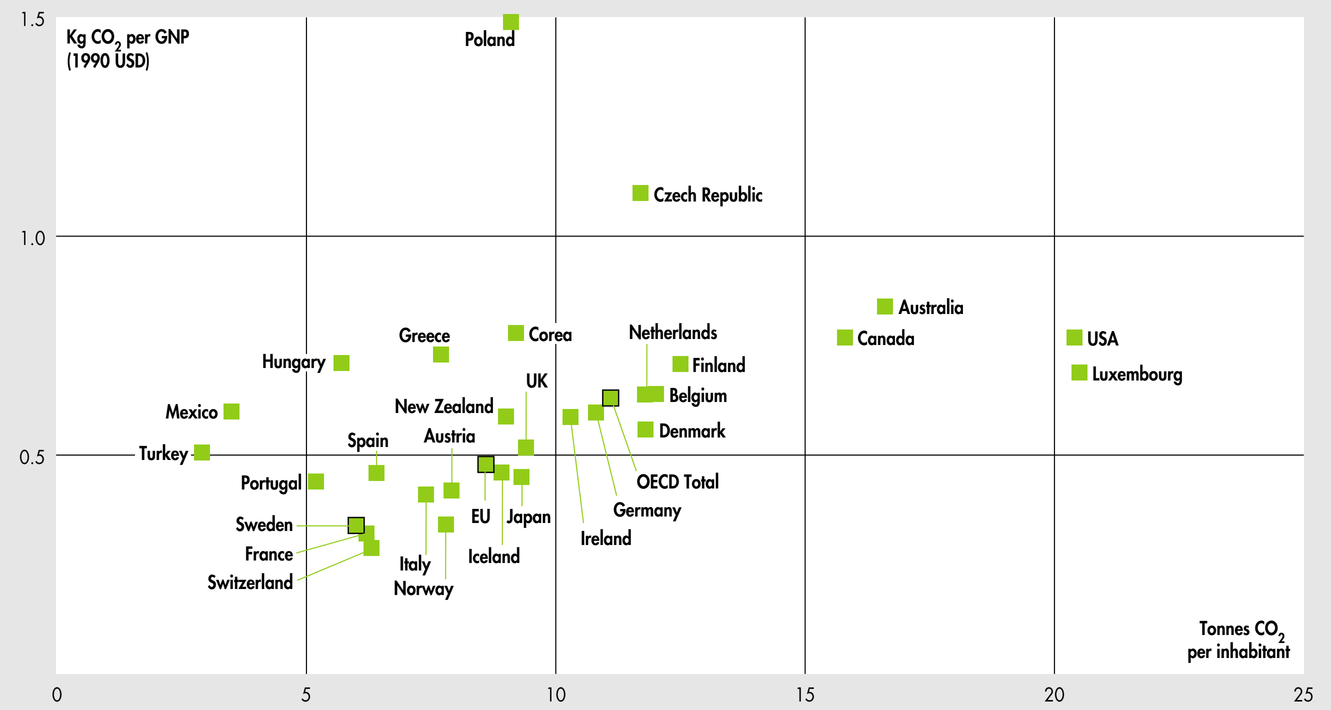
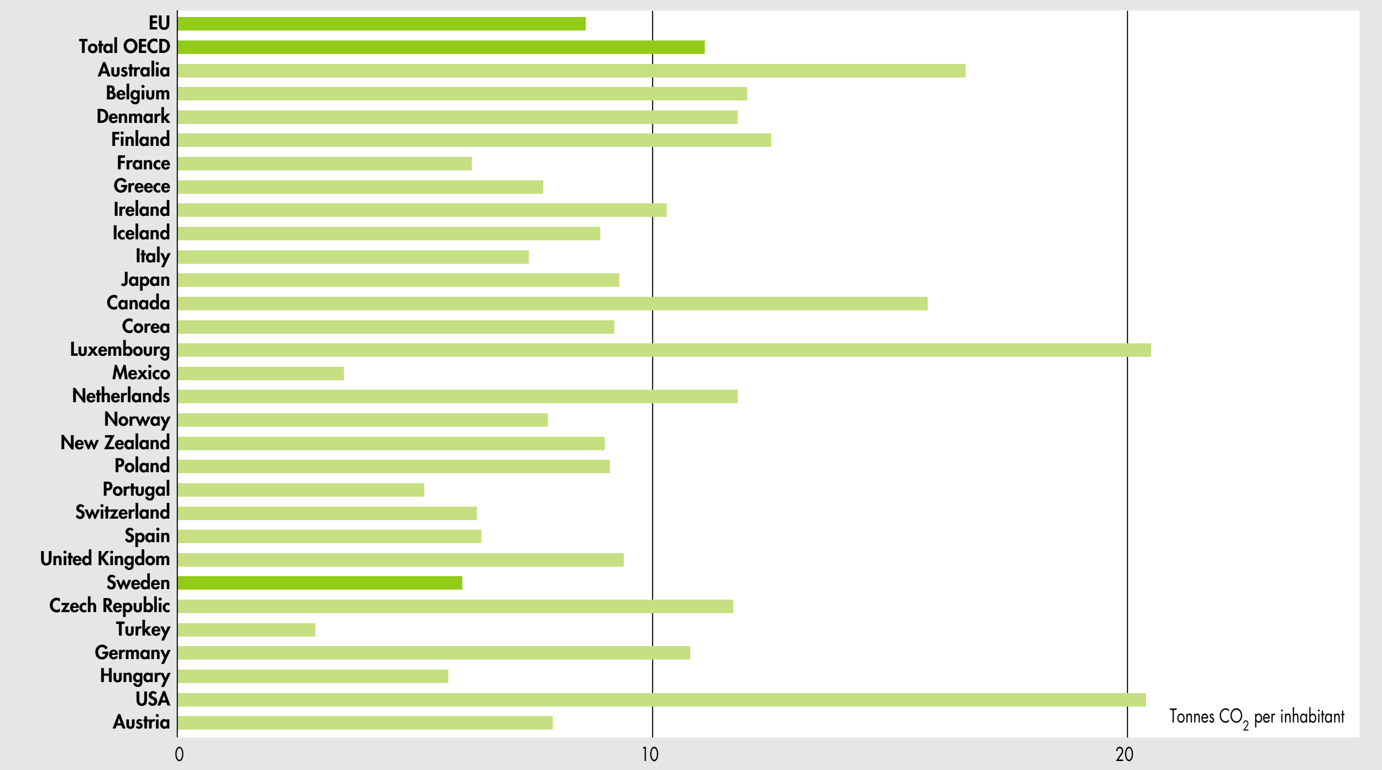


Figure 42b • Emissions of carbon dioxide (CO_2) per inhabitant 1998 in EU and OECD-countries



Alternating current (AC)
Electric current in which the direction of flow of the electrons is constantly reversing.

Automotive petrol
Petrol intended for use in spark ignition internal combustion engines.

Biofuel
Fuel consisting of biomass, or that has been prepared or produced from biomass.

Biogas
Gas produced from biomass as the raw material, e.g. by fermentation.

Biomass
Material of biological origin, and which has not been processed, or processed to only a very limited extent.

Blast furnace gas
Flammable gas consisting of a mixture of nitrogen, carbon monoxide and hydrogen, produced by the reduction of iron ore in a blast furnace.

Brown coal
Combustible solid containing about 70–75 % by weight of carbon. Brown coal can be likened to compacted peat, and is at an early stage in the conversion to coal.

Carbon dioxide, CO_2
Carbon dioxide, CO_2, is a gaseous oxide of carbon, formed by complete combustion of substances containing carbon, e.g. hydrocarbons.

Chemical energy
Energy released or absorbed when the bonds between atoms or molecules are changed.

Coal
Combustible rock-like substance with a high content of carbon. Coal is an intermediate stage in the geological conversion from brown coal to anthracite.

Cold condensing power station
A power plant that produces only electricity, using a steam turbine cycle. Efficiency is 35–45 %: the remainder of the thermal energy in the fuel is removed by the cooling water to the sea, lake, river or atmosphere.

Coke
The solid residue from the pyrolysis of coal.

Coke oven gas
Flammable gas produced by the coking of coal.

Coking plant
Plant for the production of coke and the cleaning of coke oven gas.

Combined heat and power plant
A power plant that produces both electricity and heat, supplying the heat to a district heating system.

Conversion losses
Energy loss in a conversion plant or process, resulting from the less than 100 % efficiency of the process.

Cracking
Chemical modification of heavy hydrocarbons in petroleum to lighter hydrocarbons.

Crude oil
Petroleum from oil wells that has not been processed other than the possible removal of dissolved gases and solids, and which is in transport or being stored or is used as a raw material.

Degree of energy utilisation
The relationship between the amount of (electrical) energy actually produced and that which is theoretically possible over a given period of time.

Diesel engine
Internal combustion engine of piston type, in which the heat of compression is sufficient to ignite the combustible mixture of fuel and air.

Diesel fuel
A light oil for use in diesel engines.

Digester gas, sludge gas
Flammable gas formed by anaerobic bacterial action on biological material.

Digestion
Controlled biodegradation of organic substances under anaerobic conditions, by which the substances are transformed without air change in water-filled pores and in which evil-smelling are produced, such as hydrocarbons, ammonia, hydrogen sulphide etc.

Direct current (DC)
Electric current of which the electron flow is always in the same direction, e.g. from a battery.

Direct electric heating
Electric heating that supplies heat to the heated area without intervening heat storage or heat carrier other than air.

District heating
The provision of a public heating supply, delivered by means of hot water in supply and return pipes. After supplying heat to a building's own space heating and domestic hot water heating system, the cooled district heating water is pumped back for reheating.

Efficiency
A measure of how efficiently a power station or heating plant works. It indicates that proportion of the energy in the fuel or input that is converted to useful electricity and/or heat.

Electrical energy
Energy released or absorbed when electrons move through a solid, a liquid, a gas or a vacuum.

Energy
A measure of work performed in a given time: the product of power and time. Energy is expressed in watt-hours (Wh).
Energy balance
1. The balance of energy supplied and energy used.
2. A presentation of energy supplied and energy used.

Energy carrier
A substance, material or service used to carry energy, e.g. water, air, electricity, battery cells, or fuels such as coal, crude oil, logs etc.

Rational use of energy
Making the best use of energy supplied to a system.

Energy conversion
A process that converts one form of energy to another form.

Energy crops
Crops grown for use as energy raw materials.

Energy forest
Trees or bushes grown for use as energy raw materials.

Energy saving
Reduction in the use of energy by refraining from the use of services etc.

Energy system
A system of plant, equipment etc. that meets a need for energy, e.g. for a house, a factory or a town.

Energy use
Utilisation of electrical energy, heat or some other form of energy.

Ethanol
Ethyl alcohol, normally produced by fermentation of sugar or some other biomass.

Exergy
That part of a quantity of energy in some particular form that can be completely converted into work. The terms energy and exergy describe the suitability of a form of energy for energy conversion. The less the proportion of exergy, the greater the amount of energy that is lost as heat.

Fossil fuel
Fuel formed from biological materials during earlier geological periods, e.g. coal and petroleum.

Fuel
A substance containing substances having chemically or otherwise bound energy that can be utilised for conversion to heat or other form of energy.

Fuel cell
A cell for direct conversion of chemical energy to electrical energy.

Fuel oil
Combustible oil intended for oil burners, consisting of low or high viscosity or semi-solid mixture of hydrocarbons, produced from crude oil by distillation or cracking.

Gasification
The conversion of solid materials, e.g. coal or peat, to a gaseous form, with or without chemical change of the substances involved.

Gas turbine
Power plant for the production of electric energy. A gas turbine consists of an air compressor, combustion chambers and a power turbine driven by the exhaust gases. In turn, the power turbine drives the generator.

Gasworks
A facility for the production gas by means of gas generators.

Gasworks gas
Gas of a medium calorific value, containing methane, nitrogen, butane and (in low concentration) carbon monoxide, with the addition of a substance to provide a tracer smell.

Geothermal heat
Heat flowing from the interior of the earth to the surface.

Greenhouse effect
Accumulation of heat in the lower atmosphere through a reduction in cooling that is caused by outward radiation from the earth to space, caused primarily by the ability of carbon dioxide to absorb thermal radiation.

Greenhouse gases
Gases in the atmosphere that reflect natural thermal radiation out from the earth into space. Examples include water vapour, carbon dioxide, methane, nitrous oxide etc.

Heat pump
A device for raising the temperature of energy from a low-temperature source such as water, air, etc., to a higher temperature. To do this, it requires a certain input of some other form of energy, usually electricity.

Hydro power plant
A power station that converts the potential energy of water to electrical energy.

Kinetic energy
Energy released or absorbed as a result of the change in velocity of a moving object.

Mechanical energy
The sum of kinetic energy and potential energy that is not electrical energy.

Motor fuel
Gaseous, liquid or solid fuel intended for starting, running or heating a machine, a vehicle engine etc.

Natural gas
Flammable, non-volcanic gas found in porous rock strata, often together with and/or partly dissolved in, petroleum.

Natural gas combination plant/cycle
A combined gas turbine/steam turbine plant, fuelled by natural gas.

Normal year
To enable fair comparisons to be made between the use of electricity, heating etc. from one year to another, the climatic conditions of the years concerned must first be converted to equivalent conditions of a statistically average year.

Nuclear energy
Energy released in nuclear reactions or by radioactive decay.

Nuclear power plant
A power plant that utilises nuclear energy for the production of electrical energy.

Oil equivalent
The quantity of fuel oil that, in practical use, is regarded as providing the same quantity of energy as some quantity of other fuel.

Paraffin (Am.: kerosene)
A clear, colourless and low viscosity liquid, consisting of hydrocarbons, produced by distillation with or without refining.

Peat
Organic earth-like material formed in wet and oxygen-deficient conditions by the degradation of dead plant and animal material by bacterial and chemical action.

Petrol (Am.: gasoline)
A clear, colourless and low viscosity liquid, consisting of hydrocarbons, produced by distillation of crude oil, by cracking of gaseous or liquid petroleum fractions or by synthesis.

Petroleum product
Gaseous, liquid or solid mixture of hydrocarbons, produced from crude oil by distillation, cracking or some other process.

Potential energy
Energy released or absorbed by changing the position of an object.

Power
The rate of doing work, given by the quotient of energy and time (= energy per unit time)

Power balance
1. The balance of power input and output.
2. A presentation of input and output power.

Power shortage
The state of an energy system, e.g. an electricity supply system, not having sufficient capacity immediately to supply the power demand.

Pumped storage power station
Hydro power station which, when not producing power from water falling through the turbine, can be used to pump water from a lower level to a higher level for later production of power from it.

Refining
To clean or purify a raw material by wholly or partly removing pollutants or hazardous constituents.

Renewable energy source
An energy source that can be renewed or replaced at the same rate as it is used.

Sludge gas
See: digester gas.

Speed control
Control of the speed of, say, a fan, in order to control some other quantity, e.g. an air flow.

Statistically average year
A year for which the meteorological conditions are the average of those over a period of years.

Steam coal
Coal that is used primarily for burning.

Thermal power plant
A power station in which heat is converted to electricity.

Tonne-kilometer
Unit of transport work, calculated as the product of the aggregated distance in kilometer over which a number of tonnes have been carried and the number of tonnes.

Toe (tonnes of oil equivalent)
See Oil equivalent.

Useful energy
Energy used for its intended purpose within a defined system.

Waste heat
Heat released from processes.

Wind power plant
A power plant that converts wind energy into electrical energy.

Units and Conversion Factors

The international standard unit for measurement of energy is the joule (J), although the watt-hour (Wh) is often used in Sweden. One joule is equal to one watt-second, which means that one watt-hour is equal to 3 600 J. International comparisons often use the tonne of oil equivalent (toe), which represents the energy obtained by burning one tonne of oil, i.e. 11.6 million Wh.

When measuring larger quantities of energy, the joule, watt-hour and even toe are inconveniently small units. Instead, multiples such as thousands or millions are used, indicated by the following abbreviations:

k	(kilo)	10^3	thousand
M	(mega)	10^6	million
G	(giga)	10^9	thousand million
T	(tera)	10^{12}	million million
P	(peta)	10^{15}	thousand million million

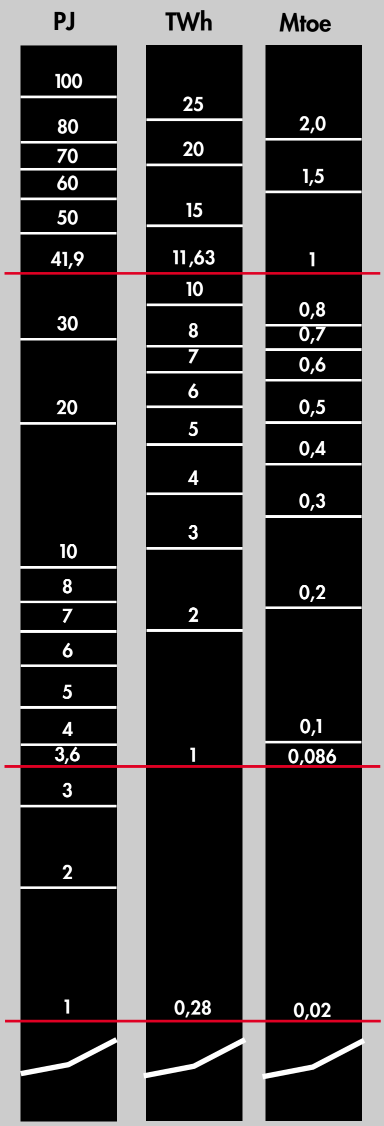
Units commonly used for comparison are the PJ, TWh and Mtoe. See the diagram on the right for conversions between them.

Practical terms

What are these various energy units, expressed in practical terms? A rough guide is as follows:

- 1 kWh can run a cooker hotplate for one hour.
- 1 MWh can power a private car for 1000 km (= 621 miles).
- 1 GWh represents the energy used by a medium-sized town in one day.
- 1 TWh is the quantity of energy supplied by a large nuclear power plant in about two months' full-load operation.

Conversion scales, energy units (logarithmic scales).



Conversion factors for energy carriers:

Crude oil	1 Mtonnes	=	11 TWh	=	42 PJ
Gas oil	1 Mtonnes	=	12 TWh	=	43 PJ
Heavy fuel oil	1 Mtonnes	=	11 TWh	=	41 PJ
Natural gas	1 Gm^3	=	9.7 TWh	=	35 PJ
Coal	1 Mtonnes	=	7–8 TWh	=	25–30 PJ
Forest fuels	1 Mton TS*	=	5–5.5 TWh	=	18–20 PJ
Forest fuels (40% moisture content)	1 Mtonnes	=	3 TWh	=	11 PJ
Peat (50% moisture content)	1 Mtonnes	=	2.5–3 TWh	=	9–11 PJ
Automotive petrol	1 Mtonnes	=	12 TWh	=	43 PJ
Methanol	1 Mtonnes	=	6.35 TWh	=	23 PJ

*Dry solids

Electricity for household purposes

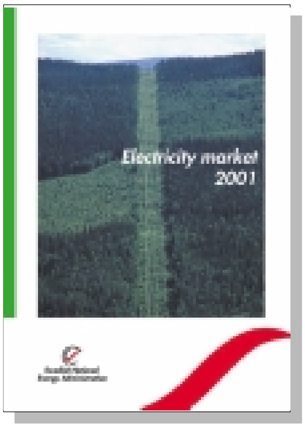
A family of four persons in a detached house uses about 5500 kWh per annum of electricity for household purposes. *Average breakdown* of electricity for household purposes is as follows:

Refrigerators and freezers	1 400 kWh
Food preparation	1 000 kWh
Clothes care	1 000 kWh
Lighting	900 kWh
Dishwashing	500 kWh
Other appliances	700 kWh
Total	**5 500 kWh**

A *modern, energy-efficient* washing machine should not use more than about 200 kWh/year, and a tumble dryer should not use more than about 200 kWh/year. Similarly, a new, larger, energy-efficient refrigerator should not use more than about 130 kWh/year, and a new energy-efficient medium-sized chest freezer should not use more than about 270 kWh/year.

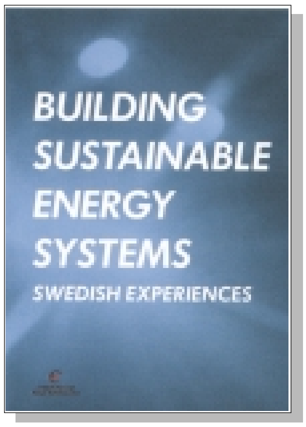
The Electricity Market, 2001

This publication provides a general overview of the Nordic electricity market, coupled with easily accessible information on the market. It includes data on electricity production and use in the Nordic countries, the structure of the electricity market as seen by those involved in it, trade in electricity between the Nordic countries and within northern Europe, the effect of the electrical sector on the environment and electricity prices in the Nordic and other countries. Published annually.



Building Sustainable Energy Systems Swedish experiences

This book is a collection of articles illustrating the changes that have occurred in the energy sector over the last 30 years. 25 writers, with different backgrounds and working in different disciplines, were asked by the Administration to contribute to the book and give their views on the changes, as seen from their various viewpoints. The themes of the chapters include, for example, energy policy and its economic effects, technical development, the liberalisation of the electricity market, biomass, ethanol and efficiency improvement measures. The book does not necessarily represent the views of the Administration, but is intended to be a forum for discussion.



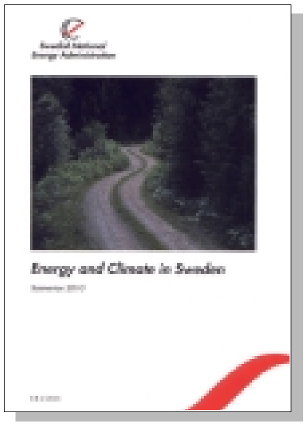
The National Energy Administration's 2001 Climate Report

The report is the material provided by the Administration for Sweden's third national report to the Climate Convention. It presents a concentrated description of the measures that have been taken within the energy sector to limit Sweden's emission of greenhouse gases. In addition, it describes scenarios for Sweden's energy supply for the period up to 2020.

An English edition will be published in the spring of 2002

Energy and climate in Sweden: 2010 scenarios

The National Energy Administration has produced a number of scenarios of Sweden's carbon dioxide emissions, extending to 2010, as part of the work called for by the Climate Convention. The results are presented in this publication.



GENERAL

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Further information on the Administration's publications can be found on its web site, www.stem.se

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It is difficult to give specific instructions on how to download the files, as this depends on the type of computer, internet connection, operating system etc. that you have. But it is a good idea to check how large the file is before you start to download it.

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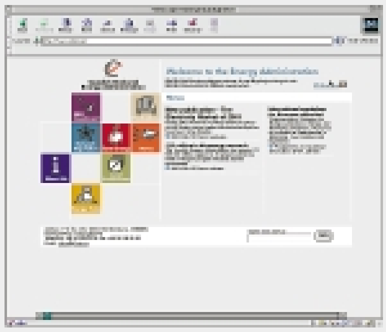
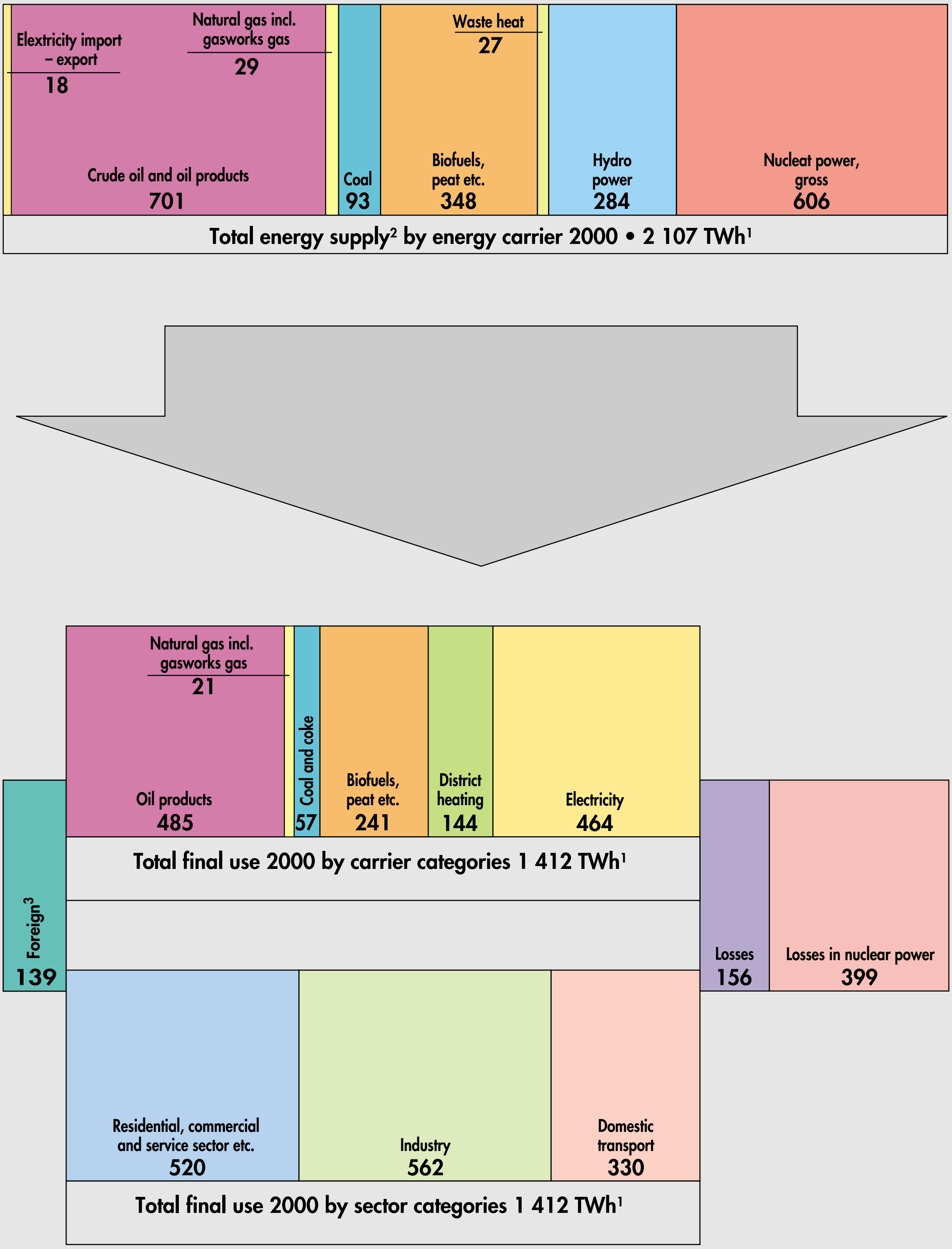


Figure 1 • Energy supply and use in Sweden 2000, PJ



[1] Preliminary figures. Due to rounding up or down of these figures, total figures may not always agree exactly with the sums.
[2] Including windpower, 0.44 TWh.
[3] International marine bunkers and energy for non-energy purposes.

Swedish National Energy Administration

The Swedish National Energy Administration was established on January 1, 1998, and is Sweden´s national authority on issues regarding the supply and use of energy.

The main task of the Administration is to implement the energy policy programme approved by the Riksdag in the spring of 1997. The aim of the programme is to establish an ecologically as well as economically sustainable energy system.

We work to promote a safe, efficient and environmentally sustainable supply and use of energy. We do so by supporting research on renewable energy sources and technology procurement of energy-efficient products and by providing investment support for the development of renewable energy.

The Administration also serves a supervising function as monitoring authority of the recently deregulated electricity market. The Department for Structural and Market Analysis provides analyses of the linkages between energy, the environment and economic growth.

Swedish National
Energy Administration

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