Energy in Sweden 2002

ET 20:2002

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Further general information is available from the Agency's Information Department.

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Preface

Energy markets – both national and international – are changing rapidly, partly as a result of changes in the aims and purposes of energy and environmental policies in Sweden and in other countries. In recent years, Swedish energy and environmental policy has increasingly concentrated on establishing or improving long-term conditions for effective energy markets. The reform of 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 conditions governing development of the energy markets.

In June 2002, the Swedish Parliament approved the Government's proposal for a secure, efficient and environmentally sustainable supply of energy. The guidelines set out in the 1997 energy policy declaration remain in place. The country's energy policy is to provide secure short-term and long-term supplies of electricity and other forms of 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.

In the 2002 energy policy declaration, it is primarily the targets of the guide measures intended to influence development in the short term that have been changed. A new guide measure, intended to encourage the use of electricity from renewable sources, will be introduced in January 2003 in the form of a certificate trading system. The introduction of this system, together with a greater emphasis on information and the dissemination of knowledge, means that the Energy Agency will have a number of new duties. It will, however, continue to be responsible for most of the measures intended to improve the efficiency of energy use.

An important element in the development of the electricity market is that the transmission of electricity, which is a monopoly service, should be operated efficiently. This is an area in which the Agency plays an important part. Its authority has now been extended, making it an expert authority in the field of electricity trading, and including responsibility for continuous monitoring of prices and competition in the market.

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

Energy in Sweden, which is published annually by the Swedish Energy Agency, is intended to provide decisionmakers, journalists and the public with a single source of easily available information on conditions and developments in the energy sector. ■

Eskilstuna, November 2002

Thomas Korsfeldt
Director-General

Becky Petsala
Head of Department,
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Information on statistics

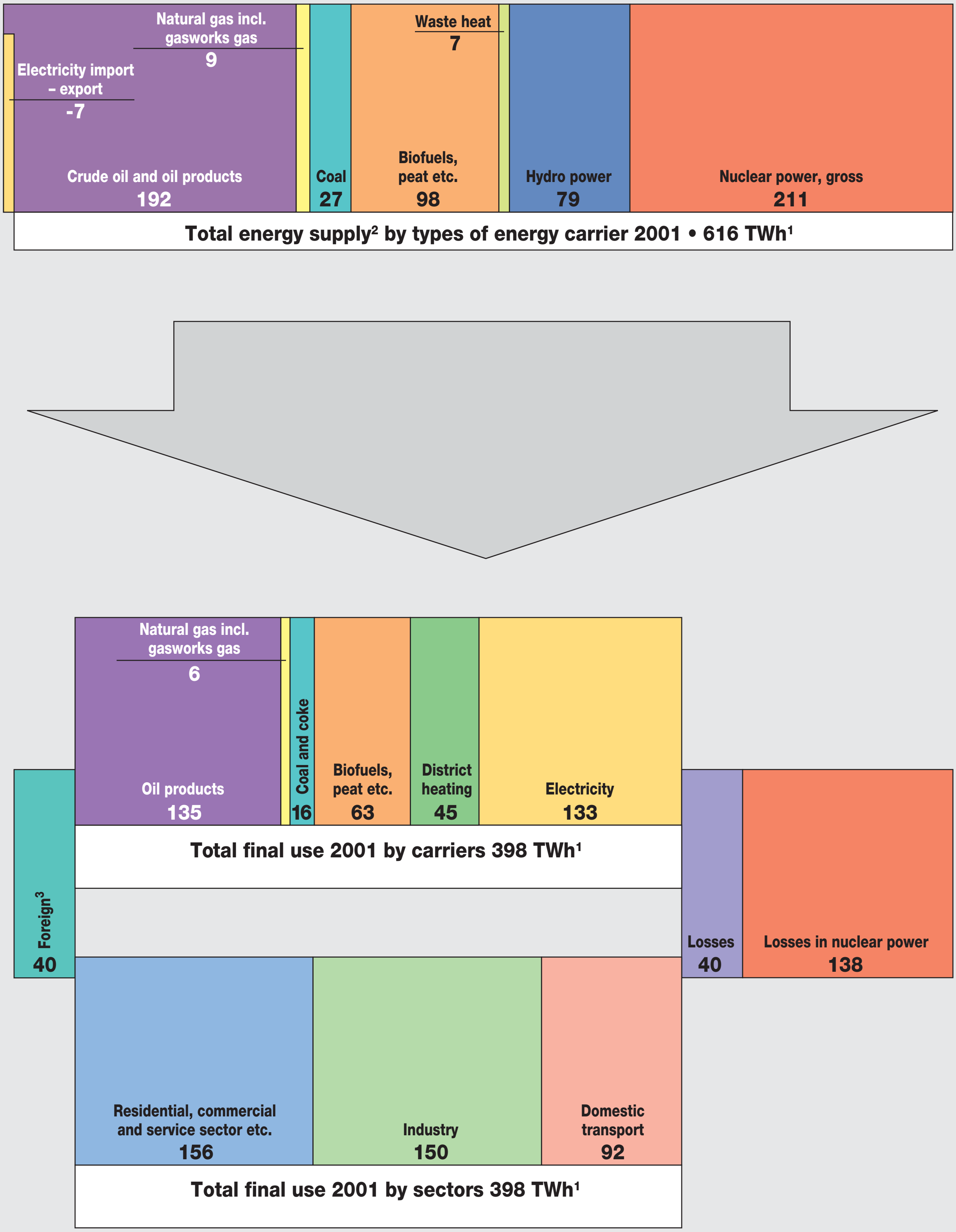
Statistics in the 2001 edition of *Energy in Sweden* were revised in comparison with those of previous editions. These revisions applied mainly to those for the years from 1983 to 1999, although entire time periods were updated in some tables. Much of this work of revision was carried out in conjunction with Statistics Sweden.

With effect from the 2001 edition, statistics that are based on material from Statistics Sweden are preliminary for the two preceding years: statistics for earlier years are definitive.

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 2001, TWh

The same figure, expressed in PJ, can be found on page 49



[1] Preliminary figures. Due to rounding up or down of these figures, total figures may not always agree exactly with the sums of the individual items.

[2] Including windpower, 0,45 TWh.

[3] Foreign maritime trade and energy for non-energy purposes.

Current policy areas

The main features and directions of the energy markets are determined largely by political considerations, which affect developments in energy use and energy production. The political structure, in turn, is established partly at national level and partly at EU level. International developments and agreements also influence developments. The following pages discuss a number of areas of current interest in the fields of energy, climate and the environment.

Sweden's Energy Policy

In June 2002, Parliament approved the Government's proposal for a national energy supply policy, based on an agreement between the Social Democrats, Centre Party and the Left Party. The new agreement confirms the guidelines set out in the 1997 energy policy decision. The overall objective of the country's energy policy is to ensure, in both the short and long terms, a reliable supply of electricity and other forms of 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.

Changes in the 2002 energy policy agreement are concerned primarily with the thrust of the guide measures intended to influence developments in the shorter term. A new guide measure, aimed at increasing the use of electricity from renewable sources by 10 TWh between 2002 and 2010, is intended to encourage the production of electricity from low-environmental-impact and renewable sources. This will be done by means of a system based on the issue and trading of certificates determined by the source of the electricity. The Government intends to submit further details of this proposal to Parliament during the autumn of 2002. It is intended to make electricity from renewable sources equally competitive with that from other sources. However, wind power will still need to be supported for some years as it becomes established. In addition, the new energy policy includes planning objectives for wind power.

The new policy also emphasises the importance of improving the efficacy of the energy markets. The Government intends to provide additional facilities for constant monitoring of price developments in the gas and electricity markets, in which work the Swedish Energy Agency will be playing a greater part.

The updated policy also includes measures intended to improve the efficiency of energy use, such as those concerned with information and training, local and regional initiatives and technology procurement. The Government has also given notice that it may modify the taxation of CHP production, bringing it into line with taxation of industrial back-pressure power. Further details will be announced in the 2003 Budget Bill. The Government also announced the setting up of an investigation as to whether an agreement, similar to that reached in Germany concerning a controlled, responsible phasing-out of nuclear power production, would also be appropriate in Sweden. The Government intends to conduct negotiations with the power industry. The Government's earlier decision, that it will not be possible to close the second reactor at Barsebäck before 2003, still stands. The Government will reconsider the closure decision, presenting the results to Parliament in the spring of 2003.

The emphasis of strategic contingency planning has been modified. This will build on the earlier overall concept, concentrating on preparedness for dealing with serious peacetime emergency situations and/or international crises. The new considerations will allow for the mutual dependence of various infrastructural aspects, with a particular area of priority being that of the interdependence of electricity, telecommunications and IT.

Swedish climate strategy

In March 2002, Parliament approved the Government's proposal for a formal Swedish climate strategy, in the form of a strengthening and more precise definition of the environmental quality objective of limited effects on climate. Limited effects on climate have now become one of fifteen environmental quality objectives, of which others include fresh air, natural levels of acidification only, a toxin-free environment, protection of the ozone layer and living lakes and waterways. The overall purpose of the environmental quality objectives is to pass on a society to the next generation in which Sweden's major environmental problems have been solved.

Expressed as a mean value over the period from 2008 to 2010, Swedish emissions of greenhouse gases are to be at least 4 % lower than they were in 1990. This objective represents a Swedish commitment over and above the country's undertakings in accordance with the Kyoto Protocol. Strictly, under the terms of the apportionment within EU countries, Sweden is permitted to increase its emissions by up to 4 %. The 4 % reduction objective is to be achieved without allowance for absorption in carbon sinks or flexible mechanism credits. Flexible mechanisms are defined as:

- Joint Implementation, by which an industrialised country can be credited with emission reduction units when it helps to finance projects that reduce net emissions in another industrialised country.
- Clean Development Mechanisms, by which industrialised countries finance emission-reduction projects in a developing country.
- Trading in Emission Rights, by which a country that has reduced its emissions by more than it undertook to do can sell emission rights to another country having difficulty in meeting its objectives.

Climate work and the national objective will be continuously monitored. If emissions do not fall in accordance with the objective, the Government may propose additional measures or, if necessary, reconsider the objective. At all times, the competitiveness of Swedish industry will be borne in mind. It is proposed that progress checks should be carried out in 2004 and 2008. The Government intends to complement the 2004 progress check with consideration of a formal objective for the flexible mechanisms.

As part of the work of publishing the climate policy objective, the Government also approved the Kyoto Protocol, which was officially ratified by Sweden on 31st May 2002 in conjunction with other EU states.

Sweden's transport policy

In December 2001, Parliament approved the Government's proposal for the infrastructure to provide a long-term sustainable transport system. This included the overall objective from the 1998 transport policy decision intended to ensure a nationally viable, efficient and long-term sustainable transport provision for business and the public. The overall objective has now been complemented by a sixth sub-objective concerning a transport system with equal opportunities for women and men, with the other five sub-objectives being 1) an available transport system, 2) high transport quality, 3) safe traffic, 4) a good environment and 5) positive regional development. The National Rail Administration and the National Road Administration are responsible for planning investments in new railways and roads, for developing and modernising transport systems and for ensuring the retention and maintenance of existing rail and road networks, to a total value of SEK 364 000 million over the period 2004-2015. Some of these resources will be made available earlier, during the period 2002–2004.

Work in progress

The country's energy taxation system is being reviewed, with the aim of making it easier to understand and of linking it more closely to environmental effects. As part of this latter purpose, the Government decided in the spring of 2000 to restructure taxation to encourage a trend towards environmental improvements, starting in 2001. This involves raising taxes on environmentally undesirable activities, while at the same time reducing taxes on work. This gradual transfer of taxation is intended to continue over a ten-year period, to a value of about SEK 30 000 million. A parliamentary committee has been appointed to oversee the strategy, investigating the formulation of rules for reducing energy taxation of sectors exposed to competition. The committee will publish its report by not later than 31st December 2002.

In addition, a parliamentary delegation has been appointed to produce a proposal for a framework of a Swedish system for operating the Kyoto Protocol's flexible mechanisms, i.e. trading in emission rights and the two project-based joint implementation and clean development mechanisms. The proposal is intended to include identification of which emission sources shall be eligible for coverage by the quota, emission ceilings for those involved in the trading system and details of apportionment and determination of emission rights. The proposal is due for submission to the Government by the end of 2002, with the intention that its recommendation should come into force by not later than 2005. A negotiator has also been appointed, responsible for preparing material and proposals for outline agreements for joint application by Sweden and other countries. This work is due for reporting not later than 1st December 2002.

The Government has also asked the National Board of Housing, Building and Planning to investigate the effects of a ban on the use of direct electric heating in new buildings with effect from 2005.

Energy Matters within the EU

Work is in progress at EU level on the creation of a single market for energy, with the intention of improving competition in energy supply. The Electricity Market Directive was adopted in 1996, with the objective of creating common rules for production, transmission and distribution of electricity. It will have the effect of gradually opening the market to competition: under the terms of the directive, 33 % of the electricity market must be open to competition in 2003. Several countries have opened their markets to competition at all customer levels, including the Nordic countries, the UK, Austria and Germany. On the other hand, three countries – France, Greece and Portugal – have not yet started to open their markets. The Gas Market Directive was adopted in June 1998: as with the Electricity Market Directive, its objective is progressively to open the European natural gas market to competition. Five years after coming into force, at least 28 % of the natural gas market must be open to competition, increasing to 33 % after ten years. In March 2001, the Commission put forward a proposal for modifications to the Gas and Electricity Market Directives. The proposed changes include a new, accelerated timetable for the opening up of markets, by which the markets must be open for all customer categories by 2005. In response to views from the European Parliament and the Council of Europe, the Commission put forward a revised proposal in June 2002. It is expected that the changes will be confirmed by the Summit Meeting in Copenhagen at the end of 2002, to be phased in over a period of 18 months.

Renewable energy in the EU

The EU has established a target for the proportion of its total energy use from renewable resources to have been increased from the present 6 % to 12 % by 2010. A review of progress was published in January 2001, acknowledging that some improvements have been made, but that more positive action will have to be taken if the objective is to be achieved. Nevertheless, the Commission feels that the target set out in the White Paper is realistic. A special 'Support for Electricity from Renewable Sources in the Single Market for Electricity' Directive sets a target of 22 % for the proportion of electricity from renewable sources by 2010. Both the objectives are indicative, i.e. not binding on the various member states. The directive requires the member states to take the necessary steps to achieve the objective, and to submit regular progress reports.

Security of energy supply in the EU

In November 2000, the Commission published a Green Paper entitled 'Towards a European Strategy for Security of Energy Supply'. It noted that the EU is still increasing its use of energy, and is becoming increasingly dependent on external energy products. If nothing is done over the next 20–30 years, 70 % of EU energy requirements will depend on energy from external sources, as opposed to 50 % today. The Green Paper suggests some bases for a long-term energy strategy. Important elements in this strategy include comprehensive modification of consumer habits, with taxation being one

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way of controlling demand, increasing the use f energy from renewable sources, analysing the use of nuclear power in the medium to long term and, for oil and coal – the imports of which are growing – considering a system of strategic storage and planning new import paths.

Other EU energy matters

In May 2001, the Commission presented a draft directive concerning the energy performance of buildings. This is now being worked on, and a decision is expected at the end of 2002. It will include common methods for calculating minimum standards of energy performance, application of the standards to new buildings and extensively renovated buildings, energy certification of designs and in connection with the sale or renting of a building, and inspection of HVAC systems. In July 2002, the Commission released its draft Cogeneration Directive. The proposal does not give any indicative national objectives for the proportions of electricity to be provided by cogeneration: instead, member states are required to analyse and document their potentials for a greater proportion of cogeneration production. The draft directive also sets out criteria for assessing the benefit of cogeneration in comparison with separate production, concentrating on the energy efficiency gains achievable through combined production. In addition, the Commission has published a plan of action and two draft directives for encouraging greater use of alternative fuels in the transport sector. Initially, the use of biofuels will be encouraged by legislative and taxation measures. The first draft directive prescribes an obligatory minimum proportion of biofuels, with effect from 2005. The second draft directive opens the way to reducing spot taxes on biofuels. In the field of taxation, and in addition to the above proposals concerning spot taxes on biofuels, the Commission has put forward a draft proposal for taxation of energy products. This proposal, which dates from 1997, defines a general taxation system for the taxation of energy products. However, it has not yet been adopted due to a lack of political agreement between the member states.

EU climate strategy

The EU Commission has also launched the European Climate Change Programme (ECCP), which consists of two parts: a list of priority measures and a plan for an emission rights trading system, intended to come into operation in 2005. The list of priority measures includes both those that are in process of being drafted, such as the Directive on the Energy Performance of Buildings, and measures on which more work is needed, such as long-term agreements with industry.

The Commission presented a draft directive on trading in emission rights in October 2001, under which about 46 % of the theoretical EU emissions would be covered by the trading system. Electricity and cogeneration plants with an input power rating of more than 20 MW would be among those covered. The draft also proposes that, between 2005 and 2007, all member states should issue emission rights to participating power plants at no cost. By not later than June 2006, the Commission shall have reviewed initial experience of operation in order to decide the most suitable harmonised method of assigning rights for continued use. The draft is now being discussed. Ministers attending the Council Environment meeting in December 2001 clarified their positions concerning a number of fundamental aspects. The Danish chairman of the conference has called for agreement at the meeting on 17th October 2002. The central questions relate to the proportioning and assignment procedure, whether the system is to be obligatory for the member states, the industry sectors and gases to be covered by the scheme and the link to other emission trading schemes and to the project-based trading mechanisms.

International Cooperation

International negotiations on the climate have continued since the 1992 Rio de Janeiro UN Framework Convention on Climate Changes. The Kyoto Protocol, which was signed in 1997, became a first step in quantifying the measures necessary to achieve the objectives of the 1992 Convention. The Protocol calls for a 5.2 % reduction in emissions by the industrialised countries between 1990 and 2008–2012, referred to as the first commitment period. Implementation of the Protocol required it to be ratified by at least 55 parties to the Convention, responsible for at least 55 % of emissions. Before agreement could be reached, it was necessary to clarify the rules that would be applied in practice and, at the Seventh Conference (held in Marrakesh in the autumn of 2001), the parties reached agreement on how the political decision should be expressed in legally binding text. As the USA has withdrawn from the negotiations, it was necessary for the EU, Japan and Russia to ratify the Protocol before it could come into force. The EU ratified the Protocol on 31 st May 2002, followed by Japan on 4th June 2002. At the World Summit on sustainable development in Johannesburg in September 2002, Russia stated that it intended to ratify the Protocol, which would enable it to come into force. The Eighth Conference will be held in New Delhi at the end of October 2002.

World Summit on sustainable development

A World Summit on sustainable development was held in Johannesburg at the end of August 2002, attended by delegates from 190 countries, who negotiated a number of difficult problem areas. In terms of setting concrete objectives or specific dates, the delegates failed to reach agreement on access to energy supplies or a change to renewable energy sources: instead, it was agreed that programmes to improve the availability of energy should be included in national development plans for tackling poverty, and that this must be done in a sustainable manner. All countries should change from the use of fossil fuels to renewable energy, with a massive world-wide increase in the proportion of renewable energy. In addition, the Summit recommended that the industrialised countries, in particular, should phase out subsidies to fossil fuels. ■

Sweden's energy balance

The total quantity of energy used must always be balanced by a corresponding quantity of energy supplied. This chapter gives details of the balance between Sweden's total energy supply and its total energy use.

Total Energy Supply

Sweden's energy supply has increased by 35 % between 1970 and 2001, from 457 TWh to 616 TWh in 2001.[1]

The combination of 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, compared to 31 % by 2001. In 1970, most of the oil supply went to the residential and service sectors. Today, 55 % of the oil supplies go to the transport sector. Much of the energy previously supplied by oil has over the last 30 years, been replaced by nuclear power and biofuels. Today, nuclear power provides about 206 TWh[1] (68 TWh of electricity) and hydro power provides about 64 TWh per year under normal precipitation conditions. Normal year production of hydro power is based on a mean value of precipitation over the period 1950–1996. The precipitation has been high over the last few years, and if these years were included in the statistical serie, normal year production would be higher. 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 fully 16 % in 2001. These fuels are supplied mainly to the industrial sector and district heating producers.

In international terms, the energy supply of Sweden includes a relatively large proportion from renewable sources. These include biofuels, hydro power and wind power. In 2001, these renewable sources accounted for 29 % of the country's total energy supply.

The 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, while colder years increase the need. 2001 was warmer than an average year.

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[1] These quantities are expressed in accordance with the international method, which includes energy losses in nuclear power stations.

Figure 2a • Total energy supply in Sweden 1970–2001

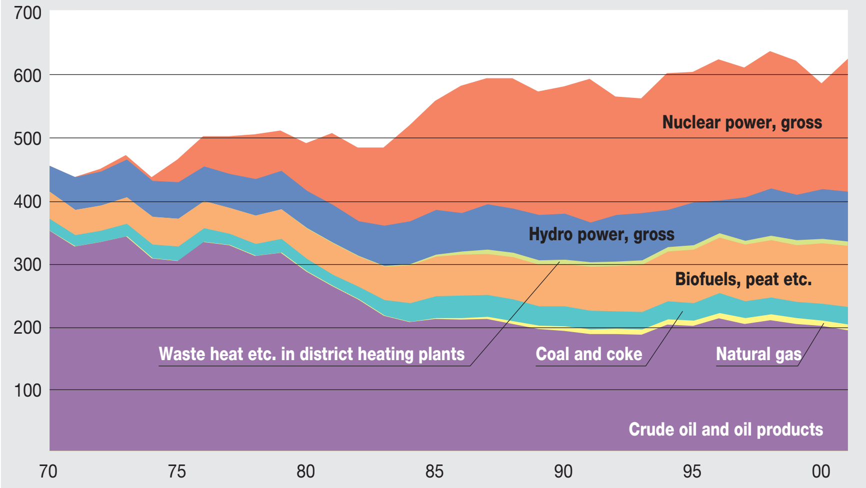
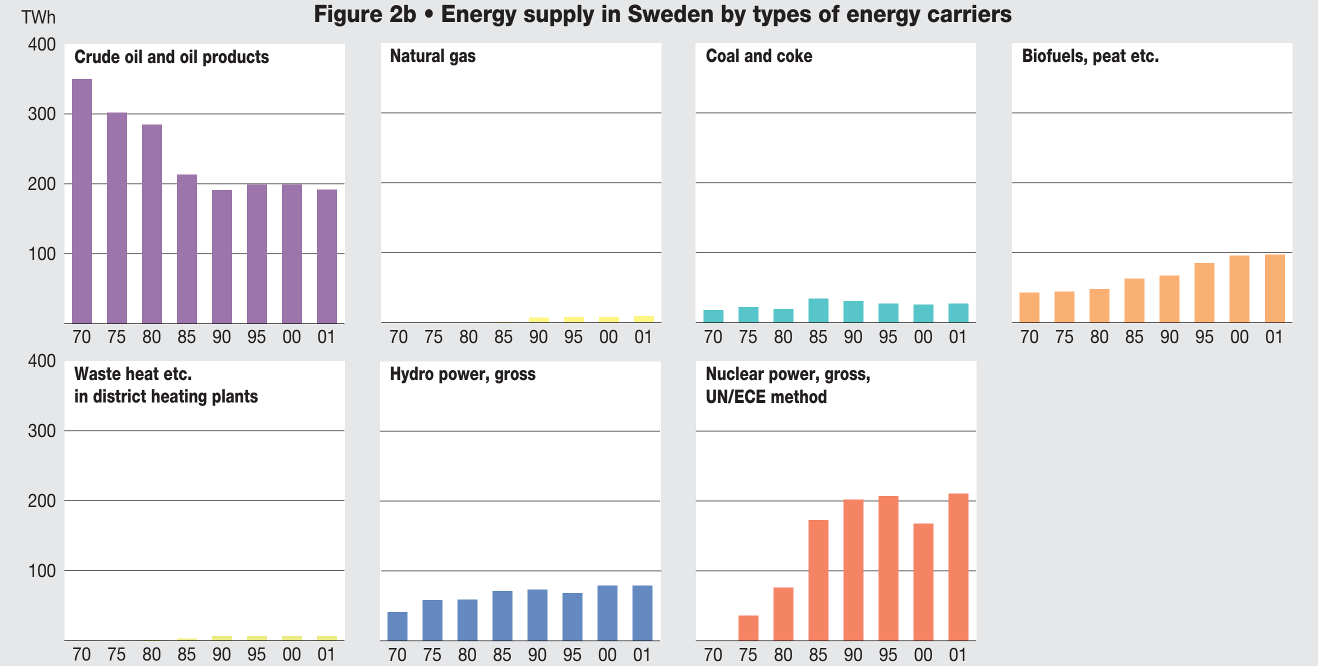


Figure 2b • Energy supply in Sweden by types of energy carriers



The Agency's forecast for the period up to 2003[2] expects total energy supply to be 619 TWh in 2002 and 631 TWh in 2003, with net imports of electricity amounting to 9 TWh and 7 TWh respectively.

Total Energy Use

Total energy use in 2001 amounted to 616 TWh, spread over the following five sectors:

- Industry
- Transport
- Residential and service etc.
- International shipping and products used for non-energy purposes
- Conversion and distribution losses.

The first three sectors above account for what is referred to as total final energy use, which amounted to 398 TWh in 2001. According to the Agency's forecasts for 2002 and 2003[2], total final energy use in the two years is expected to increase to 402 and 407 TWh respectively.

Bunker oils for international shipping and coal and oil products used for non-energy purposes amounted to 40 TWh in 2001. Non-energy purposes are such as raw materials and feedstocks for the plastics industry, lubricating oils and oil products used in the building and civil engineering sectors, e.g. asphalt and surface coatings etc.

Conversion losses are associated with electricity and heat production, and in refineries and coking plants. They do not, however, include losses in hydro power production. Conversion losses in nuclear power plants make up a major item, amounting to over 22 % of total energy use in 2001. Conversion losses also include the energy sector's own internal use. Distribution losses occur in connection with supplies of electricity, natural gas, town gas, coke and blast furnace gas, as well as with district heating. Total conversion and distribution losses in 2001 amounted to 178 TWh, of which 138 TWh were in the nuclear power stations.

Trends in the patterns of energy use by industry and the residential and service sector have remained essentially unchanged since 1970. However, total use by the transport sector (excluding international shipping) has increased by 64 % since 1970. ■

[2] Energy supply in Sweden, short-term forecast, 2002-02-25

Figure 3a • Total energy use in Sweden 1970–2001

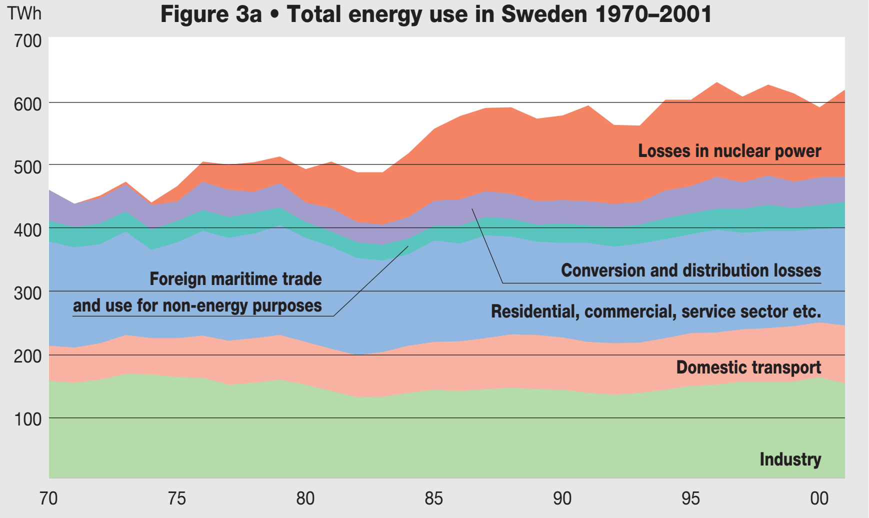
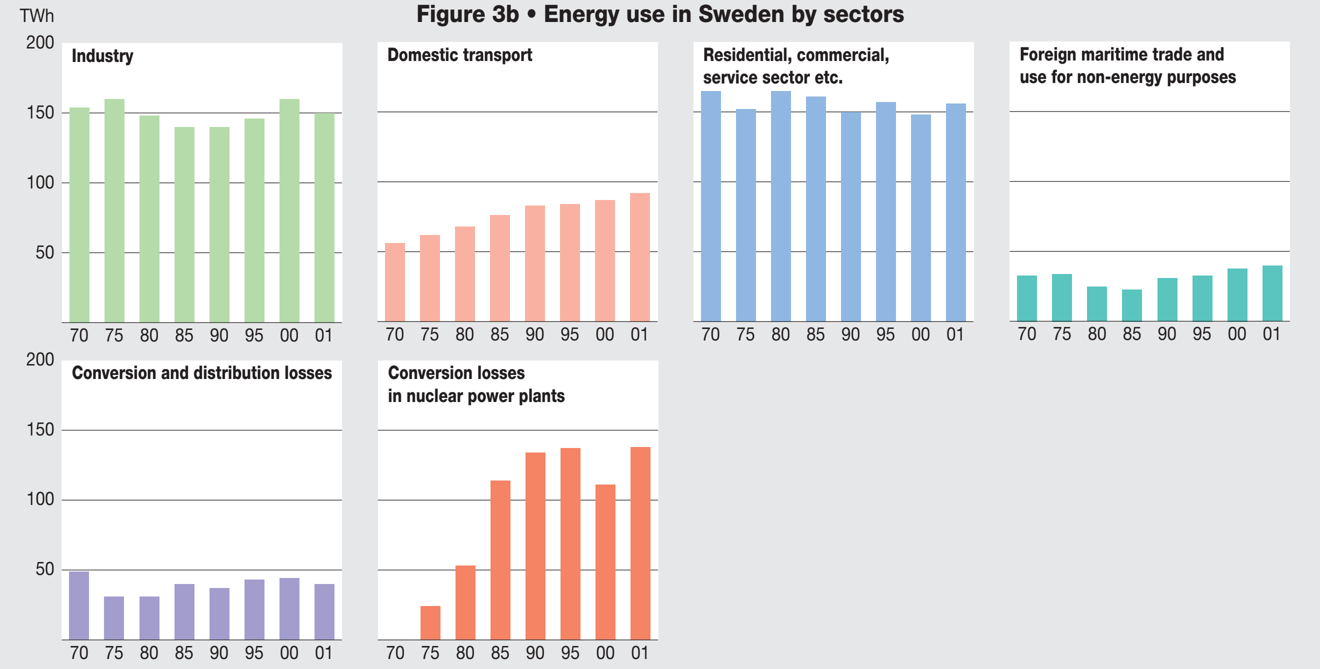


Figure 3b • Energy use in Sweden by sectors



Energy markets

The energy markets are changing in step with development in technology and with increasing awareness of the effects of energy systems on the environment, society and the economy. Electricity markets in several countries have been opened to competition over the last few years, and the same process is now occurring in natural gas markets. Work on reducing emissions of greenhouse gases is in progress in most countries of the world, and is affecting the markets for fossil fuels and biofuels. This chapter describes the changes that have occurred over the last 30 years.

The Electricity Market

Major changes have occurred in the electricity markets in the Nordic countries and the EU over the last few years. In 1991, Norway was the first Nordic country to create a competitive market in which users could choose their electricity suppliers. Sweden followed in 1996 and Finland in 1998, while the Danish electricity market will be fully open to competition in 2003[3]. Today, all the Nordic countries except Iceland are trading on the Nordic electricity exchange, Nord Pool. The price of electricity in the Nordic countries is determined largely by hydro power availability in Sweden and Norway. There has been a run of wet years in Sweden since 1997: 2001 was an exceptionally wet year, with a record hydro power production of 78.5 TWh. Nevertheless, electricity prices during the year were very high, due primarily to the fact that precipitation in Norway was lower than normal.

[3] At present, all consumers using more than 1 GWh/year can choose their electricity supplier.

Electricity use

In 2001, electricity use in Sweden amounted to somewhat over 150 TWh. Between 1970 and 1987, electricity use increased very substantially, at a rate of about 5 % per annum. However, this rate of increase has since declined, so that electricity use increased by only 0.65 % per annum on average between 1998 and 2001. Electricity use in Sweden is linked primarily to two sectors, the residential and service sector and the industrial sector. Between 1970 and 1987, annual electricity use in these two sectors increased on average by 6.7 % and 2.7 % respectively. These increases stabilised over the following years, so that between 1998

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Figure 4a • Use of electricity in Sweden 1970–2001

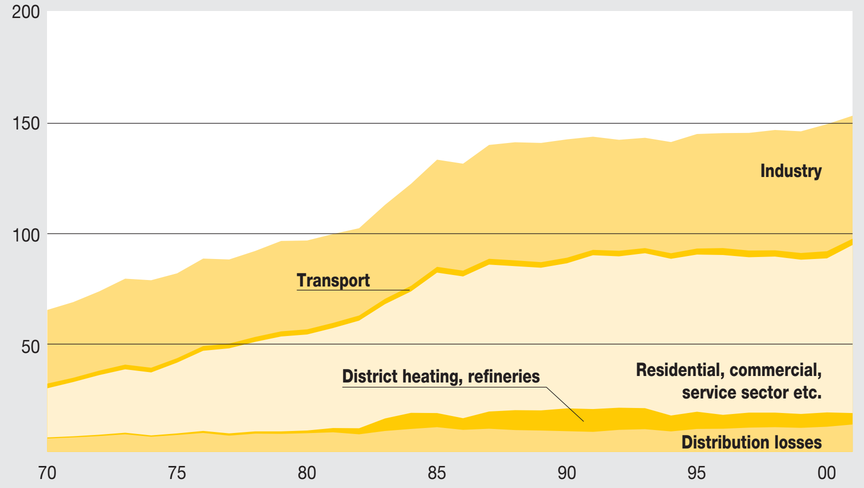
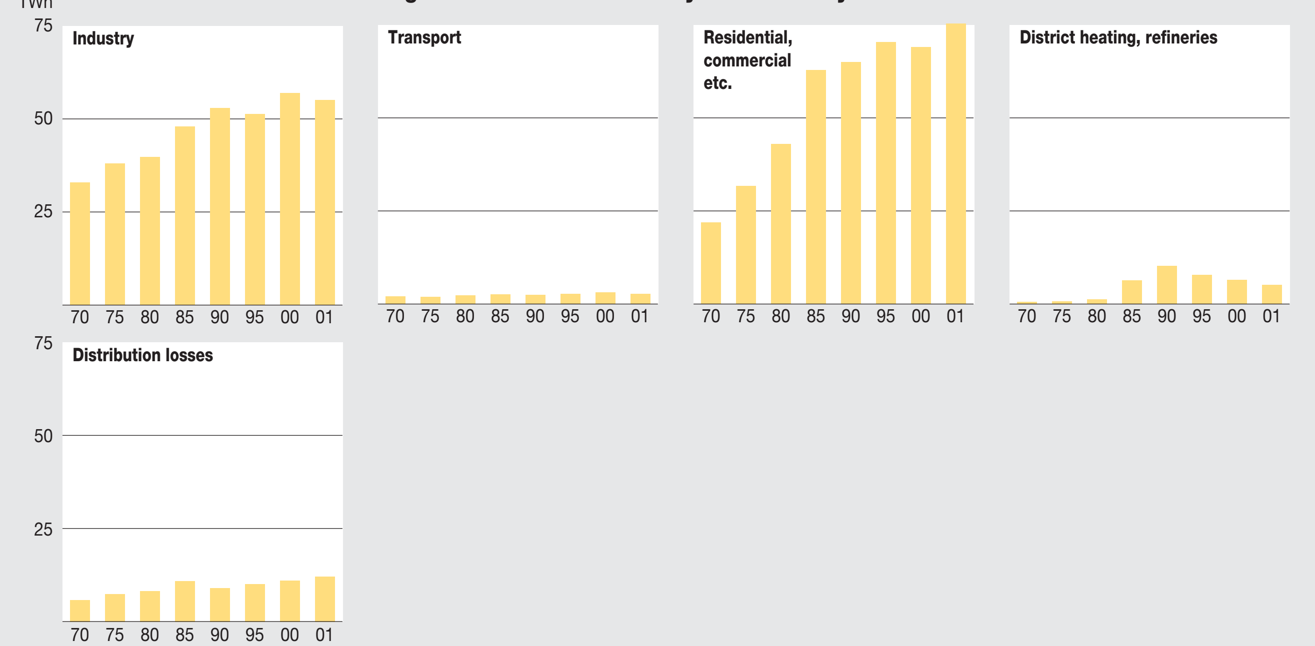


Figure 4b • Use of electricity in Sweden by sectors



and 2001 the annual increases in the two sectors were only 1 % and 0.6 % respectively. The substantial increase in the use of electricity in the residential sector up to 1987 was the result mainly of a change from oil to electricity for heating purposes. In recent years, it has been primarily the use of domestic electricity and electricity for building services systems that has increased in this sector. The use of electricity for heating has remained at a stable level for some years now, which has been assisted by the availability of grants for conversion from electric heating. 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 railborne transport. Total electricity use also includes the losses associated with the transmission of electricity and with its use in district heating plants and refineries.

Electricity production

Over the last 30 years, there have been considerable changes in the production mix of the country's electric power. At the beginning of the 1970s, hydro power and conventional thermal cold condensing power produced most of the electricity in Sweden. The oil crises of the 1970s provided further impetus for the construction of nuclear power plants, in order to reduce the country's dependence on oil. Today, hydro power and nuclear power supply a very substantial proportion of the country's electricity, amounting to somewhat over 94 % in 2001, with

Figure 5 • Wind power development 1982–2001

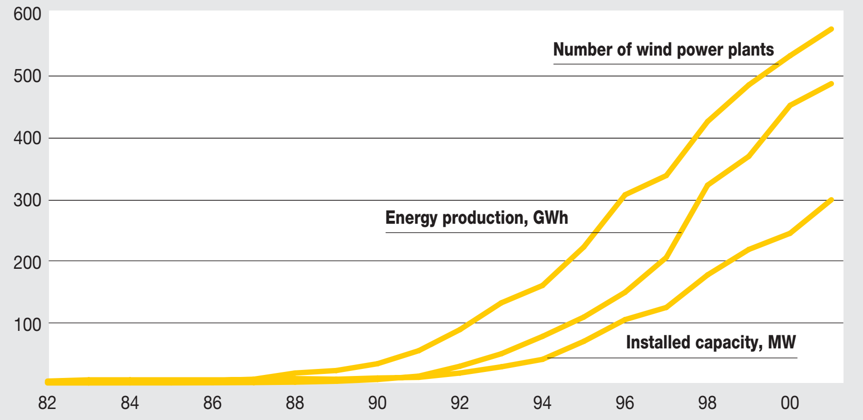
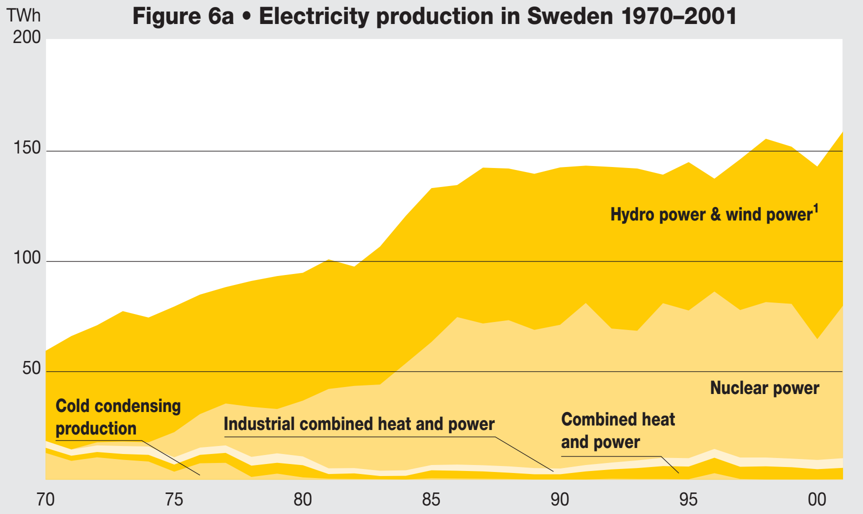
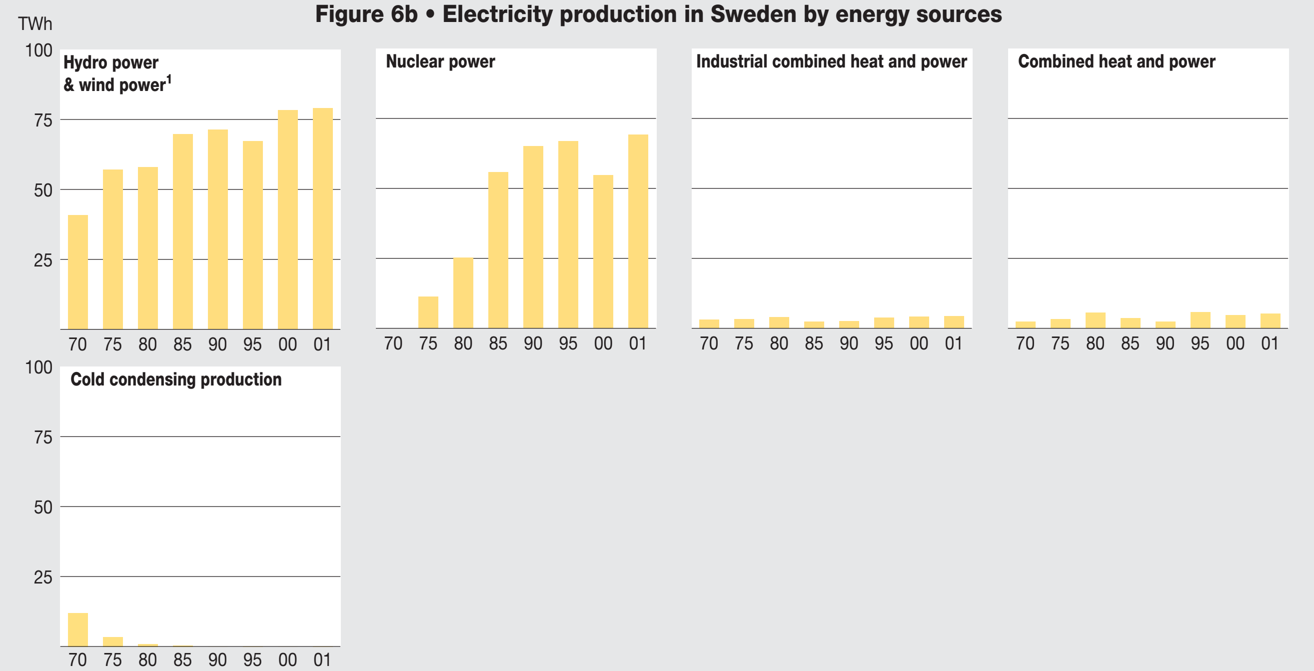


Figure 6a • Electricity production in Sweden 1970–2001



[1] Including wind power 0.4 TWh.

Figure 6b • Electricity production in Sweden by energy sources



oil-fired cold condensing production and gas turbines providing primarily reserve capacity.

This production structure is once again in the process of change. Sweden has decided to phase out nuclear power production: Barsebäck 1 was closed in 1999 and Barsebäck 2 will be closed when the conditions set by the Parliament are fulfilled. These include "the loss of electricity production being compensated by the introduction of new production capacity and reduced use of electricity"[4]. Parliament's last review of the situation, in 2001, decided that the necessary conditions would be fulfilled before the end of 2003. Continued phase-out of nuclear power production, as in Germany, is also under discussion. Under the German model, the Government and the power industry reach an agreement on a total production figure for electrical energy, in the form of a maximum quantity that may be produced by the existing reactors during their remaining life. This production volume can be distributed relatively freely in terms of time and between nuclear power plants.

The Swedish and EU targets for the reduction of greenhouse gases have also affected the production mix of electric power, in the form of a greater element of renewable energy. Wind power is a renewable energy source which has expanded substantially in Sweden over the last ten years. Despite this, however, its share of the country's electricity production is still very modest.

In addition to nuclear power, hydro power and wind power, Sweden also operates a certain amount of combustion-based power production. 35 % of the fuel for this production is supplied by coal, 35 % by biofuels and about 26 % by oil.

[4] Report of the Standing Committee on Economic Affairs, 2001/02:NU17

The cogeneration proportion of this production, producing both heat and power, has acquired increasing importance both in Sweden and elsewhere in the EU as an efficient technology.

2001 was a very wet year in Sweden, with hydro power production reaching a record level of 78.5 TWh. Nuclear power production was also relatively high, at 69.2 TWh, which could be due to the fact that electricity prices were high during the year, and so made it worthwhile to produce electricity from this source. Combustion-based power production amounted to 9.7 TWh, and 0.45 TWh from wind power from the country's 570 wind power plants (as at the end of 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. Today, there is also a joint Nordic power exchange, Nord Pool, on which all the Nordic countries except Iceland trade. 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, Finland and Denmark (the latter from the beginning of 2002), which has also helped to encourage trade. Competition has meant that the utilities find it cheaper to buy power from neighbouring countries than to run production plant with low merit order. This has resulted in the decommissioning of plant, such as gas turbines and most of the oil-fired cold condensing plant that was previously available for peak-lopping duty during (for example) cold weather, that is not specifically required for actual breakdown reserve.

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

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Figure 7a • Supply of fuel in electricity production 1983–2000

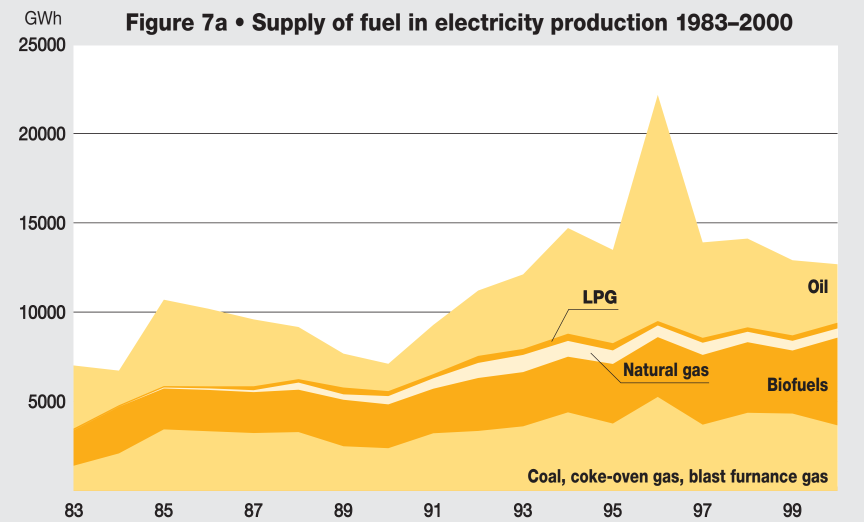
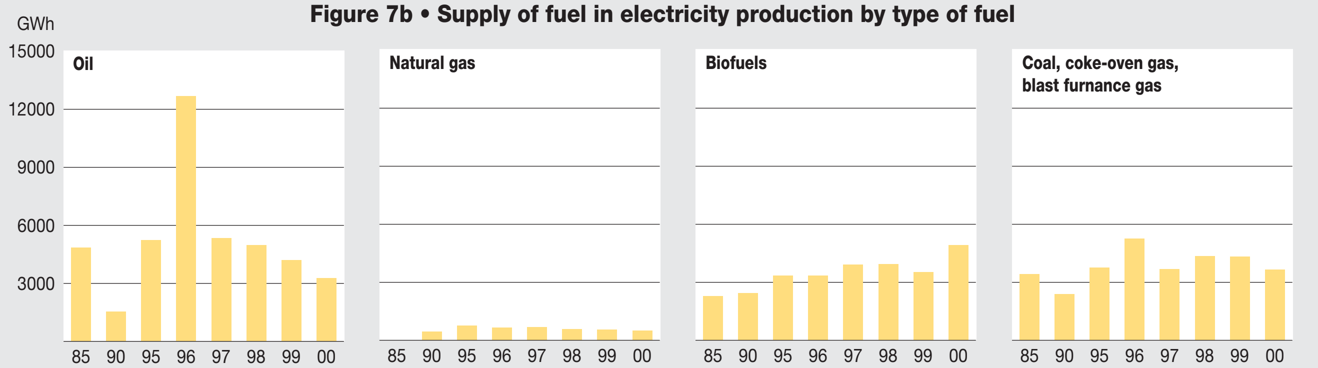


Figure 7b • Supply of fuel in electricity production by type of fuel



Polish utilities also trade electricity with the Nordic countries, despite not being allowed to trade via Nord Pool. However, as yet, the quantities of such trading are still relatively small.

During 2001, Sweden was a net exporter of electricity, primarily due to an excellent availability of water, but also assisted by high availability of the Swedish nuclear power plants. Most of the electricity was exported to Norway, which had a poorer availability of water power during the year. Exports to Germany and to Poland also increased, but decreased 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. It then fell substantially until the end of 2000, due partly to plentiful precipitation and partly to increasing competition on the common electricity market. Although 2001 continued the pattern of high precipitation, electricity prices during the year were very high, due partly to relatively low precipitation in Norway. Prices fell during the start of 2002, but are still at a high level in comparison with earlier years.

The price also varies over the year: between 1998 and 2002, these variations have followed a similar pattern, being higher during the winter and lower during the summer. The variations depend on the amount of precipitation, demand – which in turn depends primarily on temperature – 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 the year 2001, the average lowest area price was in Finland, while the highest was in western Denmark.

Figure 8 • Sweden´s electricity imports January 2001–July 2002

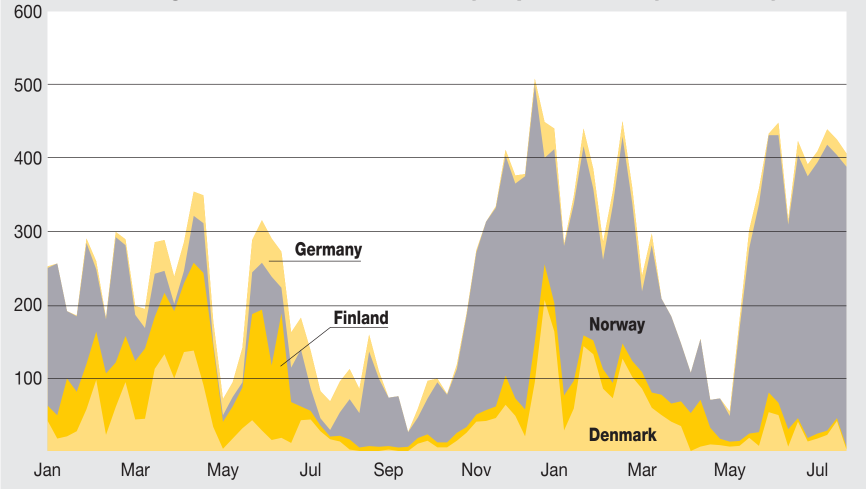
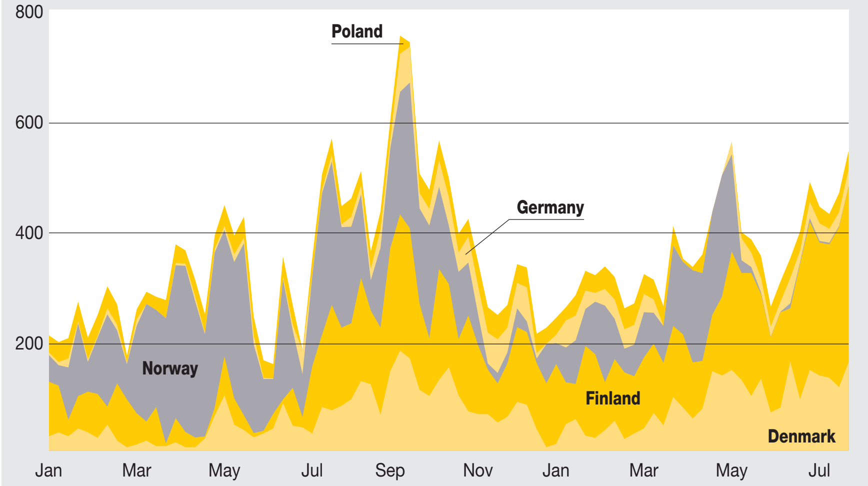


Figure 9 • Sweden´s electricity exports January 2001–July 2002



International development

The electricity market in many parts of the world is at present undergoing extensive changes in terms of changing market conditions, new technology and greater environmental awareness. One of the effects of the EU Electricity Market Directive is that at least 33 % of the electricity markets in the EU states must be open for competition by 2003. Proposals to accelerate this process, so that 35 % of the market would be open to competition by 2003, and all the electricity markets would be open to competition by 2005, were put forward in 2001. The degree of openness varies between states: the electricity markets in Sweden, Finland, the UK, Germany and Austria are fully open to competition, which means that all companies and households are free to choose their electricity suppliers. Denmark (2003), Spain (2003) and Holland (2004) 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 international 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 – Vattenfall in Sweden, Statkraft in Norway and Fortum in Finland – have all bought into competing companies on the northern European market. In the same way, PreussenElektra in Germany 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.

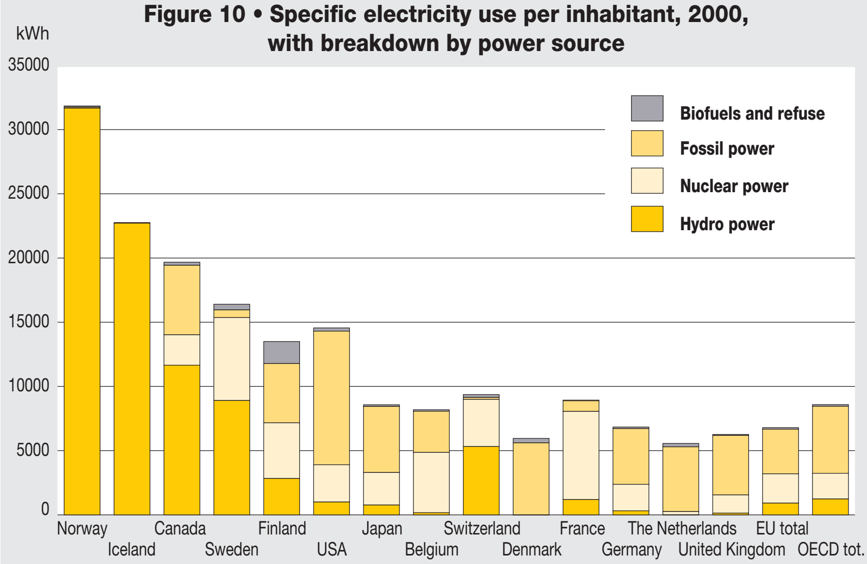
Electricity production from renewable sources

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[5], 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. A system of tradable certificates will be introduced in Sweden at the beginning of 2003, under which those producing electricity from certain forms of renewable energy sources will be assigned tradable certificates for each MWh of electricity produced from renewable energy. The distribution utilities and, in certain cases, electricity users will be required to purchase these certificates in proportion to the amount of electricity that they supply or use. this will create a market for the certificates. The proportion of certificates that distributors and users will be required to buy will be progressively increased from year to year in order to encourage greater production of such electricity.

Discussions are also in progress within the EU on trading emission rights for greenhouse gases (concentrating initially on carbon dioxide), as a means of meeting EU undertakings for emission reduction in accordance with the Kyoto Protocol. Introduction of such a system would also encourage electricity production from renewable sources.

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

Figure 10 • Specific electricity use per inhabitant, 2000, with breakdown by power source



Electricity use varies between countries

In Sweden, per-capita electricity use is relatively high in comparison with that of other countries: only Norway, Iceland and Canada have higher per-capita uses. All these countries have plentiful supplies of cheap hydro power, a relatively cold climate and (apart from Iceland) highly electricity-intensive industries based on natural resources such as forest or ores. 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 Swedish per-capita electricity use would be reduced by about 20 %. Per-capita electricity use in the USA is about one percentage point lower than in Sweden, while that in the industrialised European countries is only about half that in Sweden. Another factor of considerable importance for the high per-capital electricity use in Sweden is the early change from oil-based to electric heating. Discussions are now in progress in Sweden on more frequent meter readings in order to increase consumers' awareness of costs and the use of electricity.

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. In the USA, Ger- →

many, Holland and the UK, fossil fuels provide over 60 % of electricity production. Biofuels still account for only a very small part of electricity production in the industrialised countries, 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. Electricity production in Sweden from combustion processes is relatively small, and is based primarily on fossil fuels as fuels used for electricity production are exempt from carbon dioxide tax. About half of the EU's electricity production is based on fossil fuels, with somewhat over 30 % on nuclear power, 14 % on hydro power and less than 2 % on biofuels and refuse.

Biofuels

In 2001, the use of biofuels, peat etc. amounted to over 97 TWh. These fuels are mainly indigenous, and consist of:

- Wood fuels (logs, bark, chips and energy forest),
- Black liquors in pulp mills
- Peat
- Refuse
- Straw and energy grasses.

Biofuels can be processed into pellets, briquettes or powder in order to increase their energy density and to simplify handling. They are used mainly in the forest products industry, district heating plants, the detached house sector and for electricity production. The availability of raw materials for biofuels is good. It is estimated that, by 2010, the potential for the use of biofuels in Sweden will be about 160 TWh[6]. There is a relatively extensive commercial importation of biofuels, although it is difficult to obtain statistics and quantities are difficult to estimate. In the national statistics for the country's energy balance, they are included as indigenously produced, based on the use statistics. The investigations into the import quantities indicate a figure in the range 5–9 TWh, which means that they are a significant raw material energy source.

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 2001, they provided 34.5 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. In 2001, the pulp industry used a total of 7.7 TWh of wood fuels for energy production, while sawmills and other woodworking industries used 8.3 TWh of wood fuels. Other industry sectors used 0.7 TWh of biofuels.

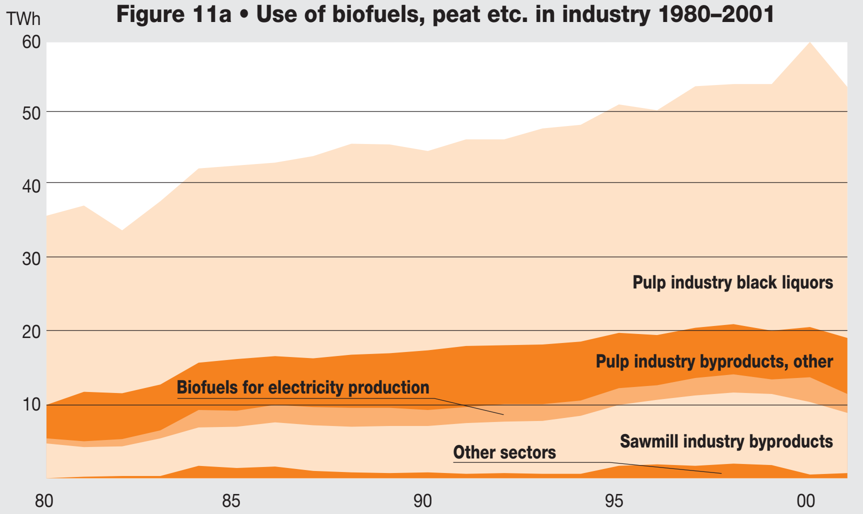
District heating plants

About 30 TWh of biofuels, peat etc. were used for heat production in district heating plants in 2001. Of this, wood fuels accounted for 18.6 TWh, tall oil pitch for 1.3 TWh, refuse for 5 TWh, peat for 3.5 TWh and other fuels for 1.5 TWh.

The use of wood fuels by the district heating sector has increased by a factor of five since 1990. 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, have also been increasingly used in recent years, amounting to a total of 3.7 TWh in 2000.

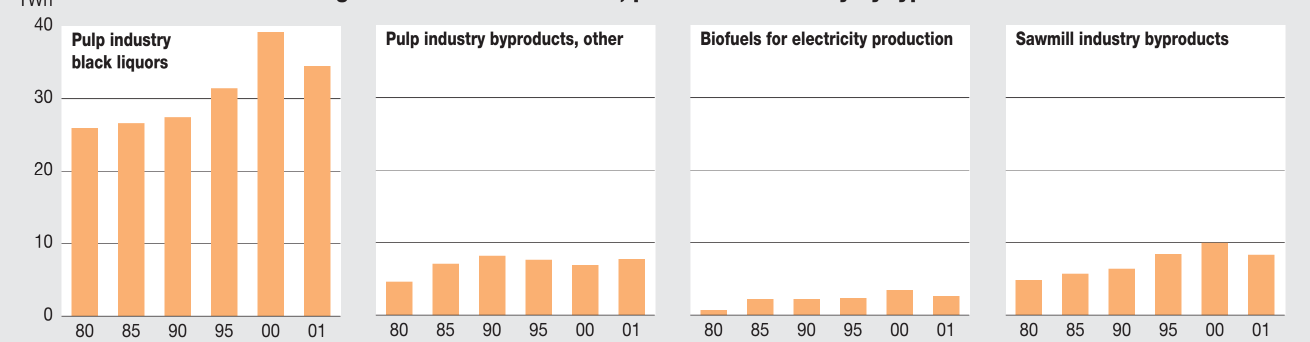
Refuse has been used for district heating production since the 1970s, and provided 5 TWh of energy in 2001. New regulations came into force on 1st Janu-

Figure 11a • Use of biofuels, peat etc. in industry 1980–2001



[6] Swedish Energy Agency, Climate Report 2001.

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



ary 2002[7], under which combustible refuse must be separated from other refuse, coupled with a ban on disposing of unsorted combustible refuse to landfill. Refuse must be processed in some way before disposal in landfill. Most local authorities will probably choose incineration, although in many cases there is insufficient incineration capacity to meet the need, which has resulted in a number of applications to county councils around the country for dispensations for landfill disposal. However, it is very likely that incineration of refuse will increase over the next few years. Since 1st January 2002, landfill disposal has been taxed at a rate of SEK 288/tonne of refuse[8]. Refuse sent for combustion is exempted from the tax, but the ash is taxed. The EU Refuse Incineration Directive[9] 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 applies to new plant with effect from 28th December 2002, and to existing plants from 28th December 2005.

The use of peat amounted to 3,5 TWh in 2001, which is the second highest quantity to date.

[7] SFS 2001:512 and SFS 2001:1063

[8] SFS 1999:673

[9] Directive 2000/76/EEC.

Energy crops, such as energy plantations, straw etc., have been used since the beginning of the 1990s, although such use is still relatively limited, amounting to about 0.9 TWh in recent years. Energy plantations dominate over the use of straw fuels. Although there is considerable potential for greater use, the area planted with such crops has remained almost unchanged in recent years, amounting to somewhat less than 15 000 hectares in 2001.

The detached house sector

Over 9,3 TWh of biofuels, peat etc., mainly in the form of logs, were used in detached houses for heating in 2001. Wood firing is commonest among property-owners with good access to forests, e.g. in agricultural or rural areas. The use of pellets is still relatively modest in this sector, amounting to 0.5 TWh in 2001.

Electricity production

4.4 TWh of biofuels were used for electricity production during the year. 2.6 TWh of biofuels were used in industrial back-pressure plants for the production of 2.2 TWh of electricity, with black liquors and wood fuels accounting for virtually the entire quantity. 1.8 TWh of biofuels were used in cogeneration plants supplying district heating, producing 1.5 TWh of electricity.

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Figure 12a • Use of biofuels, peat etc. in district heating 1980–2001

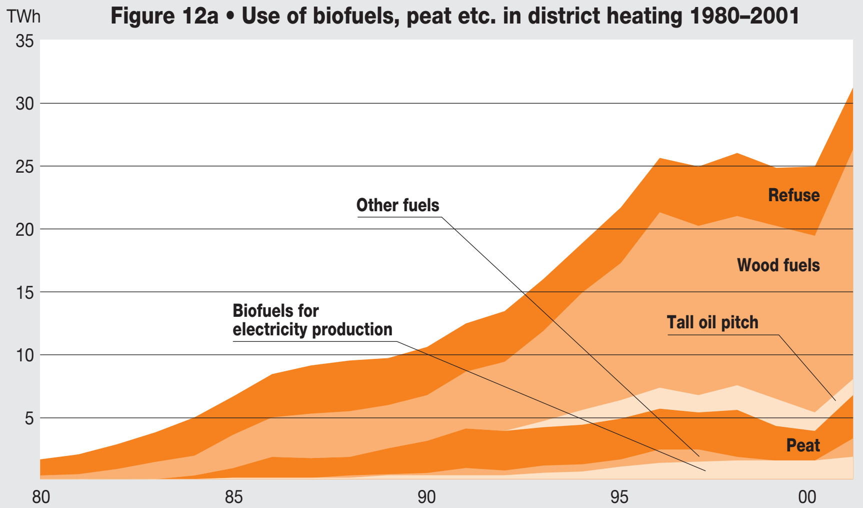
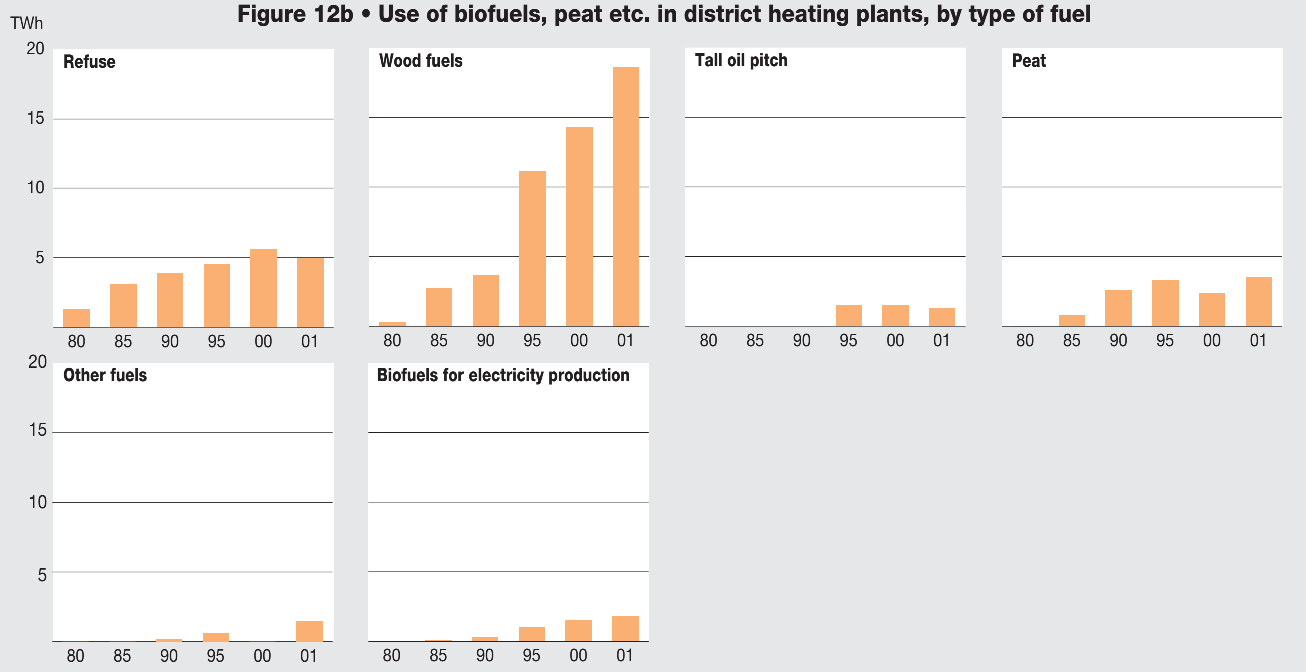


Figure 12b • Use of biofuels, peat etc. in district heating plants, by type of fuel



An international context

Seen in a European perspective, Sweden acquits itself well in terms of its high proportion of biofuels, making up about 16 % of its energy supply. It is 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 make use of the highest proportions of biofuels in their respective energy systems. Other countries with high volumes of biofuels, but in which the share of the energysystem is rather small, 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.

District heating and district cooling

District heating and district cooling are similar energy supply systems. District heating began to establish itself firmly in Sweden during the 1950s, but district cooling did not appear until the 1990s. District heating supplies residential buildings, commercial premises and industries with heat for space heating and domestic hot water production. District cooling, on the other hand, finds a market almost exclusively in the commercial sector for air-conditioning of shops and offices, and are in industry for process cooling. While district cooling tends to be confined to the centres of towns, district heating has a wider geographic spread, extending out to the suburbs of urban areas. On average, district cooling is more expensive per kWh than district heating: the average price of district heating in Sweden is about 40 öre/kWh[10], while that of district cooling is over 50 öre/kWh[10]. District cooling is supplied by the district heating utilities, and the two production systems are often integrated with each other.

District heating

District heating is the centralised production and supply of hot water, distributed through a piping system and used for the space heating of buildings, primarily in urban areas. It is one of many forms of heating on the heating market, and is characterised by the fact that there is a contractual arrangement, usually for a somewhat longer term, between the supplier and the user. It is produced in hot water boiler plants or cogeneration plants (CHP). Smaller heat distribution systems supplying heat to a limited residential area are known as group heating systems, and are generally smaller than district heating systems.

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. However, several new types of district heating distribution systems, suitable for use in smaller urban areas, have been developed in the last few years, and are used in what are referred to as local heating systems. Using simplified technology, it can be viable for such systems to cover areas of lower load density.

Local authorities began to look at district heating during the latter half of the 1940s: Sweden's first public district heating system was started in Karlstad in 1948. Its use spread during the 1950s and 1960s as a result of the extensive invest-

[10] VAT excluded

Figure 13a • Use of district heating 1970–2001

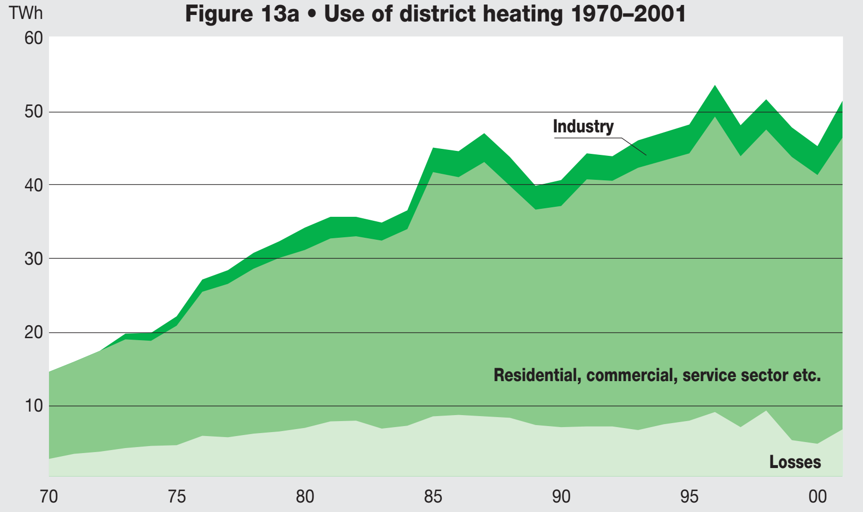
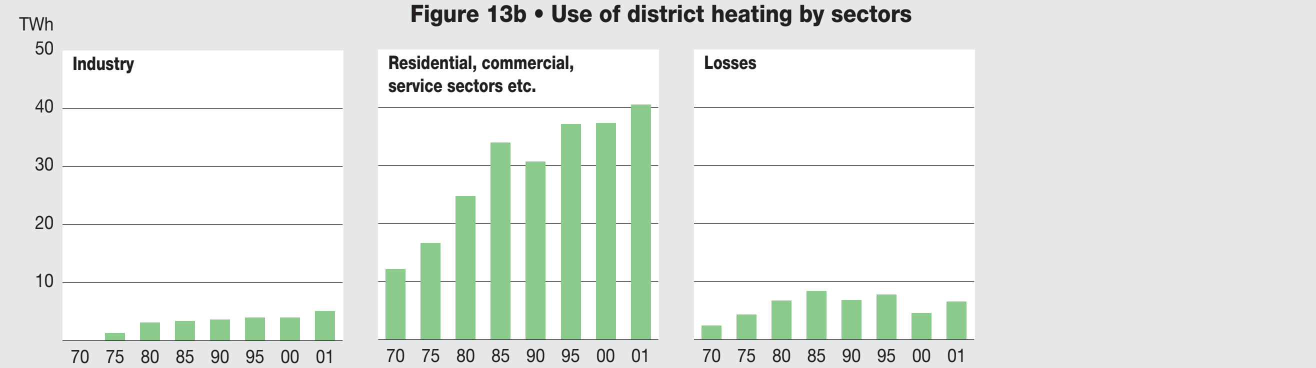


Figure 13b • Use of district heating by sectors



ments in new housing and other buildings and 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, due to the latter's ability to replace oil through its flexibility of fuel use.

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 from heating of residential buildings and commercial premises.

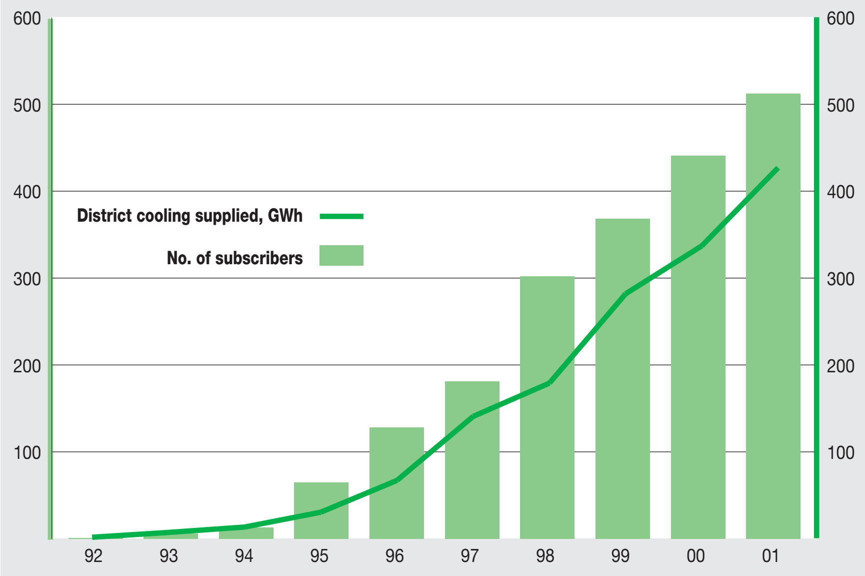
Today, investment support is available for biofuel-based CHP. The 1997 energy policy programme introduced grants for investment in district heating systems. However, take-up was poor, due to the fact that the costs for extension of mains and conversion of electrical heated buildings were too high, and the grants were withdrawn in 1999. They have since been reinstated, but will cease at the end of 2002, when the short-term element of the 1997 energy policy program expires.

District heating is not price-controlled, although the regular price comparisons by the Public Service Fee Group[11] and the Agency's annual surveys of the heating markets provide information on price differences between areas. Pressure for price control, which could perhaps be justified by the presence of local district heating monopolies, comes from a number of sources, including the the Swedish Competition Authority. The possibility of opening district heating networks to competition, by providing access to third parties, is being discussed at present.

Today, district heating supplies over 40 % of the total residential and commercial premises heating requirement. It

[11] Formed by housing companies, the Property Owners Association and the Tenants Association and monitors local authority charges for heating, domestic hot water, water, sewage treatment, electricity and public waste management.

Figure 14 • District cooling supplied 1992–2001



is the commonest form of heating in apartment buildings, supplying heat to about 75 % of the heated floor area, while over 50 % of commercial and similar premises are heated by it. In detached houses, on the other hand, the proportion is only about 8.5 %.

The country has about 12 000 km of distribution mains. 45.7 TWh of district heating were supplied in 2001. Of this, about 60 % was used for residential space heating, almost 30 % for heating commercial premises and over 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 has 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 2001 was 52.1 TWh, of which biofuels accounted for 29.9 TWh, or somewhat over 57 % of total energy supply.

The use of electricity in the sector, with most of it being accounted for by electric boilers and heat pumps, has fallen substantially 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 between electricity producers and district heating suppliers were terminated in connection with restructuring of the electricity market in 1996. 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 12 % of the total energy input: 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, although many have common owners. There has been considerable consolidation of ownership since 1996, with Vattenfall and Sydkraft being particularly active in purchasing local authority energy utilities, including their district heating businesses. Of the Swedish District Heating Association's about 170 member companies, 63 % are owned by local authorities, 21 % are privately owned, 8 % are owned by the state and 6 % are still operated as local authority services.

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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.

District cooling can be provided by a property-owner for the property. The National Property Board, for example, provides district cooling for parts of the Government offices in Stockholm, while the Civil Aviation Administration operates a district cooling system at Arlanda. The statistics provide data only for commercial district cooling, i.e. with the supplier and consumers being different parties. So far, it is only existing district heating suppliers that have established commercial district cooling systems.

There are several ways in which district cooling can be produced. Many district heating companies use waste heat or lake water as a heat source for heat pumps to produce district heating: for every three units of district heat, two units of cold water can be produced for district cooling. Another way is to install an absorption refrigeration plant at or near a customer's premises, powered by district heating. A further alternative is simply to use cold water from the sea or a lake.

The country's first district cooling system was started up in Västerås in 1992. In 1995, Stockholm Energi (nowadays Birka Värme Stockholm AB) followed with the supply of district cooling to central Stockholm, based on sea water cooling from Lilla Värtan. By combining this with the cooling from the cooled Lilla Värtan water that had been used as the heat source for Stockholm Energi's large district heating heat pump, it was possible to guarantee low district cooling temperatures even at times when the sea water alone was too warm.

The market for district cooling has expanded strongly since its introduction in 1992, powered by such factors as new building regulations, higher internal heat loads in offices and shops and greater awareness of the importance of good working conditions. Property owners who already have contracts with district cooling suppliers in one town may ask for district cooling in other towns. The market has further been assisted by the phase-out of ozone-depleting refrigerants, as property owners have been forced to buy new equipment, convert existing equipment or find other solutions for providing air conditioning.

At the beginning of 2002, there were 26 commercial district cooling suppliers, some operating more than one system. The length of mains amounted to over 118 km,

Figure 15a • Energy supplies to district heating 1970–2001

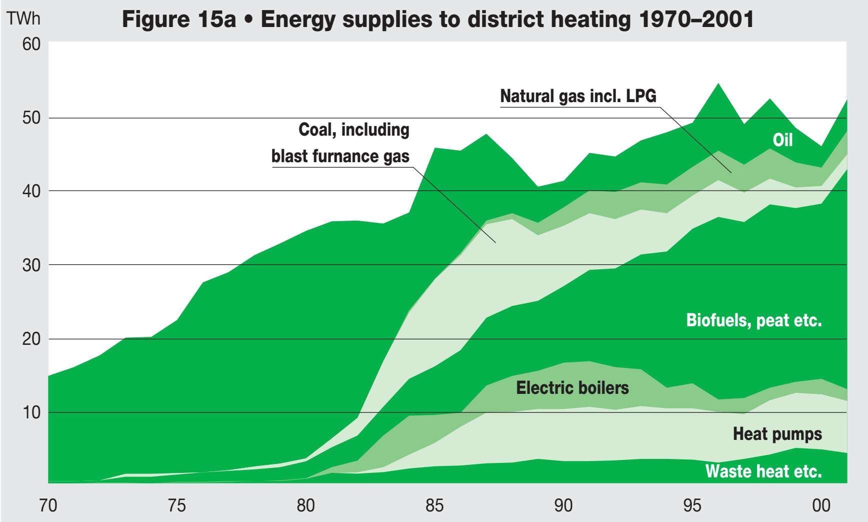
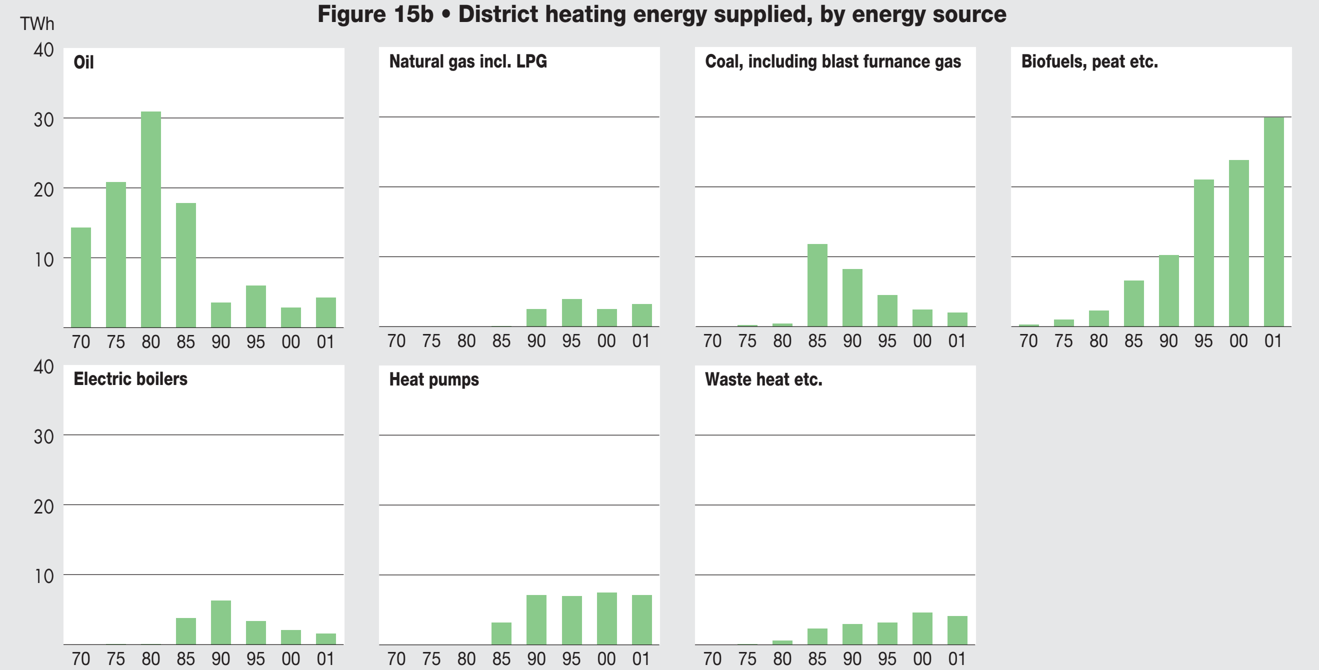


Figure 15b • District heating energy supplied, by energy source



through which 425 GWh of district cooling were supplied. It is expected that deliveries will increase in coming years.

The Oil Market

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 over USD 18 per barrel. Prices continued to rise by a further 60 % in 2000, reaching USD 29 per barrel. The price fell by 15 % in 2001, to just below USD 25 per barrel. During the first two quarters of 2002, the one-month price has varied between USD 19 and USD 26 per barrel.

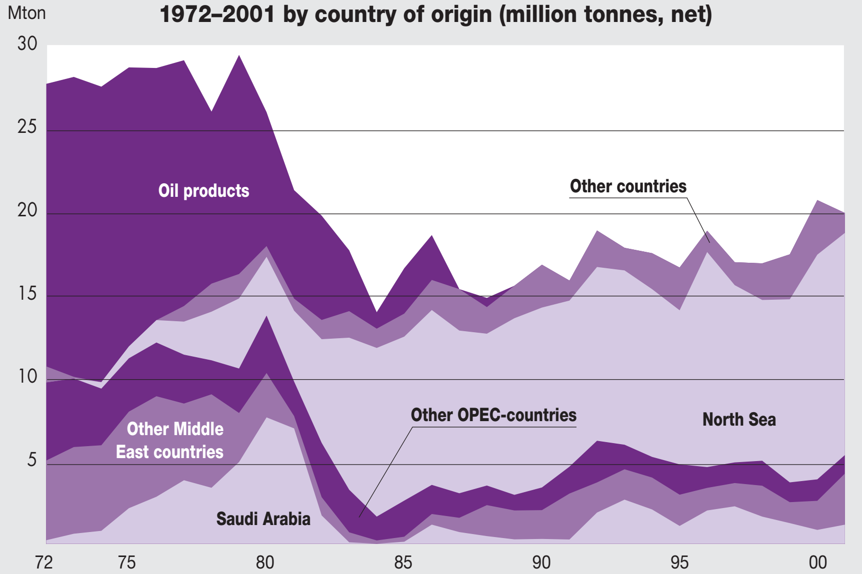
The price rise started at the beginning of 1999, when the major OPEC oil-producing states agreed to reduce output in order to raise the low world market price. The price rose rapidly, so that it is today more than 100 % higher than it was before the production cutbacks started. However, this massive rise cannot be explained solely by the fact that the OPEC countries reduced output. During 2000, and up to the middle of 2002, 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. Possible explanations are the unsettled situation in the Middle East, market jitters as to whether the OPEC countries will maintain their production and how large the stocks of oil in the USA and Asia are.

There are many psychological factors involved when attempting to explain price changes in the oil market: expectations of a cold winter, for example, as there has been a run of mild winters in recent years. At the beginning of September 2002, the futures prices of oil for delivery at the end of the year was somewhat higher than the spot price, which indicates that the market is expecting future price increases. Prices are expected to fall in 2003 and 2004.

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.

Figure 16 • Swedish imports of crude oil and petroleum products, 1972–2001 by country of origin (million tonnes, net)



Between 1991 and 2001, world oil production increased by over 14 %, amounting to almost 74.5 million barrels/day in 2001. OPEC's member states account for about 40 % of this, and possess 78 % of reserves, which thus gives them a considerable hold over the oil market. Other major oil producers are Norway, Mexico, Russia and the USA. During 2001, the OPEC states' oil production has been reduced on three occasions, by a total of 3.5 million barrels/day. OPEC further reduced its output by 1.5 million barrels/day on 1st January 2002, coupled with a reduction of almost 0.5 million barrels/day by an number of non-OPEC countries. 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 75.4 million barrels/day, increasing to 76.2 million barrels/day in 2000 and 76.4 million barrels/day in 2001. During the first quarter of 2002, total demand increased to 76.7 million barrels/day, only to fall to 75.4 million barrels/day during the second quarter.

Future total demand for oil will depend largely on world economic developments. An IEA forecast in August 2002 expects total world demand in 2002 to rise by 0.3 %, followed by a further 1.4 % rise in 2003. During 2001, the greatest percentage increase in demand occurred in the Middle East, while Europe showed the greatest increase in absolute volume terms. During 2002 and 2003, China and the Middle East are expected to be the areas showing the greatest increase in demand.

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 fallen by almost 50 % since 1970. It is, in particular, the use of oil for heating that has declined: 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.

Use of oil in Sweden rose by 1 % between 2000 and 2001. The total use of oil in 2001 (including that for foreign maritime traffic) amounted to 16,9 million m^3. 66 % of all oil consumption was for transport.

Sweden's import trade in oil products is almost 80 % greater than the country's

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actual use of the products. The 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 47 % in 2001.

Almost 40 % of Sweden's total import of oil products, and 46 % of the country's crude oil imports, comes from Norway. A further 12 % of crude oil imports come from Denmark.

The Coal Market

Coal is divided into two types: hard coal and brown coal, which have different calorific values. Hard coal is a relatively high-value coal, while brown coal has a lower energy content. Sweden uses almost exclusively hard coal. Hard coal is divided traditionally into two categories: coking or metallurgical coal, which is used in the iron and steel industry, and steam coal, which is sometimes also referred to as energy coal, and is used for energy supplies.

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. Prices started to rise again in 2000, reaching a peak in January 2002, since when they have fallen somewhat. The five major exporting countries are Australia, South Africa,

Figure 18 • Spot (nominal) and real prices of light crude 1970–2001

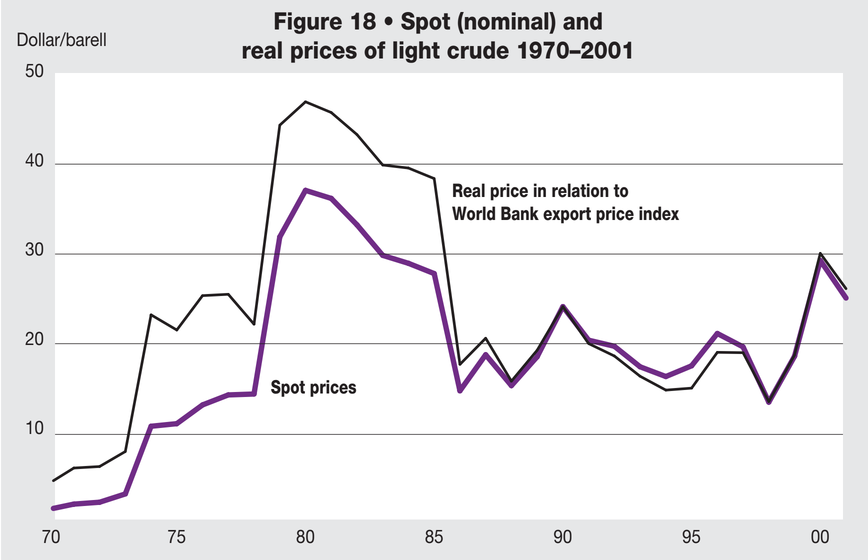


Figure 17a • Swedish use of oil products 1970–2001

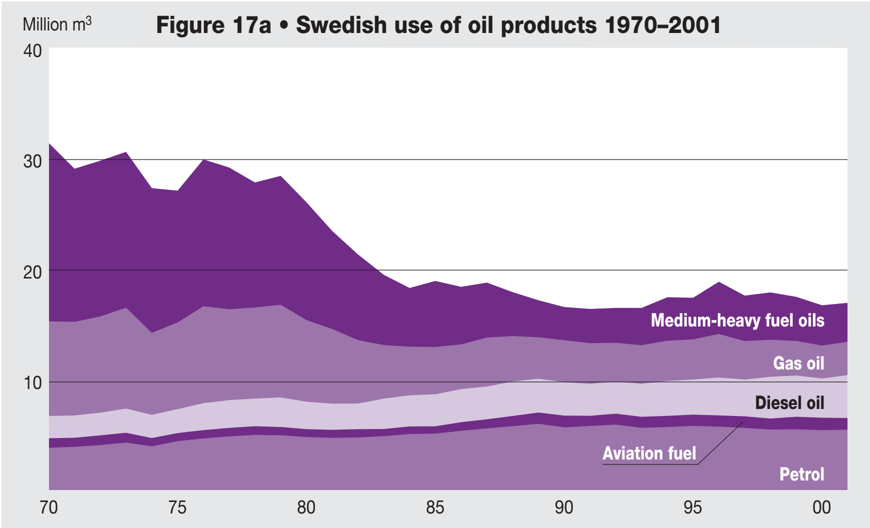
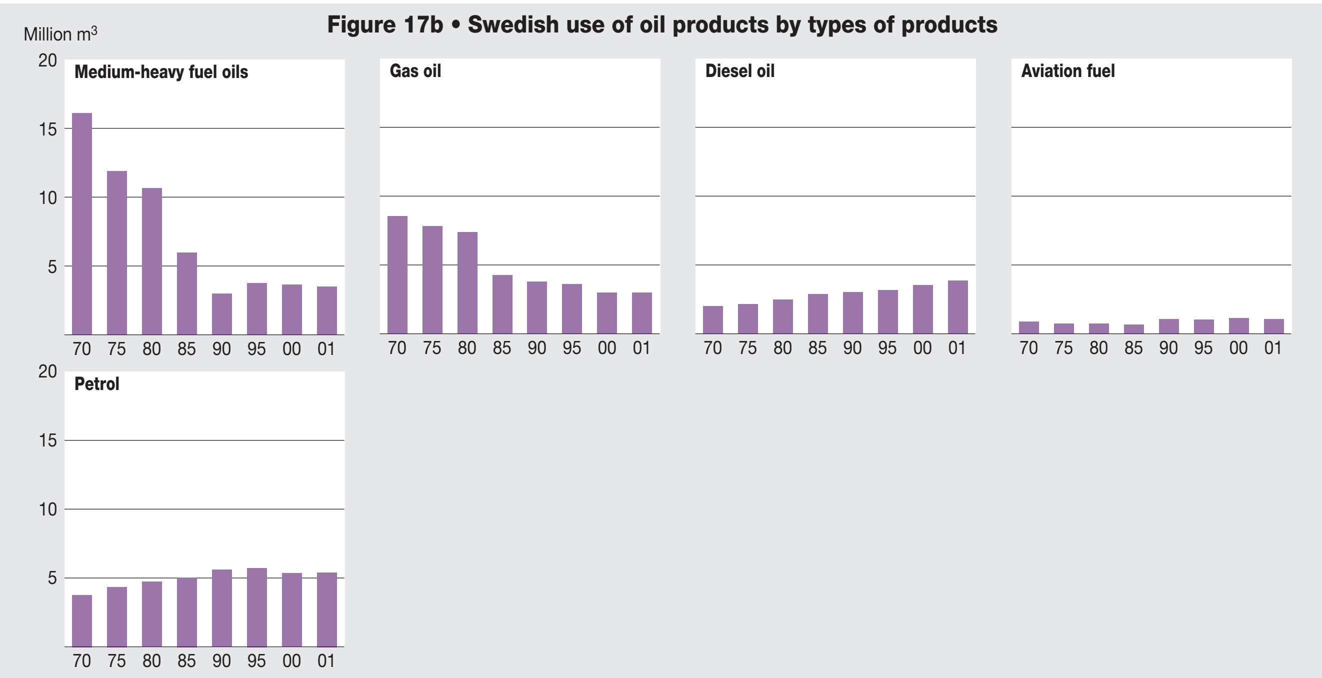


Figure 17b • Swedish use of oil products by types of products



China, Indonesia and the USA, together accounting for over 70 % of world trade in coal. If production continues at the present rate, estimated and economically profitable reserves would last for over 200 years. The largest accessible reserves of hard 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. During the 1990s, the increasingly stringent environmental standards imposed on coal firing, together with rising taxation, have meant that the use of coal for district heating has stagnated, although other uses have increased somewhat. A total of 3.28 million tonnes of hard coal was used in Sweden in 2001. 1.92 million tonnes of this were coking coal, leaving 1.36 million tonnes for energy purposes. To this must be added a net import of 0.33 million tonnes of coke.

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. Coke is essentially pure carbon, produced in coke ovens from metallurgical coal. The coking process also produces gas, which is used for energy purposes either in the iron and steel industry or for other purposes in the vicinity of the plants. Coke itself is used in the iron and steel industry for reduction of the iron ore and as an energy input to the process. Some of the energy content of the coke is converted to blast furnace gas, which is, in turn, used for energy purposes either in the industry or in the district heating sector. 1.92 million tonnes of metallurgical coal were used in industry in 2001, together with 0,87 million tonnes of energy coal and the country's entire net import of 0.33 million tonnes of coke. The quantity of energy coal correspond to 6.6 TWh.

District heating and CHP production

The use of coal for district heating has fallen considerably 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, replacing it by biofuels. However, CHP plants still use some coal, as that proportion of the coal used for electricity production is exempt from energy and carbon dioxide tax. Some of the coking and blast furnace gas is also used by the district heating sector. In 2001, the sector used 0.48 million tonnes of energy coal (3.7 TWh). Of this, 0.33 million tonnes were used for electricity production which, together with the coking oven and blast furnace gas that was used for electricity production, gave a total of 2.1 TWh of electricity.

The Market for Energy Gases

Sweden uses a relatively small quantity of energy gases in comparison with many other European countries. However, the distribution network for natural gas in Sweden is being extended. The rest of Europe is covered by an extensive natural gas distribution network. The use of natural gas in Europe has increased over the last couple of decades, primarily by replacing coal and oil.

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Figure 19a • Swedish use of energy coal 1985–2001

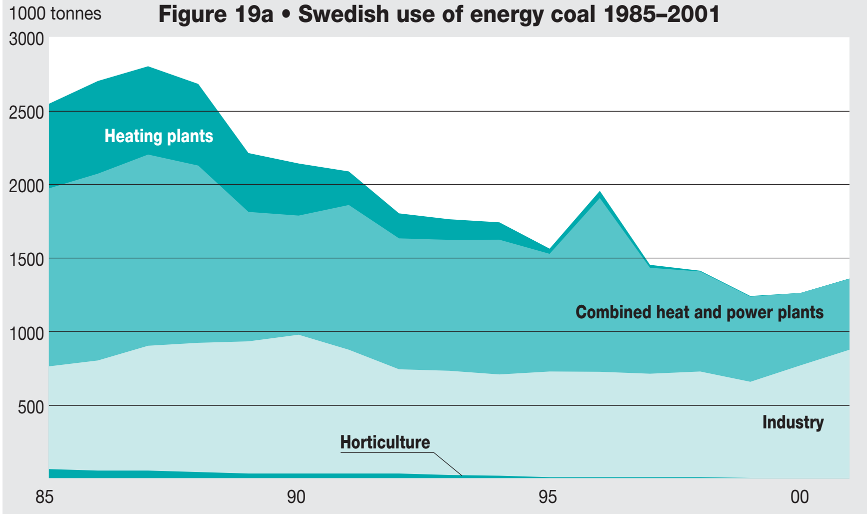
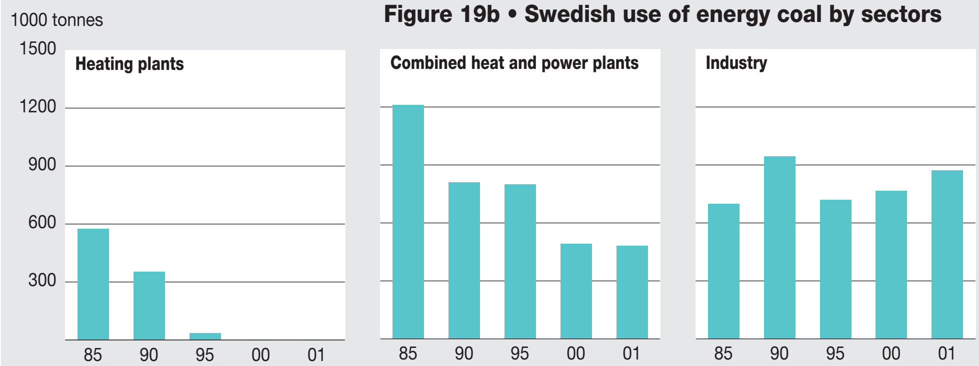


Figure 19b • Swedish use of energy coal by sectors



Natural gas

Natural gas was introduced to Sweden in 1985, since when use has gradually increased, stabilising at the present level in 1992. In 2001, imports amounted to 917 million m^3, equivalent to 8.9 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 17 %. A small amount of natural gas is also used as motor fuel.

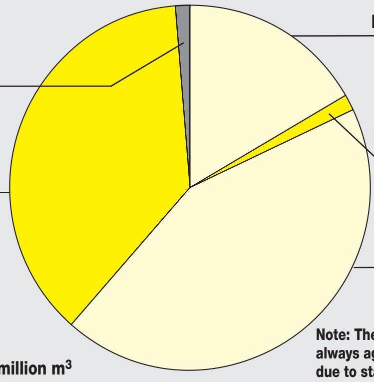
Natural gas is distributed at present to 28 local areas, where it provides about 20 % of energy use. On the national scale, it supplies somewhat over 1 % of total energy use.

The gas is supplied exclusively from fields in the Danish sector of the North Sea. After transiting Denmark, a pipeline under Öresund 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. Nova Naturgas AB owns, and is responsible for operation of, the trunk main, and for importation and transportation of the gas for other distribution companies. Sydgas AB is responsible for the branch mains in southern Sweden, and is at present building an extension of the system from Hyltebruk to Gislaved and Gnosjö.

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 2008.

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 20 • Supply and use of natural gas by sectors in Sweden 2001



LPG

Imports of LPG to Sweden in 2001 amounted to 882 000 tonnes, while 231 000 tonnes were exported. 580 000 tonnes were supplied to the Swedish energy system, equivalent to 7.4 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 2001, 4.1 TWh of LPG were used in industry and 0.3 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, carbon dioxide, carbon monoxide etc. 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 2000, 57 GWh were used for electricity production and 316 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 2001.

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 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 2001, commercially viable reserves amounted to 155 000 x 109 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 (36 %) and in the Middle East (36 %). The world proportion of total energy supply met by gas has grown rapidly over the last decade, so that it is nowadays the fastest growing primary energy source in the world.

Natural gas is included in the EU'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, liberalisation of the natural gas markets in Europe is proceeding at different rates. The directive is due to be implemented in three stages, with those customers (known as eligible customers) who are able to choose their suppliers taking at least 20 % of the total consumption in their national market by 2000, progressively increasing to 28 % in 2003 and 33 % in 2008. 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. The directive was incorporated in Swedish legislation on 1st August 2000, in the form of a new Natural Gas Act.

The EU Commission put forward a revised draft in June 2002, with the aim of accelerating the liberalisation of the electricity and gas markets. One of the main proposals is to allow all non-domestic customers to be designated as eligible customers by not later than 1st January 2004. In addition, it is proposed that all customers should be eligible customers by 1st January 2005. If the proposal is approved during the EU presidency of Denmark, it is hoped that the gas markets will be fully liberalised by 2005.

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 considerably over the next ten years. Total use of natural gas is also expected to increase substantially.

Figure 21 • World production of natural gas, 2001, billion m³

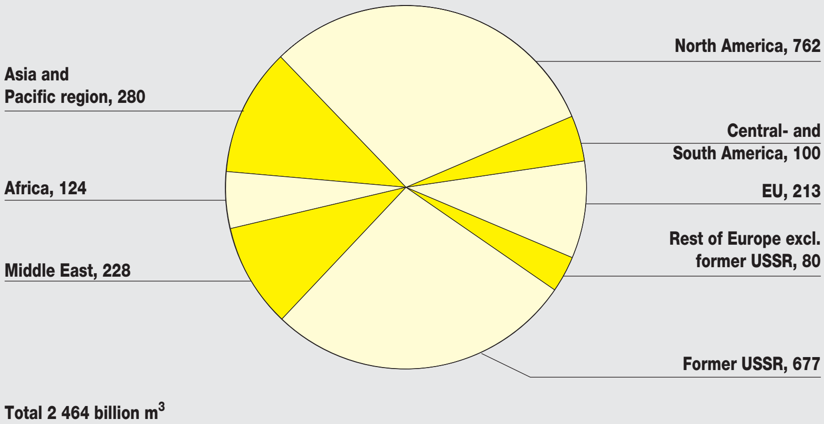
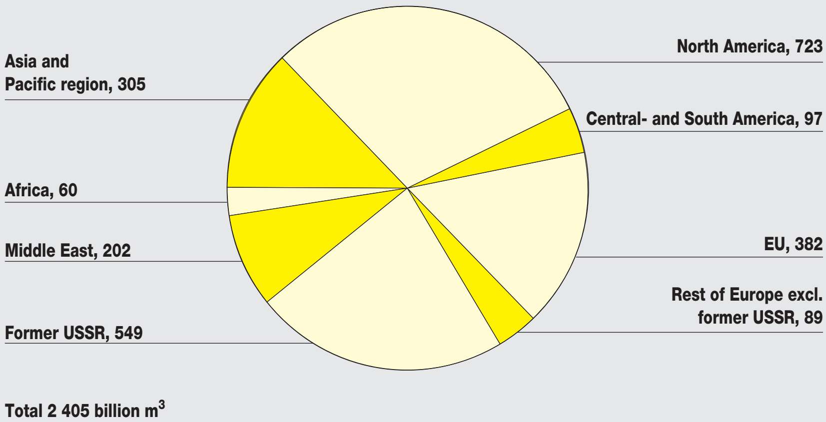


Figure 22 • World use of natural gas, 2001, billion m³



Only 3,1 % of the earth's natural gas reserves lie within Europe. At the present rate of use, this would last for only 16 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.

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 (1998/99:NU8) decided 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 2006. ■

Energy use

The use of energy can be divided up into three sectors: the residential and service sector etc., industry and transport. This chapter describes energy use in 2000/2001 and development since 1970 for each sector.

Residential and Service Sector etc.

In 2001, energy use in this sector amounted to 156.2 TWh, which is 8.4 TWh more than during the previous year. It represented almost 39 % of Sweden's total final energy use.

About 86 % 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 2 %, and other service applications for 7 %. These latter applications include 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 variations in energy demand from one year to another. To enable proper comparisons to be made, it is necessary to correct for climatic conditions. 2001 was almost 7 % 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 2001 amounted to 159.4 TWh, a reduction of 0.8 % relative to 2000.

Total energy use has remained stable

The total temperature-corrected energy use in the sector has remained relatively static between 1970 and 2001, 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 2001, total use of fossil fuels in the sector amounted to 26.8 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. However, the figures do not include the fossil fuels used for producing the electricity and district heating.

The number of dwelling units, i.e. single-family houses and apartments in apartment buildings, increased by almost 40 % between 1970 and 2001. However, the rate of new building during the 1990s was very low, amounting on average to 14 300 dwelling units per year, which can partly explain why energy use in the sector has not increased in recent years. 2001, however, saw an increase, with work starting on 19 200 dwelling units. Floor areas of commercial premises 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.

Figure 23a • Final energy use within the residential, commercial, service sector etc. 1970–2001

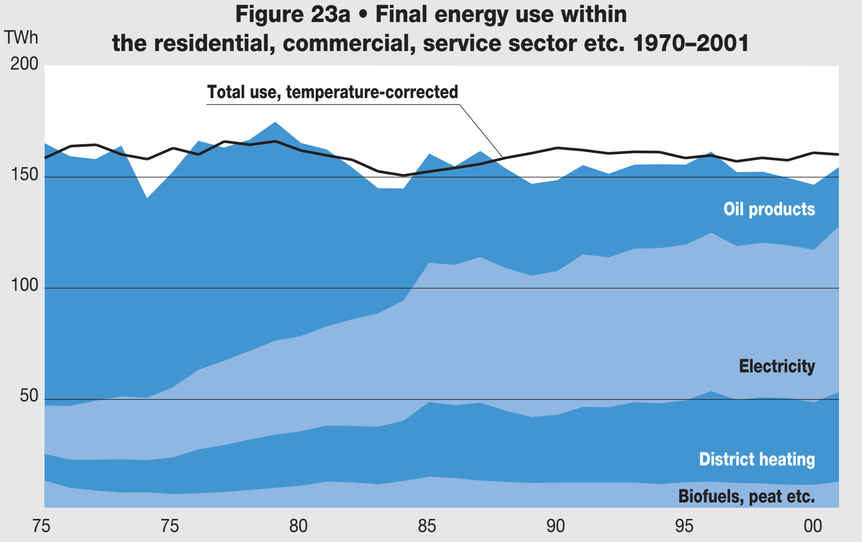
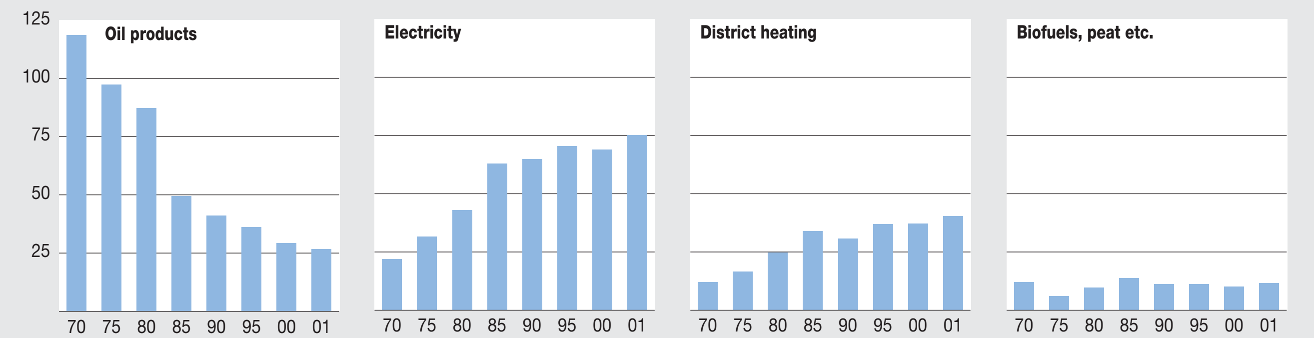


Figure 23b • Final energy use within the residential, commercial, service sector etc. by types of energy carriers



Heating and domestic hot water

Of the 93 TWh that were used for space heating and domestic hot water production in 2000, it is estimated that about 44 % were used in detached houses, 30 % in apartment buildings and 26 % in commercial premises and public buildings.

Over a third of all detached houses in the country were heated by electricity alone in 2001. Approximately 19 % of detached houses have only direct-acting electric heating, with 15 % having water-borne electric heating. About 11 % of detached houses are heated by oil alone, 7 % by district heating and 5 % by biofuels 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 increased substantially in the sector from 1970 to 1990, with the increase being greatest up to the first half of the 1980s. The use of electric heating in detached houses remained relatively stable during the 1990s. 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, for example, heat pumps, a pellets-fired stove or a wood chip- burning boiler.

Another common heating system in detached houses is electricity in combination with biofuels and/or oil firing, which allows users to change between electricity, oil or biofuels. The proportion of detached houses with such systems is over 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. The total use of electricity for space heating in detached houses and agricultural properties amounted to 13 TWh in 2001.

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 for 10 % of apartments, equivalent to 3 TWh of oil. The use of electric heating in apartment buildings is relatively low, amounting to 2 TWh in 2000.

The main source of heat in offices, commercial premises and public buildings is also district heating, with about 55 % 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 doubled between 1970 and 2000, from 9.2 TWh to 17.7 TWh, with most of this increase occurring during the 1970s and 1980s. Over the last ten years, use has been relatively stable. The rising use of domestic electricity can be explained by an increase in the number of households and greater ownership of domestic appliances.

Building services systems

The use of electricity for equipment in commercial premises and for building services systems has increased substantially, from 8.4 TWh in 1970 to 29.9 TWh in 2000. The reasons for this development include rapid growth in the 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, which has increased the need for lighting and other services. Lighting and ventilation which, at the beginning of the 1990s, accounted for about 70 % of the use of electricity in building services systems,

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Figure 24a • Electricity use in the residential, commercial, service sector etc. 1970–2000, corrected for climate variations

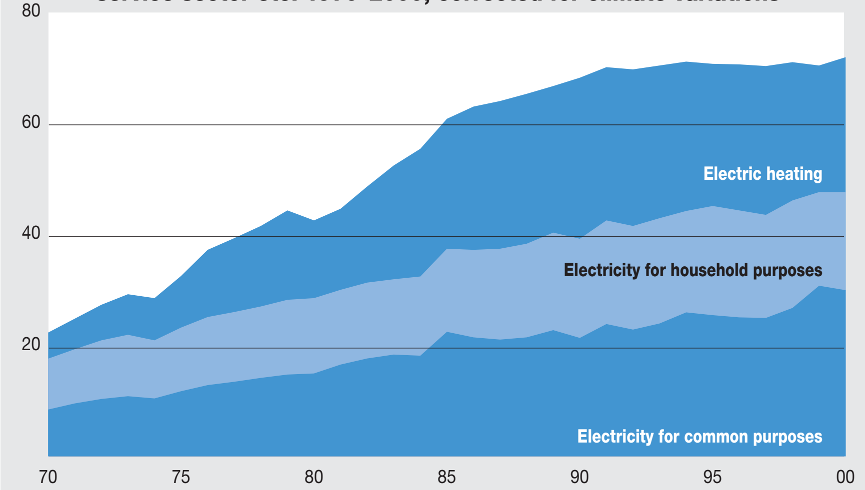
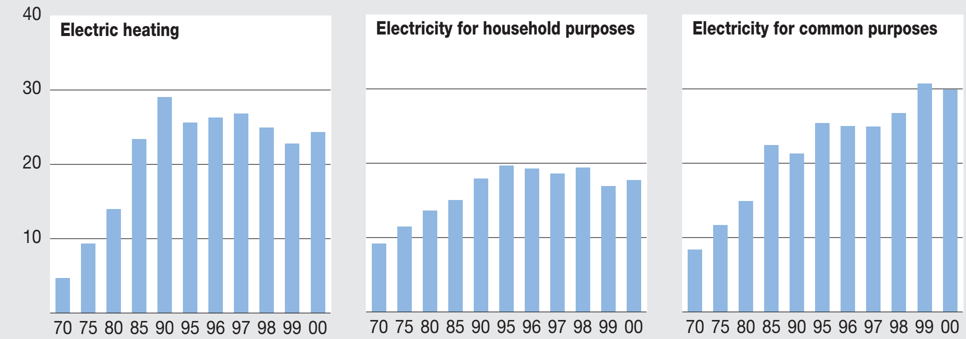


Figure 24b • Electricity use in the residential, commercial, service sector etc. by application, corrected for climate variations



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.

Energy saving measures

Despite an increase in total residential and commercial floor areas, and in the number of energy-demanding appliances in use, total temperature-corrected energy use in the sector in 2001 was no higher than during the 1970s. 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, this 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. 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 purchased 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. Heat pumps normally deliver 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.

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.

Industry

In 2001, industry used 9.9 TWh less energy than during 2000, amounting to 150.2 TWh, or 38 % of the country's final energy use.

Figure 25a • Final energy use in industry 1970–2001

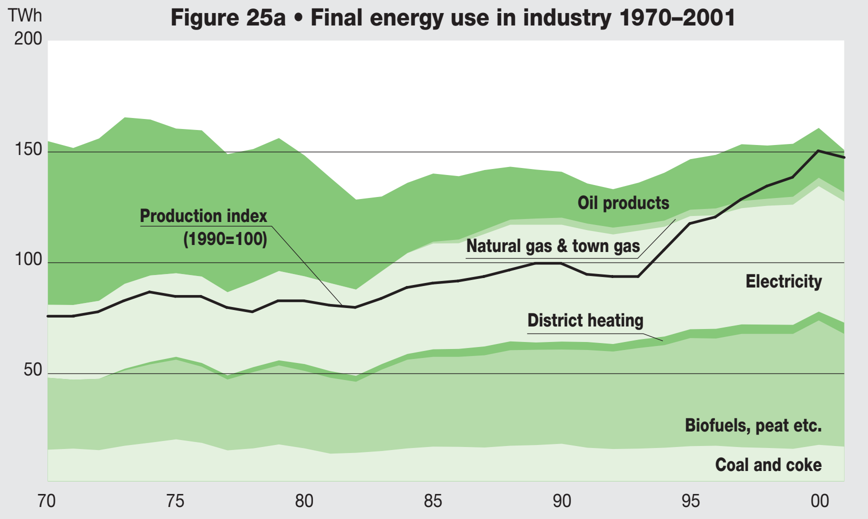
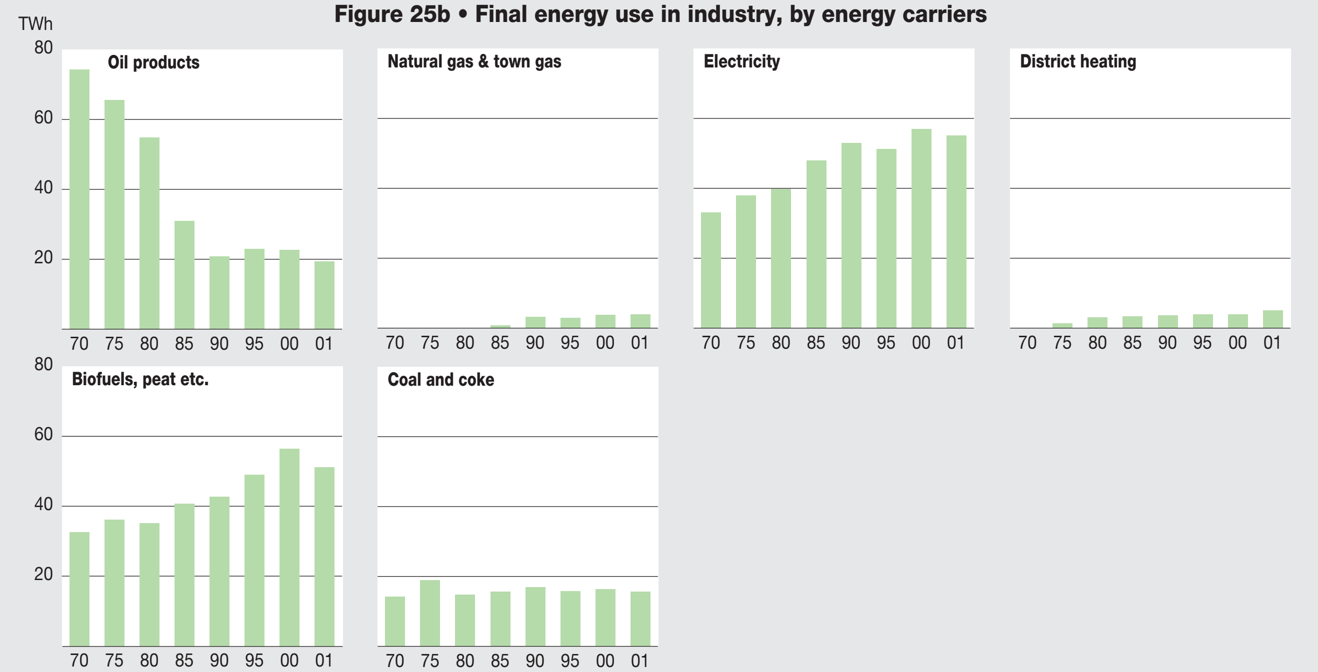


Figure 25b • Final energy use in industry, by energy carriers



Classified by energy source/carrier, this consisted of 19.3 TWh of petroleum products, 15.6 TWh of coal and coke and 55.1 TWh of electricity. Use of natural gas amounted to 3.9 TWh, and that of district heating to 5.1 TWh. Supplies of biofuels, peat etc. amounted to 51.2 TWh: of this, about 42 TWh were used in the pulp and paper industry, mainly in the form of black liquors. Final energy use in industry therefore consisted of 26 % of fossil energy and 34 % 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 47 %, the iron and steel industry about 15 % 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 % per annum, which was reflected by a fall of almost 6 % in energy use over the period. 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 until 2000. This was followed by a downturn in 2001, with a negative growth rate for industry as a whole. Output volume in 2001 was almost 70 % higher than in 1992, while energy use was only 13 % higher. During the same period, the use of electricity increased by 5,4 TWh, or 11 %. When comparing the time period from 1975–1997 with that from 1990–1997, it can be seen that the relationship between energy use and increased indus-

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Figure 26 • Specific use of oil in industry 1970–2001, 1991 price level

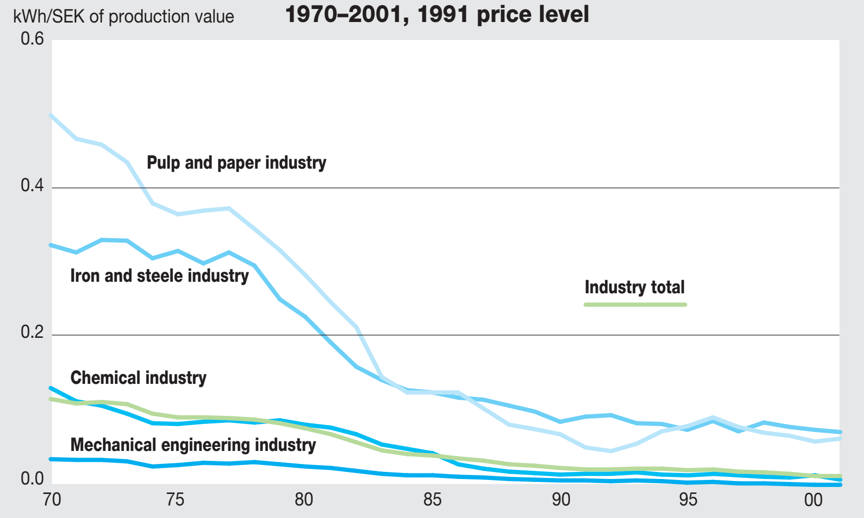


Figure 27 • Specific use of electricity in industry 1970–2001, 1991 price level

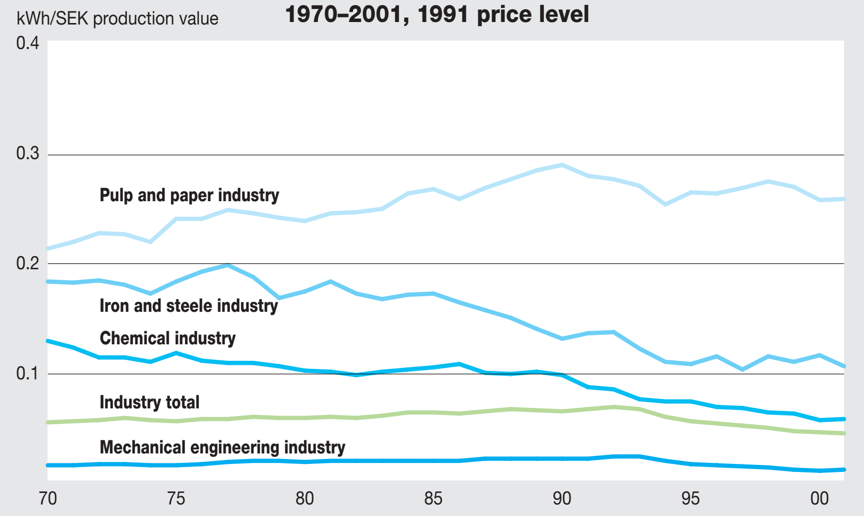
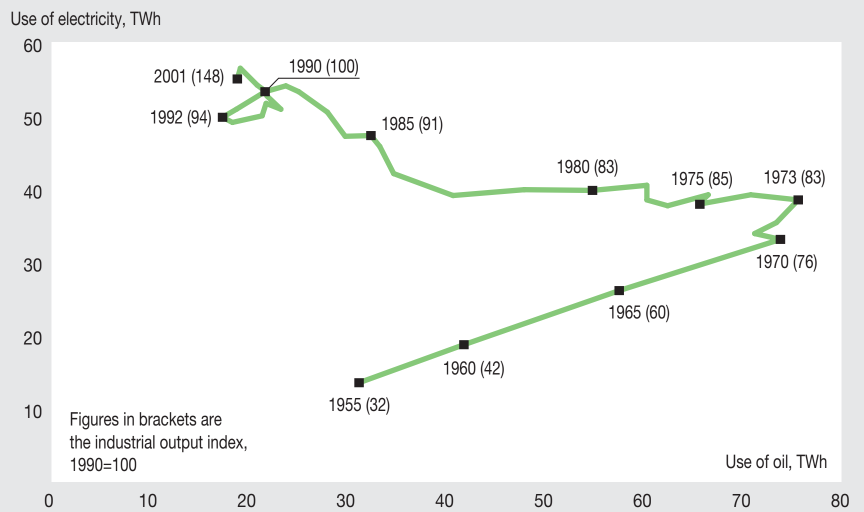


Figure 28 • Use of oil and electricity in industry 1955–2001



trial 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, due to 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 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 37 %. At the same time, the use of oil has fallen from 48 % to 13 % in terms of industry's energy use. Between 1970 and 2001, the proportion of biofuels, peat etc. has increased from 21 % to 34 % of total industrial energy use. However, over the period from 1992 to 2001, the use of oil products increased by 1.9 TWh, or 11 %. 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 2001, it fell by 52 %, 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 81 % between 1970 and 1992, while specific use of electricity increased by 23 %.

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 has continued to fall. Between 1992 and 2001, it fell by 34 %, with specific use of oil falling by 36 % and that of electricity falling by almost 34 %. 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. Over a longer period of time, specific energy use has been reduced by technical development and structural changes.

Transport

Energy use for transport (excluding foreign maritime traffic) in 2001 amounted to 92 TWh, or 23 % of the country's total final domestic energy use. Foreign maritime transport used 16,5 TWh of bunker oils. Energy use in the transport sector consists almost entirely of oil products, primarily petrol and diesel fuel. In 2001, the use of these two fuels provided 85 % of the country's energy requirement for domestic transport. The use of petrol increased in 2001, after having shown a declining trend over the previous few years. The use of diesel fuel also increased, but that of aviation fuel and bunker oils for foreign maritime traffic decreased. These reductions are due partly to economic conditions and partly to general world unease. Use is largely dependent on general economic conditions and technical development. The two main guide measures, intended to reduce the

Figure 29a • Final energy use in the transport sector 1970–2001

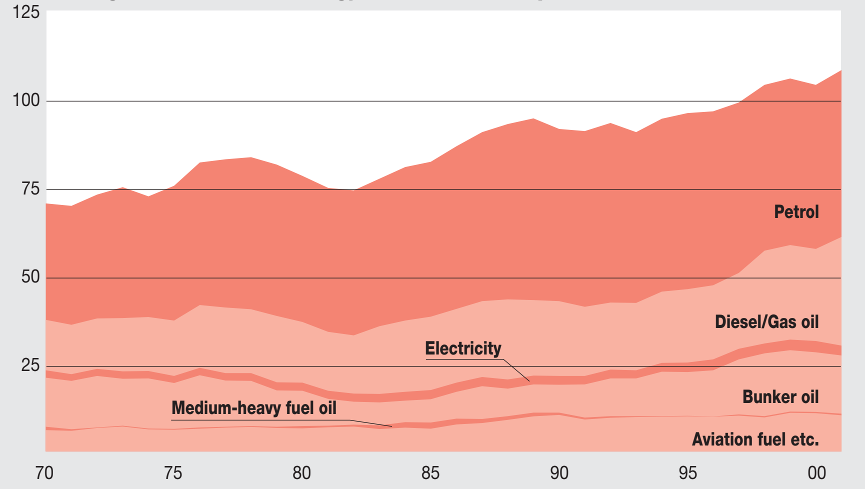
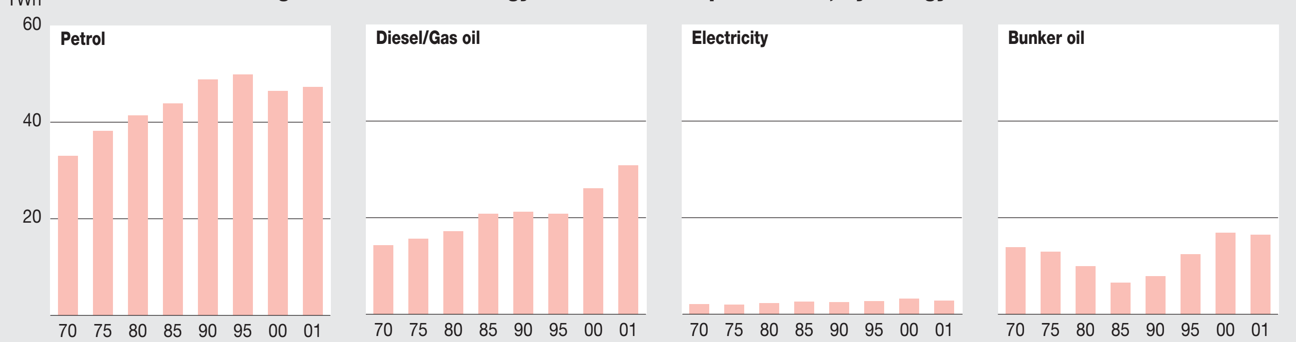


Figure 29b • Final energy use in the transport sector, by energy carriers



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, and accounts for less than 0.5 % of domestic transport energy use: 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.

Transport work

Since 1975, domestic passenger transport work has increased by 50 %, so that it amounted to 123 billion person-km in 2000. Road traffic accounts for 90 % of passenger transport work. Railways carry a further 7 % and air travel 3 %. Domestic goods transport has increased by 34 % since 1975, amounting 89 billion tonne-km in 2000. Of this, 43 % were carried by road, 22 % by rail and 35 % by ship. In recent years, goods transport by road has increased at the expense of rail and ship transport.

Environmental impact

All forms of transport produce emissions that are harmful 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 grow 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 EC to reduce carbon dioxide emissions from new passenger cars by 25 % by 2008, relative to the 1995 levels. Corresponding agreements have also been reached with Japanese and Korean vehicle manufacturers. Draft guidelines were presented last year for a 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 in 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. ■

The international perspective

World energy supply is dominated by fossil fuels, with oil being the most important of them. However, there are major differences in the use of energy between countries and between regions, due largely to the differing circumstances in each country. One such factor can be the country's GNP, while others are industrial structure and climate. An International Energy Agency forecast expects world demand for energy to increase by 2 % per annum until 2020, with most of this increase being accounted for by the developing countries.

Energy Supply in the EU

The EU is one of the heaviest 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.

A mix of energy sources

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. However, total use of oil in 1999 was somewhat lower than during previous years. On the other hand, the use of coal has fallen considerably, to less than half of its 1985 level, so that it nowadays supplies somewhat over 4 % of final energy use. The greatest reduction has occurred in Germany.

The use of natural gas continues to rise: since 1985, it has increased by 42 %, accounting for almost 24 % of final energy use in 1999. A European Commission forecast expects the consumption of natural gas to increase by almost 50 % between 1995 and 2010, after which it is expected to stabilise until 2020. 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.

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

Figure 30 • Total final energy use in the EU, 1985, 1990 and 1999

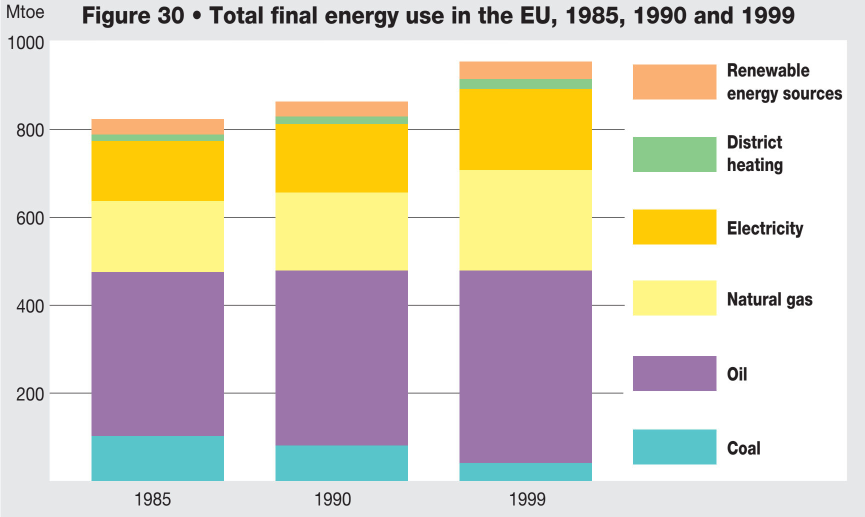
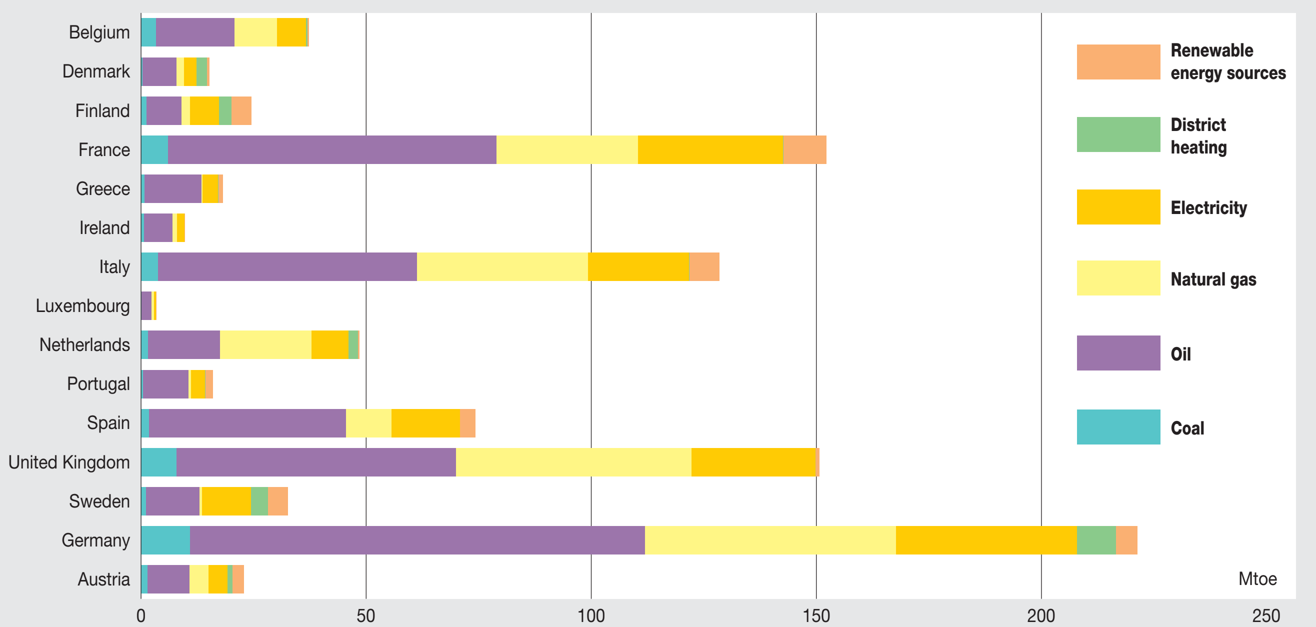


Figure 31a • Total final energy use, by the EU member states, 1999, Mtoe



is rising even more rapidly. From having been almost 60 % self-sufficient in energy supply in 1985, the EU was only 52 % self-sufficient in 1999. If nothing is done to break this trend, the EU may have to import up to 70 % of its energy within the next 20–30 years.

15 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 less than 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, but this is distorted by the country's substantial iron and steel industry and by the fact that the country's low motor fuel prices attract vehicles on their way across Europe to fill up with fuel there. As Sweden and Finland have a relatively high proportion of energy-intensive industries, together with a cold climate, they also have relatively high per-capita energy demands, as have Belgium and Holland.

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 32 shows energy use by different forms of energy carriers for the priority applicant countries and for the other applicant countries.

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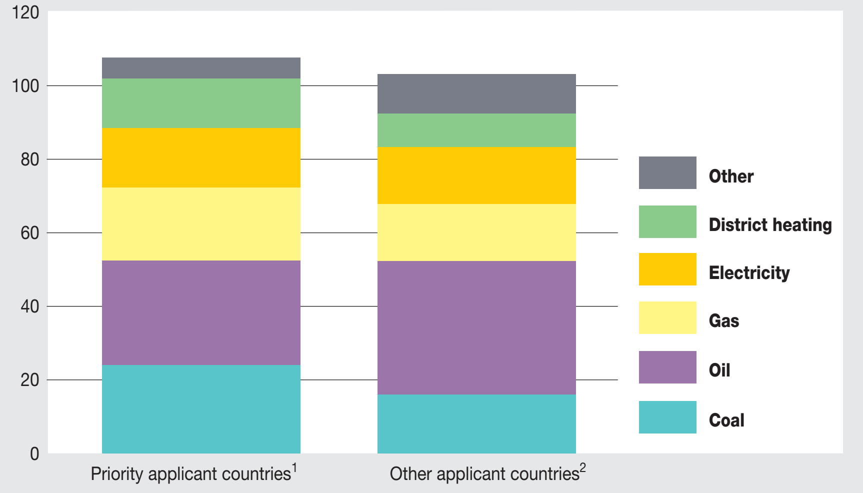
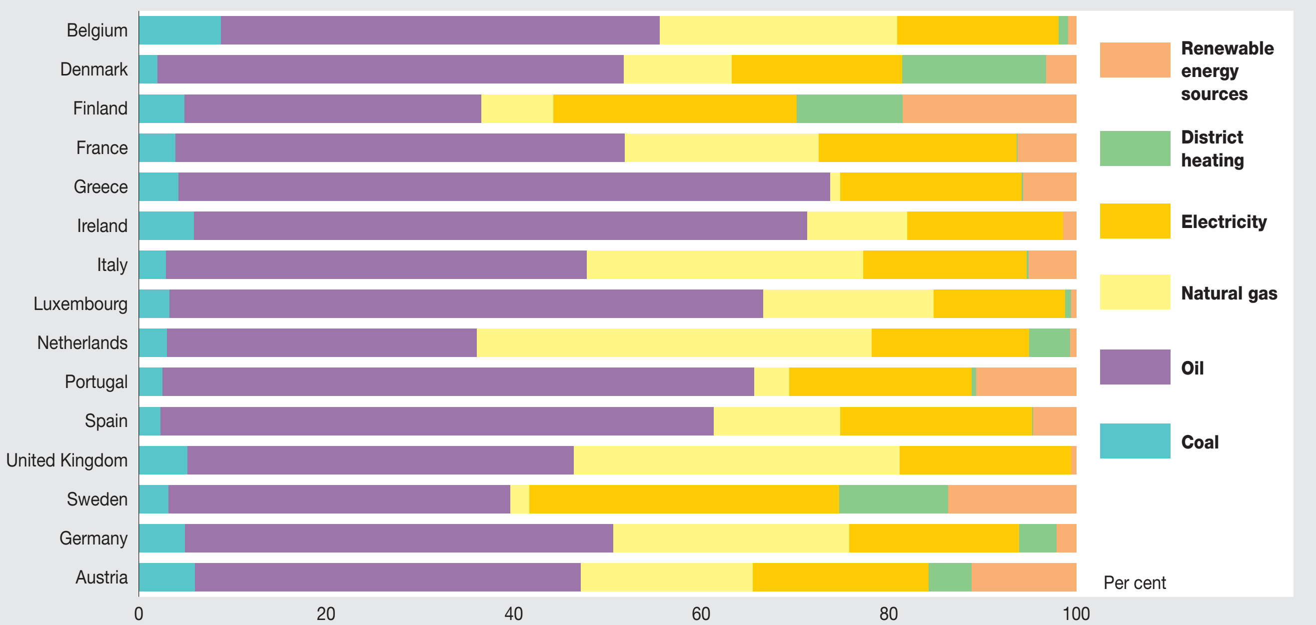
Figure 32 • Total final energy use in Central and Eastern European candidate countries, broken down by energy carriers, 1998



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

[2] Except Malta.

Figure 31b • Total final energy use, by member countries, 1999, proportions



World Energy Supply

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 22 % and natural gas at 21 %. Historical development since the 1980s until 1999 shows that 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 wind power account for about 2 % of world energy supply, while nuclear power accounts for 7 %. The use of biomass has been stable since 1990, contributing about 11 % to world energy supply.[11]

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.

Figure 33 • Worls oil reserves 2001 (billion barrels)

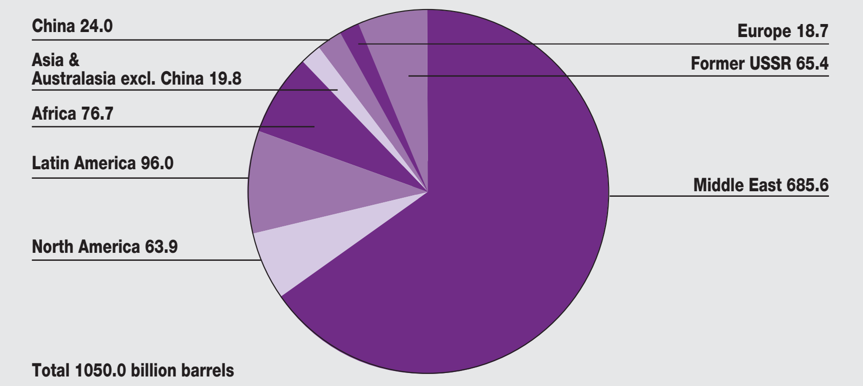
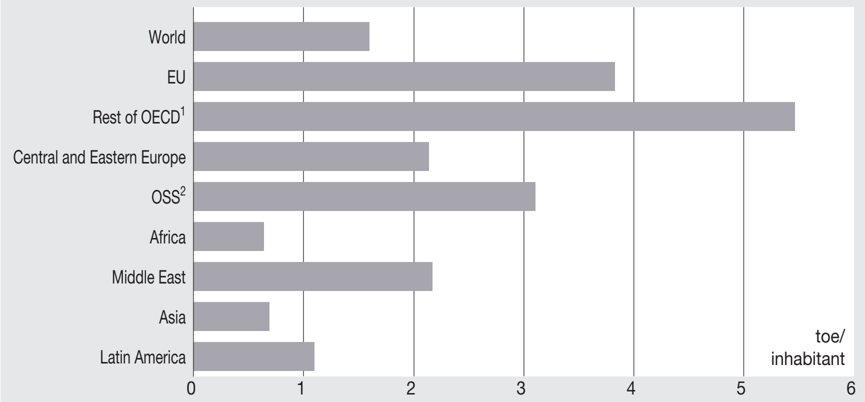


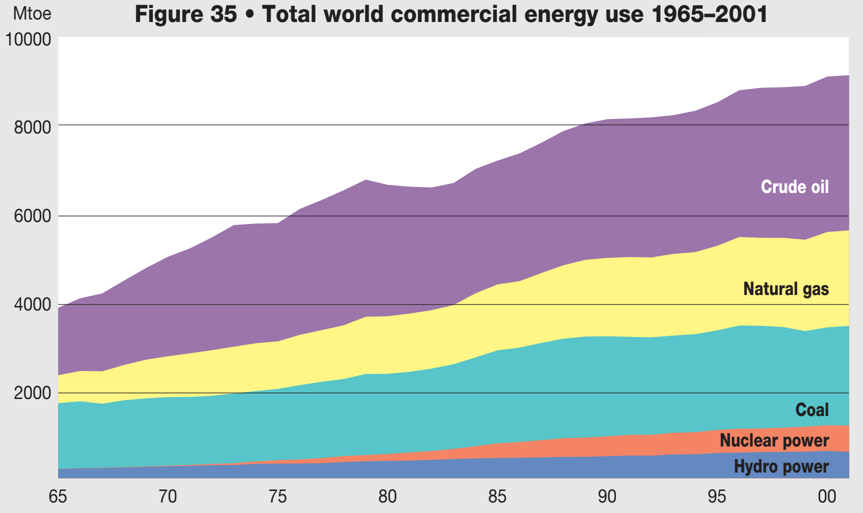
Figure 34 • Total energy use per inhabitant 1999



[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 35 • Total world commercial energy use 1965–2001



Note: The figures for hydro power have been revised by BP.
Source: The BP Statistical Review of World Energy 2002.

Resources and reserves

Proven resources of fossil fuels – 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:

- 216 years' production of coal
- 40 years' production of oil
- 62 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 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 oil market is dominated by OPEC which, together with Russia, also dominates the gas market. The EU increased its oil production by almost 4 % in 1999, but it is expected that both oil and gas production will decline within a few years. The greatest proportion of the world's energy production in 1999 came from the NAFTA countries (24 %), followed by Asia (20 %), the Middle East (13 %), the former Soviet Union (13 %) and Western Europe (10 %). As far as international trade is concerned, the Middle East, Africa and the former Soviet Union are net exporters. Asia is the region in which energy imports are rising the most rapidly, and is expected soon to be second only to the EU in terms of imports.

[11] European Commission, 2001.

Energy use in different regions

During the 1990s, total world energy use has risen less rapidly than it did during the 1980s. The average rate of increase during the 1990s was 0.8 %, but rose to over 2 % in 2000. In 2001 the rate of increase was 0.3 %.

Energy use in the OECD states increased more slowly during the 1980s than in the rest of the world, but this situation was reversed in the 1990s. Energy use in the former Soviet Union fell substantially during the first half of the 1990s, and continued to do so during the second half, but at a slower rate: a slight upturn can be seen for 1999. Within the European Union, energy use increased slightly during the 1990s. North America and Japan showed higher increases than in the EU up to 1997, and also in 1999, while 1998 was characterised by higher energy use in the EU but lower use in Japan. Since 1990, energy use has also increased substantially in Latin America, the Middle East and Asia.

World per-capita energy use varies considerably from one area to another. The EU, for example, uses six times as much energy per capita than does Africa or Asia, and three times as much as in 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. Future world per-capita energy use will be very dependent on development in Asia and the former Soviet Union.

Table 1 shows energy intensities, i.e. the amount of energy used per unit of GNP, in various parts of the world, in order to give an idea of how much energy is used in proportion to economic production.

It can be seen that Asia, Central and Eastern Europe and the former Soviet Union use four, five and nine times as much energy respectively per unit of output (expressed in economic terms) as does the EU. Asia, however, has shown a sharply reduced energy intensity during the 1990s. The countries in Eastern and Central Europe have also 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 decade.

Energy use in the former Soviet Union is highly inefficient. The break-up of the Soviet Union, has been reflected by greater use of energy per unit of output during the 1990s. However, energy utilisation is now expected to improve. 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	1999	1990/1980 % per year	1999/1990 % per year
World	553	507	455	-0.9	-1.2
EU	291	248	231	-1.6	-0.8
Rest of OECD[1]	447	369	349	-1.9	-0.6
Central- and Eastern Europe	1 622	1 481	1 162	-0.9	-2.7
OIS[2]	1 846	1 807	2 120	-0.2	1.8
Africa	932	1 092	1 110	1.6	0.2
Middle East	370	688	828	6.4	2.1
Asia	1 756	1 357	960	-2.5	-3.8
Latin America	470	492	495	0.5	0.1

[1] USA, Canada, Mexico, Norway, Switzerland, Iceland, Australia, Japan, New Zealand and Turkey.
[2] The Organisation of Independent. Consists of twelve states, of which Russia and Ukraine are the largest. For statistical reasons, figures for the Baltic states have also been included in the table.
Source: European Commission, ’2000- Annual Energy Review’.

Forecasts

According to a forecast from the International Energy Agency (IEA) in 2001, world energy demand is expected to continue to rise steadily, at about 2 % per annum until 2020. Much of the increase is expected to occur in the developing countries, with about 68 % of the increased demand originating from them.

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.

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 price of gas will rise towards the end of the scenario period.

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 %.

Forecasts for carbon dioxide emissions

The IEA reference scenario expects a continued increase in carbon dioxide emissions, rising at over 2,1 % per year until 2020, with the fastest-growing developing countries making a significant contribution. China is expected to increase its emissions by 3.3 billion tonnes, which can be compared with the 2.8 billion 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 countries. ■

Taxes and prices

The use of energy has been taxed in Sweden since the 1950s: the objectives have varied over the years. The present policy to encourage sustainable development and to reduce environmental impact has meant that taxes on environmentally harmful activities have been increased, while taxes on labour have been reduced: one of the objectives of this shift is to reduce carbon dioxide emissions. Energy taxation is at present under review. This chapter describes the shift in the emphasis of taxation, types of taxes for various parties and fuel price developments.

Energy Taxes

The objectives of energy taxation have varied over the years: originally, the objective was to finance the State's public spending requirements, but in later years the emphasis has increasingly been on 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, the aim was 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.

The energy taxation system is complex. There are different taxes on electricity, energy, carbon dioxide, sulphur and NOx, 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 in the rest of Sweden, whether it is being used by domestic consumers, industry or the energy sector, and so on. In 2001, revenues from energy and environmental spot taxes raised over SEK 53.6 billion, or about 2,4 % of GNP. This revenue is expected to remain more or less the same over the period 2002–2004. Work on reforming the energy taxation system forms an important part of the shift towards 'greener' taxation, which is intended to encourage more efficient use of energy and the use of biofuels, to provide incentives for companies to reduce environmental impact, to ensure the competitiveness of industry, to create the right conditions for domestic production of electricity and to simplify the energy system.

Table 2 • General energy and environmental taxes from 1st January 2002, excluding value-added tax

		Energy tax	Carbon dioxide tax	Sulphur tax	Total tax	Tax öre/kWh
Fuels[1]						
Gas oil, SEK/m³	(0.05 < % sulphur < 0.2)	707	1 798	54	2 559	25.7
Heavy fuel oil, SEK/m³	(0.4 % sulphur)	707	1 798	108	2 613	24.7
Coal, SEK/tonne	(0.5 % sulphur)	301	1 564	150	2 015	26.7
LPG, SEK/tonne		138	1 890	-	2 028	15.9
Natural gas, SEK/1000 m³		229	1 346	-	1 575	14.2
Crude tall oil, SEK/m³		2 505	-	-	2 505	25.1
Peat, SEK/tonne, 45 % moisture (0.24 % sulphur)		-	-	40	40	1.5
Motor fuels						
Petrol, 95 octane, environmental class 1, SEK/l		3.16	1.46	-	4.62	51.1
Diesel, environmental class 1, SEK/l		1.32	1.8	-	3.12	31.9
Natural gas/methane, SEK/m³		-	1.07	-	1.07	9.6
Gasol, kr/kg		-	1.3	-	1.3	10.1
Electricity use, öre/ kWh						
Electricity, northern Sweden		14.0	-	-	14.0	14.0
Electricity, rest of Sweden		19.8	-	-	19.8	19.8
Electricity, gas-, heat or hot water supply						
Northern Sweden		14.0	-	-	14.0	14.0
Rest of Sweden		17.4	-	-	17.4	17.4
Electric boilers > 2 MW, 1/11–31/3						
Northern Sweden		16.4	-	-	16.4	16.4
Rest of Sweden		19.8	-	-	19.8	19.8

Note. In addition to the taxes shown, value-added tax is levied at a rate of 25 % (refundable to companies and industry). An environmental levy of SEK 40 kr/kg of emitted nitric oxide is payable for boilers, gas turbines and stationary combustion plant having an annual output of 25 GWh or more, but is repaid in proportion to the plant's energy production and in inverse proportion to emissions.The energy and carbon dioxide taxes on LPG and natural gas, when they are used as motor fuels, amount to SEK 1 298/ tonne and SEK 1 067/1 000 m³ respectively. Note that the conversion factors for certain energy carriers have been altered with effect from 2002.

[1] Fuels used for electricity production are exempted from energy and carbon dioxide taxes. However, some of the fuel is regarded as being used for internal purposes, and is therefore taxed. Biofuels are untaxed for all users. Fossil fuels used for heat production in CHP plants are taxed at half the normal energy tax rate.

Source: The National Tax administration, processed by the Swedish Energy Agency.

Table 3 • Energy and environmental taxes for industry, agriculture, forestry and fisheries from 1st January 2002, excluding value-added tax

		Energy tax	Carbon dioxide tax	Sulphur tax	Total tax	Tax öre/kWh
Gas oil, SEK/m^3	(0.05 < % sulphur < 0.2)	-	539	54	593	6.0
Heavy fuel oil, SEK/m^3	(0.4 % sulphur)	-	539	108	647	6.1
Coal, SEK/tonne	(0.5 % sulphur)	-	469	150	619	8.2
LPG, SEK/tonne		-	567	-	567	4.4
Natural gas, SEK/1000 m^3		-	404	-	404	3.6
Crude tall oil, SEK/m^3		539	-	-	539	5.4
Peat, SEK/tonne, 45 % moisture (0.24 % sulphur)		-	-	40	40	1.5

Note. Manufacturing industry pays no energy tax, and only 30 % of the general carbon dioxide tax.
Source: The National Tax Administration, processed by the Swedish Energy Agency.

The Budget Bill and green tax exchange

It was decided in the spring of 2000 that a total of about SEK 30 billion of taxation revenue should be transferred over a ten-year period. This is proposed to continue during 2003, with higher energy taxes that 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 carbon dioxide tax on fuels was raised by 15 % on 1st January 2002, which is intended to increase the impact of carbon dioxide tax in relation to energy tax, and to help to reduce carbon dioxide emissions. The energy tax on fuels, such as petrol and diesel fuel, was reduced by an amount corresponding to the increase in the carbon dioxide tax, although there was no rise in the tax on LPG, natural gas or methane when used as motor fuels. The 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.

Higher carbon dioxide taxes mean that electricity would have become cheaper in relation to other forms of energy carriers, and so the tax on electricity was raised by 1.2 öre/kWh from 1st January 2002.

The boundary for exemption from the sulphur tax was reduced from 0.1 % by weight to 0.05 % by weight. When setting the rate of tax as determined by the percentage of sulphur by weight, the percentage figure is rounded up to the nearest tenth of a percent. However, if the sulphur content exceeds 0.05 %, but not 0.2 %, the taxation basis weight is rounded up to 0.2 %.

The tax rates (except the sulphur tax) of all fuels, including motor fuels, have been increased by 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 increased by 15 % with effect from 1st January 2002. A sulphur tax was introduced in 1991, and is levied 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 NOx was introduced in 1992, at the rate of SEK 40/kg of NOx emissions from boilers, gas turbines and stationary combustion plant supplying at least 25 GWh per annum. However, it is intended to be fiscally neutral, and is repaid to operators of plant in proportion to their energy production and in inverse proportion to their NOx emissions, so that only those with the highest emissions are net payers.

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 NOx levy and sulphur tax in certain cases. However, the use of electricity is taxed, at rates that vary depending on in which part of the country the electricity is used, and on what it is used for. Nuclear power plants were previously taxed on the basis of their electricity production, but since 1st July 2000 the tax has been based on the gross thermal power output from their reactors[12]. 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.

A system of tradable certificates for electricity from renewable sources will be introduced on 1st January 2003. During a transition period, this will be complemented by targeted subsidies for wind power, probably in the form of an environmental bonus. It will be progressively reduced over a number of years.

Fuels used for heat production pay energy tax, carbon dioxide tax and, in certain cases, sulphur tax, as well as the NOx levy. The use of heat, however, is not taxed. In principle, biofuels and peat are tax-free for all users, although the use

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

Figure 36 • Current energy prices in Sweden including taxes 1970–2001

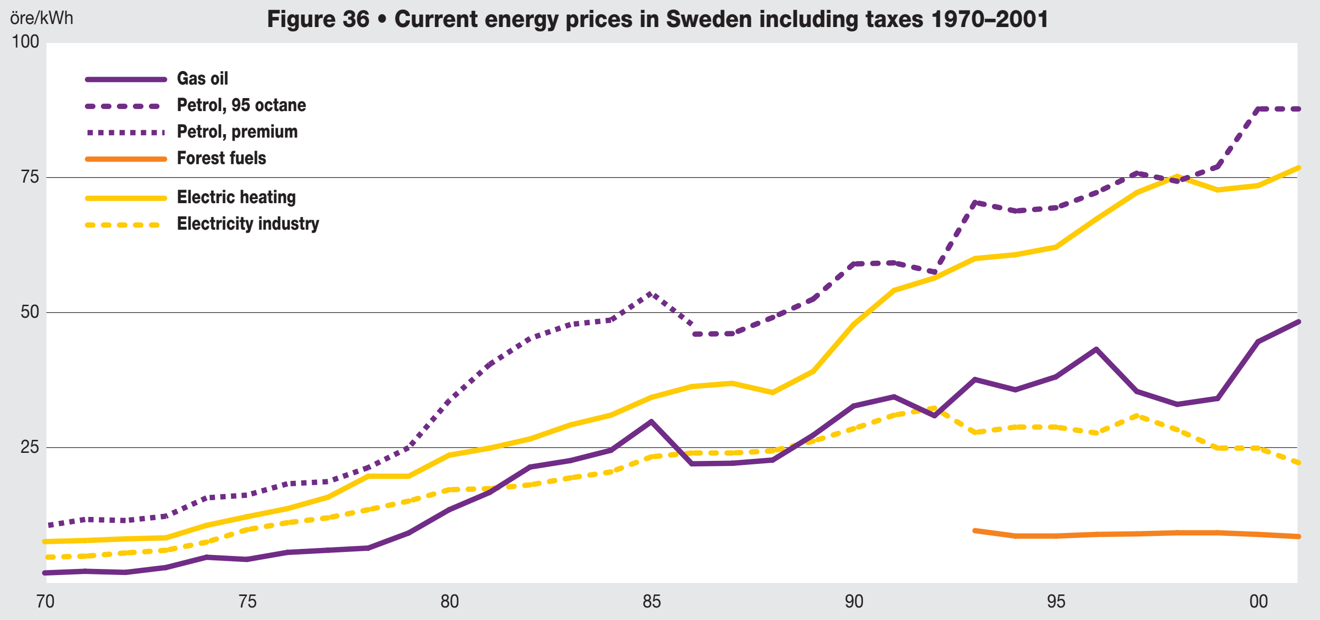


Table 4 • Fuel prices and price of electric heating in Sweden, excluding taxes and value-added tax, actual prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
Crude oil, US $/barrel	23.81	20.05	19.37	17.07	15.98	17.18	20.8	19.3	13.11	18.25	28.98	24.77
Gas oil, SEK/m³	2 146	2 131	1 790	2 207	2 004	2 205	2 603	1 759	1 457	1 580	2 606	2 563
Medium-heavy fuel oil, SEK/m³	1 702	1 535	1 316	1 652	1 525	1 525	1 526	1 014	853	997	1 850	2 170
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	3.12
Coal, SEK/tonne	358	366	307	309	317	336	340	367	372	327	355	449
Forest chips, SEK/m³				95.2	87.2	87.2	89.6	90.4	92.0	92.0	89.6	86.6
Electric heating, öre/kWh	31.5	36.1	37.9	40.0	39.7	40.7	43.6	45.2	45.0	43.0	42.2	43.3

Note. A table defining various environmental classes is included in the tables appendix, *Energy in Sweden; Facts and Figures*.
Source: The Swedish Petroleum Institute, Eurostat, Statistics Sweden, BP and The Riksbank, processed by the Swedish Energy Agency.

of peat attracts the sulphur tax. Special rules apply for simultaneous production of heat and electricity (CHP): the portion of 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.

The latest energy policy notice sets out planned changes to taxation of CHP, bringing it into line with taxation of back-pressure power in industry. Further details will be included in the 2003 Budget Bill.

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 in the rest of the country. Manufacturing industry, horticulture and – since 1 st 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 2001. 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 harmful classes. Apart from the increase due to indexing, petrol and diesel fuel taxes have not been raised for 2002. 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. This was followed by a fall to slightly below USD 25/barrel in 2001. The prices of processed oil products track the price of crude oil, and so have a substantial impact on consumer prices. The import price of coal rose considerably in 2001, stabilising at a higher level in 2002. The availability of forest chips was good in 2001, and the price continued on a relatively stable level.

The end prices paid by consumers depend to a considerable extent 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 2001, 57 % was tax, which can be compared with 53 % in 2000. The proportion of the total price of petrol and diesel fuel made up of tax remains unchanged, at 67 % for petrol and 55 % for diesel fuel.

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 valueadded 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 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 January 2001	28.3	37	76.8	99.8
Total price, 1st January 2002	34	43.8	87.9	111.3

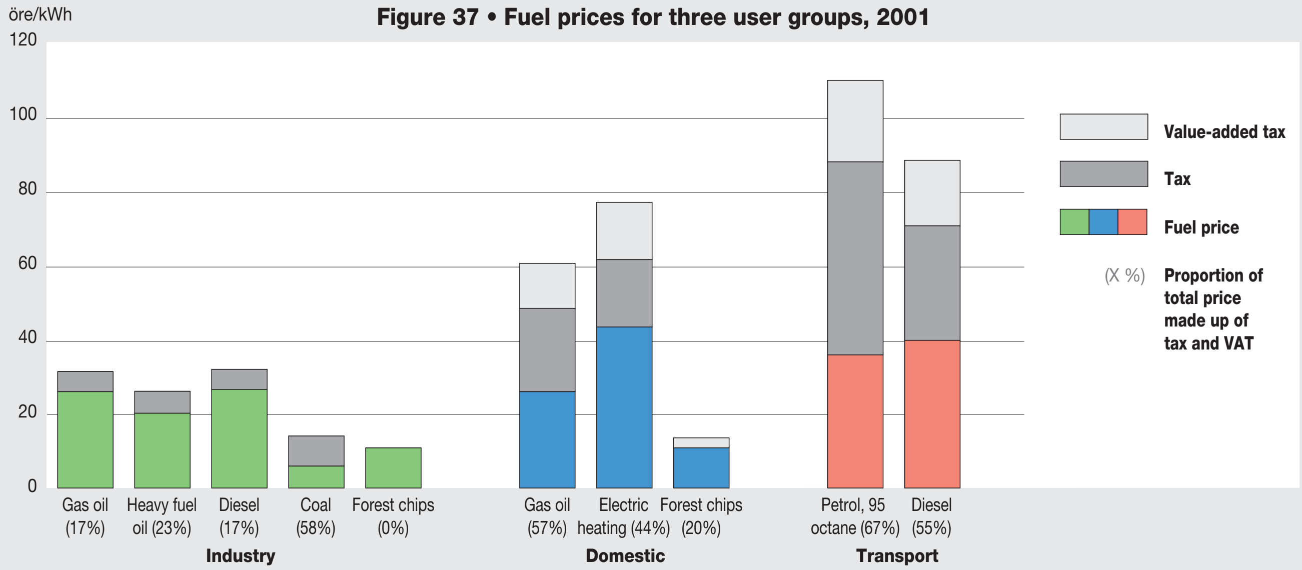
[1] Annual energy use, 140 000 MWh: power demand, 20 MW.
[2] Annual energy use, 350 MWh: power demand, 100 kW or 160 A.
[3] Annual energy use, 20 000 kWh: power demand, 20 A, supply fuse rating.
[4] Annual energy use, 5 000 kWh: power demand, 16 A, supply fuse rating.

Table 6 • Total fuel prices, including taxes and value-added tax, for industrial and domestic users, 2001

	Industry	Domestic
Gas oil, SEK/m³	3 097	5 973
öre/kWh	31	60
Heavy fuel oil,		
SEK/m³	2 812	
öre/kWh	26	
Diesel fuel[1],		
SEK/m³	3 156	
öre/kWh	31.9	
Coal, SEK/tonne	1 064	
öre/kWh	14	
Forest chips[2],		
SEK/tonne	259	324
öre/kWh	10.8	13.5

[1] Per road tanker-load.
[2] 50 % moisture content.

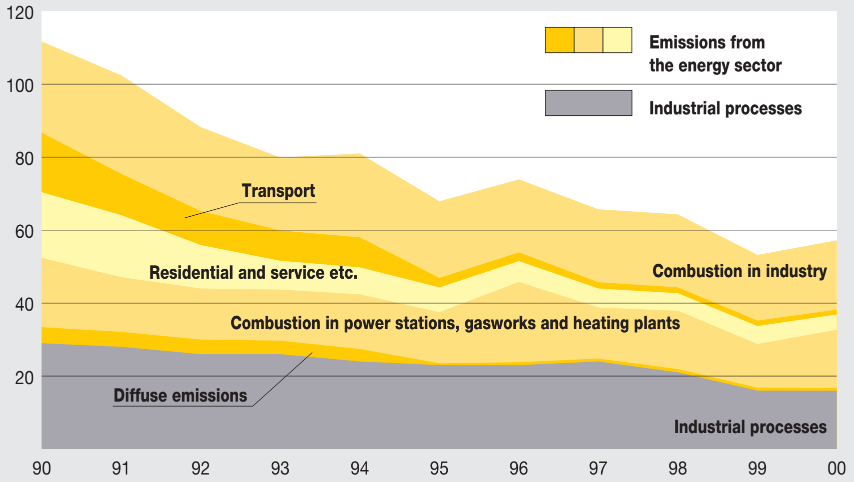
Figure 37 • Fuel prices for three user groups, 2001



The environmental situation

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. Environmental impact occurs at local, regional and global level. The boundaries between these levels are fluid, being determined not only by the type of emission, but also by how far it spreads. There are several working areas at regional and global levels where countries are working together to attempt to tackle environmental problems.

Figure 38a • Emissions of sulphur dioxide (SO_2) in Sweden 1990–2000



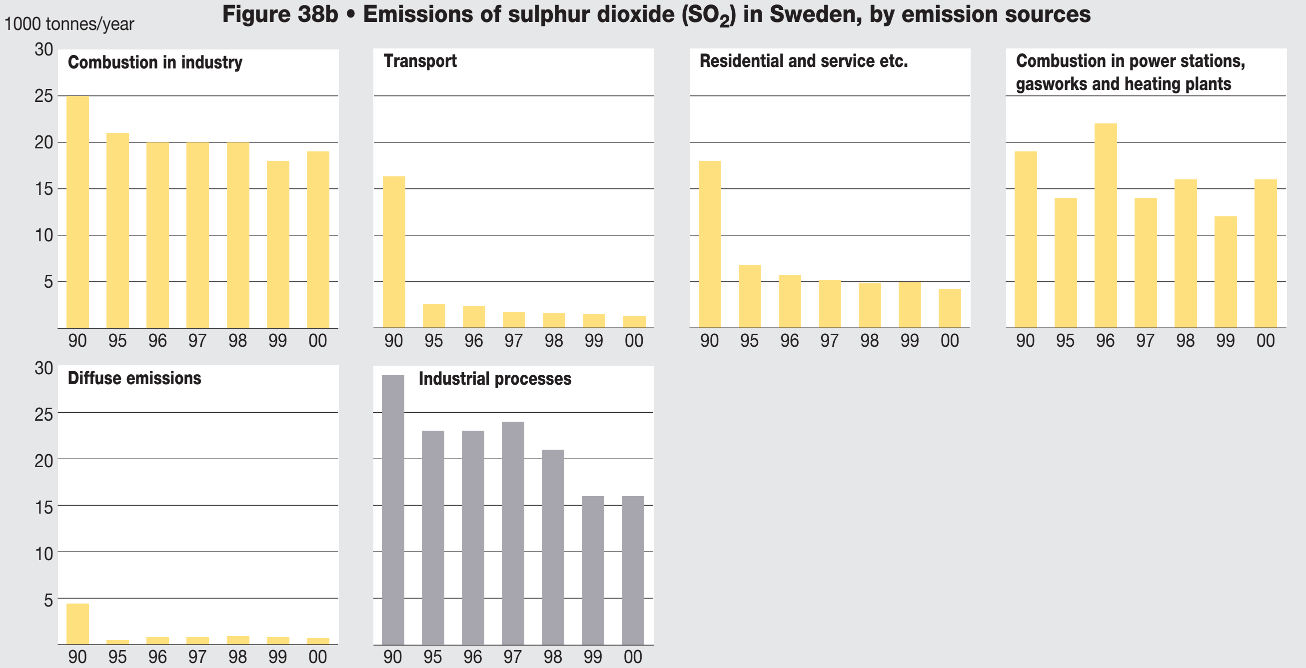
Local Environmental Problems

Examples of local environmental problems include the fallout of dust from power stations or industrial processes, smog, and emissions of carcinogens. 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. They are generally more difficult to deal with than local environmental problems. 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.

Figure 38b • Emissions of sulphur dioxide (SO_2) in Sweden, by emission sources



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 Europe, it was in the Scandinavian countries that the problem was first noticed, 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, as this is the metal that is first precipitated. This affects the growth of forests and results in the disappearance of many sensitive species of plants and animals, both on land and in 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, 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 southwest. Large quantities of air pollutants are also carried over Sweden by southerly winds powered by anticyclones 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, although in lesser quantities, to its neighbouring countries, primarily Russia, Finland, Norway, Poland and the Baltic states, although most of the pollution is precipitated in the sea. Swedish emissions come primarily from industrial processes, the combustion of oil and from transport.

Reducing sulphur emissions

Emissions in both Sweden and the rest of Europe have fallen considerably since 1980. Sweden ratified the Helsinki Protocol in 1986, concerning reduction of sulphur emissions of at least 30 % by 1993, as compared with 1980 emission levels. This Protocol had been prepared as part of the UN Convention on Long Range Transboundary Air Pollution that had in turn been prepared by the UN Economic Commission for Europe (ECE). However, Sweden set itself a more ambitious target of reducing sulphur emissions to 20 % of their 1980 levels by 2000. This reduction was actually achieved in 1993, partly as a result of less use of oil and partly as a result of lower sulphur contents in the oil.

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

Country	2000 emission relative to 1988, %
Austria	-89
Sweden	-88
Finland	-87
Norway	-81
Denmark	-94
Germany[1]	-89
United Kingdom	-76
Poland	-63

[1] The figure for Germany represents the percentage reduction between 1999 and 1988.

Source: Data from http://webdab.emep.int, processed by the Swedish Energy Agency.

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Figure 39a • Emissions of oxides of nitrogen (expressed as NO_2) in Sweden 1990–2000

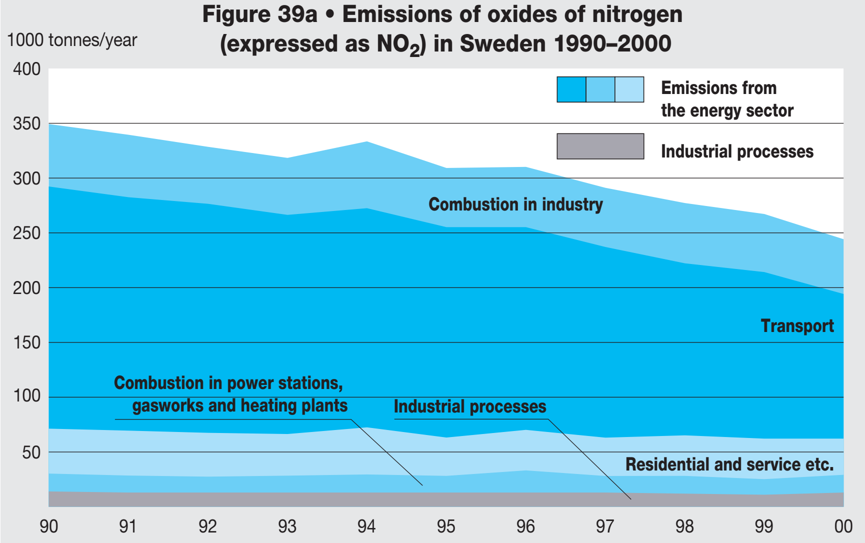
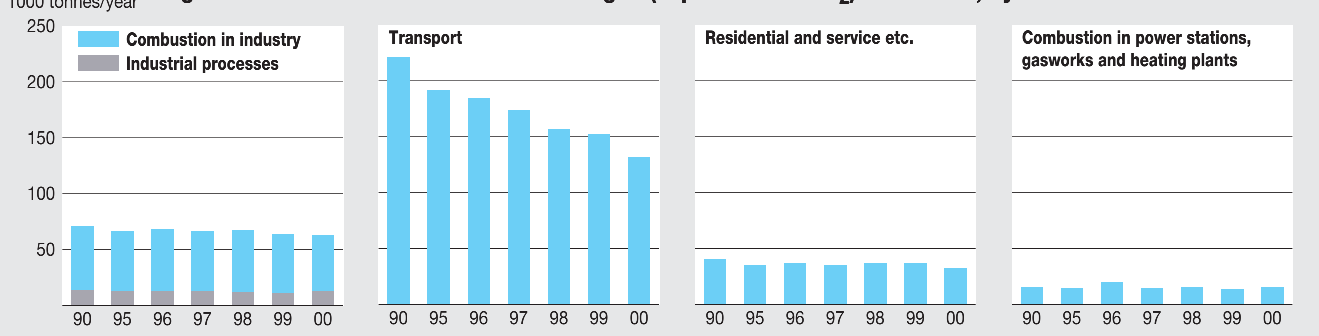


Figure 39b • Emissions of oxides of nitrogen (expressed as NO_2) in Sweden, by emission sources



At the international level, the Oslo Protocol on further reductions in sulphur emissions, drawn up by ECE in 1994, represented another step towards a reduction in emissions. Under the terms of the protocol, several 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. Nevertheless, when nitrogen levels in the ground reach saturation, nitrogen compounds make a considerably greater contribution to acidification than they do when the ground is not nitrogen-saturated. They also make a substantial contribution to another major problem, eutrophication.

Figure 40 • Deposition of oxides of sulphur in Sweden 1998 from various sources (%)

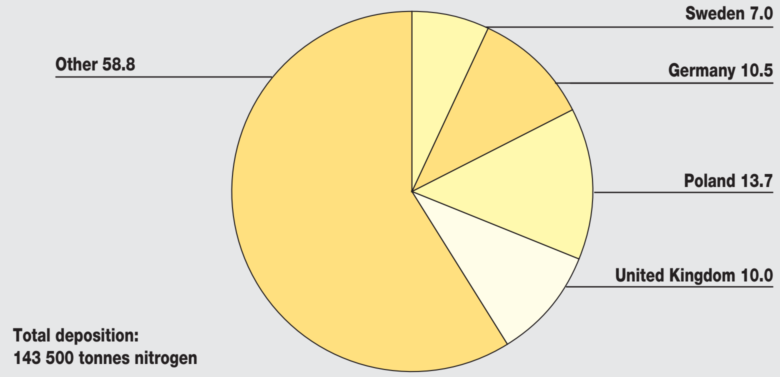
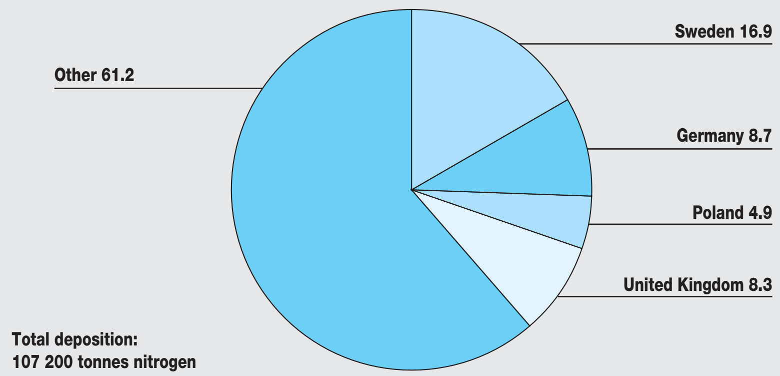


Figure 41 • Deposition of oxides of nitrogen in Sweden 1998 from various sources (%)



Eutrophication

Eutrophication, particularly of lakes and the sea, is largely due to emissions of nitrogen. On the other hand, 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, stinging nettles and willow herb, at the expense of other species, such as mosses. Eutrophication of water ecosystems results in excessive growth of plankton algae and 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 increased nutrient input, resulting in algae blooms and oxygen deficit. Lack of oxygen in deeper bottom layers make it difficult for cod to reproduce, and also contribute to a serious depletion of benthic and demersal 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, mainly due 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 NOx precipitation in Sweden originates from domestic sources. The largest contributors to NOx precipitation from other countries are Germany, the UK and Denmark.

Sweden has ratified the Helsinki Convention, which came into force on 17th January 2000, and is intended to protect the marine environments in the Baltic from pollution. A priority area in this work is to reduce eutrophication. The work is being carried out jointly by Denmark, Estonia, the EU, Finland, Germany, Latvia, Lithuania, Poland, Russia and

Sweden. OSPAR, the Convention for the Protection of the Marine Environment of the North-East Atlantic, which came into force in 1998, includes the objective to reduce marine eutrophication. Parties to it are Norway, Iceland, Switzerland, the EU and all individual EU states except Greece, Austria and Italy.

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 most 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.

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 methane, nitrous oxide (laughing gas – N_2O), ground-level ozone, HFCs and PFCs (refrigerants) and sulphur hexafluoride (an electrical insulator). 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 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 top place, followed by Luxembourg, Australia and Canada. These countries also have high emissions in relation to their GNPs, although the old Eastern Bloc countries such as Poland and the Czech Republic have even higher levels.

Sweden contributes a few parts per thousand to the world's carbon dioxide emissions, with per-capita and GNP-proportionate emissions being below the average both for the OECD countries and for the EU. Carbon dioxide emissions in 2000 were at the same level as in 1990.

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 suf- →

Figure 42a • Emissions of carbon dioxide (CO_2) in Sweden 1990–2000

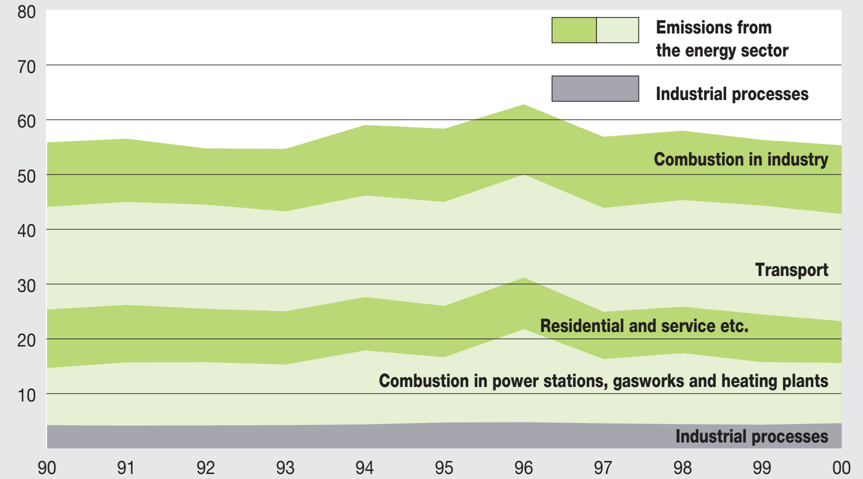
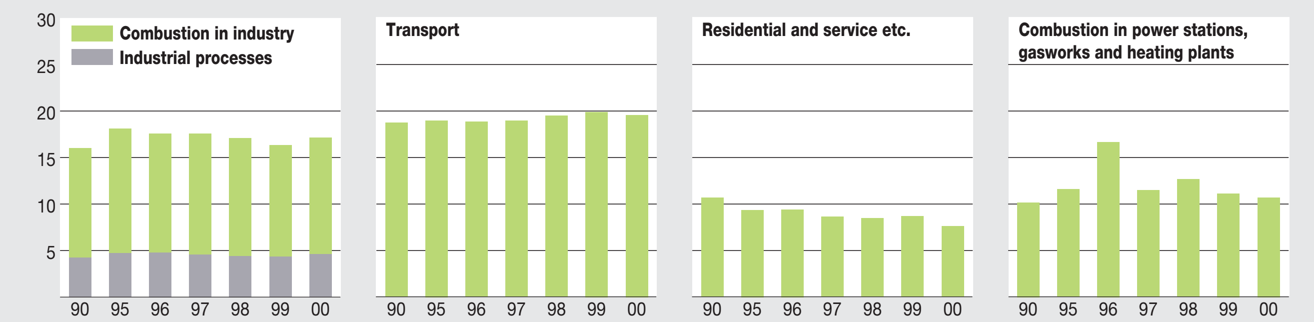


Figure 42b • Emission of carbon dioxide (CO_2) in Sweden, by sources



ficiently 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 should also regularly submit details of their progress and the steps that they have taken to the UN.

At the conference 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 conference 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 I countries, i.e. the OECD states and the previous Eastern European states, for the period 2008–2012. The reductions are expressed in relation 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 apportioning of this aggregate reduction, based on factors such as per-capita emissions and the structure of energy and industry sectors, permitted Sweden to increase its emissions by 4 %. However, Sweden has adopted a more ambitious target, of reducing its emissions by 4 %.

'Flexible mechanisms', in the form of emission trading, joint implementation and clean development mechanisms, are included in the Kyoto Protocol in order to facilitate more cost-efficient reductions. Emission trading means that countries that have emitted less than their permitted proportion of emissions can sell their remaining portion to another country that is unable to meet its obligation. Joint implementation involves effecting some improvement in another country and being credited in the home country with the resulting reduction in emission. Clean development mechanisms involve essentially the same as joint implementation, except that the improvements are carried out in a non-Annex 1 country.

Figure 43 • Emissions of sulphur dioxides (SO_2) in Europe 1980–1999

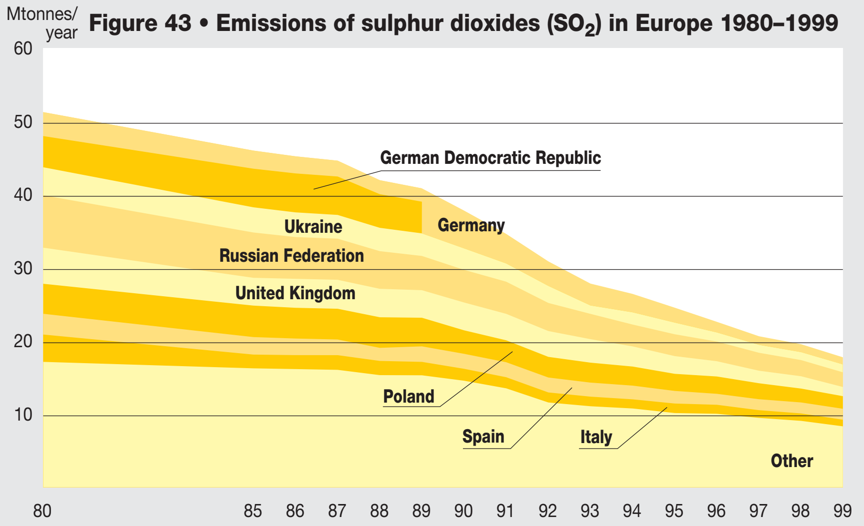
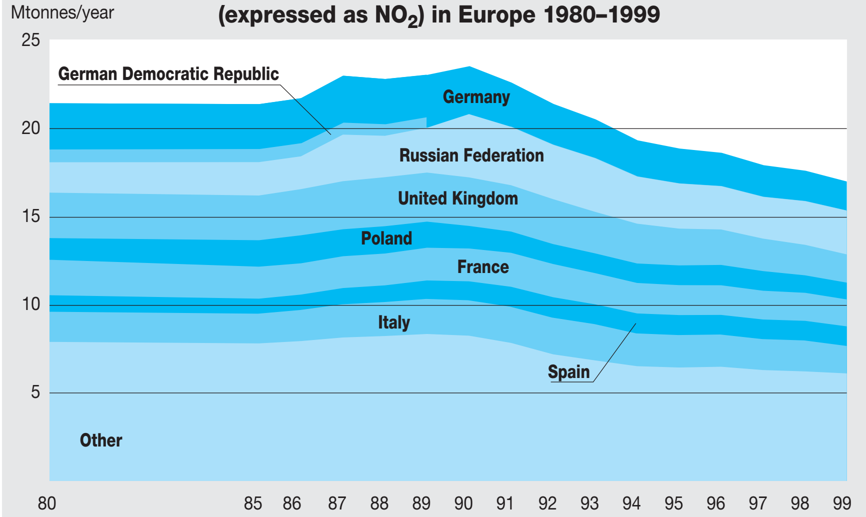


Figure 44 • Emissions of oxides of nitrogen (expressed as NO_2) in Europe 1980–1999



The Marrakesh Agreement

Since the third conference of the parties in Kyoto in 1997, negotiations on the final form and interpretation of the Kyoto Protocol have continued. The points on which agreement was sought at the negotiations in Haag, Bonn and Marrakesh related primarily to the conditions and rules for flexible mechanisms, carbon dioxide absorption in forests and the ground (carbon sinks), assistance to developing countries and means of cooperation between industrialised countries and developing countries, and the drafting of sanctions and other responses against countries failing to fulfil their obligations. Since then, a major blow to the process has been the withdrawal of the USA from the negotiations in April 2001. However, agreement was reached between the remaining states at the Marrakech meeting in the autumn of 2001, converting the Kyoto Protocol to a legally binding text, known as the Marrakesh Accord. The Protocol will come into force when at least 55 countries have ratified it. A further condition is that carbon dioxide emissions in 1990 from the Annex I states that have ratified the Protocol must account for more than 55 % of 1990 emissions from all Annex I states. The EU states jointly submitted their ratification documents in May 2002. Japan has also ratified the Protocol. The EU candidate countries have also ratified the Protocol, or are expected to do so in the near future. During the World Summit on Sustainable Development in Johannesburg in September 2002, Russia notified that it intends to ratify the Kyoto Protocol. When this is done, it is expected that the requirements for coming into force of the Protocol will be fulfilled.

Figure 45a • Emissions of carbon dioxide (CO_2) per inhabitant and GNP 2000 in EU and OECD-countries

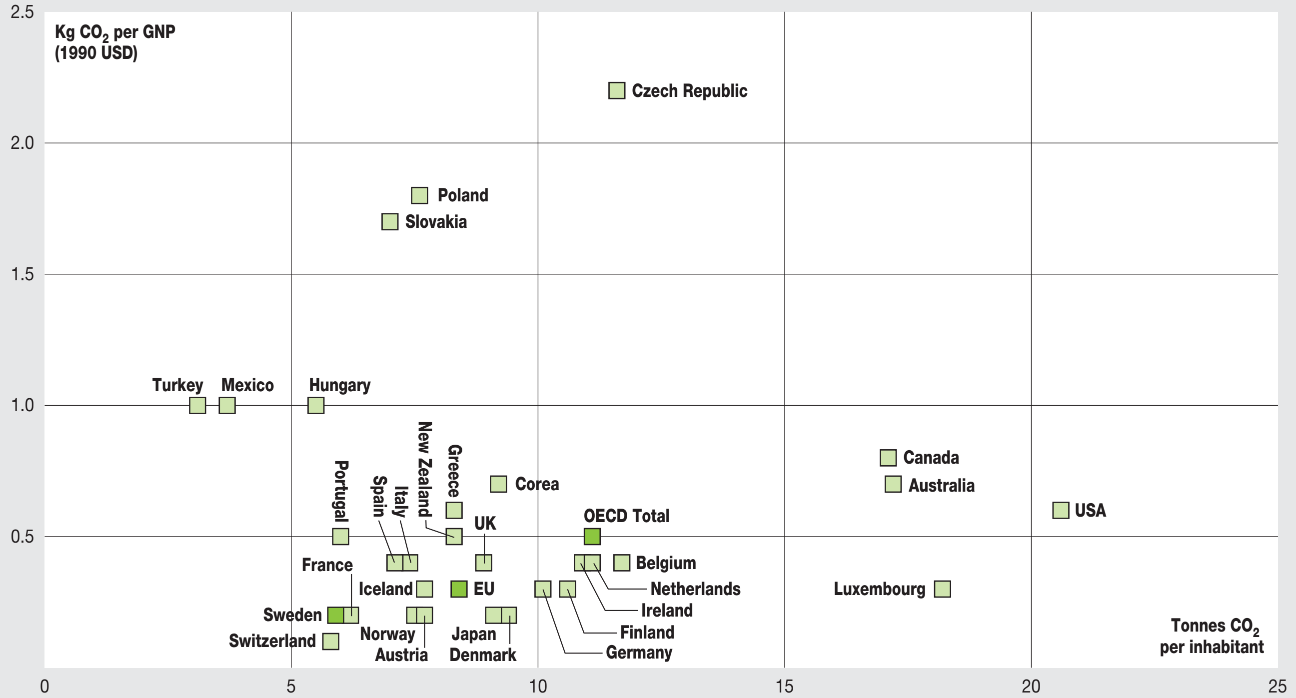
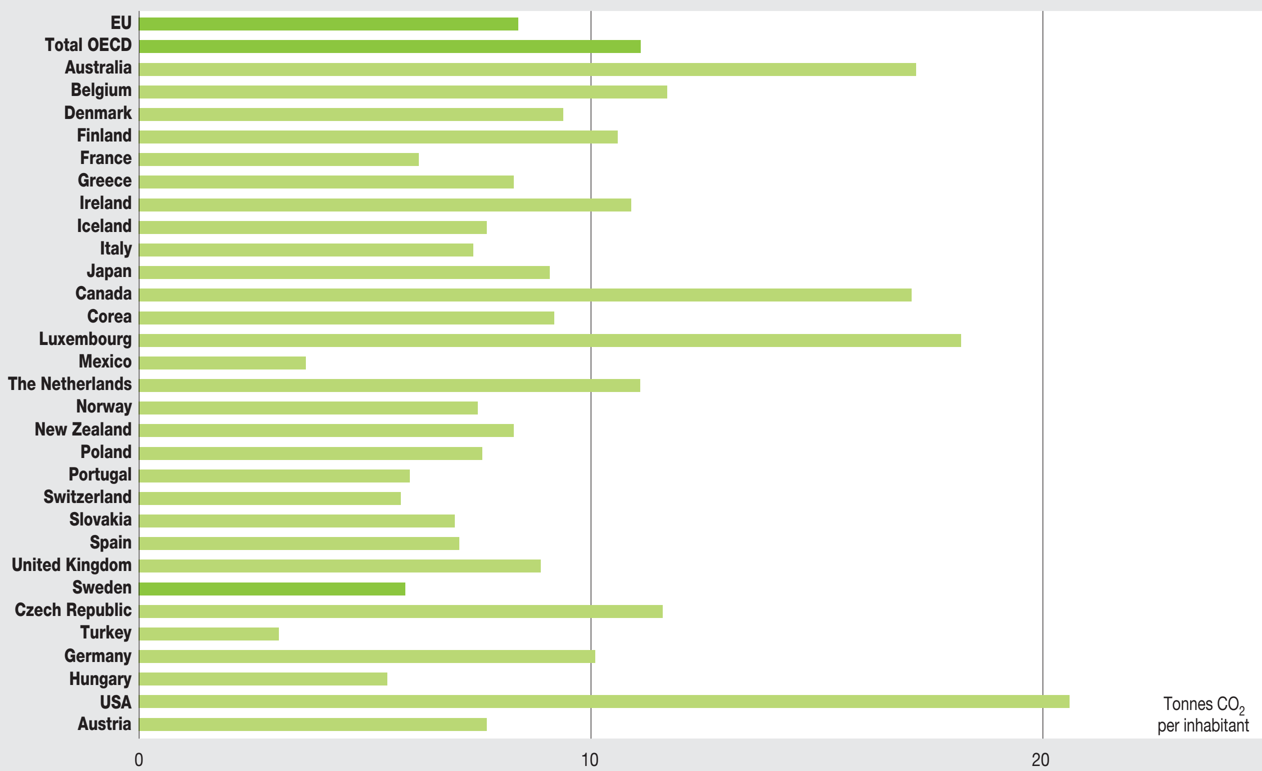


Figure 45b • Emissions of carbon dioxide (CO_2) per inhabitant 2000 in EU and OECD-countries



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.

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

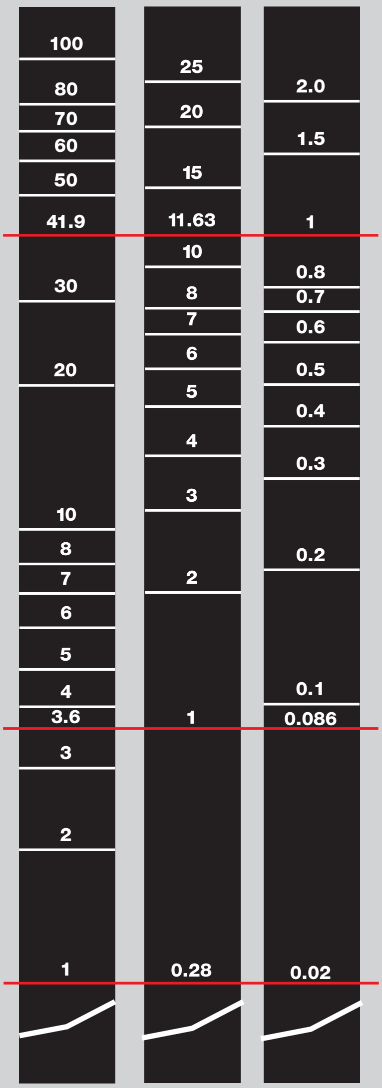
Practical terms

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

- 1 kWh is the energy used to run a small cooker hotplate for an 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 electrical energy produced by a large nuclear power unit during two months' full load operation.

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

Conversion scales, energy units (logarithmic scales)



Conversion factors for energy carriers:

Crude oil	1 tonnes	=	11.7 MWh	=	42.2 GJ
Gas oil	1 tonnes	=	11.9 MWh	=	42.7 GJ
Heavy fuel oil	1 tonnes	=	11.6 MWh	=	41.9 GJ
Natural gas	1 000 m^3	=	11.1 MWh	=	40.0 GJ
Coal	1 tonnes	=	7.6 MWh	=	27.2 GJ
Forest fuels	1 tonnes TS*	=	5–5.5 MWh	=	18–20 GJ
Pellets, briquettes etc.	1 tonnes	=	4.5–5 MWh	=	16–18 GJ
Peat (50 % moisture)	1 tonnes	=	2.5–3 MWh	=	9–11 GJ
Automotive petrol	1 tonnes	=	12.2 MWh	=	44.0 GJ
Methanol	1 tonnes	=	5.5 MWh	=	19.7 GJ
Ethanol	1 tonnes	=	7.5 MWh	=	26.9 GJ

*Dry solids

See *Energy in Sweden, Facts and Figures* for further and/or more detailed conversion factors.

Electricity for household purposes

An investigation from 1994 found that a family of four, in a detached house, used about 5 500 kWh of domestic electricity per year. *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**

In 2000, a new, modern, energy-efficient washing machine or tumble dryer used less than 200 kWh/year. Similarly, a new, efficient large refrigerator used less than 130 kWh/year, while a new, energy-efficient medium-sized freezer used less than 270 kWh/year. ■

A Glossary of Energy Terms

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.

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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.

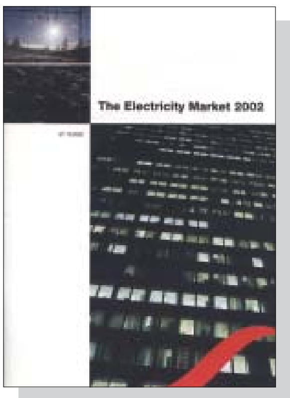
Useful energy
Energy used for its intended purpose within a defined system.

Waste heat
Heat released from processes.

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

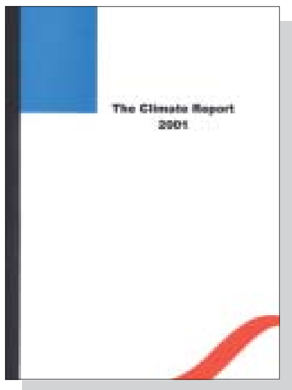
Other Publications

The Electricity Market, 2002
Item no. 1483



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.

The climate report 2001
Item no. 1465



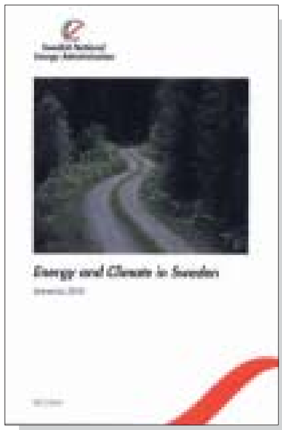
The report serves as source information that the Swedish Energy Agency submitted on the occasion of Sweden's third national report to the Climate Convention. The report gives a collective description of the measures that have been taken in the energy sector for restricting the emissions of greenhouse gases. In addition, scenarios are presented for Sweden's energy supply during the period up to 2020.

Building Sustainable Energy Systems Swedish experiences

Item no. 1390

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.

Energy and Climate in Sweden Scenarios 2010



Item no. 1376

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

All publications can be ordered from the Swedish Energy Agency's Publications Department, Box 310, SE-631 04 Eskilstuna.

Fax: +46 16 544 22 59. Telephone: +46 16 544 20 00. E-mail: forlaget@stem.se

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

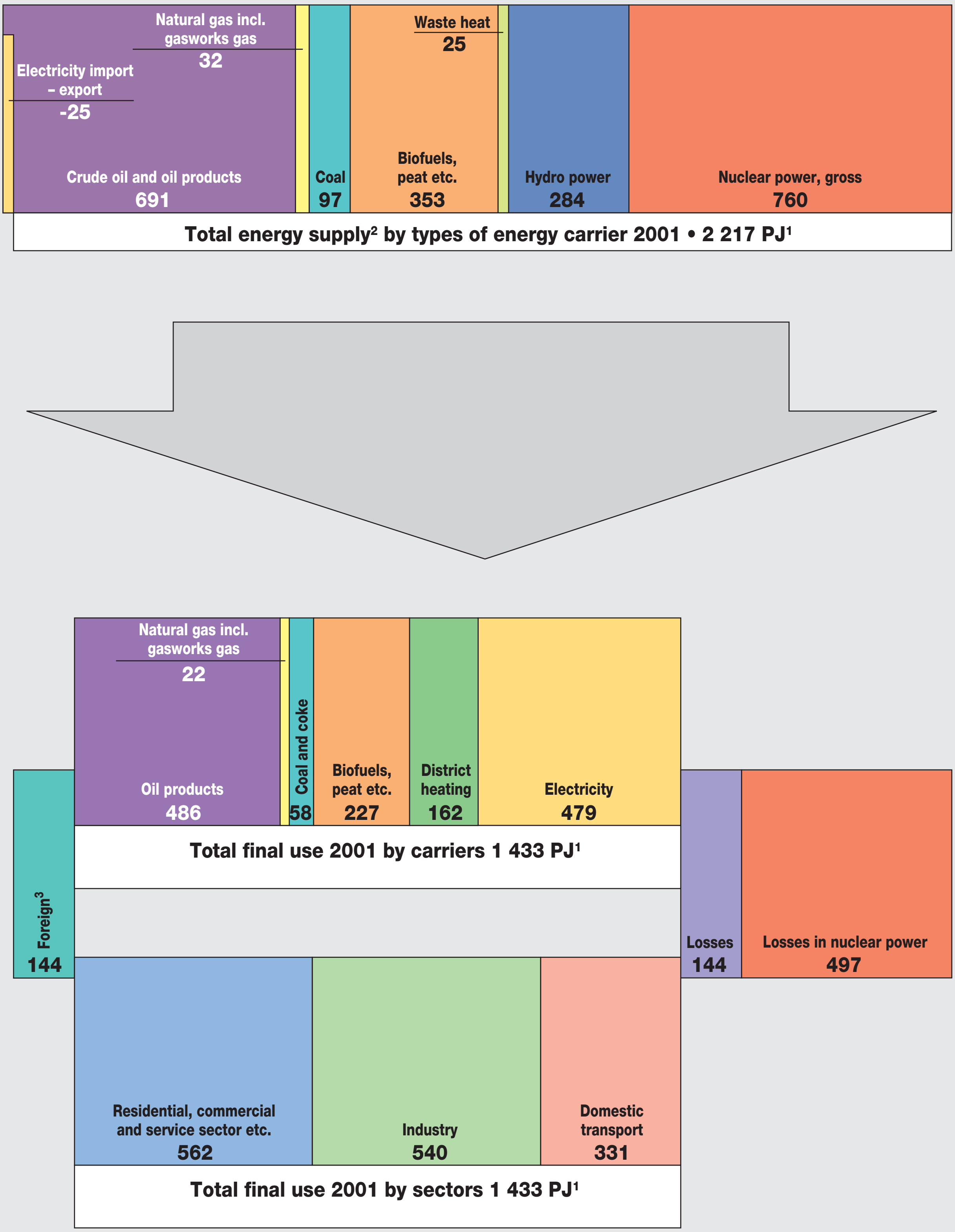
Energy in Sweden on the internet

Energy in Sweden is available as a downloadable pdf file from the Agency's web site (www.stem.se). It can be found in several ways, but the simplest is to click on Publications and then do a search (Find) for *Energy in Sweden*. This will produce a list of all previous editions of *Energy in Sweden*, *Energy in Sweden, Facts and Figures* and the overhead picture series.

If you encounter difficulties, contact the Agency's publications section or the postmaster at stem@stem.se.

Alternatively, you can contact the Agency by telephone on +46 16 544 20 00.

Figure 1 • Energy supply and use in Sweden 2001, PJ



[1] Preliminary figures. Due to rounding up or down of these figures, total figures may not always agree exactly with the sums of the individual items.
[2] Including windpower, 162 PJ.
[3] Foreign maritime trade and energy for non-energy purposes.

Efficient and environmentally sustainable energy system

The Swedish Energy Agency is engaged on promoting a secure, environmentally sustainable and efficient energy system in Sweden.

The Swedish Energy Agency is the central Swedish authority on energy. The Agency supports a large number of research and development programmes in the field of energy, in close cooperation with universities, institutes of technology and industry. Priority is given to renewable energy sources and alternative fuels.

The work on reducing the climatic impact of the energy sector is pursued on both national and international levels. The Agency also participates in a number of energy projects in the EU and in other international cooperation. Developments on the energy markets are continually analyzed.

The Swedish Energy Agency monitors the operations of network companies and promotes more efficient energy markets. By 2003, the Agency is responsible for the electricity certificate system. New efforts in training, information and advice are aimed at stimulating more efficient energy utilization by industry and households. In addition, the Swedish Energy Agency is also responsible for preparedness matters in the field of energy.

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