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Box 310, SE-631 04 Eskilstuna
Fax: +46 16-544 22 59
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E-mail: forlaget@stem.se

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Preface

Conditions in the energy markets change rapidly, reflecting not only energy and environmental policy in Sweden, but also wider changes in the rest of the world. In recent years, Swedish energy and environmental policy has been increasingly concentrated on establishing or improving the long-term conditions for efficient energy markets. Restructuring of the Swedish electricity market, greater internationalisation and the effects of the energy system on the wider environment and on climate are important factors that influence the direction of energy policy and so also development of the energy markets.

The line that was started by the 2002 Energy Policy Agreement, under the name of Working Together for a Reliable, Efficient and Environmentally Aware Energy Supply (Bill no. 2001/02:143), continues. The shift in taxation policy to encourage the move towards a sustainable energy system and reduced environmental impact continues, as exemplified by the introduction of the green electricity certificate system on 1st May 2003.

In 2002, the Government appointed a special negotiator to reach agreement with the nuclear power industry on the long-term phase-out of nuclear power production. One of the starting points for these negotiations is the 'German model', under which each reactor is assigned a particular overall production quantity of energy, instead of a specific closure date.

One of the more important tasks of the Swedish Energy Agency is to monitor developments in the energy and environmental fields, and to provide information on the current energy situation in respect of aspects such as changes in the pattern of energy use and energy supply, energy prices, energy taxes and the environmental effects of the energy system.

Energy in Sweden 2003, together with its statistics supplement, Energy in Sweden, Facts and figures 2003, is intended to provide decision-makers, journalists and the public with a single source of easily available information on conditions and developments in the energy sector.

Eskilstuna, February 2003

Thomas Korsfeldt
Director–General

Klas Tennberg
Head of Department
The System Analysis Department

Paul Westin
Project leader

EDITORS:
Anna Andersson (Energy balance),
Göran Andersson (Energy balance, Coal),
Johanna Andréasson (Residential and Service),
Eva Centeno López (Electricity Market),
Erik Filipsson (Taxes and Prices),
Per Grunéus (Industry),
Tobias Jakobsson (Energy gases),
Anders Jönsson (Transport)
Gunilla Karlsson (Energy policy, Environment),
Therése Karlsson (International),
Marcus Larsson (Biofuels and Oil),
Mathias Normand (Taxes and Prices)
Christian Sommer (Environmental problems),
Paul Westin (District heating and district cooling).

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Current policy areas

The framework conditions of energy markets are determined largely by political and legal considerations. In Sweden, the aim of the political decisions is to influence development of energy use and energy production in a sustainable direction. The markets are affected primarily by national and EU decisions, although global agreements are becoming increasingly important. This chapter discusses a number of areas of current interest in the fields of energy, environmental policy and climate policy.

Sweden´s energy policy

The 1997 energy policy agreement set out a strategy for continued restructuring of the country's energy system. The energy policy programme consisted of two parts: the short-term programme, which was concerned primarily with replacing the loss in electricity production capacity resulting from the closure of Barsebäck, and the long-term programme which concentrated on research, development, demonstration and politically justified measures intended to counter climate change. The short-term programme was concluded in 2002, while the long-term programme continues until 2004.

In June 2002, Parliament approved the Government's proposal for a new energy policy programme, intended among other points to replace the concluded short-term programme, and based on an agreement between the Social Democrats, the Centre Party and the Left Party. The guidelines set out in the 1997 energy policy decision remain: the 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 in Sweden, with minimum adverse effects on health, the environment and climate, while at the same time supporting 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. The agreement incorporates a longer-term element intended to restructure the energy system through encouragement of electricity production from renewable sources and of more efficient use of energy. A new guide measure, in the form of trading in certificates of electricity production, has been introduced in 2003 in order to encourage the production of electricity from renewable sources and with minimum environmental impact. The trading prices of the certificates will depend primarily on the relationship between demand for 'green' electricity and the availability of such electricity. The actual magnitude of this demand depends in turn on the quota obligation applied to energy users. The overall objective is that the use of electricity from renewable sources should increase by 10 TWh/year between 2002 and 2010. The quota-based production certificate system will make support for renewable electricity production competitively neutral. On-shore-wind power will continue to be subsidised during a transition period, by means of an output subsidy of 18 öre/kWh in 2003, reducing annually until it is finally abolished in 2010.[1] In addition, the agreement includes a planning objective for wind power, so that plans for siting 10 TWh/year of wind power production shall have been agreed by 2015.

The 2002 energy policy decision 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 and market introduction of energy-efficient technology.

In 2002, the Government appointed a special negotiator to reach agreement with the power industry on long-term phasing out of nuclear power production. One of the starting points of these negotiations is the 'German model', under which each reactor is assigned a particular overall production quantity of energy, instead of a specific closure date.

In March 2003, the Government put forward a Bill indicating that Parliament's conditions for closing Barsebäck 2 have now been fulfilled, apart from the effect on the country's power balance and on environment and the climate. The Government therefore decided that closure of Barsebäck 2 shall be included in the negotia-

[1] The reduction for off-shore wind power is set at a slower rate and the subsidy will be 12 öre in 2009.

tions with the nuclear power station operators concerning continued phase-out of the remaining reactors. However, the Government emphasises that particular attention should be paid in the negotiations to the possibility of early closure of Barsebäck 2.

In September 2003, the Commission on Energy Technology and Development submitted its report[2] on evaluation of the long-term elements of the 1997 energy policy agreement. The report states that although the various research, development and demonstration projects that have been carried out are both relevant and of good quality, they are not alone sufficient as a driving force for restructuring the country's energy system. The report includes proposals for a broader long-term energy policy programme, starting in 2005.

Swedish climate strategy

The Government's Climate Policy Bill was approved by Parliament in March 2002, setting out the objective of reducing the country's greenhouse gas emissions by 4% as a mean value over the period 2008–2012, in relation to the 1990 levels. This is a more ambitious objective than that required in accordance with the Kyoto Protocol, which in fact permits Sweden to increase its emissions by up to 4%. The international commitment will become legally binding when a sufficient number of countries has ratified the Protocol to bring it into force.

It is assumed that this emission reduction will be achieved by measures at national level, without having to credit measures carried out in other countries under the terms of the Kyoto Protocol flexible mechanisms or through the use of carbon sinks in the form of forests. Nevertheless, at the same time and in accordance with the Energy Policy Bill of June 2002, Sweden intends to obtain experience of, and contribute to, application of the flexible mechanisms in the Protocol. The decision not to employ the flexible mechanisms as a means of achieving Sweden's national objectives is reviewed in 2004.

The flexible mechanisms make it possible, and provide an incentive, to implement emission-reducing measures where they are most cost-effective. The Swedish Energy Agency is responsible to the Government for planning and implementing Joint Implementation and Clean Development Mechanism projects. A special Joint Implementation Commission was appointed by the Government at the end of 2001, to investigate the opportunities for Swedish JI projects in other countries. In December 2002, the Commission presented its final report[3], which concluded that there are excellent prospects for cost-efficient JI projects in Eastern Europe. The work of the Commission has resulted in the opening of negotiations for bilateral JI agreements with Russia, Estonia and Lithuania, and with the conclusion of negotiations with Romania. The Agency is preparing a test package of 3–4 small and medium-sized JI projects in the field of renewable energy and energy efficiency improvements in Eastern Europe. As far as CDM projects are concerned, the Agency aims to put together a geographically balanced portfolio of projects, concentrating of small-scale projects in the field of renewable energy sources. Five such project proposals have been selected, and work is continuing on them.

Climate work and the national objective will be continuously monitored, with the Environmental Objective Council presenting an annual report of progress towards achieving the environmental quality objectives.[4] If emissions are not reduced in accordance with the objective, the Government may propose additional measures or, if necessary, reconsider the objective, subject to consideration of the competitiveness of Swedish industry. Progress checks will be carried out in 2004 and 2008. The Government intends to complement the 2004 progress check with consideration of an objective for the flexible mechanisms. During 2003, the Swedish Environmental Protection Agency and the Swedish Energy Agency have been asked to prepare material that will be needed for evaluating the success of the country's climate policy in the 2004 progress check. This work includes developing a new projection[5] for greenhouse gas emissions, and performing an evaluation of the efficacy of present guide measures and other actions. In addition, the work will include investigation of the effects of further measures, and of the effects of integrating the flexible mechanisms into the national stage objective. This work is to be concluded, and the results presented, by 30th June 2004.

A Parliamentary delegation was appointed

FACTS

The three flexible mechanisms are:

- Joint Implementation, JI, by which industrialised countries can be credited with emission reductions to meet their own commitments when they perform projects in other countries for which emission targets have been set under the terms of the Protocol.
- Clean Development Mechanisms, CDM, are essentially the same as Joint Implementation Mechanisms, except that they are carried out in countries for which emission limits have not been set under the Protocol, i.e. generally developing countries. CDM projects must also assist sustainable development in the countries of their implementation.
- Trading in emission rights, by which countries that have reduced their emissions by more than they are required to do can sell emission rights to other countries having difficulty in meeting their objectives.

[2] ERDD – *one* element in restructuring the energy system (SOU 2003:80).
[3] Joint Implementation – Agreements for a Better climate (SOU 2002:114).
[4] The Environmental Objective Council: Environmental objectives – Are we achieving the stage targets? Swedish Environmental Protection Agency, 2003
[5] 'Projection', as used in climate policy, means 'scenario of emission development'.

in 2001 to prepare a proposal for a Swedish system for application of the Kyoto Protocol flexible mechanisms, together with the necessary legal framework. The delegation submitted an interim report in May 2003, concentrating on trading in emission rights within the EU. This report also included proposals for a national allocation plan, and for how handling of the trading system should be organised.

Transferring taxation

The Government took the first steps in shifting the emphasis of taxation towards accomplishment of green objectives in 2001. Taxes on environmentally harmful activities were raised, while taxes on work were reduced. This transfer of taxation is intended to continue over a ten-year period, to a value of about SEK 30 000 million (see also Taxes and prices). In addition, the Taxation Reduction Committee (SNED), which had been asked to oversee the regulations for reducing energy taxation in certain sectors, submitted its report in April 2003. The Committee had been asked to investigate the structure of reducing energy taxation in sectors exposed to competition. The Committee's report includes a proposal for a new energy taxation model, giving equal treatment in terms of taxation to all commercial activities. It is suggested that two sectors, the energy conversion sector and the services sector, which were previously taxed on the same basis as domestic households, should instead be taxed on the same basis as industry. In addition, the Committee has suggested that present-day taxation relief rules should be replaced by a single relief rule.

In its 2002 energy policy agreement, the Government proposed changes in the taxation of combined heat and power production in the form of increased tax relief on fuels used in CHP plants for heat production. The effect of these changes would be to bring them into line with tax on industry, and would encourage electricity production in CHP plants rather than in cold condensing power stations, in which a large quantity of the process heat is rejected. The EU Commission has approved this proposed changed, which came into force on 1st January 2004.

Other Commissions

A special investigator was appointed in 2003, with the task of putting forward proposals for harmonising Swedish legislation and reporting with the EU Electricity and Gas Market Directives. The investigator will also evaluate how structural changes have affected competition in the electricity market. An interim report was presented in 2003, with the final report in September 2004.

In 2003, the Government appointed a committee to investigate the competitiveness of district heating in the heating markets, with the aim of improving consumer protection against unreasonable prices. The investigation will consider whether it might be appropriate to introduce third-party access, i.e. opening the supply of heat via distribution systems to competition. The work also includes analysis of, and if necessary proposing changes to, the legislation intended to prevent cross-subsidies between monopoly services (electricity, water, sewage) and activities that are exposed to competition (electricity supply, district heating), as operated by electricity and heat utilities. This report is due to be submitted at the end of June, 2004.

2003 also saw the appointment of an investigator to propose national objectives and strategies for continued work on the introduction of renewable motor fuels, in accordance with the EU Renewable Motor Fuels Directive. The investigator will look at the requirement for petrol stations to supply at least one renewable-based motor fuel by 2005, and will also investigate the feasibility of introducing some form of motor fuels certificate, similar to that used for electricity produced from renewable sources. An interim report is due to be submitted in February 2004, with the final report at the end of December of that year.

Energy in the EU and international climate negotiations

The EU single market for energy

Work is in progress at EU level on the creation of a single market for energy, so improving competition in energy supply. The Electricity Market Directive was adopted in 1996, with the objective of creating common rules for the production, transmission and distribution of electricity. It is having the effect of gradually opening the electricity market to competition. Several countries have opened their markets to competition at all customer levels, including the Nordic countries, the UK, Austria and Germany. The Gas Market Directive was adopted in June 1998: as with the Electricity Market Directive, it is progressively opening the European natural gas market to competition. A new time plan for opening the electricity and gas markets to competition was approved by the EU Parliament in June 2003. According to the present Electricity and Gas Market Directives, markets must be fully open for the commercial sector in 2004, and for all customers by 2007.

Work within the EU on the Trans-European Network (TEN) for energy constitutes an important element in opening the energy markets to international competition. Improving power and gas pipeline connections between countries increases cross-border carrying capacity, and thus competition. Although some important projects can receive EU funding assistance, an EU parliamentary decision in June 2003 means that this can be provided only in exceptional cases.

Renewable energy in the EU

The EU has established a target for the proportion of total energy use in the EU derived from renewable sources to have been increased from its present 6% to 12% by 2010. A special 'Promotion for Electricity from renewable Energy in the internal Electricity market' Directive sets a target of 22% for the proportion of electricity from renewable sources by 2010. Both these objectives are indicative, i.e. not binding on the member states. Under the terms of the Directive, the member states are required to take the necessary steps to achieve the objective, with progress being evaluated on the basis of national reports in 2005.

In the spring of 2003, an agreement was reached between the Commission, the Council and the European Parliament concerning a directive to encourage the use of motor fuels from biofuel sources, or other renewable motor fuels. Under the terms of the directive, a certain proportion of total sales of motor fuels must be met by biobased fuels. As a quantitative reference level for the Union as a whole, the target is expressed as at least 2% of motor fuel sales, based on energy content, being met by biobased fuels by the end of 2005. By 2010, the total proportion of biobased fuels is required to have increased to 5.75% of sales, in terms of energy content. These targets are also indicative.

Security of energy supply in the EU

In November 2000, the Commission published a Green Paper for the energy sector. It noted that the EU is still increasing its use of energy, and is becoming increasingly dependent on imported energy products. If nothing is done over the next 20–30 years, 70% of EU energy requirements will depend on energy from imported products, 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 way of controlling demand, increasing the use of 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 increasing), considering enhancement of the present system of strategic storage and the planning of new import paths.

During 2002, the Commission adopted a proposal for a new framework programme in the energy sector, under the title of 'Intelligent Energy for Europe'. With a budget of EUR 200 million over the period 2003–2006, the programme consists of four sub-programmes:

- ALTENER: renewable energy
- COOPENER: international energy cooperation
- SAVE: improving the efficiency of energy use
- STEER: energy use in the transport sector.

The Sixth Framework Programme of EU-financed research was started in 2003. Of a total budget of EUR 17 500 million, energy research received EUR 810 million under the theme of 'Sustainable Development'.

An energy taxation directive

Energy taxation of fuels based on mineral oils has been harmonised across the EU, with the current directives prescribing not only minimum tax rates but also certain grounds for exemption from, or reduction of, tax. Further departures from the requirements of the directive can be provided through special decisions. In March 2003, the Council reached political agreement on a new energy taxation directives, setting minimum tax rates not only for mineral oils but also for the competing forms of energy carriers of electricity, coal and natural gas. An EU legal framework was created governing the structure of energy taxation on industry, with the directive defining rules for energy-intensive industry. This affects Swedish legislation and a minimum tax on electricity is introduced for the electricity intensive industry July 1 2004..

Other EU energy matters

In July 2002, a directive was published to support CHP production in the single EU energy market. In May 2003, the national energy ministers decided to follow the EU Parliament's addition concerning the Commission's proposal for encouraging CHP production. This addition is over and above the EU Commission's proposal that all EU states should produce at least 18% of their electricity from CHP production by 2010.

A directive concerning the energy performance of buildings was adopted in December

2002, setting out detailed requirements to reduce the use of energy in buildings, which accounts for 40% of total EU energy use. According to the Commission, this use of energy could be reduced by about 22% through energy conservation and measures intended to improve the efficiency of energy use. Together with the National Board of Housing, Building and Planning, the Swedish Energy Agency has submitted a report to the Government with proposals on how this directive could suitably be applied in Sweden.

EU climate strategy and emission rights trading

The EU Commission has launched a European climate programme. The programme consists of two parts: a list of priority measures, and a plan for an emission rights trading system, intended to come into operation on 1st January 2005. The list of priority measures includes both those that are in process of being drafted, and measures on which more work is needed, such as long-term agreements with industry.

In October 2001, the Commission presented a draft directive for a system of trading in emission rights. Under the terms of the proposal, about 46% of theoretical EU CO_2-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 95% of the 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 Council and the Parliament approved the Directive in June 2003. A central point which is still under discussion concerns to what extent the project-based JI and CDM mechanisms should form part of the European emission rights trading system. During the summer of 2003, the Commission presented a draft directive that modifies the Emission Rights Trading Directive by linking the project-based JI and CDM mechanisms to the trading system. This link directive describes how this should be arranged and possible limitations on JI and CDM in the trading system.[6] An advantage of including the project-based mechanisms in the European trading system is that it would drastically reduce the market value of emission reductions due to the fact that the reductions would be effective in countries having lower marginal costs for the reductions. On the other hand, a drawback is that the lower market prices would reduce the incentive to develop expensive new environmental technology for application in Europe.

International climate negotiations

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 undertakings necessary to achieve the objectives of the 1992 Convention. The Protocol calls for a 5% overall reduction in emissions by the industrialised countries by 2008–2012, referred to as the first commitment period. Before agreement on the Protocol could be reached, it was necessary to clarify the rules that would be applied in practice and, at the Seventh Conference (held in Marrakech in 2001), the parties reached agreement on how the political decision should be expressed in legally binding text. By the end of 2002, a large number of countries (together responsible for 44% of total emissions of carbon dioxide from the industrialised countries) had ratified the Kyoto Protocol. However, for the Protocol to be come into force, it must be ratified by 55% of Annex 1 parties to the Protocol also producing at least 55% of the emissions. In order to reach that level, it will be necessary for Russia to ratify the Protocol. Among the industrialised countries, the USA and Australia have withdrawn from the international agreement. As the USA has withdrawn from the negotiations, it is necessary for the EU, Japan and Russia to ratify the Protocol before it can come into force. The EU ratified the Protocol in May 2002, followed by Japan in June of the same year. 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. However, one year later, Russia notified that it was not yet ready to ratify the Protocol. The Ninth Conference will be held in Milan in December 2003 and, in expectation of the coming into force of the Kyoto Protocol, will deal with technical and other matters of detail of importance for implementation of the Protocol. ■

[6] ECCP, European Climate Change Programme

[7] The EU Commission link proposal: KOM (2003) 403, final 2003/0173 (COD)

FOR FURTHER INFORMATION, SEE ALSO:

www.regeringen.se for government bills and commission reports
www.riksdagen.se for parliamentary committee reports
www.europa.eu.int – EU directives, strategies and draft directives
– For matters relating to energy and transport, search under the EU Commission's Directorate-General for Energy and Transport
– For environmental and climate matters, search under the EU Commission's Directorate-General for the Environment.
– See also the Council of the European Union.
www.unfccc.int for information on the international climate negotiations (United Nations Framework Convention on Climate Change).

Sweden’s energy balance

Energy can never be destroyed or consumed, but only converted (which, in everyday terms, means ’used’). The total quantity of energy used must therefore always be balanced by a corresponding quantity of energy supplied. An energy system can be represented by two sides – supply and use. This chapter gives details of the balance between Sweden’s total energy supply and its total energy use.

The energy balance is based on statistics from Statistics Sweden (SCB). The statistics are definitive for the period 1970–2000: for the years 2001–2002, they are preliminary, and may therefore be changed when SCB has processed additional material.[1]

Figure 1 shows Sweden’s total energy supply and use, by source and by energy carrier. The total supply in 2002 amounted to 616 TWh, including a net importation of about 5 TWh of electricity. The greatest proportions of energy supply were met by oil and nuclear fuel, followed by biofuels and hydro power. Wind power contributed about 0.5 TWh in 2002. Much of the input energy in nuclear fuel is cooled away, while other losses on the supply side include conversion losses in power stations, distribution losses in district heating and electricity distribution systems and processing and transport losses in the case of solid fuels.

Energy use in the various sectors shows that electricity and district heating are the most important energy carriers for the residential and service sector, that electricity and biofuels are the most important for industry, and that oil products dominate energy use in the transport sector. This latter sector uses about twice as much oil as the two other sectors combined, despite the fact that they each account for about two-fifths of energy use, while the transport sector accounts for only about one-fifth of energy use. Ethanol and other biobased motor fuels supply somewhat over 0.5 TWh.

Aggregated and simplified, Figure 1 shows overall energy flows from supply to use, and can be said to represent a technical perspective of the energy system. However, energy is supplied only to meet users’ demand for energy, which in turn depends on the functions needed by the users. The rest of this chapter therefore describes use before supply, as it is the use of energy that determines how much energy in the form of electricity, heat etc. that has to be produced.

The figure does not show the losses that arise in connection with final energy use. All the conversion processes associated with the use of energy in the residential and service sector, in industry and in the transport sector are associated with losses, and it is here that improvements in the efficiency of energy use, or the use of new technology, can reduce overall energy use while maintaining the various functions required, such as lighting, heating, cooling, mechanical drives, computer processes etc.

Total energy use

Total energy use in 2002 amounted to 616 TWh, spread over the following three user sectors and two other categories:

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

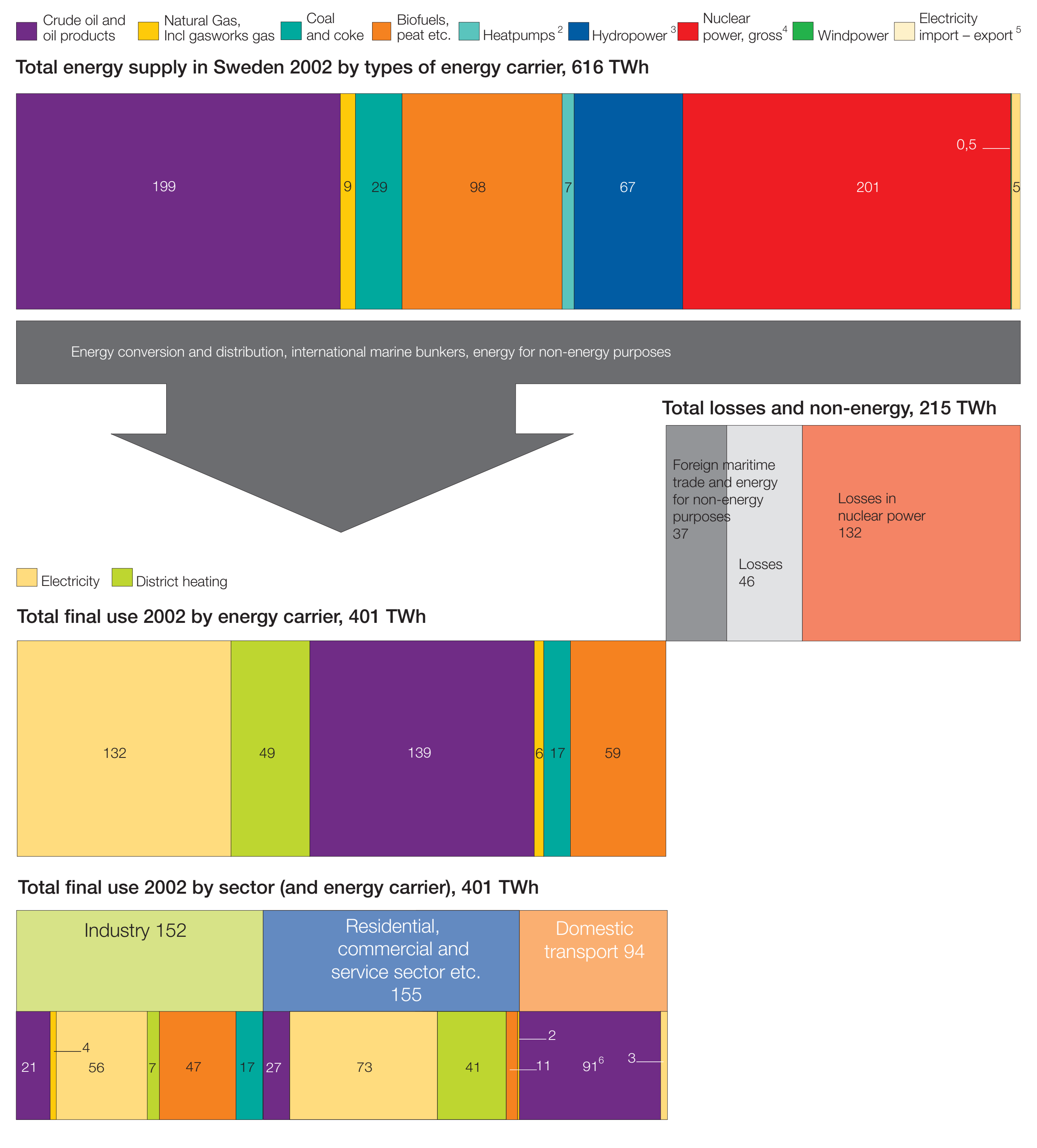
The first three sectors above account for what is referred to as total final energy use, which amounted to 401 TWh in 2002. Bunker oils for international shipping, and coal and oil products used for non-energy purposes, amounted to 37 TWh during the year. Non-energy purposes are those such as raw materials 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.

Electricity and heat production involve conversion losses, as do refineries and coking plants. However, losses in hydro power production are not included. 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 2002 amounted to 178 TWh, of which

[1] This means that there may be differences between the statistics in this year’s edition of Energy in Sweden in comparison with those given for 2000 and 2001 in last year’s edition. In the same way, statistics given here for 2001 and 2002 may be changed in next year’s edition of Energy in Sweden.

FIGURE 1

Energy supply and use in Sweden, 2002, TWh.[1] (In PJ, see final page.)



Note:
[1] Preliminary statistics. Due to arithmetical rounding of the individual items, there may be a small difference in the totals.
[2] Large heat pumps in the energy sector (e.g. supplying district heating systems). Energy supplied to the energy system is the output heat, 7 TWh. Heat absorbed from the surroundings was somewhat less than 5 TWh, while input drive energy from electricity was somewhat over 2 TWh.
[3] Hydro power and wind power together up to and including 1996.
[4] Nuclear power is gross energy, i.e. as the gross input energy in the fuel, in accordance with the UN/ECE guidelines.
[5] Net import of electricity, treated as electricity supply.
[6] Use of oil products for transport includes ethanol, about 0.5 TWh.
[7] Source of all other figures, if not indicated, Statistics Sweden, processed by the Swdish Energy Agency.

Source: Statistics Sweden, The Swedish Energy Agency.[7]

132 TWh – over 21% of the country's total energy use – were in the nuclear power stations.

Industry, and the residential and service sector, use essentially the same amount of energy now as in 1970. However, much has changed: the total heated floor area of premises, for example, is greater, population numbers have risen by about 10%, and industrial production is considerably higher than it was in 1970. As a result of the move away from oil to electricity, some of the losses have also been 'moved' to the supply side of the energy system. However, total energy use by the transport sector (excluding international maritime traffic) has increased by 68% since 1970. For the industrial sector, variations in energy use from one year to another are due mainly to economic conditions, while for the residential and service sector they are partly due to differences in the climate from one year to another. 2002 was somewhat warmer than the statistical average.

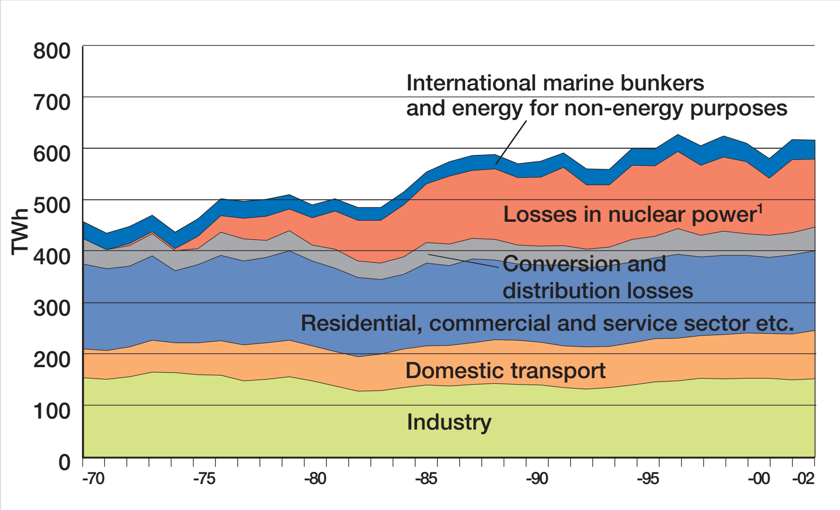
Total energy supply

Sweden's total energy supply in 2002 was 616 TWh, see figure 3a. 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. 2002 was warmer than an average year. Energy supply has increased by 35% since 1970, from 457 TWh to 616 TWh. Over the same period, demand for energy has increased by 7%. The reason for this difference between the increase in supply and the increase in demand is that much oil has been replaced by electricity in the two user sectors of industry and the residential and service sector. Electricity is a highly efficient energy carrier as far as users are concerned, although there are considerable losses in the production stage. By changing from oil to electricity, much of the conversion losses have therefore been transferred from the end-users to the supply side of the energy system, and this can be seen best in the substantial losses associated with nuclear power generation. In addition, the shift to electricity production from nuclear power also resulted in an increase in conversion losses. Taken together, all this means that the make-up of energy supply has changed since 1970. The supply of crude oil and oil products has fallen by over 40%, while the supply of electricity has increased by over 240% as a result of the construction of nuclear power stations and expansion of hydro power production. The supply of biofuels has more than doubled. During the 1980s, local authority energy utilities installed large heat pumps for supplying district heating. In the middle of the 1980s, natural gas was brought to towns along the west coast, while wind power construction started in the middle of the 1990s. Supplies of coal and coke as fuels increased at the beginning of the 1980s, but has since been declining.

Nuclear power used 201 TWh of fuel energy input in 2002, to produce 65.6 TWh of electricity. Hydro power, meanwhile, produced 66 TWh of electricity. Hydro power production was high at the beginning of the year, but very

FIGURE 2

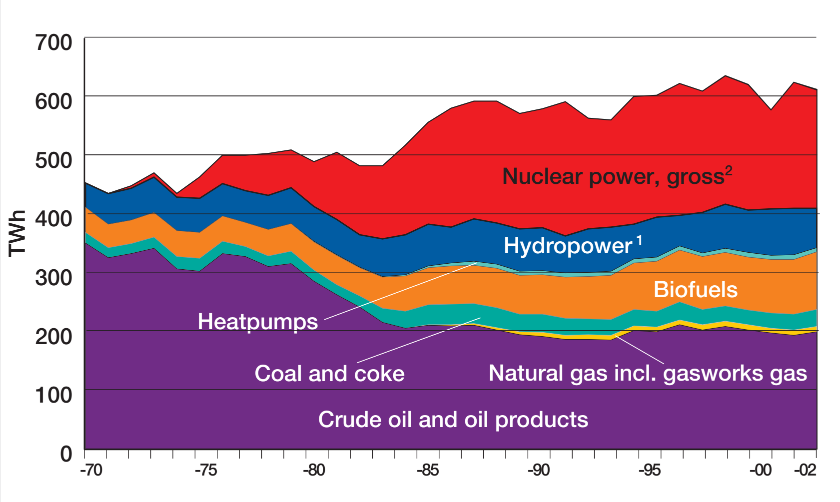
Sweden's total energy use, excluding net exports of electricity, 1970–2002.



Note: [1]In accordance with the UN/ECE method for accounting for nuclear energy.

FIGURE 3a

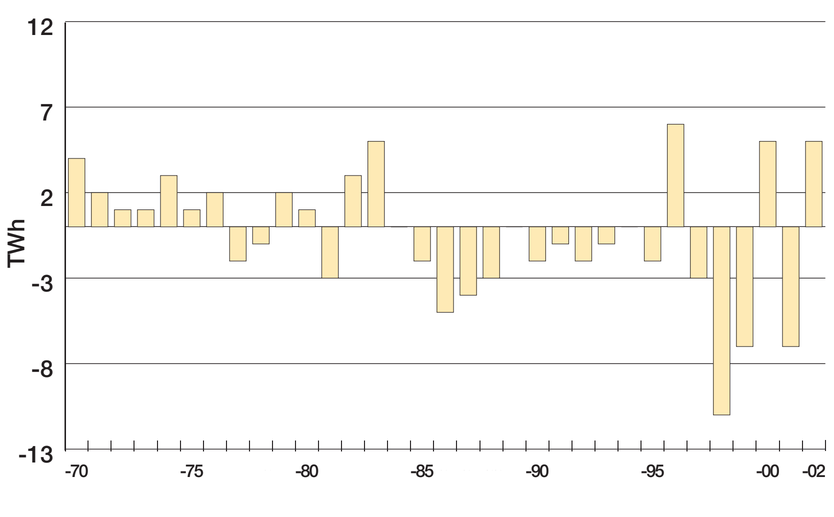
Energy supply in Sweden, excluding net electricity imports, 1970–2002.



Notes: [1]Includes wind power up to and including 1996.
[2] In accordance with the UN/ECE method for accounting for nuclear power production.

FIGURE 3b

Swedish electricity import minus net electricity export, 1970–2002.



low at the end of the year after an extremely dry summer and autumn. Hydro power production varies widely, depending on the amount of precipitation during the year. A normal year's production is about 64 TWh, which is based on a mean value of precipitation over the period from 1950 to 1996. In recent years, precipitation has been very high, which would have the effect of increasing a statistically average year's production if the precipitation quantities for these years were included in the statistical series. Fuel-based thermal power production produced 11.2 TWh of electricity, while wind power supplied 0.56 TWh. In international terms, Swedish energy supply includes a relatively large proportion from renewable sources, which include biofuels, hydro power and wind power. In 2002, these renewable sources supplied 27% of the country's total energy supply. ■

Energy markets

The energy markets are changing in step with developments in technology and with awareness of the effects of energy systems on the environment, society and the economy. Electricity markets in several countries have been opened to competition in recent years, and the same process is now occurring in the 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, together with a review of the present markets for electricity, biofuels, district heating and district cooling, oil, coal and energy gases.

The electricity market

Major changes have occurred in the electricity markets in the Nordic countries and the EU over the last few years. These changes have resulted in a move away from national or regional monopolistic electricity utilities to international markets, subject to competition, and from which electricity users can choose their electricity suppliers. In 1991, Norway was the first Nordic country to set up a competitive market, and was followed by Sweden in 1996, Finland in 1998 and Denmark in 2003. Today, all the Nordic countries except Iceland are trading on the Nordic electricity exchange, Nord Pool. The Nordic electricity market is becoming increasingly integrated with the electricity markets on the east and south side of the Baltic, while German and Polish companies are active on the Nordic electricity market. The electricity systems in the Baltic states will, in due course, be linked to the Nordic electricity system, and there is already some trade in electricity between Finland, Russia and the Baltic states.

The price of electricity in the Nordic countries is determined largely by hydro power capacity and availability in Sweden and Norway, the availability of the nuclear power stations in Sweden and Finland and international price levels of various fuels. There was a run of wet years in Sweden from 1997 until the latter half of 2002, which was dryer than normal. Nevertheless, hydro power production of 66 TWh for the whole of 2002 was somewhat higher than a statistically average year, of 64.5 TWh. However, despite this higher production, electricity prices at the end of the year were high. In recent years, too, increases in taxation have increased the price of electricity to consumers.

Electricity use

In 2002, electricity, including distribution losses, use in Sweden amounted to almost 149 TWh. Between 1970 and 1987, use increased very substantially, at an average rate of about 5% per annum. However, this rate of increase has since declined, so that electricity use increased by only 0.5% per annum on average between 1998 and 2002. Between 2001 and 2002, electricity use in Sweden fell by 1.2%, which can possibly in part be ascribed to high electricity prices during the second half of 2002. However, general economic conditions have a greater effect on electricity use, and less electricity is used during a warmer year than during a colder year.

Electricity use in Sweden is linked primarily to two sectors, the residential and service sector and the industrial sector, which together accounted for 129 TWh in 2002, i.e. 87% of the country's total electricity use. 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 and 2002 the annual increases in the two sectors were only 1% and 0.4% 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 38% of all the electricity used in industry. Electricity use in the transport sector is relatively little, amounting to less than

2.7 TWh in 2002, and being used almost entirely for rail transport. Total electricity use also includes transmission losses and the use of electricity in district heating plants and refineries.

Electricity production

In 2002, electricity production amounted to somewhat over 143 TWh. 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 oil-fired cold condensing power produced most of the electricity in Sweden. The oil crises of the 1970s coincided with Sweden's construction of nuclear power plants, which reduced the country's dependence on oil. Today, hydro power and nuclear power supply a very substantial proportion of the country's electricity, amounting to almost 92% in 2002, with oil-fired cold condensing production and gas turbines providing primarily reserve capacity. 2002 was close to a statistically average climatic year in terms of hydro power production, which amounted to 66.0 TWh, or 46% of total electricity production. Nuclear power supplied 65.6 TWh, i.e. almost 46% of total production.

This production structure is once again in the process of change. Under the terms of the energy policy guidelines, the Barsebäck nuclear power stations will be closed. Barsebäck 1 was closed in 1999 and Barsebäck 2 will be closed when the conditions set by Parliament are fulfilled.

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. At the end of 2002, with 620 wind power plants in operation, it supplied 0.56 TWh, or somewhat less than 0.4% of total electricity production in 2002.

In addition to nuclear power, hydro power and wind power, Sweden also operates a certain amount of combustion-based power production. In 2002, it supplied 11 TWh, or 8% of total electricity production. 36% of the fuel for this production was accounted for by biofuels, 34% by coal, 25% by oil and 5% by gas. As far as combustion-based electricity production is concerned, it is expected that the use of cogeneration production based on biofuels and energy gases will increase over the next few years, partly due to the effect of changed taxation which will not disadvantage cogeneration in relation to cold condensing power production.

Transmission of electricity

A condition for proper operation of the competitive electricity market is that all parties should have unrestricted access to the power grid. At the same time, there needs to be a system operator who, independently of other parties on the market, ensures that there is at all times a balance of power flows between power demand and power production. The Swedish system operator is Svenska Kraftnät, with responsibility for the country's grid[1] and for most of the interconnections with the neighbouring countries. There are at present links between

FIGURE 4

Electricity use in Sweden, 1970–2002.

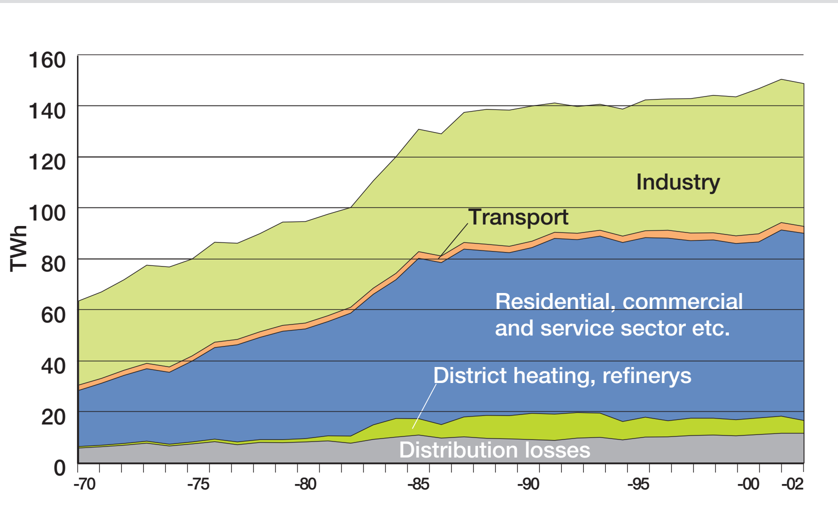
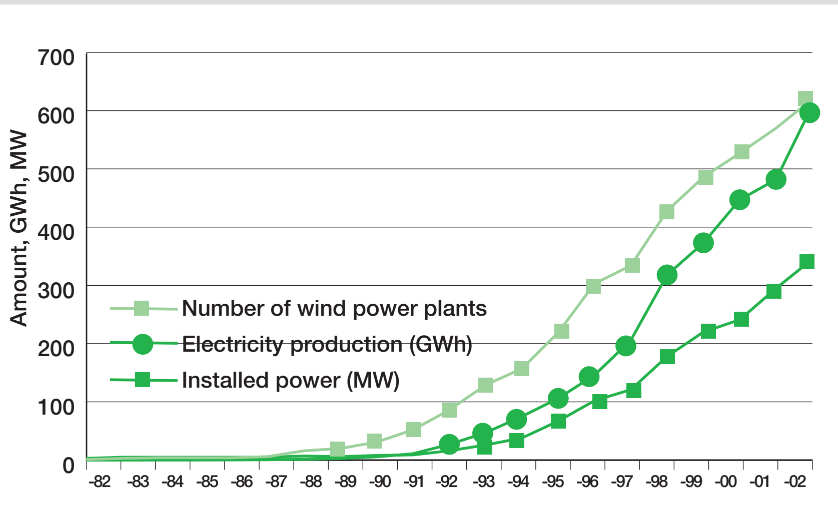


FIGURE 5

Wind power production, 1982–2002.



Source: Swedish Association of Electrical Utilities and the National Energy Agency.

[1] The grid, which is owned by Svenska Kraftnät, provides the backbone of the country's bulk power transmission system. It operates at voltages of 220–400 kV. It supplies regional power distribution networks, operating at 130 kV, and mainly owned by four larger distribution utilities. Larger electricity users, such as major industries, receive their electricity supplies directly from the regional networks. Below them, local networks operate at 40 kV, with final distribution networks operating at voltages between 400 V and 20 kV. The local networks and distribution networks are owned by hundreds of smaller companies, many of them owned by local authorities, although the proportion in local authority ownership has declined radically since deregulation of the electricity market.

Sweden and Norway, Finland, Denmark, Germany and Poland. Interconnection capacities between these countries have been increased in recent years. A DC link between Sweden and Poland was commissioned in 2000, and transmission capacity between Sweden and Norway was increased in 2001. Strengthening the grid by means of a new 400 kV line in western Sweden is planned for completion in 2006.

The country's total installed production capacity is somewhat over 32 000 MW (as of 2002). Maximum demand in 2002, of 25 800 MW, occurred on 2nd January. However, total installed capacity can never be 100% available, and there are also limits to the transmission capacity between northern and southern Sweden. Normal capacity allows up to 7 000 MW to be transmitted from northern to central Sweden. After various reinforcement and other work to increase capacity from 4 000 MW, about 4 500 MW can now be transmitted from central Sweden to southern Sweden.

Trade in electricity

Prior to reform of the markets in the Nordic countries, electricity was traded between countries under the terms of bilateral agreements. Today, there is also a joint Nordic power exchange, Nord Pool, which trades in both electricity and financial instruments. The exchange is open to Nordic and non-Nordic parties that have entered into system power balance agreements with the system operator in the countries in which they have a physical portfolio in the form of production and/or use of electricity, and which meet national requirements in respect of compliance with taxation etc. In Sweden, this means that they enter into such agreements with Svenska Kraftnät. In 2002, 32% of the electrical energy used in the Nordic countries (apart from Iceland) was traded on Nord Pool's electricity spot market. This has resulted in pricing on the Nordic market having become more efficient as a result of reduced transaction costs and greater transparency. In addition, the exchange price can also be used as a reference for bilateral trade. Border tariffs have been removed between Norway, Sweden, Finland and Denmark, which has also helped to encourage trade.

Today, as a result of the changes in the electricity markets in the four Nordic countries, Swedish producers can sell electricity directly to customers in Denmark, Norway and Finland, without special requirements in respect of agreements for the use of transmission capacity between the countries. Swedish customers can also purchase electricity from electricity trading suppliers from other countries, operating on the Swedish market. As trading in electricity is increasing, and now includes a growing number of non-Nordic participants, Nord Pool decided during 2002 to introduce the euro as its trading currency. The number of non-Nordic traders on Nord Pool was 24 in April 2003, i.e. 8% of the total number of 319 traders.

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.

FIGURE 6

Swedish electricity production, 1970–2002.

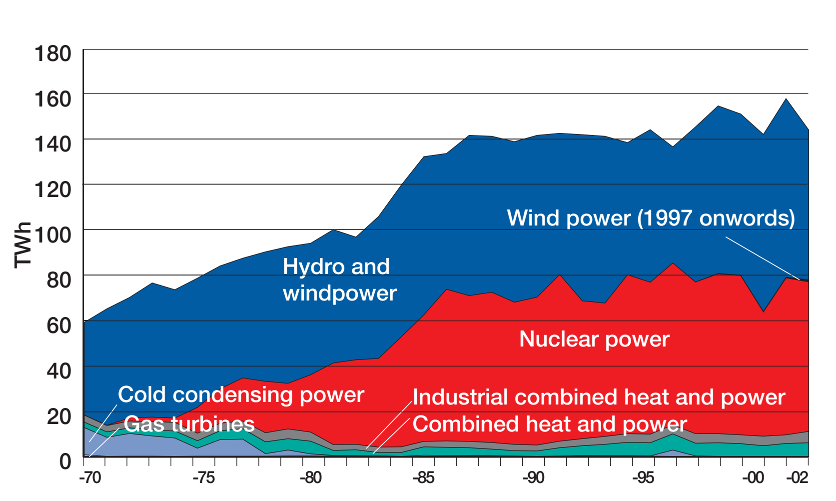
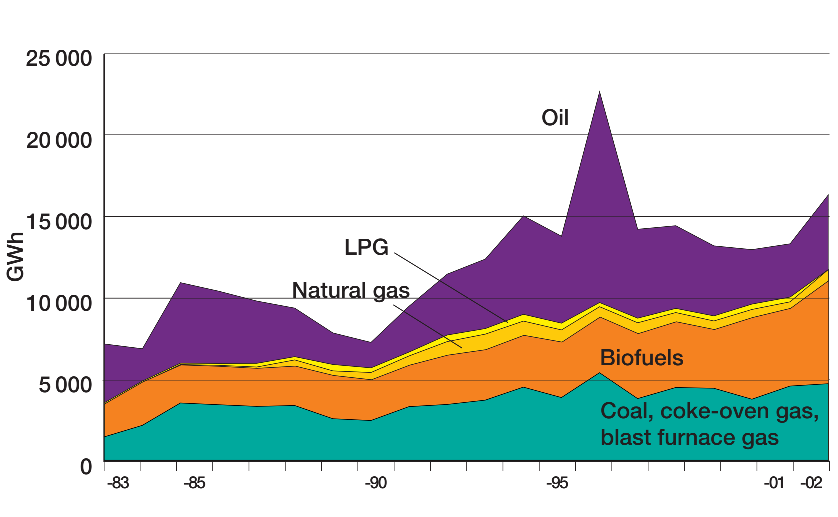


FIGURE 7

Fuel sources for electricity production (excluding nuclear fuel), 1983–2002.



During 2002, Sweden was a net importer of electricity, mainly as a result of the dramatic reduction in the amount of water available during the autumn. Most of these imports came from Norway. Sweden was also a net importer of electricity from Denmark and Germany, but a net exporter to Finland and Poland.

Price developments

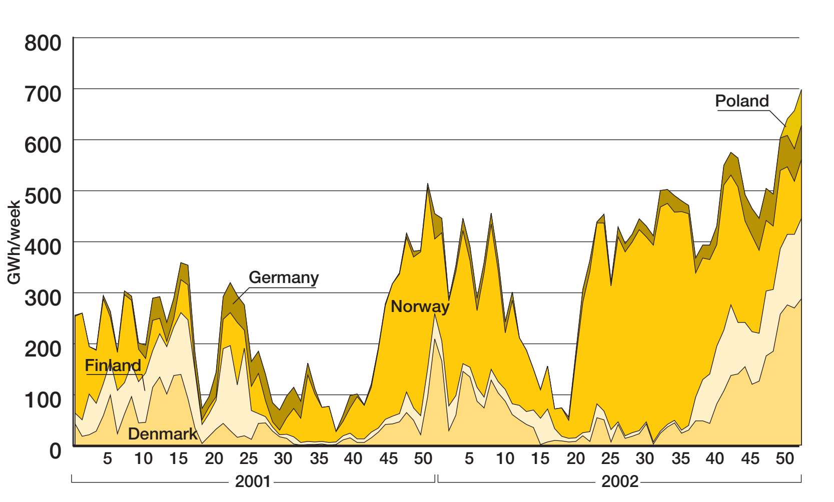
The prices of electricity vary between customer categories, between urban and rural areas and between the Nordic countries. This is due to varying transmission costs across regional and local distribution systems, different taxation regimes, subsidies, national rules and the structure of the electricity 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 the profit margin applied by each link in the chain. The price of the underlying electrical energy may be fixed or variable, while the grid price often consists of both a fixed and a variable portion. It is the price of the electrical energy that is subject to competition: it accounts for about a third of the total electricity price paid by a private customer (including taxes and value-added tax).

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 in Sweden, electricity prices during the year were very high. They fell during the start of 2002, but rose substantially during the second half of the year due to the severe lack of precipitation. This situation continued into the start of 2003, resulting in a record spot price of SEK 1 041/MWh on Nord Pool.

The exchange price also varies over the year: between 1998 and 2003, these variations have followed a similar pattern, being higher during the winter and lower during the summer.

FIGURE 8

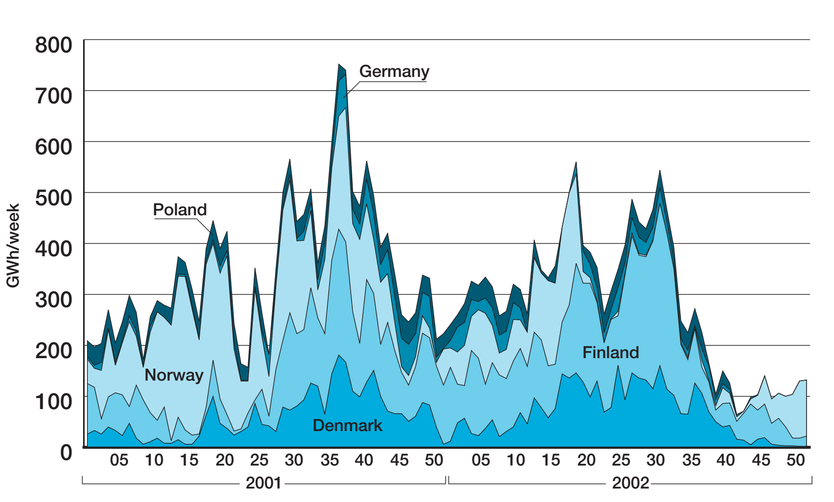
Swedish electricity imports, January 2001–December 2002, GWh/week.



Source: Swede Energy, Swedish Energy Agency.

FIGURE 9

Swedish electricity exports, January 2001–December 2002, GWh/week.



Source: Swede Energy, Swedish Energy Agency.

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 more stringent environmental requirements. One of the effects of the EU Electricity Market Directive is that the electricity markets in the member states must be progressively opened to competition. The degree of openness varies between states: the electricity markets in Sweden, Finland, the UK, Germany, Austria, Denmark and Spain are fully open to competition, which means that all companies and households are free to choose their electricity suppliers. Holland has also decided that its market will be fully open to competition in 2004. Other countries, such as France and Greece, have decided merely to fulfil the minimum requirements of the Directive. A new time plan for opening the electricity and gas markets was approved by the EU Parliament in June 2003. Under the present Electricity and Gas Markets Directive, the market must be fully open to competition for sales to the commercial sector by 2004, and for sales to all other customers by 2007.

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 been less successful, 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 means that electricity becomes an energy carrier that can be traded and supplied across national borders. Today, there are electricity exchanges in Scandinavia (Nord Pool), the UK (NETA), Austria (EXAA), Holland (APX), Germany (EEX), Spain (OMEL), Poland (Gielda) and France (PWX). Italy is planning to open a power exchange 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, other companies, such as the German E.on, are investing in the Nordic countries. In a trans-national market, electricity is produced where it is technically and economically most favourable, however subject to physical limitations set by the capacities of cross-border links and national transmission systems.

Electricity from renewable energy 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,[2] 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 market electricity prices and, at the same time, provide an incentive for cost-efficient production. A system of tradable certificates was introduced in Sweden in May 2003, under which those producing electricity from certain forms of renewable energy sources are assigned tradable certificates by the State for each MWh of electricity produced from renewable energy. The distribution utilities and, in certain cases, electricity users are required to purchase these certificates in proportion to the amount of electricity that they supply or use. In the first year, this obligation quota amounts to 7% of electricity use. It will be raised each year in order to encourage increased production of certificate-entitled electricity. This will create a market for the certificates.

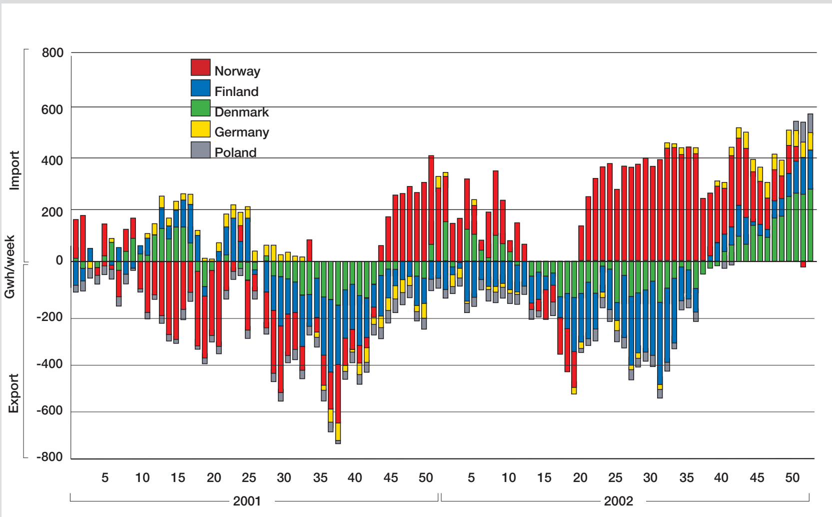
International comparison of electricity use

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. Conditions in all these countries are similar to those in Sweden: plentiful supplies of cheap hydro power, a relatively cold climate and a high proportion of electricity intensive forestry and/or steel, aluminium or mineral industries. 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 re-

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

FIGUR 10

Net exchange of electricity between Sweden and neighbouring countries, January 2001–December 2002, GWh/week.



Source: Swede Energy, Swedish Energy Agency.

duced by about 20%. Per-capita electricity use in the USA is about 21% lower than in Sweden, while that in the industrialised European countries is about 60% less than that in Sweden. Another factor of considerable importance for the high per-capita electricity use in Sweden is the early change from oil-based to electric heating as a result the 1970s oil crises and other causes.

Sweden is one of the world's countries that have a high proportion of hydro power and/or nuclear power in their electricity production. Only Iceland, Norway, Switzerland and Canada had higher proportions of hydro power in 2001, and only a few countries, including France, Belgium and Lithuania, had higher proportions of nuclear power in 2002[3]. In Holland, Denmark, the UK, the USA and Germany, 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, Denmark and Holland are, however, exceptions, producing respectively 12%, 6% and 4% of their electricity by combustion of biofuels. About half of the EU's electricity production is based on fossil fuels, with somewhat over 33% on nuclear power, 15% on hydro power and less than 2% on biofuels and refuse.

[3] Bulgaria, Slovakia and the Ukraine also produced more of their electricity from nuclear power in 2001 than did Sweden. Source: IAEA and World Nuclear Association, 2003

Biofuels, peat and refuse

In 2002, the use of biofuels, peat etc. amounted to over 98 TWh. These fuels are mainly indigenous, and consist of:

- wood fuels (logs, bark, chips and energy forest),
- black liquors in pulp mills
- peat
- refuse (industrial waste, domestic refuse etc.)

Biofuels can be processed into pellets, briquettes or powder in order to increase their energy density, simplify handling and reduce transport costs. They are used mainly in the forest products industry, for heating (district heating plants and the detached house sector) and for electricity production (producing a total of about 5 TWh of electricity).
The availability of raw materials for biofuels is good. It is estimated that, by 2010, the potential for the use of biofuels in Sweden could be about 160 TWh. However, it is important to distinguish between the theoretical potential and the realisable potential, and there are many different estimates of the quantities involved. There is a relatively extensive commercial importation of biofuels, but no reliable import or export statistics are at present collected, and so it is difficult to estimate quantities. In the national statistics for the country's energy balance, refuse imports are included as indigenously produced, and are based on the use statistics. The investigations that have been carried out into the import quantities indicate a figure in the range 5–9 TWh. Most of this is used for the supply of district heating.

The detached house sector

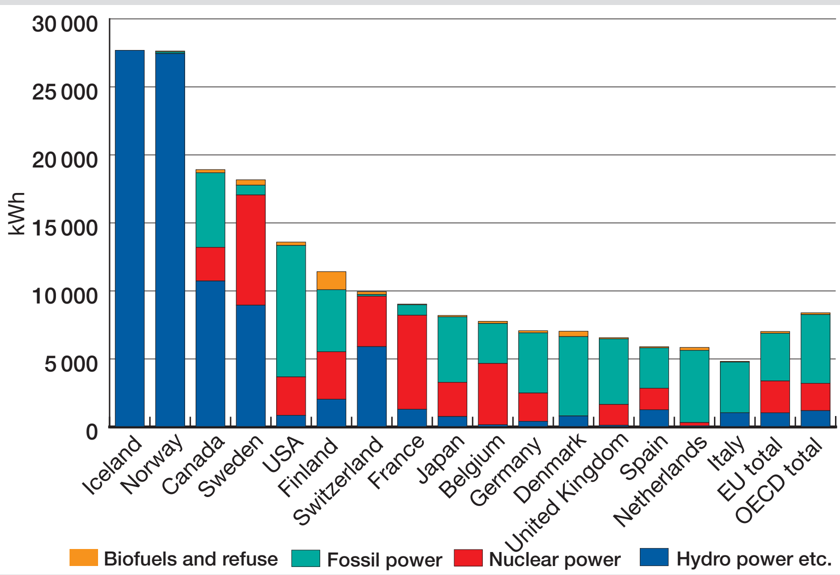
Over 6.7 TWh of biofuels, peat etc., mainly in the form of logs, were used in detached houses for heating in 2002. This quantity breaks down into about 5.8 TWh of logs (stacked volume), about 0.8 TWh of pellets and somewhat less than 0.1 TWh of chips and sawdust (loose volume). Wood-firing is commonest among property-owners with good access to forests, e.g. in agricultural or rural areas. The use of pellets is still relatively modest in the detached house sector.

The forest products industry

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 2002, they provided 34 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

FIGURE 11

Per-capita electricity production and relative breakdown of production sources, 2001.



Note: Hydro power includes other forms of renewable energy sources, but excludes biofuels. Fossil fuels are primarily coal or gas. *Source: IEA.*

2002, the pulp industry used a total of 7 TWh of wood fuels in the form of by-products for energy production, while sawmills and other woodworking industries used 5 TWh of wood fuels. Other industry sectors used 1 TWh of biofuels.

District heating plants

Over 35 TWh of biofuels, peat etc. were used for heat production in district heating plants in 2002. Of this, wood fuels accounted for 18.4 TWh, refuse for 5.5 TWh, peat for 3.9 TWh, unrefined tall oil for 3.2 TWh and other fuels for 2.0 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 about 4 TWh in 2000 (see also District heating and district cooling).

Refuse has been used for district heating production since the 1970s. Combustible refuse must now be separated from other refuse. Refuse sent for combustion is exempted from the landfill disposal tax, but the ash is taxed. In 2002, the tax rate for landfill disposal was SEK 288/tonne. From 1st January 2003, it was increased to SEK 370/tonne. Some quantities of refuse, demolition timber and similar fuels have been imported in recent years, but the amounts are difficult to estimate. However, it is likely that the combustion of refuse will increase over the next few years.

Since 2002, it has been prohibited to dispose of unsorted combustible refuse in landfill, and it will be forbidden to dispose of other organic refuse in landfill with effect from 2005. There is at present a substantial capacity shortfall in ability to handle refuse in accordance with these requirements.

Peat and energy forests

The use of peat amounted to 3.9 TWh in 2002, which is the highest amount to date. Peat is a substance that consists of dead plant and animal residues which, due to lack of oxygen in the decomposition process, contains combustible components. The formation of peat started about 10 000 years ago as the inland ice from the last ice age retreated, and is still in progress. Sweden works peat partly for fuel purposes (energy peat), and also as a soil improver etc. (cultivation peat).

Its properties when used as fuel are important when it is burnt together with wood fuels, particularly in reducing the risks of slag formation, sintering, the build-up of coatings and corrosion in boilers, and so increasing the availability and reducing the running costs of the plant.

The Peat Commission, which had been asked to investigate the role of peat in a sustainable energy system, published its report in October 2002. The report states that, in a national context, energy peat – although classified in international reports on greenhouse gas emissions as a fossil fuel – should not be assigned to any particular category, such as fossil/non-fossil, renewable/non-renewable. The report suggests that peat should be treated in the same way as wood fuels as far as the drafting of guide measures is concerned. Bearing in mind its value as a complementary fuel when burning wood fuels, its competitiveness against fossil fuels such as coal and oil should be maintained. In addition, the risk of a shortage of wood fuels in the event

FIGURE 12

Use of biofuels, peat etc. in industry, 1980–2002.

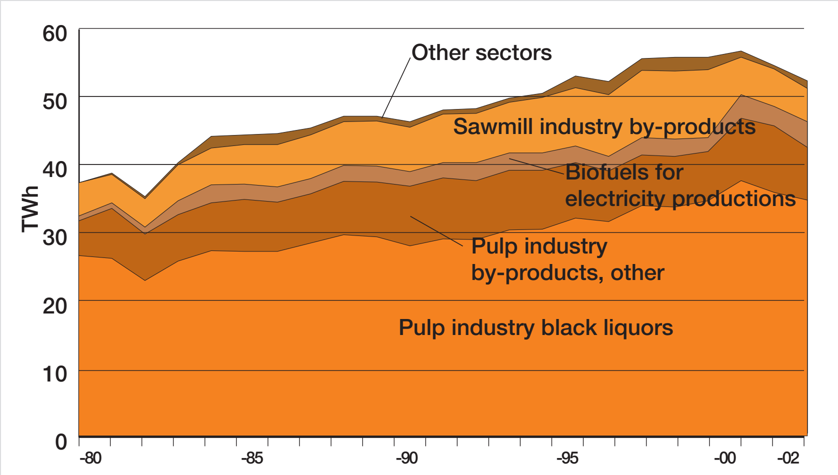
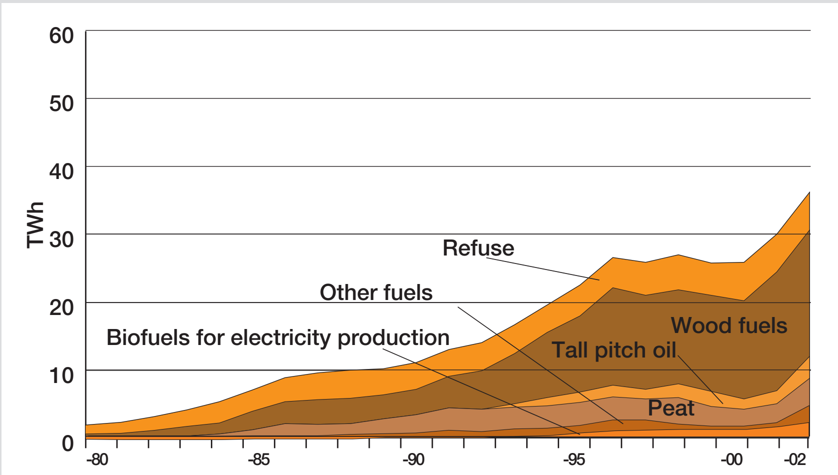


FIGURE 13

Use of biofuels, peat etc. by district heating plants, 1980–2002.



of an expected increase in demand in Europe, also indicates that peat should be regarded as a real alternative in certain situations. The Commission states that environmental factors indicate that electricity production based on peat should qualify for green electricity certificates.

Energy crops have been used as fuel for district heating plants since the beginning of the 1990s, although such use is relatively limited. Energy forest production has increased steadily over recent years, but starting from a very low level. In 2002, output amounted to about 0.2 TWh. This quantity reflects the amounts planted during earlier years, and is expected to increase, both as a result of better crops and of larger areas used. There is considerable potential for greater use, and salix is today grown on about 15 000 hectares, although this is only a very small fraction of Swedish agricultural land. Most of the plantations are in areas having good or reasonably good soils, on the plains of southern and central Sweden. The amount of land used for energy forest cultivation depends largely on European agricultural policy. Energy forests can play a part in restructuring European agriculture, while at the same time contributing to a greater production of energy crops. Production of energy forests is more energy-efficient than cultivation of other types of energy crops.

An international context

About 16% of Sweden's energy is supplied by biofuels, which is a very high proportion of any country's commercial 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 significantly high volumes of biofuels are Germany, France, Romania and Austria. In a global perspective, biofuels are the most important fuels for most of the Third World's populations, but it is difficult to quantify them as they are generally collected and used outside a commercial framework.

District heating and district cooling

Technically, district heating and district cooling are similar energy systems. District heating has been used in Sweden since 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 in industry for process cooling and cooling large computer centres. District heating systems are geographically much larger than district cooling systems, which are confined to the centres of urban areas. District cooling is supplied mainly by district heating utilities, and the two production systems are generally integrated with each other.

District heating

District heating can be defined in technical terms as 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 between the supplier and the user. It is produced in hot water boiler plants, which supply only heat, or in cogeneration plants (CHP), which supply both heat and electricity.

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 distribution mains network mean that it is difficult for systems to achieve viability in low-density detached house areas. However, several new types of district heating systems, suitable for use in smaller urban areas, have been built in the last few years, forming 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 and its use spread during the 1950s and 1960s as a result of the extensive investments in new housing and other buildings that were being made during that period, in conjunction with a substantial need for modernisation or replacement of boilers in the country's existing building stock. Group heating systems[4] were gradually linked up to form larger systems, with a particularly substantial expansion of district heating over the period from 1975 to 1985, partly due to district heating'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

[4] Heating systems that supply one or just a few blocks of 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. The urban environment in most Swedish towns has been significantly improved as a result of the expansion of district heating, which has reduced emissions of SO_2, particulates, soot and NO_x.

District heating is not price-controlled, although the regular price comparisons by the Public Service Fee Group[5] and the Swedish Energy Agency´s annual surveys of the heating markets provide information on price differences between areas. Pressure for price control, comes from a number of sources, including the Swedish Competition Authority. A review of district heating in the heating markets, by a Government commission, has been started, and is due to report in 2004. Its remit includes investigating the feasibility of opening district heating networks to competition, by providing access to third parties.

Today, district heating supplies over 40% of the total residential and commercial premises heating requirement. It is the commonest form of heating in apartment buildings, supplying heat to about 77% of the heated floor area, while about 58% of commercial and similar premises are heated by it. In detached houses, on the other hand, the proportion is only about 8%. (See also Residential and service sector.)

The country has about 13 000 km of distribution mains, which supplied 49 TWh of heating in 2002. Of this, over half was used for residential space heating, about 30% for heating commercial premises and over 15% by industry. The proportion of district heating used by industry has increased substantially since last year, although this can be explained as the results of an organisational change. Some industries have sold their own heat production facilities to district heating utilities, and then bought back the heat from the utility. This then appears in the statistics as district heating, despite the fact that it is actually district heating without distribution pipes. The results also affect the statistics for total heat supplies, which in this way increased by about 7% in 2002. However, corresponding decreases can be found in the use of biofuels by industry for heating.

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 to the district heating sector in 2002 was 55 TWh, of which biofuels accounted for 33 TWh, or over 60% 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. District heating losses have fallen since the 1980s as a result of improved technol-

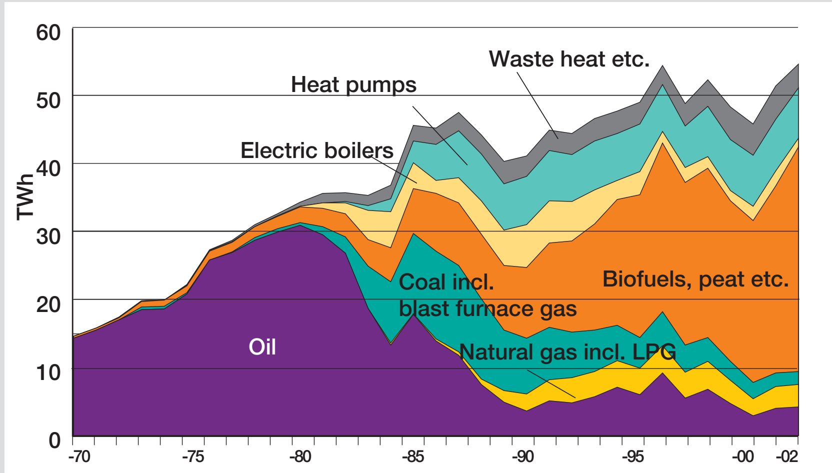
[5] Formed by large housing companies and interest organisations, and monitors local authority charges for heating, domestic hot water, water, sewage treatment, electricity and public cleaning.

FIGURE 14

Use of district heating, 1970–2002.

FIGURE 15

Energy input sources for district heating, 1970–2002.



ogy and higher load factors. In 2001, distribution and conversion losses amounted to over 12% of the total energy input: in 2002, they had fallen to about 10%. Some of the reduction, however, is due to the greater use of heat buyback, as described above, which requires no network distribution. Losses in the 1980s amounted to 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 were restructured as limited companies owned by the local authorities. Today, there are about 220 companies supplying heat in Sweden, although many have common owners. After deregulation of the electricity market, there has been a considerable consolidation of ownership as a result of some of the larger electricity utilities buying up local authority energy companies, including their district heating operations. Nevertheless, about two-thirds of the country's district heating utilities are still owned by local authorities, although many of the really large systems, such as Stockholm, Malmö, Uppsala, Norrköping and Örebro, are partly owned by private or state interests.[6]

District cooling

District cooling is used mainly in offices and commercial premises, as well as for cooling 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. In the same way as for group heating, district cooling may be provided in the form of smaller systems operated by property-owners for their own property. However, the statistics provide data only for commercial district cooling, i.e. with the supplier and consumers being different parties. It is primarily existing district heating suppliers that have established commercial district cooling systems in Sweden.

There are many ways in which district cooling can be produced. In Sweden, the commonest is for district heating and district cooling utilities to use waste heat or lake water as the heat source for heat pumps, with the cooled water from which this heat has been abstracted then providing the district cooling water. Another common method of production is simply to use cold bottom water from the sea or a lake, i.e. free cooling. A further alternative is to install heat-driven absorption chillers at or near a customer's premises powered by district heating. This particular arrangement increases the load factor of the district heating system in the summer.

One of Europe's largest district cooling operations has been built up in central Stockholm since 1995. Sweden is the leading country in Europe in terms of the technology and system architectures. The market for district cooling has expanded strongly since the first system was started up in Västerås 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 of their properties in other towns. The market has further been greatly assisted by the phase-out of ozone-depleting refrigerants, as property owners have been forced to buy new equipment, convert existing equipment or invest in replacement systems. Connection to district cooling is an attractive alternative.

In 2002, there were 28 commercial district cooling suppliers, some operating more than one system. The length of mains amounted to over 220 km, through which 597 GWh of district cooling were supplied.

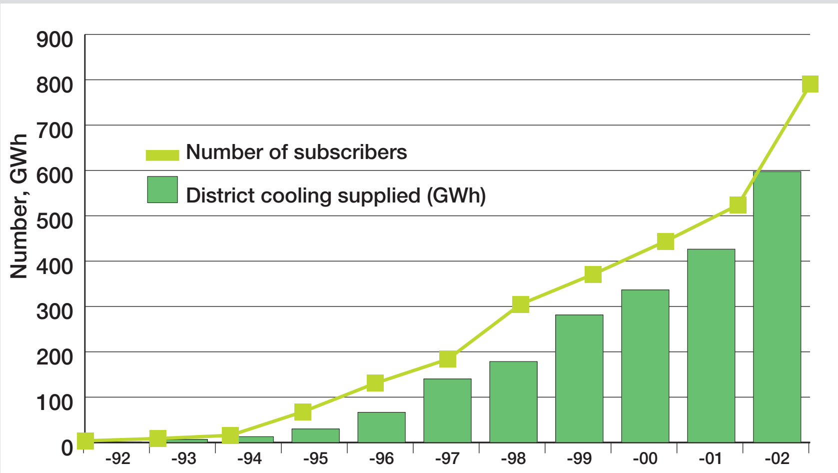
The oil market

Crude oil makes up about 40% of the trade in raw materials for the world's commercial energy markets. For over 140 years now, oil has been one of the most important energy raw materials, on the back of which industrialisation, motor traffic and economies have grown. Recent decades have seen a rapid expansion of the oil markets in the new industrialised countries in the Far East and Pacific rim, as in the major oil-producing countries of the Middle East. The

[6]Particularly the Swedish state through Vattenfall, the Finnish state through Fortum and the French state through EdF.

FIGUR 16

Supplies of district cooling, 1992–2002.



Source: Swedish District Heating Association use of oil is at present increasing rapidly in the developing countries.

Production and reserves

Crude oil is recovered from the earth's crust onshore or offshore, depending on where it is: costs differ between the two. The quality of the crude can also vary from one location to another, and it is generally more expensive to recover oil offshore than onshore. The oil cannot be used until it has been refined, which produces a range of petroleum products, primarily petrol, diesel fuel, aviation fuel and fuel oils. By far the greatest use of oil products is as motor fuels, with most of the transport sector now (and for a considerable time into the future) dependent on the use of oil. Oil products are also used for electricity and heat production, as a raw material for plastics, in other chemical industries and for many other products, such as asphalt. All this means that the oil market has a very strong effect on the entire world economy. International trade in oil, which is largely organised through an international oil exchange, also accounts for the greatest volume of products transported by international maritime trade. This trade also represents a major environmental risk.

Production methods for crude oil have become more efficient. Technical development has resulted both in improved prospecting for oil and improvements in bringing oil wells on line. New reserves can be found, thus increasing total known reserves. New technology has also made it possible to extract more oil from each well. This has reduced the cost of recovering the oil, thus giving a certain theoretical potential for lower oil prices. However, as long as output restrictions are applied by producers, oil prices are maintained at higher levels. It is difficult to put a figure on total oil reserves, and there are many different assessments thereof. The same applies to attempts to determine how long supplies will last with present technology and rates of use. (An international perspective)

Oil producers

OPEC (Organization of the Petroleum Exporting Countries) is an international organisation for cooperation between eleven oil-producing developing countries, the economies of which are strongly linked to their oil export revenues. The members of OPEC are Algeria, Indonesia, Iran, Iraq, Kuwait, Libya, Nigeria, Qatar, Saudi Arabia, the United Arab Emirates and Venezuela. Most of OPEC's production is in the Middle East. OPEC's purpose is to create stability on the international oil market, and to look after its members' economic interests. By varying the amount of oil available on the market, OPEC attempts to achieve a balance between supply and demand, and to maintain prices at a level which is in the long-term interests of its members. OPEC accounts for about 40% of world production of crude oil, and over 75% of world market net exports, i.e. that part of the market that is sold to countries with a greater demand for oil than they can meet from their own resources.

Outside OPEC, the largest oil-producing countries are the USA, Canada, Norway, the UK, Russia, Oman and Mexico, together accounting for most of the world's remaining oil production. However, with the exception of Norway and Oman, these countries have large home markets, and therefore make little contribution to net world exports. Abstraction rates in the non-OPEC countries are high in relation to their remaining reserves, which means that the oil market will become more dependent on oil production from the OPEC countries in the longer term. In general, the cost of crude production is higher in non-OPEC countries, due to the size of the fields and their accessibility. Offshore production, for example, is more common in the non-OPEC countries.

Since the oil assets in the OPEC countries were nationalised during the 1970s, OPEC has acted as a cushion on the world market. Crude oil outputs are regulated by a quota system. OPEC has attempted to maintain price levels by persuading its member states not to utilise their full production capacity, although this policy has had somewhat varied success.

FIGURE 17

Imports of crude oil, 1972–2001, by countries of origin.

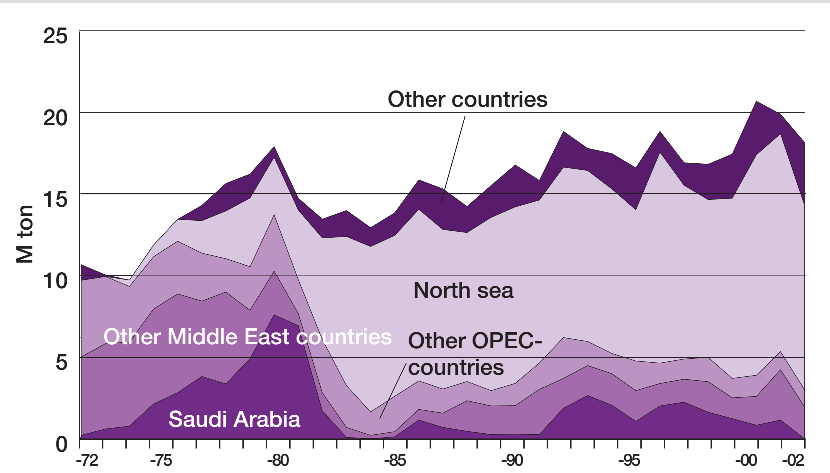


FIGURE 17b

Net imports (+) and net exports (-) of refinery products, 1970–2002

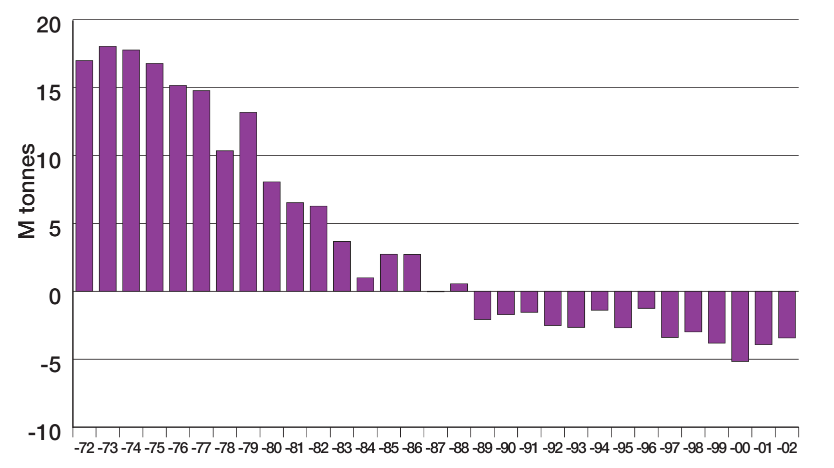


FIGURE 18

Use of oil products in Sweden, 1970–2002.

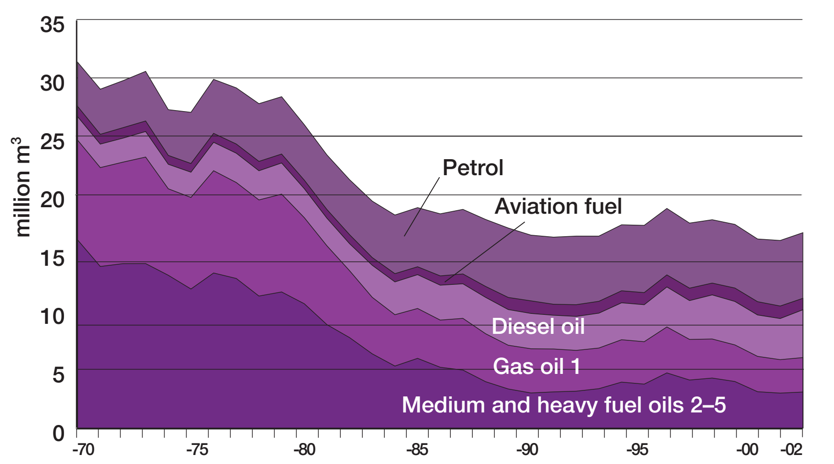
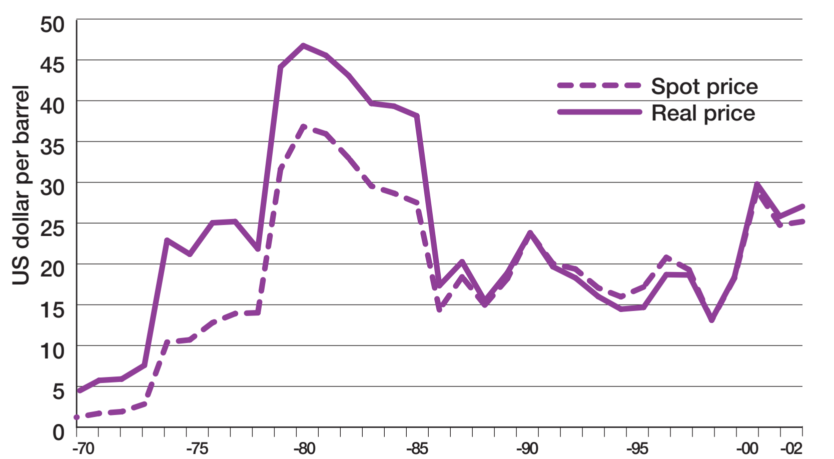


FIGURE 19

Nominal and real prices of light crude oil, 1970–2002.



Source: The World Bank, BP.

Oil prices

There are many factors that affect the price of oil: expectations of future economic trends, for example, and political conditions in the Middle East. In recent years, there have been substantial price changes on the international oil market. From record-low levels in 1998, the average prices of oil rose by 40% during 1999 to over USD 18 per barrel. In 1999, OPEC reached agreement with some of the other major oil producers (Mexico, Norway, Russia and Oman) on production cutbacks, which resulted in a dramatic price increase, of up to over USD 30 per barrel. OPEC aimed to maintain the price level in the range USD 22-28 per barrel, aiming to achieve an average price of USD 25 per barrel. This price range represents a balance between a high price of oil, which gives high revenues for the producers, and the braking effect of this price on world economy and thus on the demand for oil. The price fell by 15% in 2001, to just below USD 25 per barrel. During 2002, the price remained at approximately this level.

Oil in Sweden

In 2002, oil provided about 32% of the country's energy supply, and 33% of final net energy use (i.e. excluding losses). On the user side, it is the transport sector that is most dependent on oil, using almost twice as much oil as do the industry and residential/service sectors together.

Oil dependence has been substantially reduced since 1970, falling from 350 TWh in 1970 to 199 TWh in 2002. It is primarily the use of fuel oils that has been reduced: instead, Sweden has become more dependent on electricity, although district heating has also replaced a considerable quantity of oil for heating supplies.

Another important change since before the oil crises is the fact that Sweden nowadays exports, rather than imports, refined oil products. Prices of refined products rose steeply during the 1970s oil crises, and so an increase in refinery capacity was an important means of helping to protect the Swedish economy against excessive price increases. In fact, Sweden imports almost 80% more oil than is actually used in the country, as much of it is processed in the country and then exported. The exported proportion of Sweden's production of oil products has risen from 25% in 1986 to 47% in 2001.

The coal market

Carbon is one of the elements, which occurs in nature in the form of combinations in various minerals. Some of these minerals can be burnt, and are referred to in everyday language as coal.

By tradition, coal is divided into black coal and brown coal, depending on their calorific values. This division is not particularly precise, as no two coalfields produce coal with exactly the same properties. They can differ with respect to properties such as ash content, moisture content, the number of flammable constituents (calorific value), volatile elements, sulphur content etc. Quality differences between coals vary on a continuous scale. Black coal is a relatively high-value coal, while brown coal has a lower energy content and a higher moisture content. Sweden uses almost exclusively only black coal, which is divided traditionally into two different 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. Another division of the various forms of coal is that of anthracite, bituminous coal, sub-bituminous coal and lignite. The first two are black coals, and the last are brown coals. In some countries, sub-bituminous coal is categorised as black coal, while in other countries it is categorised as brown coal.

Since 1991, the spot price of coal in northwestern Europe has varied between USD 26/tonne and USD 46/tonne.[7] In June 2003, the price was USD 37/tonne, with a rising trend.

The largest producers of black coal are China and the USA, which together account for over 50% of world production. The five major exporting countries are Australia, South Africa, China, Indonesia and the USA, together accounting for over 70% of world trade in coal. Coal production in Europe is falling, while imports are rising somewhat. If production continues at the present rate, estimated and economically recoverable reserves would last for over 200 years. The largest accessible reserves of black coal are in Russia, the Ukraine, China and the USA, while the largest reserves of brown coal are in Russia, the USA, Eastern Europe and Australia.

Sweden's coal supply

Coal played an important part in Sweden's energy supply up to the 1950s, when it lost ground to the cheaper and more easily handled oil. The oil crises of the 1970s meant that coal again became 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 heat production has stagnated, although other uses have increased somewhat. A total of 3.3 million tonnes of black coal was used in Sweden in 2002. 1.8 million tonnes of this were coking coal, leaving 1.5 million tonnes for energy purposes. To this must be added a net import of 0.47 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 coking plants from metallurgical coal. The country's two coking plants, at steelworks in Luleå and Oxelösund, also produce gas as a result of the process. The gas is used for heat and electricity production in the steelworks, and for district heating production. The coke 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 used in the same way as the coke oven gas.

In addition to metallurgical coal and coke, ordinary energy coal is also used in industry. This use has increased over the last three years, and is now approaching the level of 1990, despite the fact that its use has attracted carbon dioxide tax since 1993. However, industry does not pay the full rate of carbon dioxide tax. 1.8 million tonnes of metallurgical coal were used in industry in 2002, together with 0.93 million tonnes of energy coal and the country's entire net import of 0.47 million tonnes of coke. This quantity of energy coal provided an energy input of 7 TWh.

District heating and CHP production

The use of coal for district heating fell 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 regarded as providing the energy for electricity production is exempt from energy and carbon dioxide tax. Some of the coking and blast furnace gas (see section above) is also used by the district heating sector. SSAB's steel mill in Luleå supplies gas to the town's district heating cogeneration plant for the production of heat and electricity, while its mill in Oxelösund supplies heat to the town district heating system. In 2002, the district heating sector used 0.55 million tonnes of energy coal (4.2 TWh) and 1.6 TWh of coking oven and blast furnace gas for electricity and heat production.

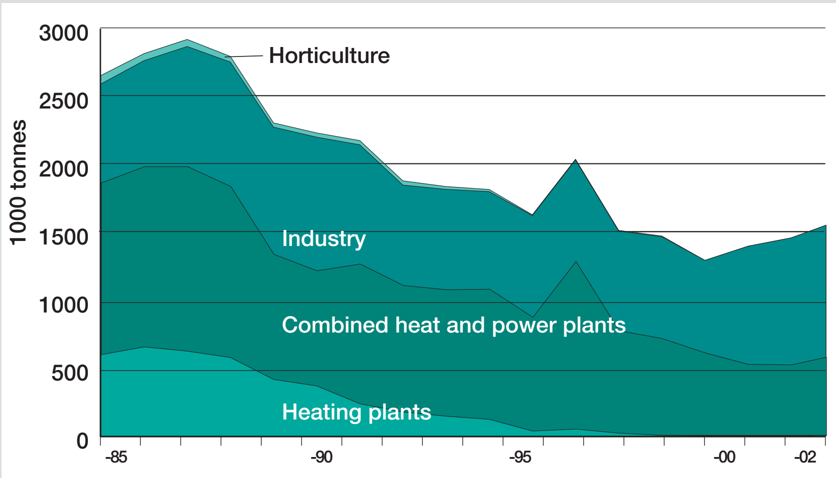
Electricity production

0.39 million tonnes of coal (3 TWh), together with 1.6 TWh of coking oven and blast furnace

[7] Tonne, as used here, refers to a tonne with a standardised calorific value of 25 121 kJ/kg = 6,978 kWh/kg

FIGURE 20

Use of energy coal in Sweden, 1985–2002.



gas, were used for electricity production in 2002, giving a total of about 3 TWh of electricity.

The energy gases market

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.

Natural gas in Sweden

Natural gas was introduced to Sweden in 1985. Its use increased rapidly until 1992, after which growth continued at a more modest rate. In 2002, imports amounted to 933 million m^3, equivalent to 9.3 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 15%. A small amount of natural gas is also used as motor fuel.

Natural gas is distributed at present to 31 municipalities, where it provides about 20% of energy use. On the national level, it supplies somewhat less than 2% of total energy use.

The gas is supplied exclusively from fields in the Danish sector of the North Sea. After transiting Denmark, a pipeline under Øresund brings the gas ashore at Klagshamn outside Malmö. A trunk main extends from Trelleborg in the south to Gothenburg, with a number of branches, including one to Gislaved 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. Sydkraft Gas AB is responsible for the branch mains in southern Sweden, and completed extension of a main from Hyltebruk to Gislaved and Gnosjö at the end of 2002. In conjunction with Verbundnetz Gas, Sjællandske Kraftværker and Norsk Hydro, it is planning to build a transmission main between Germany and Sweden, via Denmark, under the name of the Baltic Gas Interconnector. The application for the Swedish part of the project has been processed by the Swedish Energy Agency, which supported the application in its report to the Government in April 2003.

Nova Naturgas AB has started to extend the west coast distribution main from Gothenburg to Stenungssund and Bohus.

Svensk Naturgas AB, which was established in 1999, is investigating extension of the system to Stockholm, the Mälar Region and Bergslagen.

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

Production and use of natural gas internationally

In Sweden, natural gas is a marginal energy source. However, in the EU countries and in the world as a whole, it provides somewhat over 20% of energy supplies.

The world's natural gas reserves are substantial: at the end of 2002, commercially viable reserves amounted to 156 000 billion[8] 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%). Only 2% of the world's natural gas reserves lie within Europe. At the present rate of use, this would last for only 14 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

[8] American english. See table 9 in chapter 8 for definitions.

between the Russian and Norwegian natural gas fields and the continent.

Today, the world's major producing countries are Russia, the USA and Canada. Within the EU, the major producers are the UK, Norway and Holland.

The proportion of total global energy supply met by natural gas has increased rapidly during the last decade, by over 20% between 1992 and 2002. Consumption of natural gas is highest in the USA, Russia and the UK. Within the EU, natural gas has a part to play in reducing environmentally hazardous emissions, primarily by replacing coal and oil.

Transportation of natural gas

Pipeline transportation of natural gas is the main way of transporting natural gas between producers and consumers. The physical transport system can be approximately divided up into transmission and distribution. Transmission pipes carry the gas over long distances under high pressure: the quantities of energy represented by the gas can be very significant. At the reception points, the pressure is reduced in metering and pressure regulation stations, before the gas is supplied to local distribution networks for delivery to the end-users.

Several Asiatic countries, particularly Japan and South Korea, are far from their sources of supply. Gas is delivered to them by ship in liquid form, having been liquefied by extreme cooling. Liquefied natural gas (LNG) has historically been unable to compete to any greater extent with pipe-borne natural gas, due to the cost of liquefaction and maritime transport. However, recent reductions in the cost both of production and transport have partly changed this situation.

Opening the natural gas markets to competition

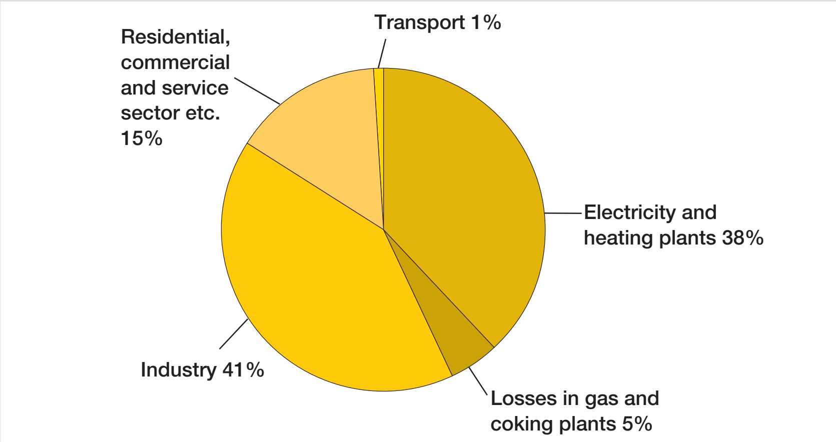
The underlying purpose of deregulation of the natural gas markets around the world has been to create the right conditions for effective utilisation of resources, thus keeping down the prices of gas. Several structural regulatory changes have been introduced in order to ensure smoother operation of the markets. Some of the most important of these are unbundling and third-party access. Unbundling involves separation of sales and of transport of the gas, and can operate at various levels. In the most extreme case, it involves a complete separation of ownership between the transport section and the sales section. In Sweden, the requirement is simply that the reports and accounts of the two activities must be separated, in order correctly to assign the costs for each and to prevent cross-subsidisation[9]. Third-party access requires the owners of transmission and distribution networks to allow other parties to use them. The UK provides an example of a country with third-party access to both its transmission network and its distribution networks. One of the reasons for its introduction has been to create competition in the sale of natural gas: in practice, if it is to work properly, it must also be accompanied by unbundling.

The USA and Canada were the first countries to begin restructuring their gas markets at the end of the 1970s. The process started by deregulating pricing of the gas itself at the production level, and this was followed by extending deregulation to create competition at the wholesale level. This required a legal distinc-

[9] Cross-subsidisation is the practice of applying the revenue from one activity to support another, thus distorting competition.

FIGURE 21

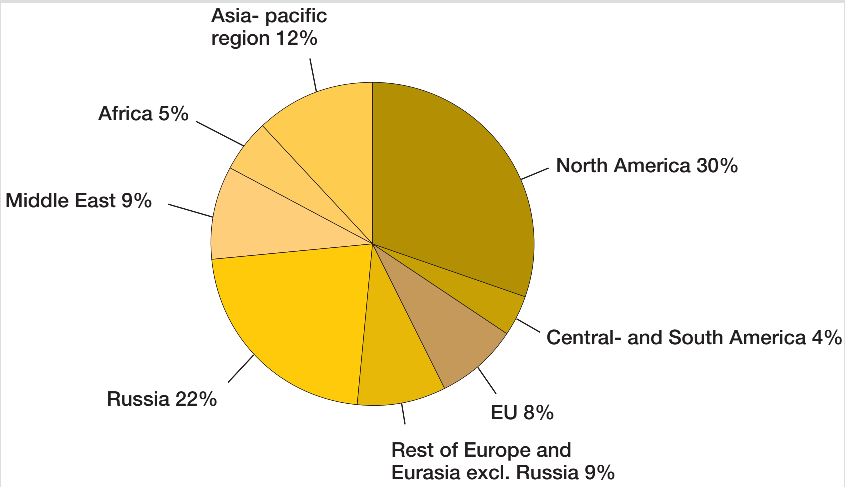
Supply of natural gas in Sweden, 2002, by sectors. Total 933 million m³.



Source: "The Statistical Review of World Energy 2003", BP

FIGURE 22

World natural gas production, 2002. Total 2 528 billion[8] m³.

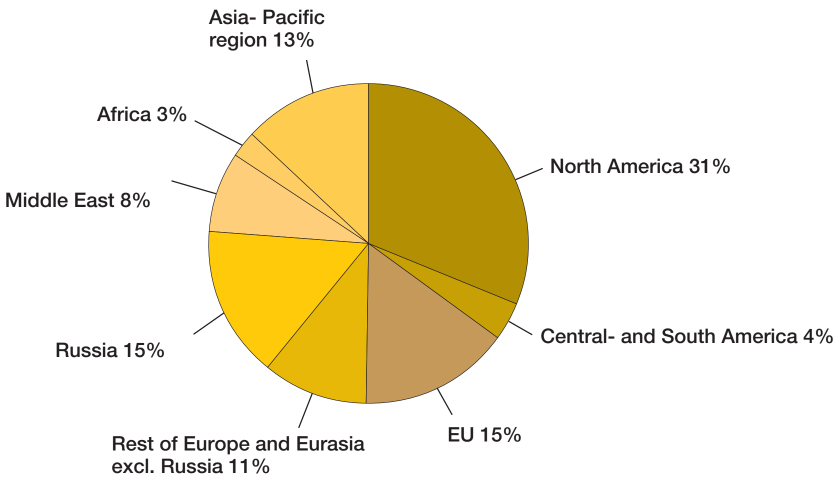


Note: Due to rounding up figures the total is 99%.

Source: "The Statistical Review of World Energy 2003", BP

FIGURE 23

World natural gas use, 2002. Total 2535 billion m³.



Source: "The Statistical Review of World Energy 2003", BP

tion between trade in gas on the one hand, and its transport on the other, i.e. unbundling. Another feature of the North American gas market reform was the requirement for third-party access to the large interstate transmission pipes.

Similar reforms were launched in the UK during the middle of the 1980s, so that, since 1998, the market there is completely open. All customers, regardless of size, have a free choice of supplier.

The EU Natural Gas Directive was issued in February 1998, with the aim of increasing competition on the European natural gas markets. It was incorporated in Swedish legislation on 1st August 2000, in the form of a new Natural Gas Act. A new Natural Gas Directive (2003/55/EC) was issued in June 2002, with the aim of accelerating liberalisation of the natural gas markets, and setting a timetable for opening the markets. By not later than 2004, all non-domestic customers must be able freely to choose their suppliers. This freedom must have been extended to all customers by 1st July 2007, thus achieving complete liberalisation of the EU gas markets.

Other energy gases

LPG

Imports of LPG[10] to Sweden in 2002 amounted to 794 000 tonnes, while 331 000 tonnes were exported. 617 000 tonnes were supplied to the Swedish energy system, equivalent to 7.9 TWh. LPG is used mainly in industry, as well as in the restaurant trade and in horticulture. 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 2002, 4.8 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. Its environmental characteristics are very similar to those of natural gas.

Biogas

Biogas consists of methane, formed by the breakdown of organic materials such as sewage sludge, refuse or industrial waste under anaerobic (oxygen-free) conditions. The process, known as digestion, occurs spontaneously in nature, e.g. in marshes. Today, Sweden has about 100 biogas plants in operation, most of them in sewage treatment plants or at landfill sites, producing digester gas and landfill gas respectively. Most biogas is used for electricity and heat production. In 2001, 28 GWh were used for electricity production and 367 GWh for heat production. Biogas can also be cleaned and distributed via the natural gas network as 'green natural gas'.

Gasworks gas

Gasworks (town gas) is produced by cracking naphtha. Fortum Värme 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 2002.

Hydrogen

Pure hydrogen does not occur naturally, but must be produced from sources such as methanol, LPG or natural gas, or by electrolysis of water. Production of hydrogen by electrolysis is energy-intensive: 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.

[10] Stastisically treated as oil in Sweden´s total energy supply.

Energy use

Modern society is very dependent on energy. We need energy for heating, for lighting and domestic equipment, to travel and for the production and distribution of goods and services. The amount of energy used is affected by many factors, including economic development, economic conditions, technical development, prices and guide measures employed in energy and environmental policy. 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 2002, together with developments in energy use since 1970.

The residential and service sector etc.

In 2002, energy use in this sector amounted to 155 TWh, which was 1 TWh more than during the previous year, and represented about 39% of Sweden's total final energy use.

About 86% of this energy is used in residential and commercial premises for space heating, domestic hot water production and the powering of 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. 2002 was 8% 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 2002 amounted to 160 TWh, an increase of 1 % relative to the previous year.

Electricity and district heating have increased, while the use of oil has decreased

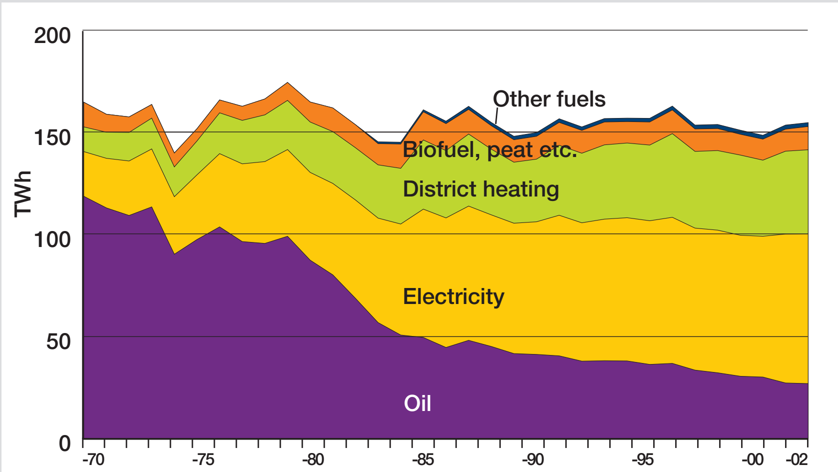
The total temperature-corrected energy use in the sector has remained relatively static between 1970 and 2002, although the relative proportions of the different energy carriers have changed. Oil crises, rising energy prices, changes in energy taxation and investment policies have all affected the shift from oil to other energy carriers. In 2002, total use of fossil fuels in the sector amounted to 28.7 TWh, as against 118.6 TWh in 1970. Much of this reduction is due to a move away from the use of oil for heating to electricity and district heating.

The number of dwelling units (single-family houses and apartments in apartment buildings) in the country increased by almost 40%, to 4.3 million, 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. 2002, however, saw an increase, with work starting on 19 200 dwelling units. Floor areas of commercial premises, however, have increased substantially since 1970.

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. Domestic electricity is

FIGURE 24

Final energy use in the residential and service sector etc., 1970–2002



that which is used for powering domestic appliances and other equipment in residential premises. Electricity for building services systems is that used for powering equipment in commercial premises and in other service applications.

Heating and domestic hot water

Of the 90 TWh that were used for space heating and domestic hot water production in 2002, it is estimated that about 44% were used in detached houses, 31% in apartment buildings and 25% in commercial premises and public buildings.

Over a third of all detached houses in the country were heated by electricity alone in 2002. Approximately 17% of detached houses have only direct-acting electric heating, with 16% having waterborne electric heating. About 10% of detached houses are heated by oil alone, 8% by district heating and 6% by wood alone. The main reason for the high proportion of electric heating is that it is cheap to install and simple to run. The use of electric heating increased substantially in the sector from 1970 to 1990, with the increase being greatest during the first half of the 1980s. The use of electric heating in detached houses remained relatively stable during the 1990s.

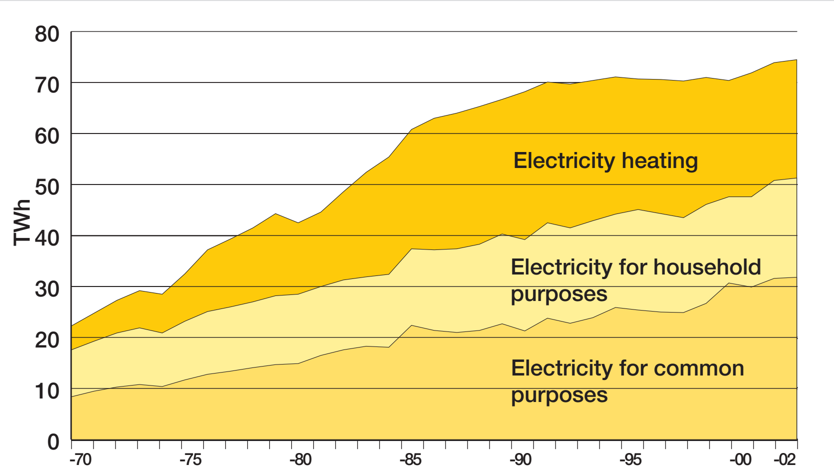
Another common heating system in detached houses is electricity in combination with a wood and/or oil fired boiler, which allows users to change between electricity, oil or wood. The proportion of detached houses with such systems is a little under 30%. They are therefore relatively flexible in their choice of fuel, with the selection being largely determined by the relative price levels of the different energy carriers. Other households, not having this ability quickly to change their energy carriers, are more vulnerable to changes in the relative prices. The total use of electricity for space heating in detached houses and agricultural properties amounted to 16.5 TWh in 2002.

District heating is the commonest form of heating in apartment buildings, with about 77% of apartments being heated by it, equivalent to a use of about 23 TWh. Oil is used as the sole or main heat source for 5% of apartments, equivalent to 2.4 TWh of oil. The use of electric heating in apartment buildings is relatively low, amounting to 1.5 TWh in 2002.

The main source of heat in offices, commercial premises and public buildings is also district heating, with about 58% of such buildings being supplied, equivalent to 14.8 TWh. The use of electricity for space heating and domestic hot water production in commercial premises amounted to 3.8 TWh, while 3.3 TWh of oil were also used for this purpose.

FIGURE 25

Electricity use in the residential and service sector etc. 1970–2002, temperature-corrected.



Domestic electricity

The use of electricity for domestic purposes doubled between 1970 and 2002, from 9.2 TWh to 19.5 TWh. Although most of this increase occurred during the 1970s and 1980s, it has still continued over the last few years. This rising use can be explained by an increase in the number of households and greater ownership of domestic appliances. To some extent, it can also be explained by an increase in the 'hidden' use of electric heating. Electricity used for floor heating, heated towel rails etc. also contributes to the overall heating of a building, although shown in the statistics as domestic electricity. However, continued improvement in the electrical efficiency of appliances - and particularly of white goods – has tended to offset this increase, as old, energy-demanding appliances are replaced by new, more efficient ones.

Building services systems etc

The use of electricity for equipment in commercial premises and for building services systems has increased substantially, from 8.4 TWh in 1970 to 31.8 TWh in 2002. 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, 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, commercial premises and public buildings is still regarded as considerable. Although companies constantly replace equipment, which also becomes steadily more efficient, there is also a trend towards greater numbers of items and equipment.

Unchanged final energy use

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 2002 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 total final energy use through reduced conversion losses in the end use processes. Different energy carriers exhibit differences in distribution and conversion losses in the process of final conversion to heat at the consumers' premises, which can be expressed in the form of mean annual efficiencies. These efficiencies allow for the aggregated effects of the combustion efficiency of the heating system, heat losses, distribution losses and shortcomings in control and adjustment of the heating system. The mean annual efficiencies of electric heating and district heating are, on average, higher than those for oil, which means that replacing oil by electric heating or district heating results in an overall reduction in final energy use.

The number of heat pumps in use has increased considerably in recent years, thus reducing the actual amount of purchased energy used for space heating and domestic hot water production. Heat pumps abstract heat from rock, the ground, air or water, and supply it to the building's heating system. Those abstracting heat from rock, the ground or lake water can supply 80–90% of the annual space heating and domestic hot water requirements of a detached house, with the remaining 10–20% usually being supplied by electric immersion heaters or an oil-fired boiler. Heat pumps normally deliver 2–3 times as much thermal energy as they use in the form of 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 2002, industry used 2.2 TWh more energy than during 2001, amounting to 152 TWh, or 38% of the country's final energy use.

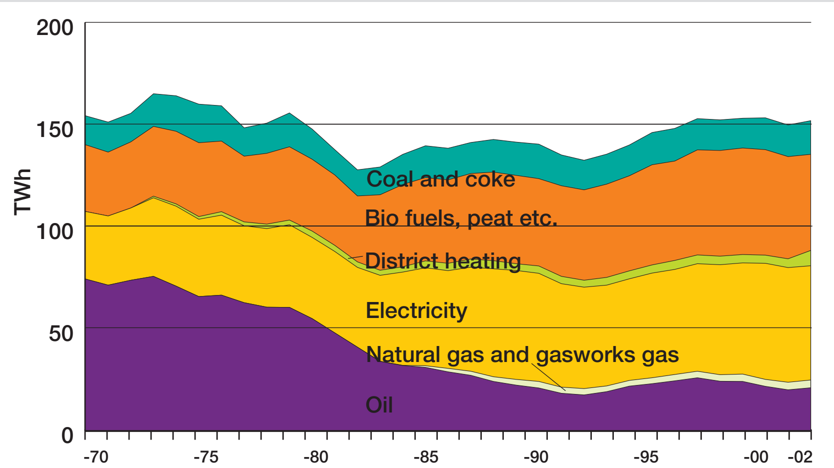
Energy use in industry

Classified by energy carrier, industry's use of energy was met by 21 TWh of petroleum products, 16.5 TWh of coal and coke and 56 TWh of electricity. Use of natural gas amounted to 3.9 TWh, and that of district heating to 7.5 TWh. Supplies of biofuels, peat etc. amounted to 47.1 TWh: of this, about 41 TWh were used in the pulp and paper industry, mainly in the form of black liquors. Final energy use in industry therefore consisted of 27% of fossil energy and 31% 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 6.5%. Together, these three energy-intensive sectors account for over

FIGURE 26

Final energy use in industry, 1970–2002



two-thirds of total energy use in industry. The engineering industry, although not regarded as energy-intensive, nevertheless accounts for about 8% of total energy use in industry, as a result of its high proportion of total industrial output in Sweden.

The relationship between industrial 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 taxation, changes in energy prices, improvements in the efficiency of energy use, investment, technical development and changes in the structure of the sector and the types of goods produced.

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. Industrial output recovered in 1993, and continued to rise substantially until 2000, during which period output increased at nearly 8% per annum. This was reflected in energy use, which increased by 13% over the period. Electricity use increased by 15%. This was followed by a downturn in 2001, and a weak recovery in 2002. Over the period 2000–2002, industrial output increased by almost 1% per annum. Energy use fell by 1% over the whole period, with the use of electricity falling somewhat more. In total, industrial output has increased by 75% between 1992 and 2002. During the same period, energy use has increased by about 15%, and the use of electricity by 13%.

FIGURE 27

Specific use of oil in industry, 1970–2002, 1991 prices.

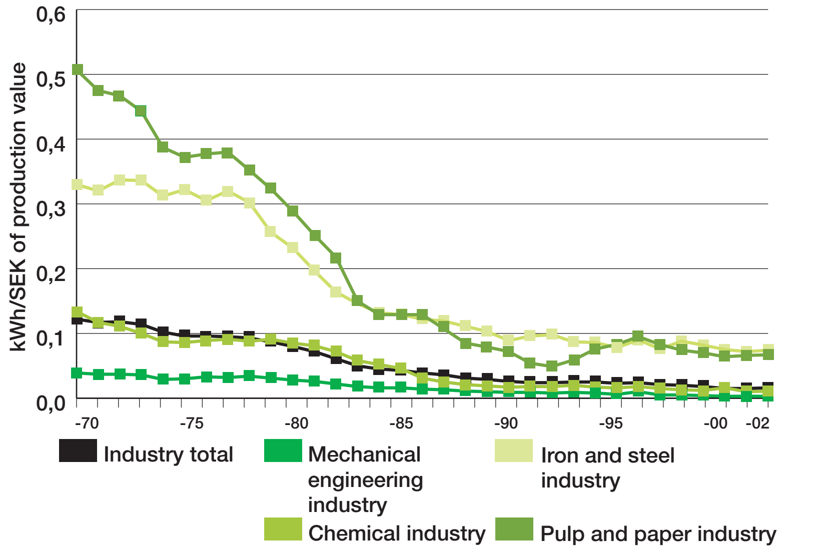
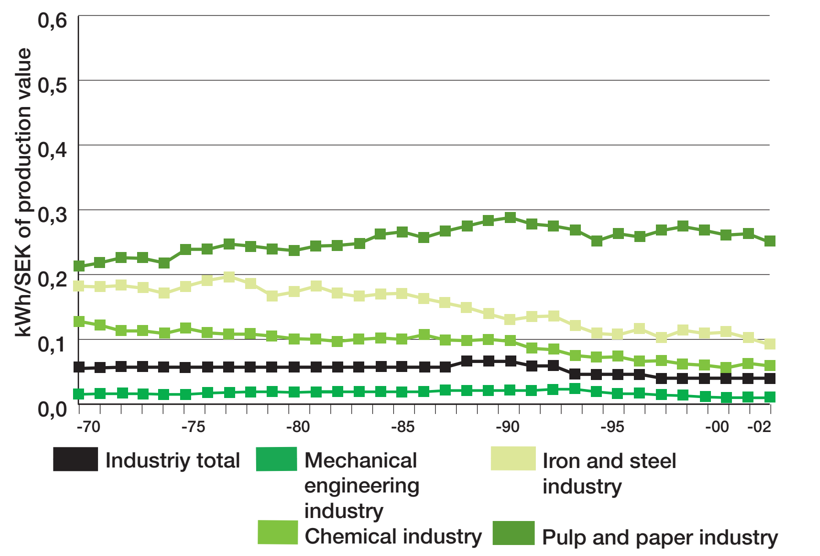


FIGURE 28

Specific use of electricity in industry, 1970–2002, 1991 prices.



Changes in use of the most important energy carriers

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 14% in terms of industry's energy use. Other forms of energy carrier, such as electricity, have therefore replaced the use of oil. One reason for this is that the cost of fossil fuels has risen. Nevertheless, despite this, the use of oil products increased by 3.5 TWh, or 20%, between 1992 and 2002. Contributory factors for this have included increased industrial output, lower energy and carbon dioxide taxes and a greater use of oil as a replacement for disconnectable electric boilers . Between 1970 and 2002, the proportion of biofuels, peat etc. has increased from 21% to 31% of total energy use in industry.

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 2002, it fell by 53%, 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 between 1992 and 2002, coupled with changes in the energy taxation of industry, is reflected in changes in specific energy use, which has continued to fall. Over this period, it fell by 35%, with specific use of oil falling by 33% and that of electricity falling by almost 36%. 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 2002 amounted to 94 TWh, or 23% of the country's total final domestic energy use. Foreign maritime traffic used 14.4 TWh of bunker oils. Energy use in the transport sector consists almost entirely of oil products, primarily petrol and diesel fuel. In 2002, the use of these two fuels provided 86% of the country's energy requirement for domestic transport. The use of petrol increased in 2001 and 2002, after having shown a declining trend since 1995. The use of diesel fuel also increased, but that of aviation fuel and bunker oils for foreign maritime traffic has decreased. These reductions are due partly to economic conditions and partly to general world unease. Use is largely dependent on economic conditions and technical development. The two main guide measures, intended to reduce the use of energy by the transport sector, are energy tax and carbon dioxide tax.

Alternative motor fuels

The use of alternative motor fuels, such as ethanol and biogas, is at present marginal, and accounts for less than 0.8% 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.

The energy tax on ethanol in E85 fuel (which consists of 85% ethanol and 15% petrol) was removed on 1st January 2003, thus reducing the price by 94 öre/litre, to about SEK 7:50/litre. However, as ethanol has a lower energy content than petrol, a vehicle running on E85 consumes about 25–35% more fuel by volume than if it had been running on petrol alone. This means that the overall energy cost of E85 is today comparable with the cost of petrol (see Taxes and Prices). For some years now, all petrol sold in Stockholm and the Mälar Region contains 5% ethanol. During 2003, the Government has reduced taxation on considerably greater volumes of ethanol than was previously the case. One of the effects of this is that fuel companies, together holding over 80% of the Swedish petrol market, now intend progres-

FIGURE 29

Use of oil and electricity in industry, 1955–2001.

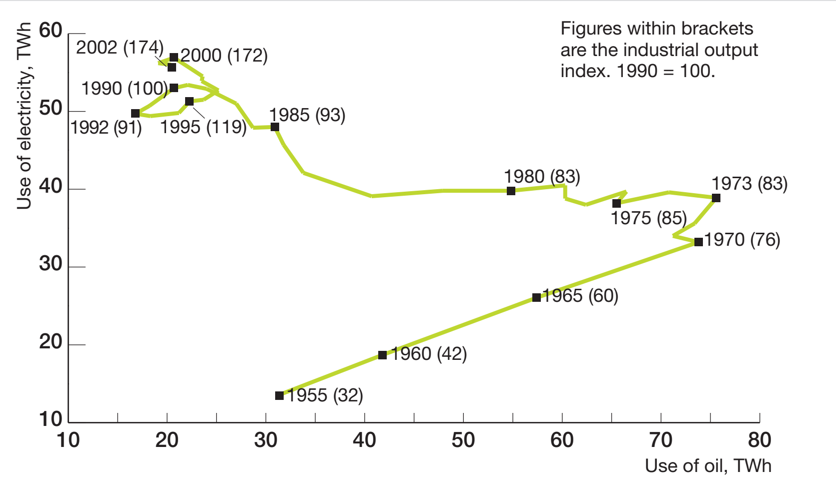
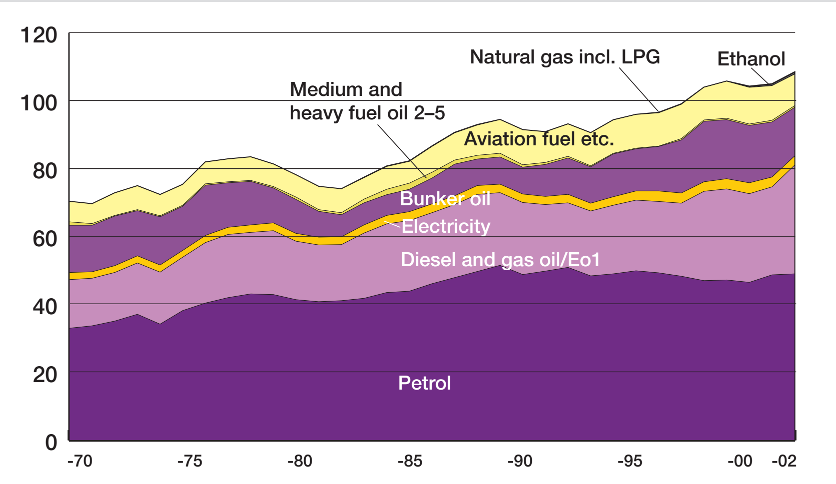


FIGURE 30

Final use of energy in the transport sector, 1970–2002.



sively to mix in up to 5% ethanol in 95-octane petrol throughout the country.

Sweden has at present two factories that produce motor fuel ethanol. During 2001, the factory in Norrköping produced about 41 000 m^3 of ethanol, while that in Örnsköldsvik produced about 16 000 m^3. This production can be compared with that in, for example, Brazil, which has an annual production of about 10 million m^3 of ethanol. A larger pilot plant, for the production of bio-ethanol from forest raw materials, is being built in Örnsköldsvik, and is expected to come on line in April 2004.

Transport work

Since 1975, domestic passenger transport work has increased by 56%, so that it amounted to 128 billion person-km. Road traffic accounts for about 91% of passenger transport work. Railways carry a further 7% and air travel over 2%.

Domestic goods transport has increased by 36% since 1975, amounting to almost 90 billion tonne-km in 2001. Of this, 41% were carried by road, 22% by rail and 37% by ship. In recent years, goods transport by road has increased at the expense of other forms of transport, but this trend seems to have been broken for 2001.

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 increase in step with the greater use of fossil fuels. It has been found difficult to reach agreement on harmonised fuel taxes within the EU. However, the European automotive industry has entered into a voluntary agreement with the EU Commission to reduce carbon dioxide emissions from new passenger cars by 25% by 2008, relative to the 1995 levels. Corresponding agreements have also been reached with Japanese and Korean vehicle manufacturers.

Draft proposals were presented in 2001 for overall guidelines for a common transport policy within the EU, intended to concentrate on transferring freight transport from road to rail and water, eliminating bottle-necks 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.

In May 2003, the European Parliament and the Council of Ministers adopted Directive 2003/30/EC on Promotion of the Use of Biofuels or Other Renewable Fuels for Transport. The Directive requires member states to have replaced 2% (in terms of energy content) of all petrol and diesel fuels sold for transport purposes by biofuels by not later than 31st December 2005. By the end of 2010, this proportion is required to have been increased to 5.75%. The proportions are voluntary, but if they are not achieved the Commission may put forward proposals for binding legislation.

Technical development

Technology advances both through improvements in existing technology and in the form of completely new technologies. Of the latter, those that are thought likely to achieve 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.

Looking further ahead than ten years, the automotive industry is pinning considerable hopes on fuel cell technology. The EU is already operating its Clear Urban Transport for Europe (CUTE) project, the purpose of which is to obtain experience of how fuel cell-powered buses work in practice. Hydrogen-powered buses will be run in commercial operation in ten European cities. Since January 2004 three such buses are in operation in Stockholm

■

An 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 countries' economic situation, coupled with industrial structure and climate. Differences can also be partly explained by the fact that the countries are in different stages of development. An International Energy Agency forecast[1] expects world demand for energy to increase by 1.7% per annum until 2030, with most of this increase being accounted for by the developing countries.

Energy use in the EU

About 30% of total energy use in the OECD states[2], and over 17% of world energy use, is in the European Union. However, in recent decades, energy use in the EU has been rising more slowly than in the rest of the world.

Oil is the dominating energy source in EU energy supply, meeting about 50% of total energy use. Prior to 1990, there was a downward trend in the use of oil, but use has again started to increase since the end of the 1990s. Within the EU, the greatest use of oil is for transport.

The use of coal has fallen by over 60% since 1990, so that in 2001 it supplied less than 3% of final energy use. Note, however, that a greater proportion of coal than this is used as the primary energy source for electricity and heat production. The greatest reduction in the use of coal has occurred in Germany. The use of natural gas continues to rise: since 1990, it has increased by 35%, so that it supplied 23% of final energy use in 2001.

Some slight increase in the use of renewable energy sources has been noted in recent years. Since 1990, the use of renewable fuels in the EU has increased by 12%, so that in 2001 they provided 3.5% of EU energy needs.

Final use of electricity in 2001 amounted to over 18% of total energy use. Since 1990, the use of electricity has increased by 26% (see also Energy markets). The use of district heating in the EU as a whole is relatively little, amounting to only about 2.2% of final energy use.[3]

Dependence on imports

As a region, the EU is the world's largest net importer of energy. Despite increased production, self-sufficiency in energy supply has fallen in recent years, as the demand for energy is rising even more rapidly. In 1980, the EU was almost 48% self-sufficient. By 1990, it had increased to somewhat less than 54%, only to fall to about 51% in 2001.[4]

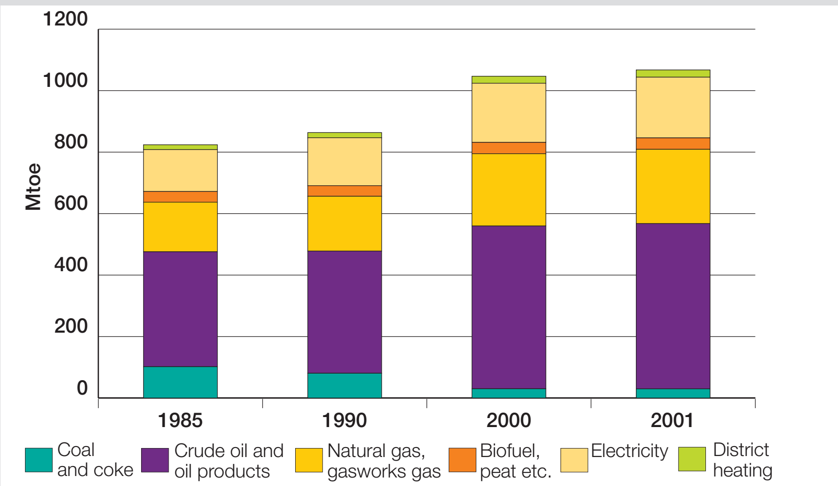
Fifteen states with different conditions

The EU consists of 15 member states, varying in terms of size, geography and economic conditions. Germany, the UK, France and Italy together account for 71% of EU GNP, while smaller countries such as Luxemburg, Portugal, Greece and Ireland have GNPs that are less than 10% of that of Germany. Climates also differ considerably, which has a considerable effect on energy requirements. Together, Germany, France, Italy and the UK account for almost 67% of total energy use, although this proportion changes somewhat when converted to per-capita energy use. Finland and Sweden have high per-capita energy uses, partly due to high proportions of energy-intensive industries

[1] IEA – World Energy Outlook 2002
[2] OECD (Organisation for Economic Co-operation and Development) consists of the EU states, Iceland, Norway, Poland, Switzerland, Slovakia, the Czech Republic and Hungary, together with Australia, Japan, Canada, Mexico, New Zealand, South Korea and the USA.
[3, 4] IEA statistics – energy balances of OECD countries 2000–2001, 2003 edition

FIGURE 31

Total final EU energy use, by energy carriers, 1985, 1990, 2000 and 2001.



Source: European Commission, Annual Energy Review (1985 and 1990). IEA, Energy Balances of the OECD Countries 2000–2001, 2003 edition (2000 and 2001).

and partly due to cold climates and low energy prices. The Benelux countries also have high per-capita energy demands, and particularly in Luxemburg.[5] On the other hand, per-capita energy use is lower in the Mediterranean countries of Greece, Italy, Portugal and Spain.

Expansion of the European Union

November 2002 saw the conclusion of EU accession negotiations with ten countries, after several years' preparatory work. These ten countries – Cyprus, Estonia, Latvia, Lithuania, Malta, Poland, Slovakia, Slovenia, the Czech Republic and Hungary – will therefore become full members of the EU on 1st May 2004. Negotiations are continuing with Bulgaria and Rumania, which are expected to join the EU in 2007. Figure 33 shows energy use by energy carrier for the two groups of candidate countries; those for which membership has now been approved, and those which are still negotiating. Together, the new member countries have a total energy use equivalent to about one-tenth of total EU use. In comparison with the present EU countries, coal is more important for them, with oil and gas being less important. However, district heating is relatively widely used in several of the candidate countries.

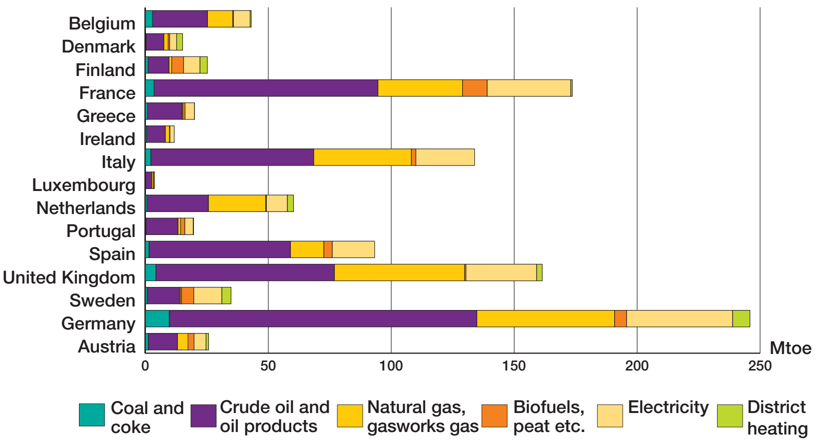
[5] Luxemburg's high per-capita energy use is due partly to energy-intensive industries and partly to low motor fuel prices, which result in considerable cross-border trade.

[6] IEA statistics – Energy balances of non-OECD countries, 2000–2001, 2003 edition

[7] BP Statistical Review of World Energy June 2003

FIGURE 32a

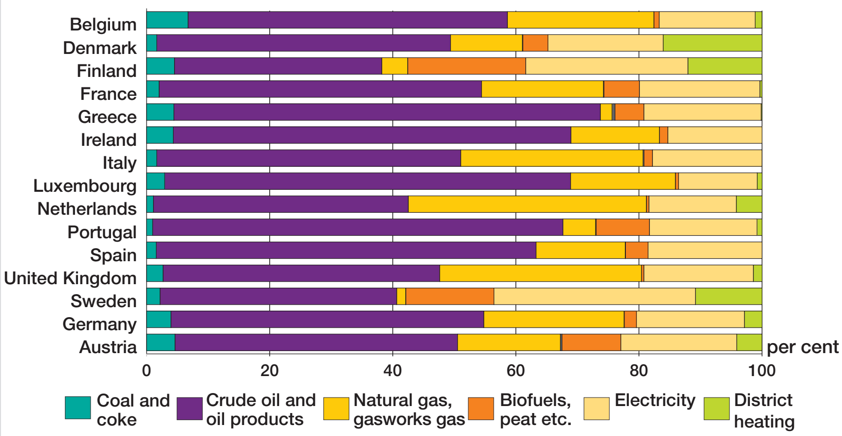
Total final energy use in the EU states, 2001, Mtoe.



Source: IEA.

FIGURE 32b

Total final energy use in the EU states, 2001, proportions.



Source: IEA.

World energy sources and energy use

World energy supply is dominated by fossil fuels, which account for about 80% of the total. Oil is the most important energy source, meeting 37% of demand, followed by coal at 22% and natural gas at 21%. Of the fossil fuels, it is the use of natural gas that has increased the most since the 1980s. 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 biofuels has been stable since 1990, contributing about 11% to world energy supply[6].

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

Resources and reserves

Reserves of fossil fuels – primarily oil, coal and natural gas – are estimates of the quantities that can be viably extracted with present economic and technical conditions. At the end of 2002, they amounted to:

- 204 years' production of coal
- 41 years' production of oil
- 61 years' production of natural gas.

The proven reserves 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[7].

Energy supplies and international trade

Non-OECD countries hold a significant part of world energy supplies and reserves, and have been able to export their surpluses – primarily of oil – to the industrialised countries. The oil market is dominated by OPEC which, together with Russia, also dominates the gas market. The EU increased its oil production by over 1% in 2002, after a few years' decline, but it is expected that both oil and gas production will fall within a few years. (See also Energy markets.)

The greatest proportion of the world's energy production in 2001 came from the NAFTA countries[8] (23%), followed by Asia (21%), the Middle East (13%), the former Soviet Union (13%) and Western Europe (12%). As far as international trade is concerned, the Middle East, Africa, Latin America 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[9].

Energy use in different regions

At the beginning of the 2000s, total world energy use increased at an average rate of 1.6% per annum, which is of the same order as during the 1970s. (During the 1980s and 1990s, the rate of increase was lower.) The greatest growth in energy use is occurring in Latin America, the Middle East and Asia, and also in Africa. Energy use in the former Soviet Union and in Eastern Europe fell during the 1990s, but started to rise again in many of these countries during the first years of the new century. Within the EU, energy use increased by slightly over 1% per annum during the 1990s. North America and Japan showed higher increases than in the EU during the 1990s, although total energy use in the USA and Japan fell in 2001. EU energy use also increased in 2001.

World per-capita energy use varies considerably between countries and between regions. The EU, for example, uses 10–15 times more energy per capita than does Africa or Asia, and four times more than in Latin America. Per-capita energy use in North America is 20 times as great as that in Africa.

Table 1 shows energy intensities, i.e. the amount of energy used per unit of GNP, in various groups of countries, 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 use twice as much energy, and the former Soviet Union uses over ten times as much energy, per GNP dollar as does the EU. These differences can be partly explained by the fact that the areas are at different stages of development. However, Central and Eastern European countries have shown a substantial reduction in their energy intensities during the 1990s. The countries in North America have also improved their efficiency of energy use. In the world as a whole, energy intensity has declined by somewhat over 15% during the last decade.

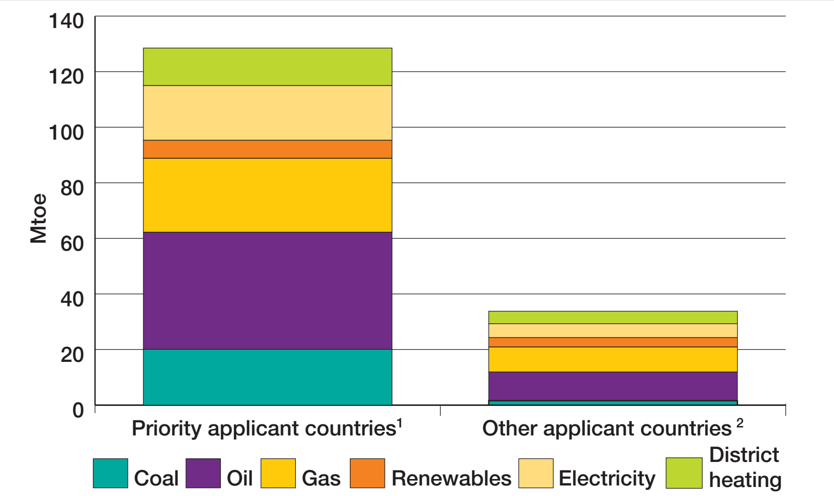
After the break-up of the Soviet Union, the economies of the new republics are in a state of flux, with major problems in the energy sector, and this has been reflected by greater use of energy per unit of output during the 1990s. It is expected that, as energy prices in these countries are now more or less equal to world market prices, efficiency of energy use will improve. It is also expected that efficiency improvements will occur in China, Eastern Asia and Latin America.

[8] NAFTA (North American Free Trade Agreement) is a free trade agreement between the three major countries of North America; the USA, Canada and Mexico.

[9] IEA statistics – Energy balances of non-OECD countries, 2000-2001, 2003 editition

FIGURE 33

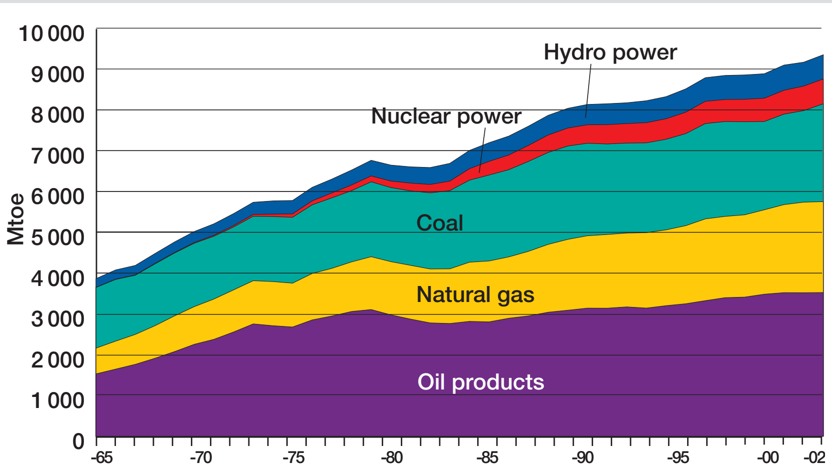
Energy use in the EU candidate countries, by energy carrier, 2000.



Note: 1) The Czech Republic, Cyprus, Estonia, Hungary, Latvia, Lithuania, Malta, Poland, Slovakia and Slovenia. 2) Romania and Bulgaria. *Source: IEA.*

FIGURE 34

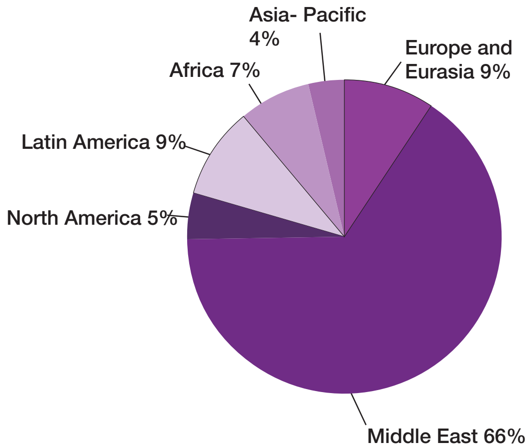
Total world commercial energy supply, 1965–2002



Source: BP.

FIGURE 35a

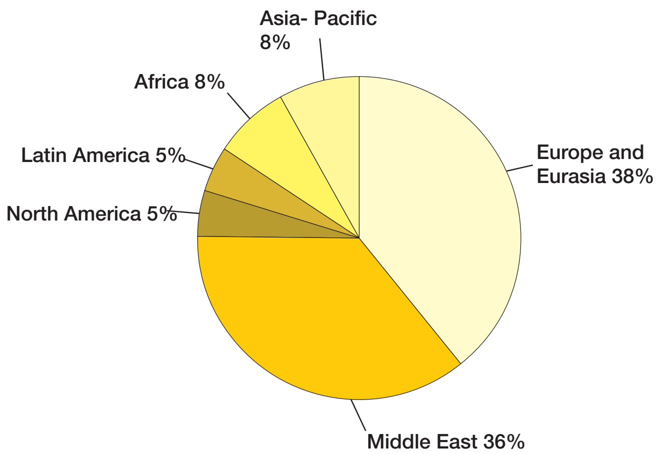
Current world oil reserves, total 1 047 billion barrels.



Source: BP.

FIGURE 35b

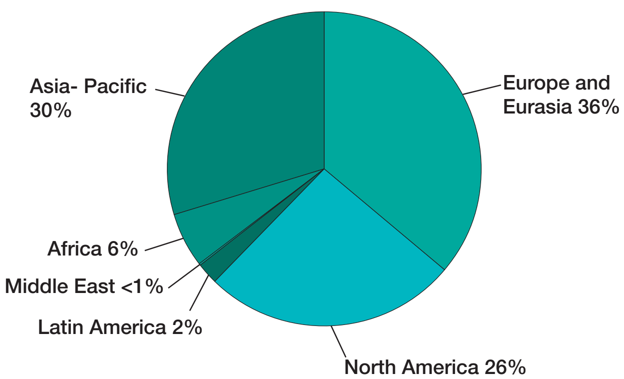
Current world natural gas reserves, total 155 780 billion m³



Source: BP.

FIGURE 35c

Current world coal reserves, total 984 453 billion tonnes



Source: BP.

Forecasts of world energy growth until 2020

According to a forecast[10] from the International Energy Agency in 2002, world energy demand is expected to continue to rise steadily, at about 1.7% per annum until 2030, which can be compared with an annual growth rate of 2.2% between 1971 and 1997. Much of this increase is expected to occur in the developing countries, as a result of economic growth and population increase, which will account for more than 60% of the increased demand.

The proportion of energy use taken by the developing countries is expected to increase from 30% to 43%, with that taken by the OECD states falling from 58% to 47%. The remaining 10% of the world's energy use will be accounted for by the transition economies in the East, with this proportion declining somewhat.

The transport sector is that in which energy demand is increasing the most. This demand, which is entirely dominated by oil products, is expected to increase at a rate of about 2.1% per annum. By 2020, it is expected that the transport sector will have overtaken the industry sector as the largest user of energy. According to the IEA forecast, energy requirements for residential buildings will increase at an annual rate of 1.7%, with industrial energy demand increasing at 1.5% per annum.

According to the forecasts, fossil fuels will continue to be the main source of energy, supplying more than 90% of the increase in demand. The demand for oil is expected to increase at an annual rate of 1.6%,with that for natural gas increasing at an even higher rate. The demand for coal, too, will increase, although not at the same rate. The part played by nuclear power will decrease, partly as a result of fewer new reactors, and partly as a result of closure of existing reactors. It is expected that the proportion of electricity production from nuclear power will fall from 17% in 2000 to 9% in 2030. The greatest increase of nuclearpower is expected to occur in Asia, and the greatest decrease in Europe and North America.

Renewable energy will become increasingly important in world energy supply. As far as the production of electricity from renewable sources is concerned, hydro power will continue to be the predominant source, although the rate of increase in the construction of new plants will be lower than that of expansion of other forms of renewable energy sources. The use of renewable energy sources other than hydro power is expected to increase by 3.3% per annum, which is more than any other primary energy source. The greatest growth will occur in the OECD states, although renewable energy will continue to provide only a small proportion of total energy supply.

World energy resources are regarded as sufficient to meet the expected increase in demand. Oil resources are sufficient, although more reserves need to be found. Reserves of natural gas and coal are particularly generous, and there is no shortage of uranium for nuclear power production. Much of the demand for oil and gas will be met by production increases in the Middle East and the former Soviet Union. However, climate problems will bring new pressures to bear on the choice of energy sources that can be used for sustainable development. The physical potential for renewable energy is substantial.

New energy sources and advanced technology are expected to be developed during the period, e.g. unconventional oil sources and fuel cells. It is expected that world trade in energy (which consists almost exclusively of fossil fuels) will increase dramatically.

Forecasts for carbon dioxide emissions

According to the IEA reference scenario[11], carbon dioxide emissions will continue to increase steadily, at a rate of somewhat over 1.8% per annum until 2030. Of this, about two-thirds will come from the developing countries. By 2030, emissions are expected to have increased to about 38 billion tonnes, which is 70% more than today. Electricity production and transport are expected to contribute to more than three-quarters of the increase in emissions. Geographically, it is expected that the proportion of global CO_2-emissions from the developing countries will have increased from 34% to 47%, while that of the OECD states will have declined from 55% to 43%. China is expected to account for a quarter of the increase in emissions. The IEA points out in its forecast that the OECD states will have difficulty in fulfilling their Kyoto commitments, particularly if it is assumed that the USA does not intend to ratify the Kyoto Protocol. ■

TABLE 1

Energy intensity[1], toe/million dollar.

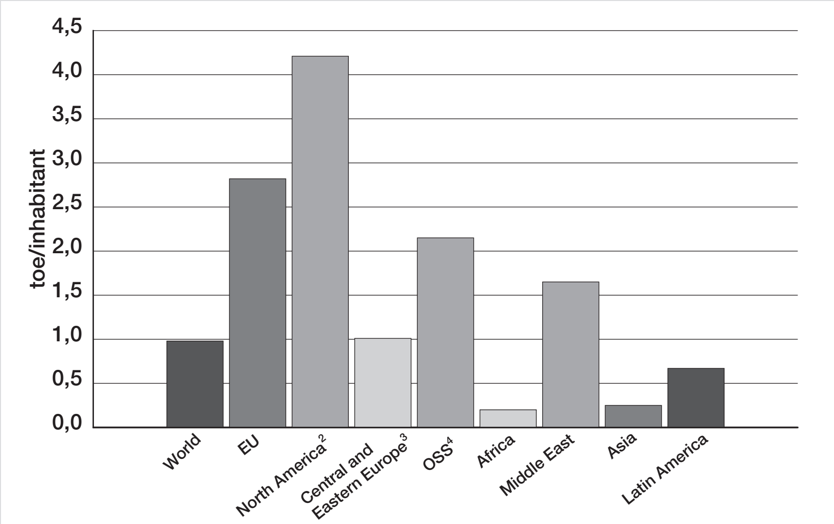
Region	1980	1990	1995	2000	2001	1990/2000	2000/2001
World	229	201	191	175	174	-14.8%	-0.5%
EU	141	117	113	107	107	-9.9%	0.5%
OECD North America	286	213	203	185	181	-14.9%	-2.4%
Central & eastern Europe[2]	321	261	238	208	207	-25.5%	-0.5%
OSS	936	1156	1472	1235	1179	6.4%	-4.5%
Africa	233	260	269	265	267	1.9%	0.8%
Middle East	140	358	459	459	473	22.0%	3.0%
Asia	299	283	273	271	272	-4.7%	0.6%
Latin Amerika	154	182	170	178	177	-2.2%	-0.9%

Note: [1] Excluding renewable fuels and energy recovery from refuse.
[2] OECD Europe, except EU-15.

Source: IEA.

FIGURE 36

Total per–capita energy use, 1999–2001.[1]



Note: [1] Energy use excludes renewable energy and energy from refuse. [2] USA, Canada and Mexico. [3] Europe, except OECD countries. [4] Confederation of Independent States. Consists of twelve states, with Russia and the Ukraine being the largest. For statistical reasons, this also includes the Baltic states. *Source: IEA.*

[10, 11] IEA – World Energy Outlook 2002

Taxes and prices

The use of energy has been taxed in Sweden since the 1950s, with the aim of achieving various political objectives, which 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 and processes have been increased, while taxes on labour have been reduced: one of the important objectives of this is to reduce carbon dioxide emissions. Energy taxation is at present under review, which will include changes to the Swedish taxation system to comply with EU competition and public subsidy rules, and accommodation with harmonised minimum EU taxation of fuels and electricity. This chapter describes the present energy taxation system and fuel price developments.

Energy taxation

The original objective of energy taxes 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. Present energy taxation policy is aimed at improving the efficiency of energy use, encouraging the use of biofuels, creating incentives for companies to reduce their environmental impact and creating favourable conditions for indigenous production of electricity.

During the oil crises of the 1970s, the aim was to reduce the use of oil and increase the use of electricity. The environmental element of energy taxation was given greater importance at the beginning of the 1990s while, since Sweden's accession to the EU, there has subsequently been a need to bring taxation into line with EU requirements. The earlier Mineral Oils Directive and the associated Tax Rate Directive are in process of revision, and will be complemented by new minimum taxation levels as part of the process of harmonisation of fuels and electricity throughout the EU. A new taxation model is also being investigated at present, with the aim of designing a coordinated and consistent taxation structure for business, while complying with EU competition and public subsidy rules.

The present energy taxation system is relatively complex. There are different taxes on electricity and fuels, on CO_2 and sulphur emissions, and a levy system on NO_x emissions. The taxes can then vary, depending on whether the fuel is being used for heating or as a motor fuel, whether it is being used by industry, domestic consumers or the energy sector and, in the case of electricity, whether it is being used in northern Sweden or in the rest of the country. In 2002, revenues from energy and environmental spot taxes raised over SEK 58 300 million, making up 8.8% of State revenue or 2.5% of GNP. (See Table 2.)

TABLE 2

Revenues raised by energy taxes in accordance with the 2002 taxation structure, SEK million.

Fuels	Energytax	CO_2-tax	Sulphur-tax	Total
Petrol	17 192	7 833		25 025
Oilproducts	5 791	10 453		16 244
Crude oil	24			24
Other fuels	130	1 087		1 217
Sulphur tax, all fuels			131	131
Electricity	13 866			13 866
Produktion tax, nuclear power	**1 796**			**1 796**
Total	**38 799**	**19 373**	**131**	**58 303**
Share of national tax revenues				8,8%
Share of GDP				2,5%

Source: National Tax Board, National Financial Management Authority, Statistics Sweden.

Types of tax and tax rates

'Energy tax' is an umbrella name for spot taxes on fuels and electricity. They can be roughly divided up into fiscal taxes and those intended to achieve environmental objectives. This latter group of taxes includes the carbon dioxide and sulphur taxes, while the general energy tax is essentially a fiscal tax. However, there is no hard and fast boundary between the types, as both groups have an environmental effect as well as a fiscal function. The general energy tax, which has existed for several decades, and with varying purposes, is payable on most fuels, and is independent of their energy content (see Table 3). The carbon

TABLE 3

Energy spot taxes from 1st January 2003, excluding value-added tax

	Energy tax	CO_2-tax	Sulphur tax	Total tax	Tax, öre/kWh
FUELS					
Gas oil, <0.05% sulphur, SEK/m^3	720	2 174	0	2 894	29.0
Heavy fuel oil, 0.4% sulphur, SEK/m^3	720	2 174	108	3 002	28.4
Coal, 0.5% sulphur, SEK/tonne	307	1 892	150	2 349	31.1
LPG, SEK/tonne	141	2 286	-	2 427	19.0
Natural gas, SEK/1000 m^3	233	1 628	-	1 861	18.6
Crude tall oil, SEK/m^3	2 894	-	-	2 894	29.5
Peat, 45% moisture, 0.3% sulphur, SEK/tonne	-	-	50	50	1.8
MOTOR FUELS					
Petrol, 95 octane, environmental class 1, SEK/l	2.94	1.77	-	4.71	52.1
Diesel, environmental class 1, SEK/l	1.00	2.17	-	3.18	32.5
Natural gas/methane, SEK/m^3	-	1.09	-	1.09	10.9
LPG, SEK/kg	-	1.32	-	1.32	10.3
ELECTRICITY USE					
Electricity, northern Sweden, öre/kWh	16.8	-	-	16.8	16.8
Electricity, rest of Sweden, öre/kWh	22.7	-	-	22.7	22.7
ELECTRICITY, GAS, HEAT OR HOT WATER SUPPLY					
Northern Sweden, öre/kWh	16.8	-	-	16.8	16.8
Rest of Sweden, öre/kWh	20.2	-	-	20.2	20.2
ELECTRIC BOILERS > 2 MW, Nov 1-Mar 31					
Northern Sweden, öre/kWh	19.2	-	-	19.2	19.2
Rest of Sweden, öre/kWh	22.7	-	-	22.7	22.7

Note: In addition to the above taxes, there is a 25% value-added tax rate (deductible for companies and industry). An environmental levy on the emission of NO_X, at the rate of SEK 40/kg of NO_X emissions, applies to boilers, gas turbines and stationary combustion plants supplying at least 25 GWh per annum. It is intended to be fiscally neutral, and is repaid to plant operators in proportion to their energy production and in inverse proportion to their NO_X emissions. A change in the regulations governing permissible sulphur content in fuel oils has resulted in the use of lower-sulphur fuel oils, so that gas oil no longer pays sulphur tax.
Fuels that are used for electricity production are exempt from energy and carbon dioxide tax, although a proportion of the electricity is regarded as being used internally by the production plant and is therefore taxed. Biofuels are untaxed for all users. Fossil fuels that are used for heat production in cogeneration plants pay only half the energy tax rate.

Source: The National Swedish Tax Board, Swedish Energy Agency.

dioxide tax, which was introduced in 1991, is levied on the emitted quantities of carbon dioxide from all fuels apart from biofuels and peat. In 2003, the general level of carbon dioxide tax is 76 öre/kg of CO_2. A sulphur tax was introduced in 1991, and is levied at the rate of SEK 30 per kg of sulphur emission from coal and peat, and at SEK 27 m^3 for each tenth of a percent by weight of sulphur in oil. Oils containing less than 0.05% of sulphur by weight are exempted from tax. The environmental levy on the emission of NO_X was introduced in 1992, at a rate of SEK 40/kg of NO_X-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 plant operators in proportion to their energy production and in inverse proportion to their NO_X-emissions so that only those with the highest emissions are net payers.

Taxation to encourage greening

It was decided in the spring of 2000 that a total of SEK 30 billion of taxation revenue should be transferred over a ten-year period. This means that taxes on energy use and emissions will be increased, offsetting a corresponding reduction in taxes on labour.

Sweden's carbon dioxide emissions are to be cut, not least in order to comply with the country's commitments under the Kyoto Protocol. The carbon dioxide tax on fuels was raised by 19% on 1st January 2003, which is intended to increase its impact in relation to the energy tax, and to help to reduce carbon dioxide emissions. The energy tax on motor fuels, such as petrol and diesel fuel, was reduced by an amount corresponding to the increase in the carbon dioxide tax element on the fuel, although there was no rise in the tax on LPG, natural gas or methane when used as motor fuels. A simultaneous change in the tax reduction rules has had the ef-

TABLE 4

Energy spot taxes for industry, agriculture, forestry and fisheries from 1st January 2003, excluding value-added tax

Fuels	Energy tax	CO_2-tax	Sulphur tax	Total tax	Tax, öre/kWh
Gas oil, < 0.05% sulphur, SEK/m^3	-	544	0	544	5.5
Heavy fuel oil, 0.4% sulphur, SEK/m^3	-	544	108	652	6.2
Coal, 0.5% sulphur, SEK/tonne	-	473	150	623	8.2
LPG, SEK/tonne	-	572	-	572	4.5
Natural gas, SEK/1000 m^3	-	407	-	407	4.1
Crude tall oil, SEK/m^3	544	-	-	544	5.5
Peat, 45% moisture, 0.3% sulphur, SEK/tonne	-	-	50	50	1.8

Note: Manufacturing industry pays no energy tax, and only 25% of the general carbon dioxide tax. There are further reductions in the carbon dioxide tax rate for energy-intensive industries. Motor fuels are taxed in accordance with the general energy and environmental taxes. No energy tax is charged on the use of electricity in industrial manufacturing processes.

Source: National Tax Board, Swedish Energy Agency..

fect of ensuring that carbon dioxide tax remains unchanged for manufacturing industry, agriculture, forestry and fisheries etc.

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 2,9 öre/kWh from 1st January 2003, thus ensuring that relative competitiveness has not been affected by the increase in environmental taxes.

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 maximum thermal power rating of their reactors. 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.

On 1st May 2003, a new system of trading in electricity certificates for the production of power from renewable sources replaced the previous system of subsidies for the production of electricity from sources such as wind power, biofuelled CHP and small-scale hydro power. During a transition period, the certificate trading system will be complemented by targeted support for wind power production in the form of the present environmental bonus of 18.1 öre/kWh, which will be progressively phased out over a period of seven years. Operation of the trading system requires that electricity users, with the exception of manufacturing processes in certain electrically-intensive industries, must buy a certain percentage of their electricity from renewable sources. For the first year of system operation, this quota obligation will be 7.4% of electricity use, increasing progressively year by year so that, by 2010, it will be 16.9% of electricity use. By that time, the system should have ensured or encouraged an increase of about 10 TWh/year in the supply of electricity from renewable sources.

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 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 receives a full rebate of energy and carbon dioxide tax. That part of the fuel which is regarded as producing electricity for internal use is subject to full taxation, while the fuel used for the net beneficial heat pays only half the normal energy tax rate.

In June 2003, the EU Commission approved the Government's proposal for a change in the structure of CHP taxation, by which fuels used for heat production in CHP plants will be treated in the same way as fuels used in the rest of industry. This means that there is proper recognition of the high energy efficiency of CHP production, thus improving its market position. This change in the energy taxation system will remove the present ability of CHP operators to set the apportioning of their fuel to either electricity production or heat production. Instead, all the fuel(s) used will be assigned to the respective taxation regime in proportion to the total amounts of electricity and heat produced. It is intended that these new rules will come into force on 1st January 2004.

Taxation at the point of use

Manufacturing industry, horticulture, forestry and fisheries are exempt from energy tax, and pay only 25% of the carbon dioxide tax (see Table 4). For 2003, simultaneous reduction of the carbon dioxide tax level and an increase in the general taxation level means that the overall taxation for these activities should be essentially the same for 2003 as it was in 2002. There are special rules for energy-intensive industrial activities, reducing that part of the carbon dioxide tax that exceeds 0.8% of the sales value of the products concerned. This reduction is at a rate of 24% of the tax above this level.

There are various tax levels for transport, depending on the environmental class of the fuel, which have resulted in considerable improvements in respect of several emission parameters. Apart from increases due to indexing, petrol and diesel fuel taxes have not been raised since the previous year. No energy tax is payable on the use of diesel fuel or fuel oils used in commercial maritime traffic or rail-bound traffic, or on aviation petrol or aviation paraffin.

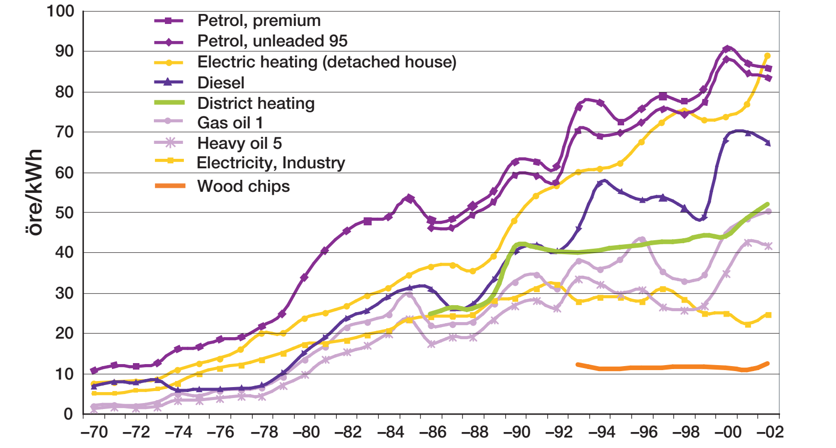
Domestic users pay different rates of electricity tax, depending on whether they live in the north of the country or in the rest of the country (see Table 3).

Prices

At about USD 25/barrel, the price of crude oil in 2002 was essentially unchanged relative to the price in the previous year. The prices of

FIGURE 37

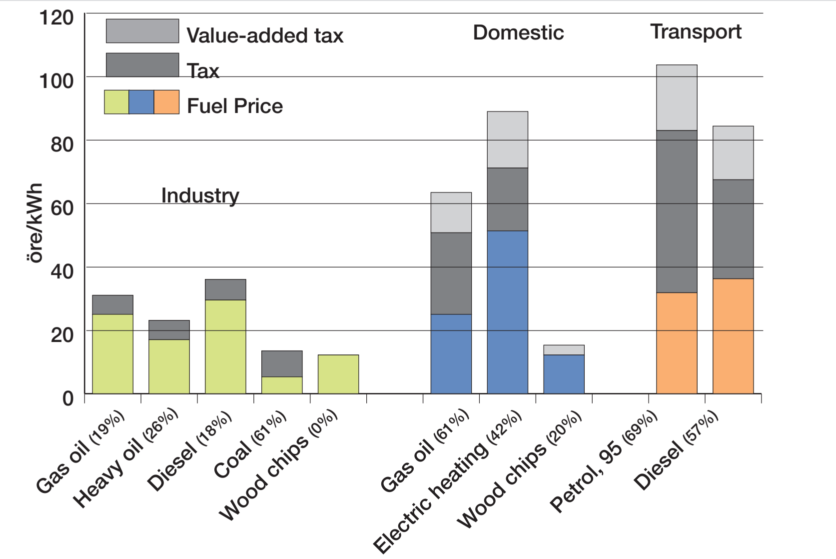
Commercial energy prices in Sweden, 1970–2002, öre/kWh.



Source: Statistics Sweden, Competition Authority, Swedish Business Developement Agency, The Riksbank, Eurostat, Vattenfall, Swedish Petroleum Institute.

FIGURE 38

Fuel prices for various customers, 2002, öre/kWh.



Source: Swedish Petroleum Institute, Statistics Sweden, Swedish Energy Agency.

TABLE 5

Fuel prices and the price of electric heating in Sweden, excluding taxes and value-added tax.

Fuels	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001	2002
Crude oil, USD/barrel	23.81	20.05	19.37	17.07	15.98	17.18	20.80	19.30	13.11	18.25	28.98	24.77	25.19
Gas oil, SEK/m^3	2 146	2 131	1 790	2 207	2 004	2 205	2 603	1 759	1 457	1 580	2 606	2 563	2 489
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	1 797
Petrol, unleaded, 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	2.88
Diesel oil, SEK/l	2.88	2.87	2.68	3.03	2.83	2.55	2.21	2.19	1.84	2.16	3.83	3.92	3.61
Coal, SEK/tonne	358	366	307	309	317	336	340	367	372	327	355	449	404
Wood chips, SEK/m^3				95.2	87.2	87.2	89.6	90.4	92.0	92.0	89.6	86.6	97.4
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	51.3

Note: The statistics appendix, Energy in Sweden in figures, shows the consumer price indices from 1970 to 2002, which means that the prices in the table can be converted to fixed prices.

Source: Swedish Petroleum Institute, Eurostat, Statistics Sweden, BP, The Riksbank, Swedish Energy Agency.

TABLE 6

Total cost of electricity for various customer groups, including taxes and value-added tax, öre/kWh.

Date	Electric intensive industry[1]	Other industry[2]	Detached house, electrically heated[3]	Detached house, other heat source[4]
1 January 2001	28.3	37.0	76.8	99.8
1 January 2002	34.0	43.8	87.9	111.3
1 January 2003	53.7	59.9	111.4	135.4

[1] Annual use 140 000 MWh, maximum power demand 20 MW.
[2] Annual use 350 MWh, maximum power demand 100 kW or 160 A.
[3] Annual use 20 000 kWh, 20 A supply.
[4] Annual use 5000 kWh, 16 A supply.

Source: Statistics Sweden,Swdeish Energy Agency, National Energy Administration.

FACTS – ENERGY TAXES 2004

Proposed changes into force on 1st January 2004, as set out in the 2003 budget bill (Bill no. 2003/04:1)

- Carbon dioxide tax increased by 18 %. Subject to approval by the European Commission, industry's relief will be increased so that there is no net change in its taxation.
- The energy tax on diesel oil will be increased by 10 öre/litre.
- The energy tax on electricity will be increased by 1 öre/kWh.
- The zero tax rate for electricity used in manufacturing industry will be replaced by a tax rate of 0,5 öre/kWh. Energy-intensive industries will be offered the opportunity to enter into long-term agreements with the State, undertaking to improve their energy efficiency in return for retention of the full tax relief.
- CHP taxation will be changed to bring it into line with the taxation rules for industry.
- The present ability of CHP producers to determine the relative apportioning of their fuels to electricity or heat production when calculating their tax liabilities will be removed. Instead, all fuels will be allocated to electricity or heat in proportion to the actual quantities of electricity or heat produced.
- The deduction for energy tax on electricity produced in CHP plants and used internally for the supply of electricity, gas, heat or water will be removed.
- All energy and carbon dioxide taxes will be increased in proportion to changes in the consumer price index over the period from June 2002 to June 2003.

processed oil products track the price of crude oil, and so have a substantial impact on consumer prices. The import price of coal fell during 2002, but is still at a somewhat higher level than in 2001. The price of wood chips rose by 12% in 2002 (see Table 5.)

The end prices paid by consumers depend to a considerable extent on taxation. In addition to the spot taxes on energy, 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 2002, 60% was tax, which can be compared with 57% in 2001. The proportion of the total price of petrol and diesel fuel made up of tax rose by three percentage points during 2002, to 70% for petrol and 58% for diesel fuel (see figure 38).

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, costs of the renewables certificates, energy tax and value-added tax. The price of the actual electricity makes up about 32% of the total cost, and it is this that can be affected by the consumer by changing supplier. The grid charge accounts for about 23% of the cost, with taxes accounting for the remaining 45%. Towards the end of 2002, Nord Pool electricity prices rose steeply as a result of low water levels in the country's reservoirs, with resulting associated need for additional marginal power production. As a result, the average price of electricity in fixed price contracts increased by 32% relative to the previous year. ■

The environmental situation

Almost all abstraction/recovery, conversion and use of energy gives rise to some form of environmental impact. The most significant environmental effects are those related to emissions from combustion of fuels. They include increasing the concentration of greenhouse gases in the atmosphere, precipitation of acidifying substances and emissions of health-hazardous or environmentally harmful compounds in flue gases and vehicle exhaust gases. Even less environmentally harmful energy processes, such as hydro or wind power generation, do have an environmental impact in the form of their effects on nature and the landscape. Although much has been done to reduce the impact of energy systems on the environment, much still remains to be done.

Environmental impact occurs at local, regional and global levels. The boundaries between these levels are fluid, determined not only by the type of impact (e.g. emissions), 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.

Local and regional environmental problems

Local environmental problems are regarded as being those that are restricted to the most immediate environment. They include emissions of pollutants to air or water, examples of which are those resulting from various forms of combustion, such as particulates, volatile organic compounds and ground-level ozone. Problems of this type generally have an immediate effect on their surroundings and are easy to detect, and so it is natural that steps to deal with them can generally be taken at an early stage.

Environmental problems are regarded as being regional if they afflict large areas, countries or, in certain cases, continents. They include acidification 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. They often have many different sources, and spread over large areas.

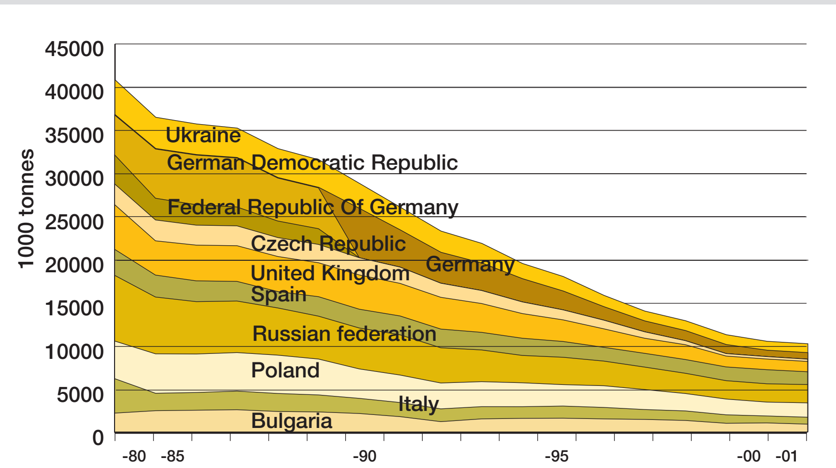
Acidification

At the beginning of the 1970s, acidification was one of the environmental problems in Scandinavia to which the most attention was 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 such as aluminium in the ground and water, making it available for uptake by plants and aquatic organisms. This adversely affects the growth of forests and leads to damage to many sensitive species of plants and animals, both on land and in the water.

The main source of 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 pre-

FIGURE 39

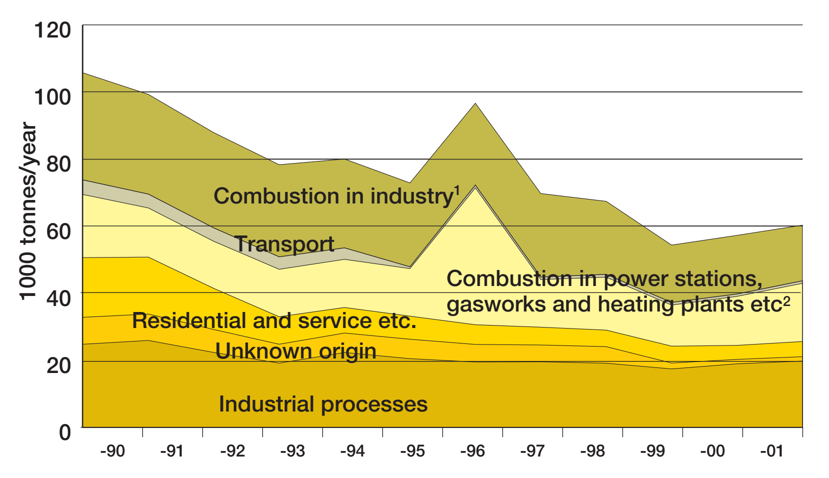
Emission of sulphur dioxide (SO_2) in Europe 1980–2001, 1000 tonnes



Source: EMEP.

FIGURE 40

Sulphur dioxide emissions in Sweden, 1990–2001.



Notes: [1] Including industrial back-pressure generation.
[2] Including coking plants and refineries.

Source: Statistics Sweden.

TABLE 7

Changes in sulphur emissions in some European countries

Country	Difference between 2000 and 1988,%
Austria	-89
Sweden	-88
Finland	-87
Norway	-81
Denmark	-94
Germany[1]	-89
UK	-76
Poland	-63

Note: [1]The percentage difference for Germany is for the period 1999 – 1988.

Source: EMEP

cipitation, and thus referred to as 'wet deposition'. Sulphur emissions can also be deposited directly in the form of sulphur dioxide, known as 'dry deposition'. As the conversion process of sulphur dioxide in the atmosphere for wet deposition takes a few days – sometimes up to a week – it means that precipitation over Sweden originates primarily from sources in other countries. The prevailing winds over Sweden are south-westerly, and so the country is exposed to depressions and fronts from the west and south-west. Large quantities of air pollutants are also carried over Sweden by southerly winds powered by anticyclones over the continent. The countries which contribute to sulphur precipitation in Sweden are primarily Germany, Poland and the UK, together accounting for over 30% of the total precipitation over the country.

Sweden also, in its turn, 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.

Reduced sulphur emissions

Emissions in both Sweden and the rest of Europe have fallen considerably since 1980, partly as a result of reduced use of oil and partly because of lower sulphur contents in the oil. Sweden has fulfilled ambitious targets of, for example, reducing its sulphur emissions in 2000 by 80% relative to those of 1980.

Some of the most important factors in international work on reducing sulphur emissions have been the Convention on Long-Range Transboundary Air Pollution (CLRTAP), EU acidification strategy and various directives and political and structural changes in Europe. A number of protocols have been developed as part of the work of the Convention, including the Oslo Protocol and the Gothenburg Protocol. The objective of the latter, which was ratified by Sweden in 2002, and which is expected to come into force in 2004, is to reduce the problems of acidification, eutrophication and low-level ozone. In addition, the EU's National Emission Ceiling Directives, which must be met by 2010, set emission limits for sulphur dioxide, NO_X, VOCs and ammonia for each individual member state.

Eutrophication

In addition to sulphur dioxide, ammonia and nitrogen dioxide also contribute to acidification. Nitrogen is also a major factor in another serious problem area, that of eutrophication. Much precipitation of nitrogen compounds falls on land, but if plants cannot utilise it all, the surplus is leached off into waterways where it contributes to excessive aquatic plant growth, algae blooms and oxygen-free sea or lake bottoms. Most of the nitrogen run-off comes from agriculture, but the energy sector also makes a noticeable contribution.

Reduction in NO_X emissions

By far the greatest proportion of NO_X emissions comes from road traffic. Although emissions of nitrogen have not been reduced as much as emissions of sulphur dioxide, they are being reduced, mainly due to the introduction of catalytic exhaust cleaning on petrol-driven vehicles. Emission requirements for both petrol and diesel cars and for heavy vehicles have been progressively tightened up during the 1990s. Emissions of NO_x have been reduced by 25%, to 250 000 tonne/year, between 1990 and 2001, despite a rise in transport work. Under the 'No eutrophication' banner, there is a sub-objective of reducing airborne emissions of NO_x in Sweden further to 148 000 tonne/year by not later than 2010. Achievement of this objective is at present threatened by the growth of transport, with road transport of goods being responsible for much of the emissions.

About 17% of NO_x precipitation in Sweden originates from domestic sources. The largest contributors to NO_x precipitation from other countries are Germany, the UK and Denmark. Solving eutrophication problems will require international cooperation, and it is here that the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and various EU directives have an important part to play. Emissions of NO_x are treated in the same way as those of sulphur dioxide in the Convention, in the Oslo Protocol and the Gothenburg Protocol (the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone) and elsewhere. The EU Directive on National Emission Ceilings has also set emission ceilings for NO_x and ammonia by 2010.

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 the greenhouse effect and by destruction of the ozone layer. The extent of global environmental problems is such that they afflict the entire globe. They are therefore difficult to tackle, as they require international cooperation.

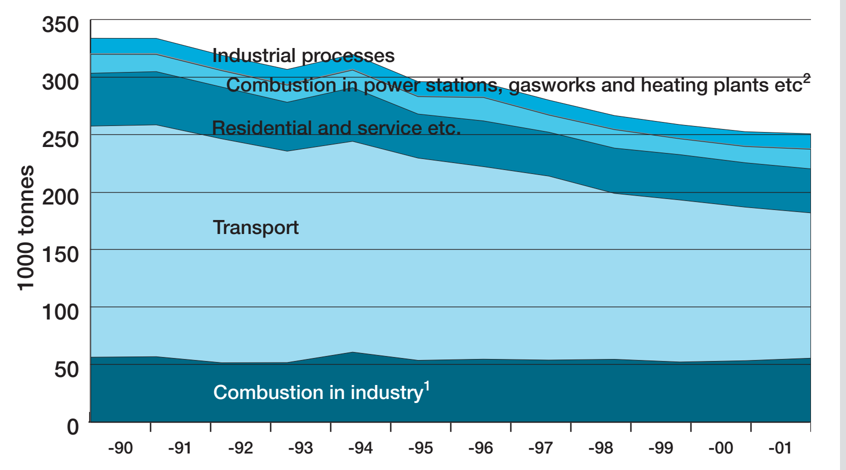
Depletion of the ozone layer

The ozone layer, in the stratosphere, protects life on earth from the sun's damaging ultraviolet radiation. In the middle of the 1970s, it was discovered that the ozone layer was being depleted, as chlorine and bromine atoms reacted with the ozone. Their source was chemicals released by industrial and energy processes. In the energy sector, ozone-depleting substances are used for applications such as air conditioning and heat pumps, and in end-user applications such as refrigerators and freezers. Today, ozone-depleting refrigerants have been largely replaced by less harmful, chlorine-free refrigerants, or in many cases by natural refrigerants such as hydrocarbons (propane and butane), or ammonia. However, the rate of replacement of the earlier refrigerants by these less harmful refrigerants varies from one part of the world to another.

Tackling depletion of the ozone layer is the first global environmental problem that has been successfully reduced by strong measures at international level. The use of ozone-destructive chemicals has been regulated by a number of international agreements (the Vienna Agreement and the Montreal Protocol). Pro-

FIGURE 41

NO_x emissions (as NO_2) in Sweden, 1990–2001.

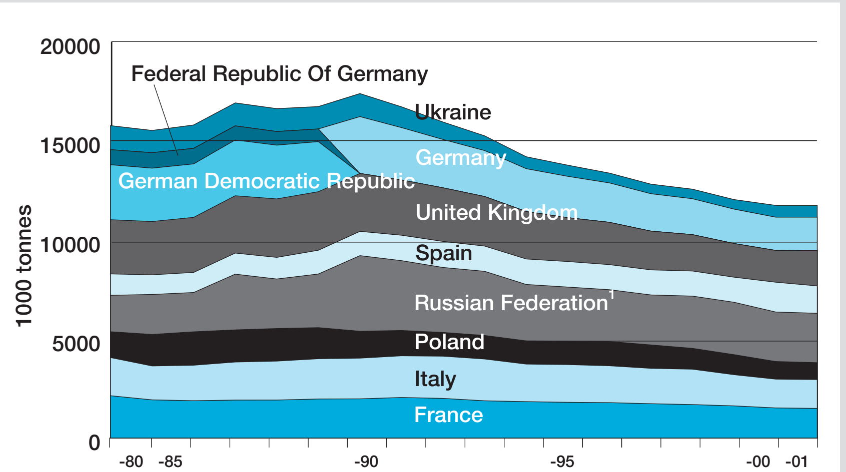


Note: [1]Including industrial back-pressure generation. [2]Including coking plants and refineries.

Source: Statistics Sweden.

FIGUR 42

NO_x emissions (as NO_2) in Europe, 1980–2001, 1000 tonnes



Note: [1]Including industrial back-pressure generation. [2]Including coking plants and refineries.

Source: EMEP

duction is declining, and it is expected that the ozone layer will be back to normal by about the middle of the next century.

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 is 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). Per molecule or per kilogram, these gases actually have a more powerful greenhouse effect but, due to their low concentrations in the atmosphere, they represent less of a problem than does carbon dioxide. The following text therefore concentrates primarily on carbon dioxide emissions.

The OECD countries emit over half of the total global carbon dioxide emissions, with the USA being responsible in turn for by far the greatest amount, of over 45%. Other countries with high emissions include Japan, the UK and Germany. In terms of highest per-capita emissions, the USA is in 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 sufficiently large number of countries. Sweden ratified the Convention in 1993, at which time it also adopted guidelines for Swedish climate policy. One of the contents of the Convention is that all industrial countries should take steps to reduce their emissions of greenhouse gases and to increase the uptake and storage of the gases. The countries should also regularly submit details of their progress and the steps that they have taken to the UN.

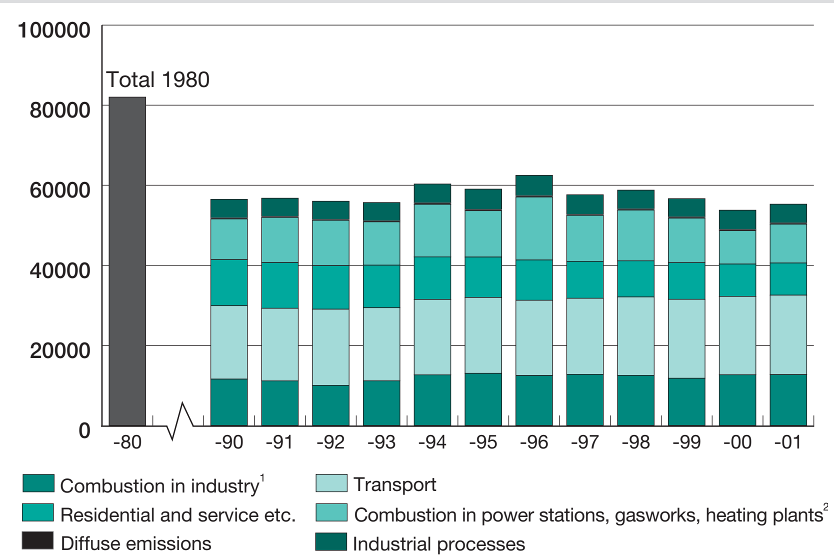
At the meeting of the parties in Berlin in 1995, it was noted that work to date was inadequate, and a process was started to produce a legally binding document. At the third meeting of the parties in Kyoto in 1997, agreement was reached on a document regulating emissions of carbon dioxide and five other greenhouse gases. The document sets out reductions for all Annex 1 countries, i.e. the OECD 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 negotiates 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 in fact to increase its emissions

[2] OECD-countries exluding South Korea and Mexico

FIGURE 43

Carbon dioxide emissions in Sweden 1980, 1990–2001.



Note: [1]Including industrial back-pressure power production. [2] Including coking plants and refineries

Source: Statistics Sweden

by 4%. However, Sweden has unilaterally adopted a more ambitious target, of reducing its emissions by 4%.

The Marrakech Accords

Since the third meeting 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 Den Haag, Bonn and Marrakech related primarily to the conditions and rules for flexible mechanisms (see below), 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.

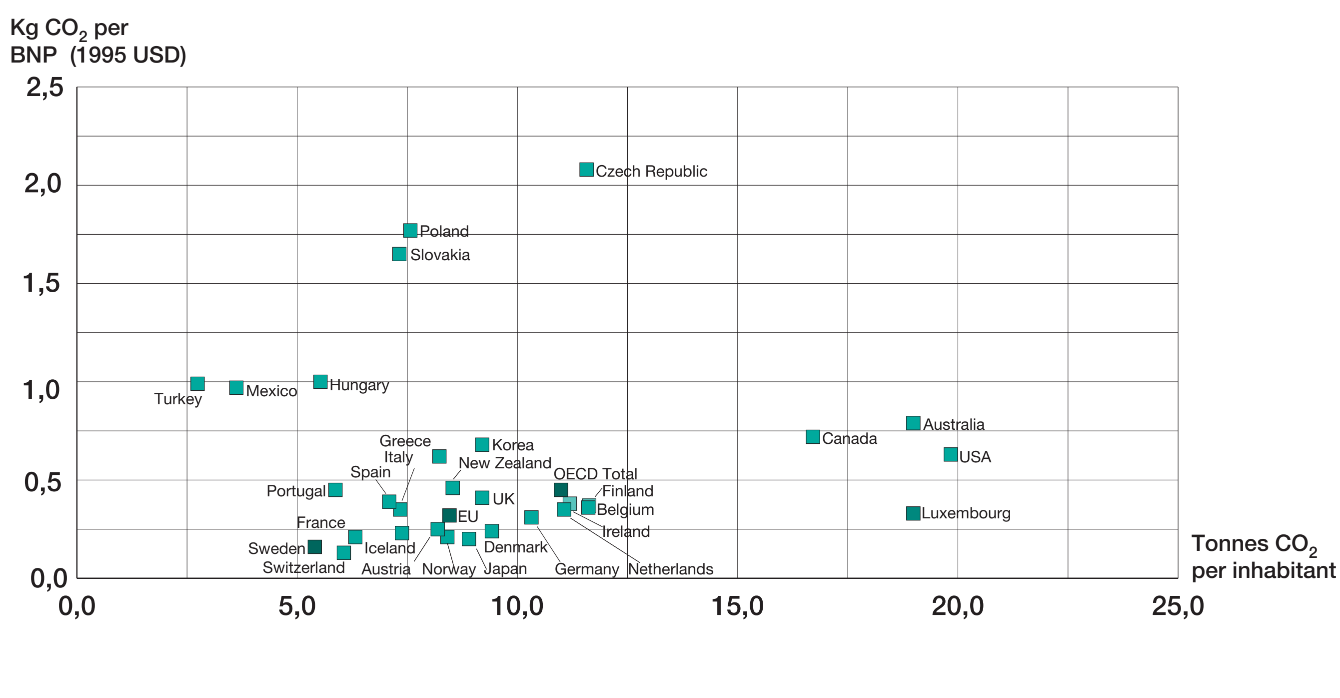
However, agreement was reached between the remaining states at the Marrakech meeting in the autumn of 2001, converting the Kyoto Protocol to a legally binding text, known as the Marrakech Accord.

'Flexible mechanisms', in the form of Emission Trading, Joint Implementation and Clean Development Mechanisms, are included in the Marrakech Accords 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 emission rights to another country that is unable to meet its commitment. Joint Implementation involves effecting some improvement in another country with commitments under the Kyoto Protocol, 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 projects are carried out in countries not having quantified commitments, i.e. generally in developing countries. CDM projects must also contribute to sustainable development in their host countries.

A major blow occurred to the process of international climate cooperation when the USA withdrew from the negotiations in 2001. A requirement for the Protocol to come into force is that it must be ratified by at least 55 countries. A further condition is that carbon dioxide emissions from the Annex 1 states that have ratified the Protocol must be less than 55% of 1990 emissions from all Annex 1 states. As the USA has now withdrawn, the Protocol must be ratified by the EU, Japan and Russia in order to come into force. The EU states jointly submitted their ratification documents in May

FIGURE 44a

Carbon dioxide emissions in 2000 from combustion, per-capita and in relation to GNP, in the EU states and the OECD countries.



Source: OECD

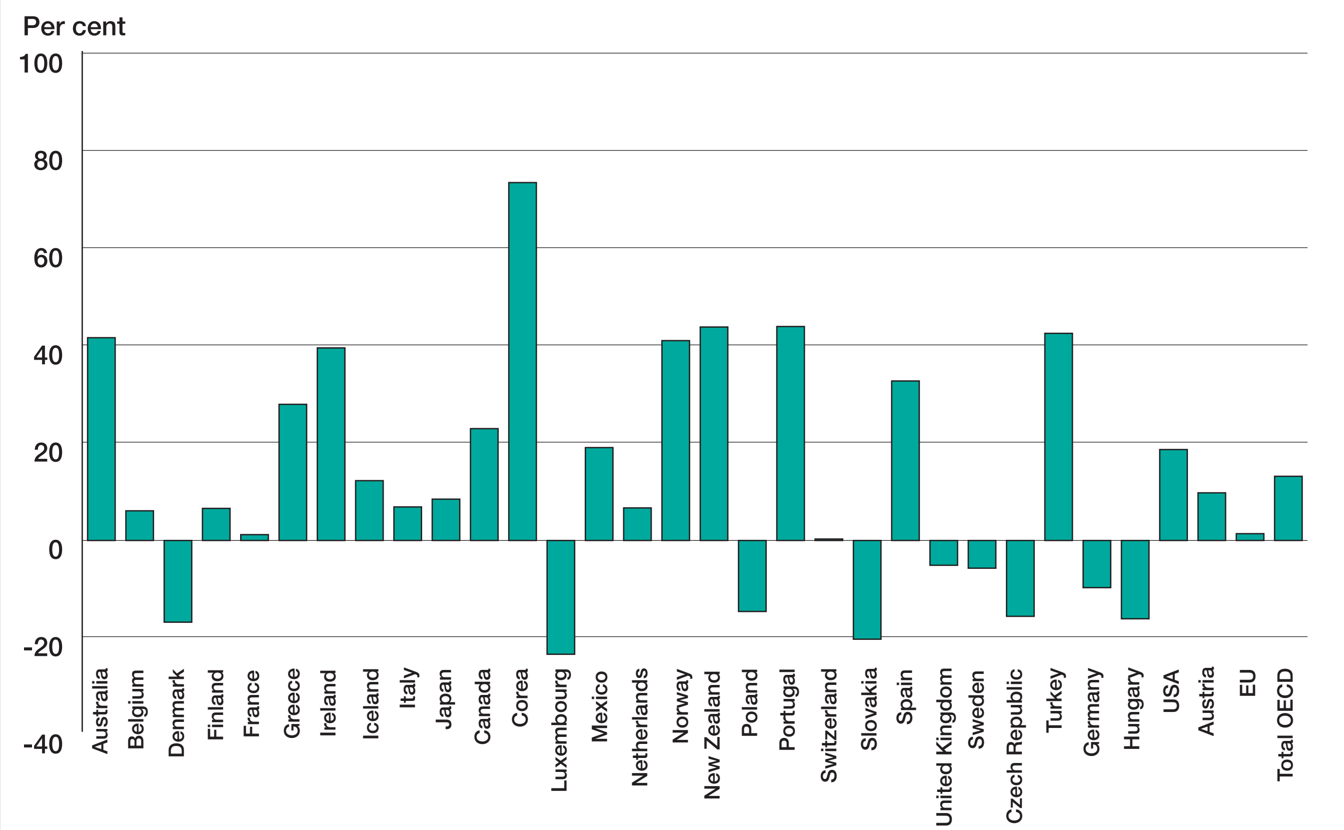
2002: Japan has also ratified the Protocol. During the Environment Summit meeting in Johannesburg in 2002, Russia announced its intention to ratify the Protocol, but a year later this has still not happened. It is expected that, when Russia does ratify the Protocol, the necessary conditions for its coming into force will have been fulfilled.

The ninth meeting of the parties was held in Milan in December 2003.

The meeting was concerned primarily with technical and other matters of detail that are important for implementation of the Protocol. ■

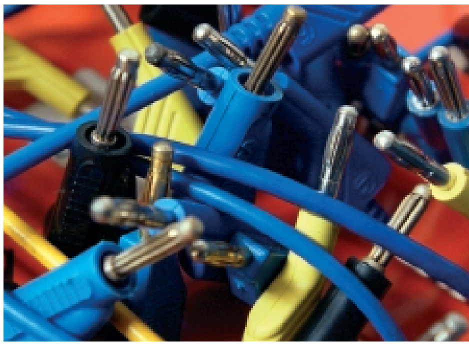
FIGURE 44b

Changes in carbon dioxide emissions in the EU and OECD states between 1990 and 2000.



Source: OECD

Energy facts



This chapter explains some energy terms that are used in Energy in Sweden. Units and conversion factors are described: the conversion factors have been used by Statistics Sweden (SCB) and the National Energy Agency to convert various physical quantities to energy quantities. Relationships between various energy units are also given, in order to make it possible to compare statistics with other international statistics.

Information on statistics and conversion factors

Statistics in the 2001 edition of Energy in Sweden and Energy in Sweden in figures were revised relative to those given in earlier editions. The changes related primarily to the years 1983-1999, but entire time series in some tables were updated. Much of this revision work was carried out in conjunction with Statistics Sweden. Starting from the 2001 edition, statistics that are based on material from Statistics Sweden are preliminary as far as the two previous years are concerned. Statistics for earlier years are definitive. Unless otherwise stated, diagrams and tables in Energy in Sweden are based on statistics from Statistics Sweden, and have generally been further processed by the Swedish Energy Agency. Conversion factors are shown when changes in fuel energy contents have occurred. During the latest such revision, for statistics from and including 2001, the specific energy contents of petroleum coke, petrol, diesel fuel, gas oil, all grades of heavier fuel oils and natural gas were changed. Note that these conversion factors are averages for various fuels, and that there are differences between qualities, not least for various wood fuels and coal. The international standard unit for energy is the joule (J). However, this is a small unit (1 J = 1 watt-second), and so for convenience the watt-hour (Wh) or kilowatt-hour are generally used. International comparisons and statistics often use the unit of toe (tonne of oil equivalent). In some applications, calories (cal) are still used.

All these units are impractically small for dealing with large energy quantities in national contexts. Instead, larger units are used through the additions of prefixes, such as petajoule (PJ) or terawatt-hour (TWh).[1] ■

[1] The meanings of names of quantities larger than the million differ between European and American usage: there is therefore scope for misunderstanding. The safest way to avoid any risk is not to use names such as billion, trillion etc. for large quantities, but to express them as figures, such as 10^9 or 10^{12}. However, for readability reasons, US definitions have been used in Energy in Sweden.

TABLE 8

Conversion between energy units as used in *Energy in Sweden*.

	GJ	MWh	toe	Mcal
GJ	1	0,28	0.02	239
MWh	3.6	1	0.086	860
toe	41.9	11.63	1	10000
Mcal	0.0419	0.00116	0.0001	1

TABLE 9

Prefixes used with energy units in *Energy in Sweden.* (US English)[1]

PREFIX		FAKTOR	
k	Kilo	10^3	thousand
M	Mega	10^6	million
G	Giga	10^9	billion[1]
T	Tera	10^{12}	trillion[1]
P	Peta	10^{15}	thousand trillion[1]

TABLE 7

Conversion factor of energy content used by SCB and Swedish Energy Agency [1]

Fuel	Physical quantity	MWh	GJ
Wood chips	1 tonne	2.0–4.0	7.2–14.4
Peat	1 tonne	2.5-3	9–11
Pellets, briquettes	1 tonne	4.5-5	16–18
Coal	1 tonne	7.56	27.2
Coke	1 tonne	7.79	28.1
Nuclear fuel	1 toe	11.6	41.9
Crude oil	1 m^3	10.1	36.3
Topped crude oil	1 m^3	11.1	40.1
Petroleum coke[2]	1 tonne	9.70	34.9
Asphalt, road dressing oils	1 tonne	11.6	41.9
Lubricating oils	1 tonne	11.5	41.4
Road fuel petrol[3]	1 m^3	9.04	32.6
Virgin naphtha	1 m^3	8.74	31.5
Light virgin naphhta	1 m^3	7.91	28.4
Aviation petrol	1 m^3	8.51	30.6
Other light oils	1 m^3	8.74	31.5
Petroleum naphtha	1 m^3	9.34	33.6
Aviation paraffin	1 m^3	9.58	34.5
Other paraffin and intermediate oils	1 m^3	9.54	34.3
Diesel fuel[4] and gas oil	1 m^3	9.96	35.9
Heavy fuel oils[5] and bunker oil	1 m^3	10.6	38.1
Propane and butane	1 tonne	12.8	46.1
Gasworks gas, coking oven gas	1000 m^3	4.65	16.7
Natural gas[6]	1000 m^3	9.99	36.0
Blast furnace gas	1000 m^3	0.930	3.35

Notes: [1] The table shows three values of conversion factors. Further values have been used in the calculations. The following values were used prior to 2001:
[2] 9.67 for conversion to MWh and 34.8 for conversion to GJ. [3] 8.72 for MWh and. 31.4 for GJ. [4] 9.89 for MWh and 35.6 for GJ.[5] 10.8 for MWh and 38.9 for GJ. [6] 9.72 for MWh and 35.0 for GJ. The value for natural gas is the net (lower) calorific value. The gross (upper) calorific value for conversion to MWh is 11.1 from and including 2001: prior to 2001, it was 10.8.

8

A little energy reference book

Ash

Ash is the unburnable residue from a fuel. Combustion oxidises the carbon and hydrogen in the fuel to carbon dioxide and water respectively, leaving the minerals behind as ash. Solid fuels contain more ash than do liquid fuels, while gases leave no ash at all. Heavy oil products, which contain more ash than light oil products, can contain up to about 1% of ash. Common ash contents of hard coal are 5-15%. Peat contains 1–15% ash, while logs contains 1–5%. Light ashes tend to be carried away in the flue gases as dust (fly ash). Dust separators can trap over 99% of fly ash for disposal. As greater quantities of fuel are taken from forests, it is important to return the minerals that they contain, and so research into how the ash can be safely and effectively returned to the forest is in progress.

About 10% of the ash constituents melt during combustion, forming slag at the bottom of the combustion chamber (bottom ash or molten ash). Combustion of coal and refuse produce the greatest quantities of bottom ash and slag. Ash may be disposed of in landfill, or be used in building materials or as bulk filling material. Before disposing of it in landfill, the risks of leaching or enrichment of heavy metals must be dealt with.

Calorific value

The calorific value of a fuel is the amount of heat released per unit quantity of the fuel when completely burnt, expressed in the SI units of J/kg or J/m^3. We distinguish between the gross or upper calorific value and the net or lower calorific value. The former measures all the heat released by burning the fuel, while the latter does not include the heat needed to evaporate the water either formed in the combustion process itself through combustion of the hydrogen in the fuel, or accompanying the fuel (i.e. as inherent dampness). Until the beginning of the 1980s, it was felt in Sweden that only the lower calorific value was relevant for practical purposes. However, with the development of condensing boilers, which utilise the latent heat of condensation of the water (e.g. by condensing the flue gases in a heating plant), the upper calorific value has also become of interest.

Coal

Coal is an umbrella name for brown coal, hard coal and anthracite. It is the world's most abundant fossil energy resource, although also that which produces the greatest carbon dioxide emissions. Both physically and chemically, it is a complete and heterogeneous substance, with considerable differences in quality and properties from one deposit to another. For trading purposes, coal is divided into essentially the following energy content groups:

- Brown coal, with a calorific value of 10 – 28 MJ/kg
- Hard coal, with a calorific value of 28 – 36 MJ/kg
- Anthracite, with a calorific value of about 34 MJ/kg.

Brown coal is normally utilised at the place of extraction, while the higher energy content of hard coal makes it worth while to export. It is divided into special grades depending on application, such as flame coal, steam coal, coking coal or forging coal.

Efficiency, coefficient of performance

Efficiency can be defined as useful energy output, divided by the energy input needed to provide it. However, for heat pumps and refrigerators we use instead what is known as the coefficient of performance. For heat pumps, this is defined as the amount of heat delivered, divided by the input drive energy. For refrigerating machinery, it is defined as the amount of heat absorbed (i.e. the amount of cold produced), divided by the input drive energy. Efficiency can never exceed 100%, but the coefficient of performance should exceed unity (1) for most types of heat pumps / refrigerating machinery. The efficiency of a nuclear power station is about 30%, while that of a cold condensing power station fuelled by fossil fuel is about 40%, and that of a CHP power station is about 70–80%. A combined cycle power station (producing only electricity, and not district heating) has an efficiency of about 60%. Typical coefficients of performance of compressor-driven heat pumps are about 3–5 (i.e. 300% – 500%), while those of compressor-driven refrigerating machines are about 2–4 (i.e. 200% – 400%). A thermally powered absorption heat pump typically has a coefficient of performance of about 1–2.

Electricity certificate

The electricity certificate system is a new, market-based support system to assist the growth of renewable electric power production (electricity from solar energy, wind power, hydro power and biofuels) in Sweden. The target is to increase the amount of such power by 10 TWh/year by 2010. All producers of such renewable power receive one certificate unit per MWh of electricity. These certificates can then be sold, as the system requires all electricity users (with a few exceptions) to buy a certain number of certificates, determined by their quota obligation. By raising this quota each year (i.e. by requiring users to buy a greater proportion of electricity from renewable sources), demand for such electricity will be increased, thus stimulating the expansion of production from renewable energy sources.

Energy

Is measured in joules, which equal 1 watt-second. One kilowatt-hour (kWh) therefore equals 3600 joules, as there are 3600 seconds in an hour.

Energy carrier

A substance or a state that can be used to store, convey or transmit energy.

Fuels are energy carriers containing chemically bound energy. Electricity is an energy carrier that, to be of practical use, needs to be supplied at a defined, known and controlled voltage, capable of supplying a useful current. It has to be produced from other energy sources. Water reservoirs store energy in potential form, i.e. capable of delivering energy if the water is discharged to a lower level through a water turbine. Hot water as used in district heating is an energy carrier that delivers heat to users. Cold water in district cooling systems is an energy carrier that removes heat from buildings, processes etc. Hydrogen is an energy carrier belonging to the fuels group, i.e. carrying energy in chemically bound form. It needs to be produced from other energy sources.

Energy gas
A fuel in gaseous form at normal pressures and temperature. The most important energy gases are natural gas, LPG (liquefied petroleum gas), gasworks gas, generator gas, hydrogen and biogas. Natural gas (which is mostly methane) and LPG (mostly propane or butane) are fossil gases found in the crust of the earth. The others are produced from energy-rich raw materials by various technical processes, Biogas (methane) is formed by the organic decomposition of organic materials by bacteria, and can be produced by digestion of sewage sludge or other biological waste.

Energy intensity and improving the efficiency of energy use
Energy intensity can be defined as the quantity of input energy divided by the output quantity/process/value, or as $E = I \times Q$, where Q is the output quantity/process/value, I is the energy intensity and E is the input energy quantity. Improving the efficiency of energy use means that we try to reduce the energy intensity (I) by various means, while leaving the output quantity/process/value (Q) unchanged, and thus reducing the amount of input energy needed.

Energy plants: Thermal power stations, combined heat and power stations (also called cogeneration power stations), combined cycle power stations and heating plants
An energy plant is one that produces electricity and/or heat.

A thermal power station produces only electricity. In practically all cases, they use steam turbines to drive a generator, with the steam from the turbine being discharged to a condenser, where it is condensed back into water by giving up its heat to the surrounding air or to some source of cold water, such as a river or the sea . This is the origin of the name, cold condensing power station. Both nuclear power stations and fossil-fuelled power stations are cold condensing power stations.

Combined heat and power (CHP) stations produce both heat and electricity. The amount of electricity that they produce, per unit of fuel input, is less than that of a cold condensing power station, but the overall efficiency is considerably higher, as the heat in the steam leaving the turbine (which is at a higher temperature than is the case for the steam leaving a cold condensing turbine) is delivered to a district heating network. In industry, this form of power generation is generally referred to as back-pressure power generation. The only difference is that, instead of the exhaust steam being used to supply heat to a district heating system, it is used instead as process steam in the industry.

Combined cycle power stations have two turbines: a gas turbine, which drives an electrical generator, with the hot gases leaving the turbine being used to raise steam to drive a steam turbine, which in turn drives a second electrical generator. The exhaust steam from the steam turbine can be used to supply district heating, or it may be condensed in the same way as in a cold condensing steam power station. Electricity yield is higher than in a cold condensing power station, but the initial plant cost is considerably higher.

Heating plants are simply boiler plants that supply only heat. For a district heating system, this is delivered as hot water, not as steam.

Energy source
These are natural resources or natural phenomena that can be converted into useful energy forms such as light, motion or heat. Examples of fossil energy sources are natural gas, crude oil and coal. They occur in finite, although very large, quantities, and are renewed only extremely slowly. Another relatively plentiful energy source, but which is not renewed, is uranium, the raw material for nuclear fuel. Renewable or flowing energy sources are constantly renewed by energy input to the earth and to nature from the sun. Water, wind and wave power are flowing energy sources. Tidal power is another, but derives from the interaction of the earth and moon. Biomass is also regarded as a solar-derived energy source, and is therefore a renewable energy source. In addition to these primary energy sources (solar, nuclear or fossil), there is also geothermal energy, originating from the earth's hot interior.

Evaporation
Evaporation is the process of changing a liquid to a gas by the addition of heat. It occurs when a liquid becomes a gas without any turbulence or violent disturbance. Boiling occurs when the liquid is raised to the temperature at which the liquid can no longer exist as a liquid, but must become a gas. The evaporation process is the most important process in energy technology, forming the basis for more or less all electricity production apart from hydro power, wind power and solar cell power, i.e. in cold condensing power stations, nuclear power stations and combined heat and power stations. All use water as the medium that is evaporated. Heat pumps and refrigerators, however, in which the evaporation processes are used in order to absorb energy, rather than to release it, use different working fluids, such as propane, ammonia or fluorocarbons, and at lower temperatures than for water. In this way, they can absorb heat from their surroundings.

Exergy and anergy
Exergy is a quality concept of energy. Energy = exergy + anergy. Exergy is that part of the energy that can be converted into work. Mechanical energy and electricity are regarded as high-quality energy, with high exergy contents. Thermal energy cannot be completely converted into work and has a lower exergy content. Thermal energy

at the same temperature as its surroundings cannot be converted into work, and is thus anergy.

Fuels
Substances or materials with chemically-bound (or fissile) energy. Fuels are usually regarded as being organic compounds or organic materials which release heat when burnt. Nuclear fuels, however, are those that release heat as a result of nuclear fission or (not yet realised on a practical scale) by nuclear fusion. The most important elements in fuels are carbon and hydrogen, and it is the reaction of these two with oxygen to form carbon dioxide and water respectively that releases heat. In addition to the combustible elements of carbon and hydrogen, most fuels (apart from energy gases) contain many other elements, in the form of non-combustible minerals that form ash.

Gasification
Gasification is a very important process in energy technology, as no fuel can burn without first being converted to gas. Gasification of a fuel generally occurs when the fuel is actually burnt. However, combustion losses can be reduced by first gasifying the fuel before combustion, and then delivering it in gaseous form. Another reason for doing this is that it makes it easier to remove various contaminants. Solid fuels can be converted to gaseous form either by pyrolysis or by partial combustion. In addition, organic non-fossil materials can be gasified by biological processes, to produce biogas. Pyrolysis (dry distillation) involves heating the solid organic material in the absence of oxygen, causing it to release volatile substances (mainly various hydrocarbons) without burning them. Light hydrocarbons released in this way (e.g. methane) remain in the gas phase even if they are then cooled, but other hydrocarbons condense to pyrolysis oil, leaving most of the fuel in solid form as carbon powder or sinter and ash. Partial combustion involves supplying steam and limited quantities of air to glowing carbon in a special reactor vessel, to produce a gas consisting of a mixture of hydrogen, carbon monoxide, carbon dioxide and nitrogen. The combustible constituents of this gas, known as water gas, are hydrogen and carbon monoxide. Generator gas consists mainly of carbon monoxide, carbon dioxide and nitrogen. Water gas is widely used in the chemical industry as a feedstock for the production of more high-value fuels and chemical products, such as methanol.

Oil
Crude oil, or petroleum, is a mixture of various hydrocarbons, ranging from the lightest that consist of just a few carbon atoms to long, heavy molecular chains containing a score or so of carbon atoms. Crude oil can be used directly in some types of plant, but is considerably more valuable, and has a wider range of uses, if it is first refined into a range of petroleum products. This is done is refineries which, in principle, are sophisticated distillation plants. The hydrocarbons in the crude oil have different boiling points, and can therefore be separated from each other by appropriate control of the temperatures and pressures in the distillation process. This produces the various common oil products of LPG (liquefied petroleum gas), petrol, paraffin (am. kerosene), diesel oil, gas oil and heavy fuel oils, together with various special products. The composition of the crude oil, which varies depending on its source, determines how much of a particular product can be obtained. However, the thickest products can be further processed by cracking, which breaks the long carbon chains into shorter chains, so increasing the yield of lighter products such as petrol and diesel fuel.

Oil equivalent
A common unit for comparing the energy contents of various fuels with each other and with a standardised measure of the energy content of fuel oil. The unit is generally that of tonne of oil equivalent (toe), which provides 41,9 GJ or 11,63 MWh.

Peat
An organic type of soil, formed under damp and oxygen–deficient conditions by the bacterial and chemical decomposition of dead plant and animal matter. Peat is renewed relatively slowly, and is therefore somewhere between renewable and fuels and non-renewable fossil fuels.

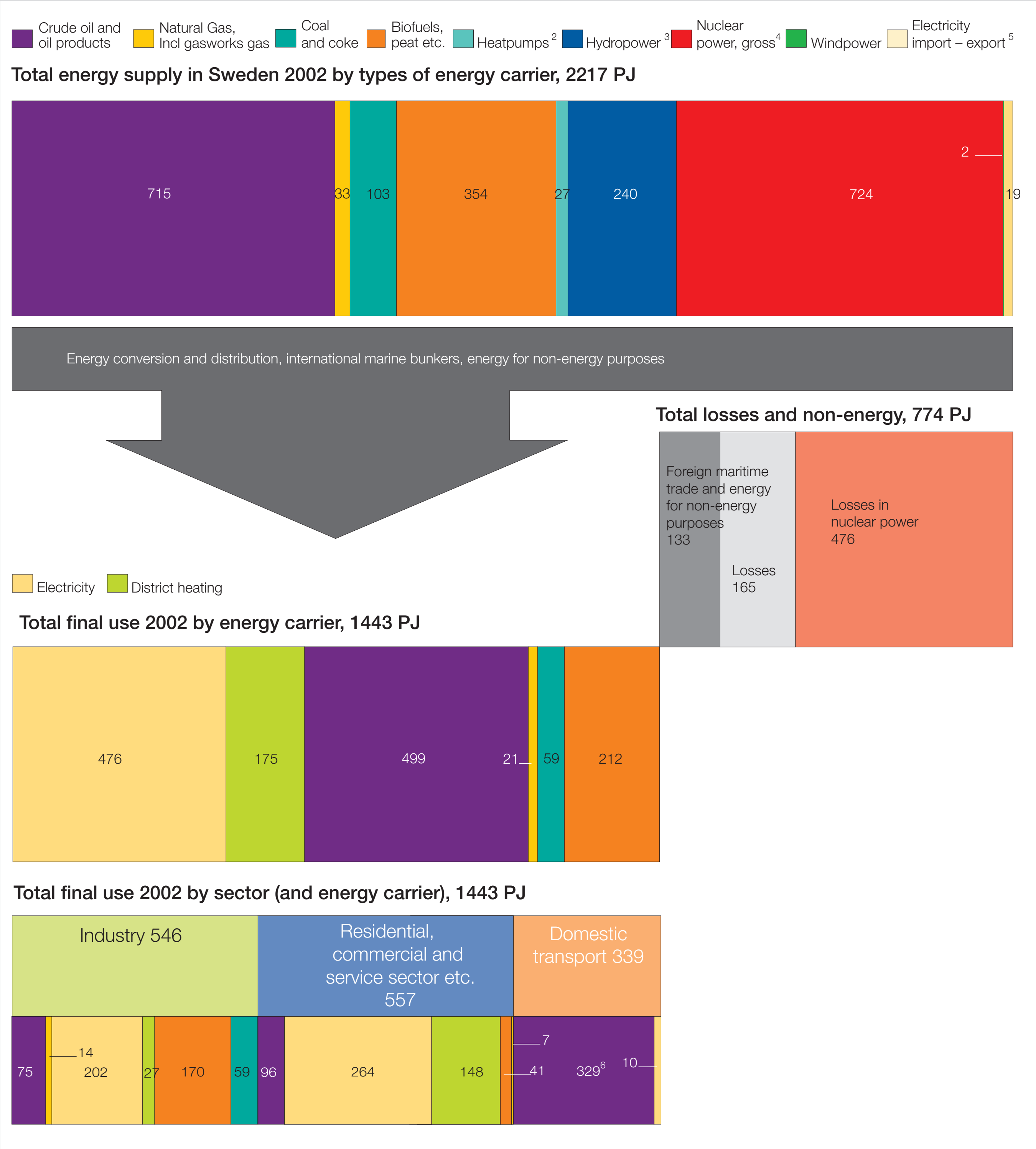
Power
Energy and power are not the same. Power is the rate of delivering energy. It is measured in joules per second, which is the same as the traditional watt. Power shortage is the state when an energy system, such as an electrical power system, is unable to supply the amount of energy required at the rate at which it is required.

Statistically average year
A statistically average year is one that is statistically average in terms of its meteorological and/or hydrological data. It provides a means of making fairer comparisons of energy supply and energy use between one year and another, eliminating the effects of weather conditions in varying the statistics.

Waste heat
Waste heat is heat discharged from industrial processes, when it has fallen to a temperature that is no longer useful in the process. It can be used by district heating systems, either by direct distribution in the mains or, if it is at too low a temperature, by raising its temperature in a district heating plant or by using it as a heat source for heat pumps. Refineries, cement factories, steel mills and pulp mills are major sources of such waste heat. Sewage effluent treatment plants also produce waste heat, but at a relatively low temperature.

FIGURE 1

Energy supply and use in Sweden, 2002, in PJ[1]. (In Twh, see page 10)



Note:

[1] Preliminary statistics. Due to arithmetical rounding of the individual items, there may be a small difference in the totals.

[2] Large heat pumps in the energy sector (e.g. supplying district heating systems). Energy supplied to the energy system is the output heat, 25 PJ. Heat absorbed from the surroundings was somewhat less than 18 PJ, while input drive energy from electricity was somewhat over 7 PJ.

[3] Hydro power and wind power together up to and including 1996.

[4] Nuclear power is gross energy, i.e. as the gross input energy in the fuel, in accordance with the UN/ECE guidelines.

[5] Net import of electricity, treated as electricity supply.

[6] Use of oil products for transport includes ethanol, about 2 PJ.

[7] Source of all other figures, if not indicated, Statistics Sweden, processed by the Swdish Energy Agency.

Source: SCB, The Swedish Energy Agency.[7]

An efficient and environmentally sustainable energy system

The Swedish Energy Agency is the central Swedish authority on energy. The agency works for the transformation of the Swedish energy system towards an environmentally friendly, secure and efficient energy system. The agency also cooperates at the international level.

The Swedish Energy Agency promotes efficient energy markets, and increased production from renewable energy sources. The agency is the regulator for gas- and electricity grid services in Sweden and is also responsible for energy preparedness measures. The Agency supports a large number of research and development programmes in the energy field in cooperation with universities, institutes of technology and industry.

Swedish Energy Agency

Swedish Energy Agency, P.O. Box 310, SE-631 04 Eskilstuna. • Visiting address: Kungsgatan 43.
• Phone: +46 (16) 544 20 00. • Fax: +46 (16) 544 20 99.• stem@stem.se •www.stem.se