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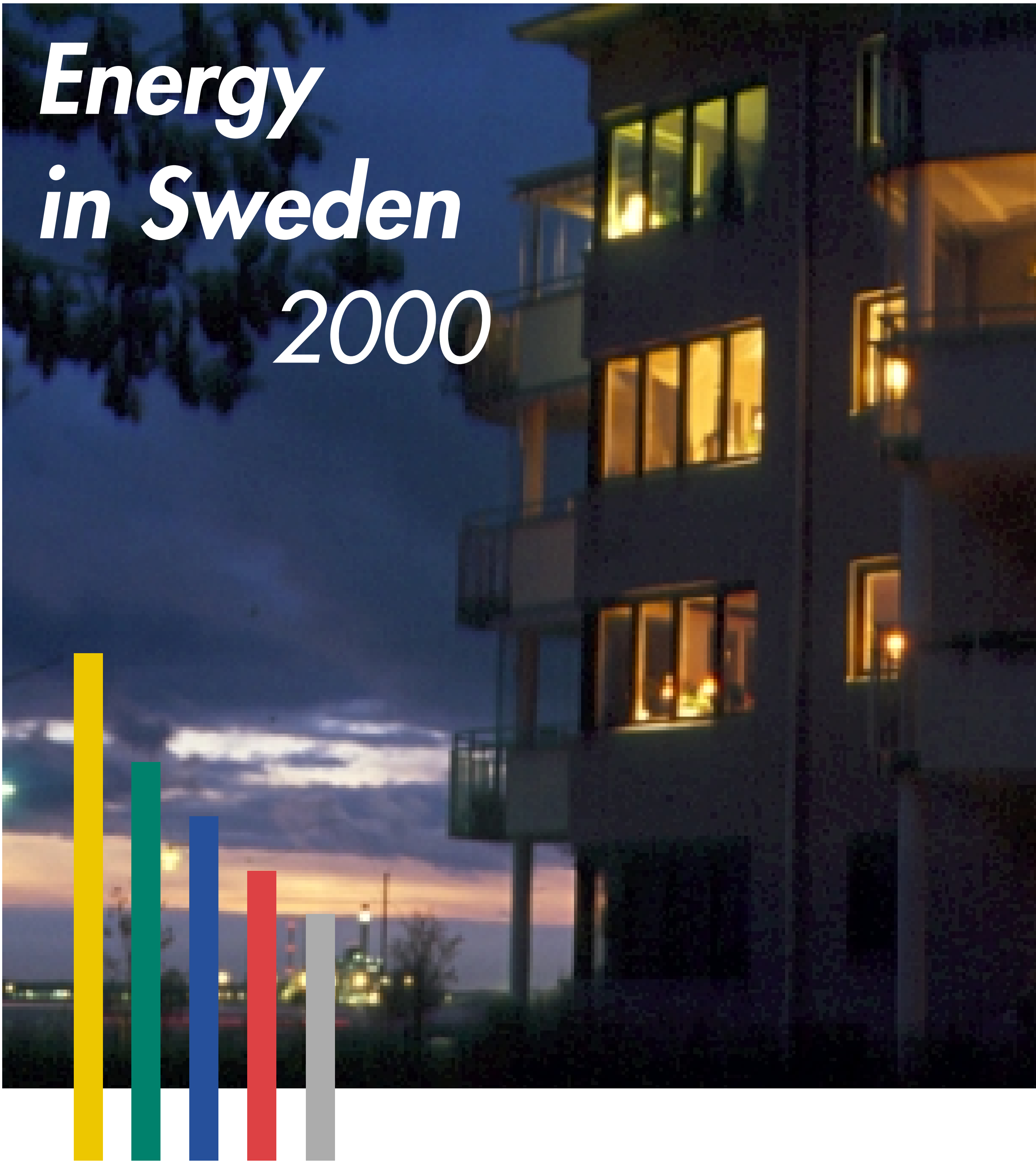
Energy in Sweden 2000



Swedish National Energy Administration

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

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

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The energy markets are undergoing a process of rapid change as a result of many factors, including a shift in the emphases of energy and environmental policies in Sweden and elsewhere. '*Energy in Sweden*', which is published annually, is intended to provide decision-makers, journalists and the general public with a coherent and easily available source of information on developments in the energy sector.

In recent years, Swedish energy and environmental policy has increasingly concentrated on establishing or improving long-term conditions for effective energy markets. Restructuring of the Swedish electricity market, greater internationalisation and the effects of the energy system on the environment and on climate are important factors that influence this policy and thus the development of energy markets. Sweden's presidency of the European Union from 1st January 2001 will be an important event. Sweden takes over the presidency from France and, at the end of its six-month period, hands over to Belgium.

Sweden's energy policy, as set out by the Swedish Parliament in 1997, is to provide secure short-term and long-term supplies of electricity and other energy on sufficiently competitive terms to enable the country to compete with supplies from other countries. The country's energy policy is intended to create the conditions for efficient use and cost-efficient supply of energy, with minimum adverse effects on health, the environment or climate, while at the same time assisting the move towards an ecologically sustainable society. An extensive energy policy programme has been started in order to facilitate restructuring and development of the energy system. The main thrust of this work is in the form of a substantial long-term concentration on research, development and demonstration of new energy technology. The National Energy Administration is responsible for implementing most of the energy policy programmes and for coordinating the work of restructuring the energy system. In addition, it is also responsible for monitoring developments in the energy and environmental sectors, and for providing information on the current energy situation, such as changes in the structure and pattern of energy supply and use, energy prices and energy taxes, as well as the effects of the energy system on the environment.

A number of changes have been made in this year's edition of *Energy in Sweden.* Two new sections have been added: a description of various areas of current policy, and a description of energy supply within the European Union. The descriptions of the national and international oil, coal, electricity and gas markets have been merged into joint texts. ■

Stockholm, december 2000

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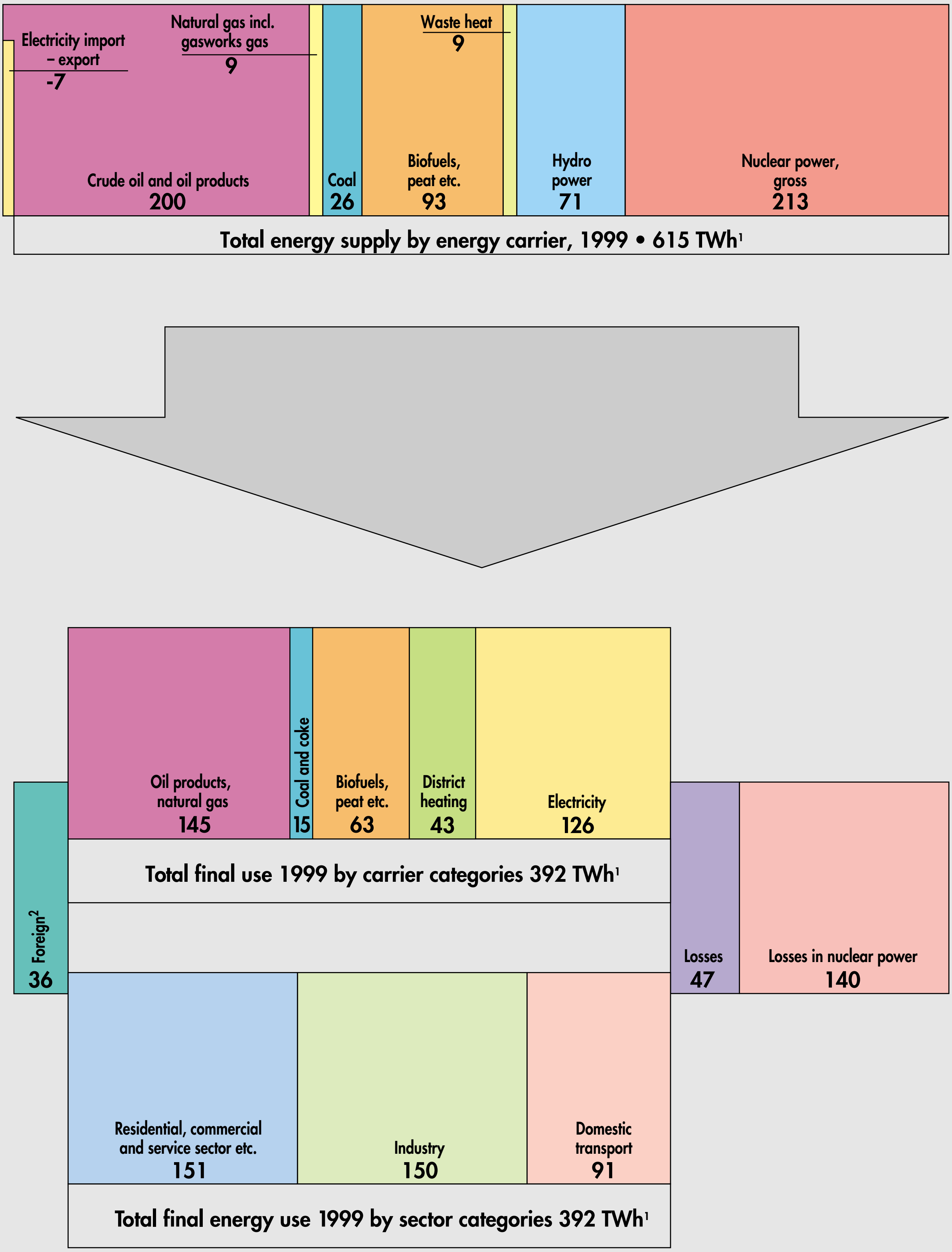
Figure 1 • Energy supply and use in Sweden 1999, TWh

The same diagram, expressed in PJ, can be found on page 41



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

[2] International marine bunkers and energy for non-energy purposes.

The form taken by energy, environmental and climate policies, both at national and international levels, will have a very considerable effect on future development of the energy sector. Since joining the European Union, Sweden has also participated in the work of advancing matters of common European interest in the fields of energy and transport. In its capacity as a member state, for example, Sweden participates in the EU Framework Programme for research and development, of which one of the working areas is concerned with renewable energy sources and more efficient use of energy.

During the spring of 2001, Sweden will hold the presidency of the EU. The main duty of the chair country is to conduct the work of the European Union and to further matters of common interest. It will also mean that Sweden will represent the European Union in contact with other countries and in international contexts. During its presidency, Sweden intends to give priority to three matters in particular: enlargement of the EU, employment and the environment. (Read more at: http://www.utrikes.regeringen.se/eu.)

National

In both the long and the short terms, the objective of Swedish energy policy is to ensure reliable supplies of electricity and other forms of energy carriers at prices that are competitive with those of other countries. It is intended to create the right conditions for cost-efficient Swedish energy supply and efficient energy use with minimum adverse effect on health, the environment or climate. Extension of cooperation in the fields of energy, the environment and climate around the Baltic is also an important objective. (Read more at: http://www.regeringen.se.)

The results of two climate official reports have been published during 2000. During the spring, the Climate Committee published its *Proposal for a Swedish climate strategy* (SOU 2000:23), in which it suggested a national target for Sweden involving reducing the emission of greenhouse gases by 2 % between 2008–2012, relative to the 1990 level. To achieve this objective, the Committee suggests a programme of work at both national and international levels. One of the elements of the international work is that Sweden should push for the introduction of European trade in emission rights of greenhouse gases. At the national level, work includes information campaigns linked to demonstration projects and investment subsidies. Some proposals also involve tightening up existing regulations.

Emission Trading: A Way of Achieving the Climate Goal (SOU 2000:45) was published in the spring of 2000. The report concentrates on how a national trading system in emission rights could be established: the Government will be presenting a Bill concerned with climate matters at the end of 2000.

EU level

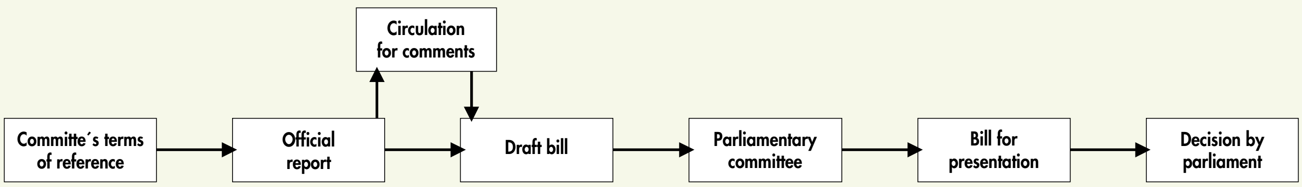
The EU Directorate-General for Energy and Transport has established a number of political priorities for the period 2000–2005. Some of these priorities relate to implementation of the single market for energy and transport, as well as to the question of how development of the transport and energy sectors can be reconciled with environmental requirements.

The objective of implementing the single market for energy and transport is supported by a number of measures, including the gas and electricity market directives. The Electricity Market Directive (96/92/EU) was adopted in 1996, followed by the Gas Market Directive (98/30/EU) in 1998. Their objectives are progressively to open up the gas and electricity markets to greater competition, which is expected to benefit European consumers through lower prices. At present, the Commission is working on preparing data and putting forward proposals for how the markets are to be opened up and what rules are to apply on them. The electricity markets in the UK, Norway, Sweden, Finland and Germany are already fully open to competition, i.e. both industrial and domestic consumers can choose their electricity suppliers. Market restructuring is well advanced in Denmark, too, but other EU countries have not progressed as far.

The emphasis of the work on how development of transport and energy can be reconciled with environmental requirements is on a number of areas, including energy efficiency (particularly within the building sector) and on encouragement of the use of renewable energy sources. A draft directive was presented by the Commission in the spring of 2000, intended to encourage the production of electricity from renewable energy sources (COM [2000] 279 Final). The purpose of the directive is to create a framework which, in the long term, will help to increase the proportion of electricity produced from renewable energy sources. The Commission's White Paper *Energy for the future – renewable energy sources* (COM [1997] 599 Final) sets out the objective of doubling the present proportion of electrical energy from renewable energy sources within the EU from 6 % to 12 % by 2010.

For the summit meeting of the Council of Ministers in June 2001, the Commission is planning to put forward a strategy for integrating environmental consideration and sustainable development within the energy sector. It represents a continuation of the progress started in Cardiff in 1998, with the aim of increasingly integrating environmental protection requirements and sustainable development in areas such as energy and transport policy. The environmental aspects will be given priority while Sweden holds the presidency of the EU.

The Commission has also published a Communication (COM [1999] 548 Final) concerning strengthening the northern di-



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

The European Commission:

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

The European Parliament:

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

The Council of Ministers:

- Makes decisions and legislates within the European Union.

The European Court:

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

The Audit Committee:

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

Read more at: http://www.utrikes.regeringen.se/eu

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

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

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

mension of European energy policy. It was noted, at the meeting of foreign ministers in Helsinki on 11-12 November 1999, that the northern dimension can be utilised to increase security, stability, democratic reforms and sustainable development in northern Europe, as well as to identify and encourage common European interests. During 2000/2001, the Commission is planning to publish a Green Paper on security of supply in the energy sector.

The work of the EU Directorate-General for the Environment includes climate matters. During the year, the Commission has published a communication on *EU policies and measures to reduce greenhouse gas emissions* (COM [2000] 88), as a precursor to ratification of the Kyoto Protocol. It is particularly within the fields of energy, transport and industry that common matters, concerning the whole of the European Union, can be of interest.

The Directorate-General for the Environment has also published a Green Paper entitled *Greenhouse gas emission trading within the EU* (COM [2000] 87), intended to start a discussion on trade in emission rights, including discussion of how such a system might be structured. It is the objective that a trading system should be in operation within the EU by 2005.

During 2000, the Directorate-General for the Environment introduced a European climate change programme, ECCP. The objective of the programme is to bring together all parties involved in work on preparations for common, coordinated policies and measures intended to reduce emissions of greenhouse gases. The programme will be concerned primarily with policies and measures within the fields of flexible mechanisms, energy supply, energy use, transport and industry.

International

The sixth meeting of the parties to the Climate Convention, COP6, was held in the autumn of 2000. The main objective of this meeting was to enable the parties to make decisions concerning the various matters remaining to be solved, including utilisation of the flexible mechanisms. The meeting considered, for example, what sanctions should be applied to countries that did not fulfil their emission undertakings. Another important issue was how the carbon sinks should be handled. The results of this meeting are decisive for the coming Kyoto Protocol ratification process. As it turned out, the Parties to the Kyoto Protocol did not reach a final agreement on some of the more difficult issues. The negotiations will thus continue in spring 2001. ■

Sweden's total energy supply has increased by 36 % between 1970 and 1999, from 457 TWh to 615 TWh[1] respectively. The average level of energy supply has been 534 TWh/year.

The constituents making up the total energy supply have changed considerably over this period. In 1970, crude oil and oil products accounted for 77 % of the total energy supply, but had fallen to 33 % by 1999. In 1970, most of the oil was used by the residential and service sectors. Today, the largest user is the transport sector, accounting for 54 % in 1999. Over the last 30 years, the use of oil has been largely replaced by the use of nuclear power and biofuels, accompanied by an increase in the 'normal year' production of hydro power. Normal year output is based on a mean value of statistics concerning inflow to the reservoirs for the period 1950–1996. Today, nuclear power can produce about 206 TWh[1] (68 TWh of electricity) per year, and hydro power can produce about 64 TWh per year under normal precipitation conditions. The total proportion of overall energy supply provided by hydro and nuclear power has increased from 9 % in 1970 to 46 % in 1999. The proportion of total energy supply provided by coal and coke in 1999 remains at the same level as in 1970, i.e. 4 %, while the proportion supplied by biofuels, peat etc, has risen from 9 % in 1970 to 14 % in 1999. Biofuels, peat etc. are used primarily by the industrial sector and for district heating production.

Total energy supply varies from year to year due partly to the effects of temperature. Years that are warmer than the statistically normal value have a lower energy supply, while those that are colder have a higher energy supply. 1999 was warmer than normal, which means that energy use, and thus energy supply, was less than would otherwise have been the case.

Compared with other countries, Swedish energy supply comes from a relatively large proportion of renewable energy sources: biofuels, hydro power and wind power. In 1999, these sources provided 26 % of the country's total energy supply. In order further to increase this proportion, investments in wind power and biofuelled CHP plants are subsidised by grants administered by the National Energy Administration.

According to the Administration's forecast for the period until 2002[2], total energy supply for 2000 is expected to fall to 589 TWh. This is due primarily to a reduction in the supply of oil, due to high oil prices and a fall in nuclear power output. Despite the fact that hydro power output has been unusually high, it is expected that overall electrical production will fall to 141 TWh as a result of reduced production of nuclear power. It is expected, on the basis of preliminary statistics and our own calculations, that Sweden will be a net importer of 4.6 TWh of electricity during 2000. According to the forecast the total energy supply for 2001 and 2002 is expected to rise to 609 TWh and 616 TWh respectively: including respective net imports of electricity of 9 TWh and 10 TWh. ■

[1] In accordance with the international method of energy accounting, which includes the energy conversion losses in nuclear power stations.

[2] Energy supply in Sweden, short-term forecast, 2000-11-02.

Figure 2a • Total energy supply in Sweden 1970–1999

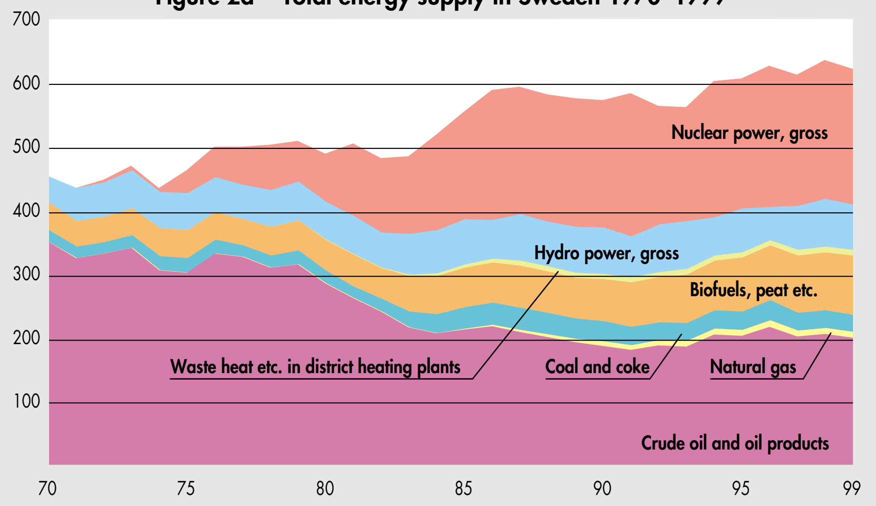
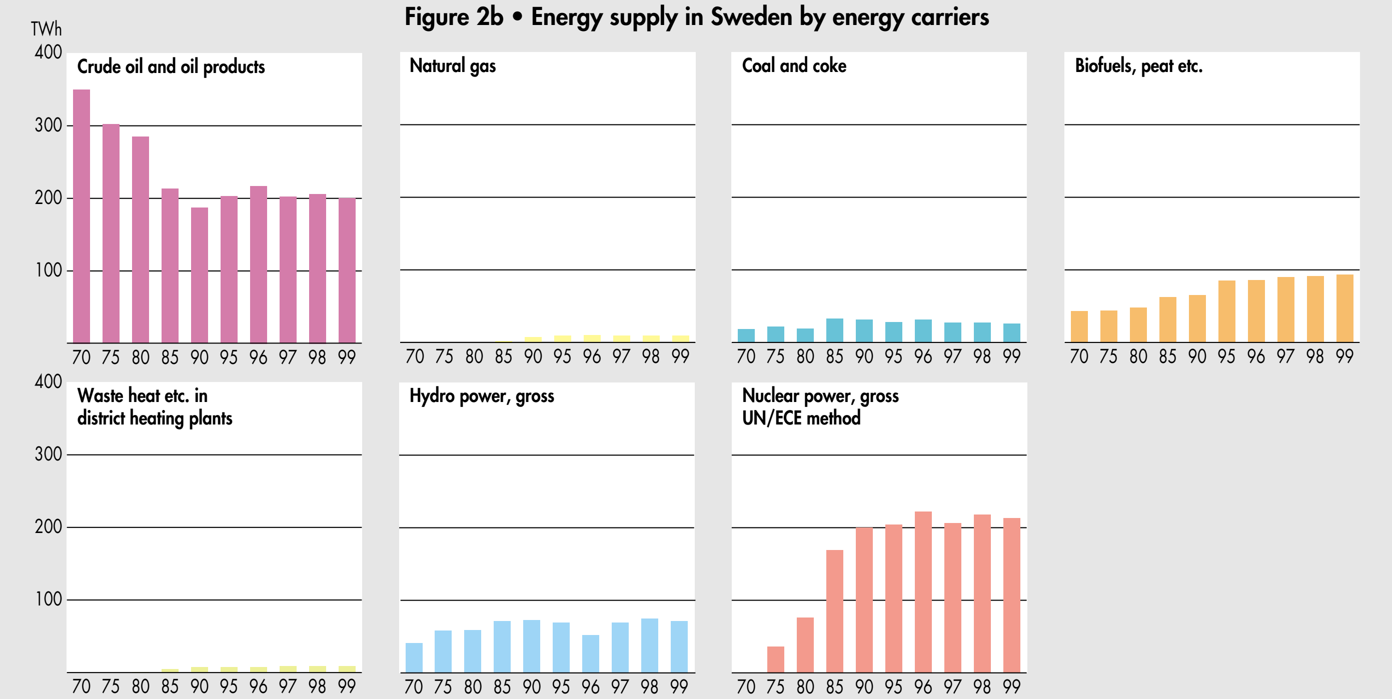


Figure 2b • Energy supply in Sweden by energy carriers



Total energy use can be divided up into three categories. First is what is known as the total final energy use, i.e. use within the three sectors of residential/services etc., industry and internal transport (i.e. excluding international marine bunkers). The three sectors in this group account for the majority of all energy use. The second category comprises the losses associated with total energy use, i.e. conversion losses in connection with electricity and heat production (although this does not include the losses associated with hydro power production), conversion losses in refineries and coking plants, energy used by the energy sector itself and distribution losses associated with the supply of electricity, natural gas, gasworks gas, blast furnace gas and district heating. The third category of energy use comprises bunker oil for international shipping, coal and oil products used as raw materials and feed stocks for applications such as the plastics industry, lubricating oils and oil products used in the building and civil engineering sectors, e.g. asphalt, surface coatings etc.

The relative proportions of final energy use accounted for in the first group have gradually changed since 1970. The residential/service and industrial sector proportions have each fallen in relation to total final energy use, while that of the transport sector has risen. Industry's proportion has fallen from 41 % to 38 %, and the residential/service sector from 44 % to 38 %, while the internal transport sector's proportion of the country's total energy use has risen from 15 % to 22 %.

[3] Energy supply in Sweden, short-term forecast, 2000-11-02.

The variations in energy use that occur from year to year are due mainly to economic conditions and to climate conditions. The reduced energy use in the residential/service sector during the end of the 1980s and the beginning of the 1990s can be partly accounted for by the fact that those years were warmer than normal. 1996, however, was colder than normal, which explains the increase between 1995 and 1996. The following years were again warmer than normal, resulting in a fall in energy use in the residential/service sector.

Total final energy use in 1999 amounted to 393 TWh. To this must be added 36 TWh for overseas shipping etc., and 186 TWh for losses, of which the losses in nuclear power plants accounted for 140 TWh. This gives a total energy use of 615 TWh for 1999.

According to the Administration's forecast for the period up to 2002[3], total energy use for 2000 is expected to fall to 589 TWh, despite the fact that final energy use is approximately the same as in 1999. The explanation for this is that the cutback in electricity production from nuclear power plants will also result in an estimated reduction in the total losses to 159 TWh.

Energy use in the industrial sector is expected to increase by 5 TWh during 2000, while energy use in the transport sector is expected to remain the same as it was during 1999. Energy use in the residential/service sector is expected to fall, due to the fact that 2000 was warmer than 1999.

According to the forecasts for 2001 and 2002 final energy use is expected to increase to 402 TWh and 404 TWh respectively. ■

Figure 3a • Total energy use in Sweden 1970–1999

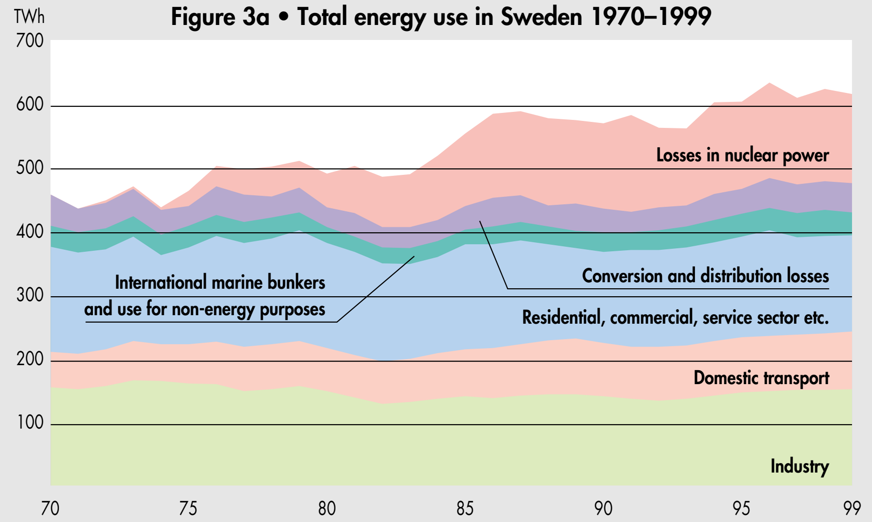
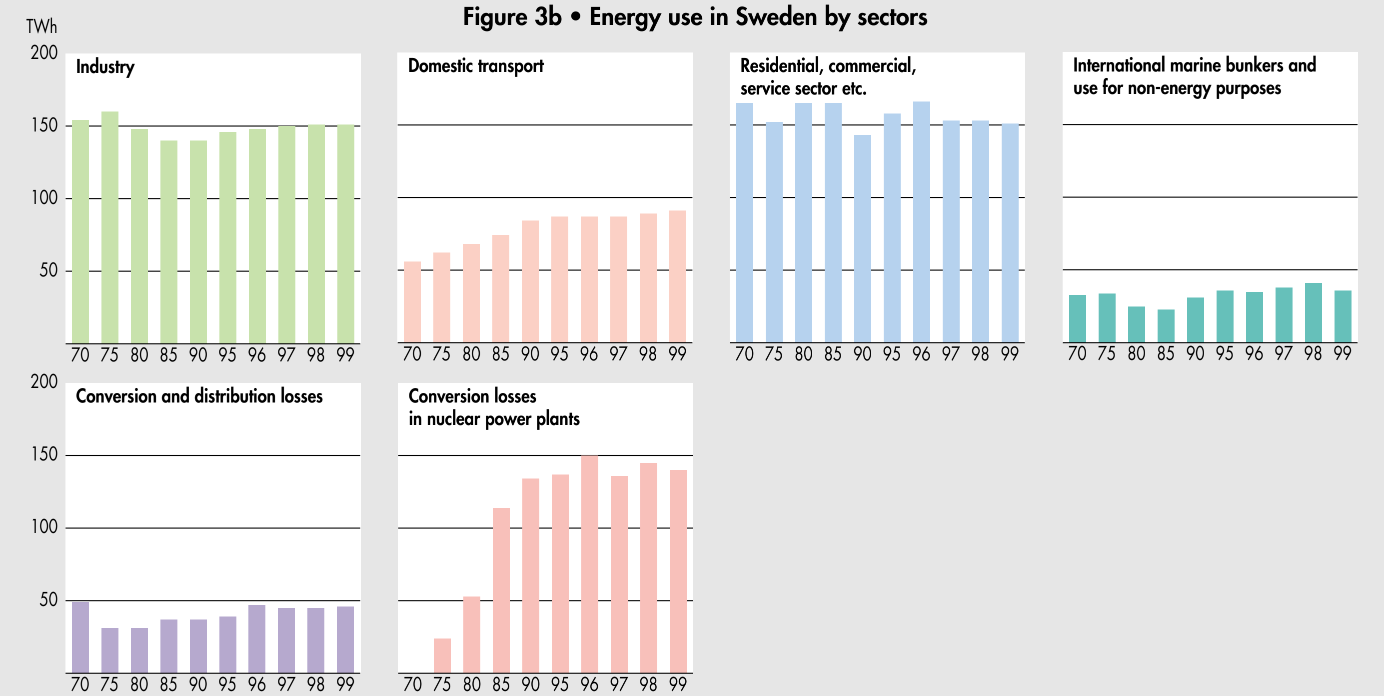


Figure 3b • Energy use in Sweden by sectors



1999 was the fourth year of the restructured electricity market in Sweden and Finland. Norway had restructured its electricity market in 1991. During the year, competition on the market increased more than it had done during the three previous years. A good availability of electricity, together with low prices on the electricity exchange, exerted pressure on the utilities to keep their prices down.

Since the restructuring of the industry, there have been a number of changes in respect of ownership of the production utilities in the Nordic countries. Gullspång Kraft and Stockholm Energi merged in September 1998 to form Birka Energi, which means that Sweden now has six main parties dominating the electricity production sector. However, on the common Nordic market as a whole, there are several other production utilities that compete. Swedish Vattenfall, Norwegian Statkraft, Finnish Fortum and German PreussenElektra all want to be leading companies in a future northern European electricity market, and are therefore investing in facilities in their neighbouring countries. This action is manifesting itself in such ways as through takeovers, purchase of shareholdings, alliances and the establishment of subsidiary companies in Sweden and in other countries.

Electricity use

Total electricity use increased by only 0.3 % per annum from 1987 to 1999, to a total of somewhat over 143 TWh in 1999. The greatest increase is to be found in the residential and service sector, in which the use of electricity varies with temperature. The increase is due primarily to a change from oil to electricity for heating, coupled with greater use of electricity for building services systems.

In industry, use of electricity has increased on average by 1.8 % per annum since 1970. Industrial use is closely linked to production conditions in a small number of important sectors: the pulp and paper industry, for example, uses about 41 % of all the electricity used in industry. Electricity use in the transport sector is relatively small, being used almost entirely by the various forms of rail transport. In addition, total electricity use includes the losses associated with the transmission of electricity, together with electricity used in district heating plants, CHP plants and refineries.

Electricity production

Electricity is produced in Sweden from hydro power, nuclear power, wind power and conventional thermal power plants. In this context, thermal power refers to combined heat and power production, cold condensing power production and gas turbines, but not nuclear power. Combined heat and power plants are employed in industry, where the heat is used for internal process requirements, and in district heating plants, where the heat is generally supplied to public district heating systems.

At the beginning of the 1970s, most of Sweden's electricity was being produced by hydro power and conventional thermal power. This was when expansion of nuclear power started, with Sweden's first commercial reactor, Oskarshamn 1, being commissioned in 1972. Since then, the proportion of electricity from nuclear power has grown substantially, so that from 1975 more electricity has been produced in nuclear power plants than in conventional thermal power plants.

Figure 4a • Use of electricity in Sweden 1970–1999

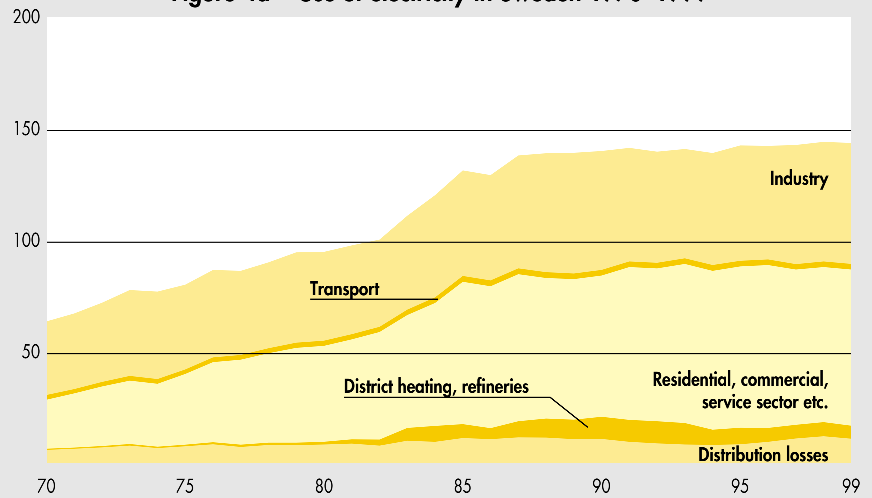
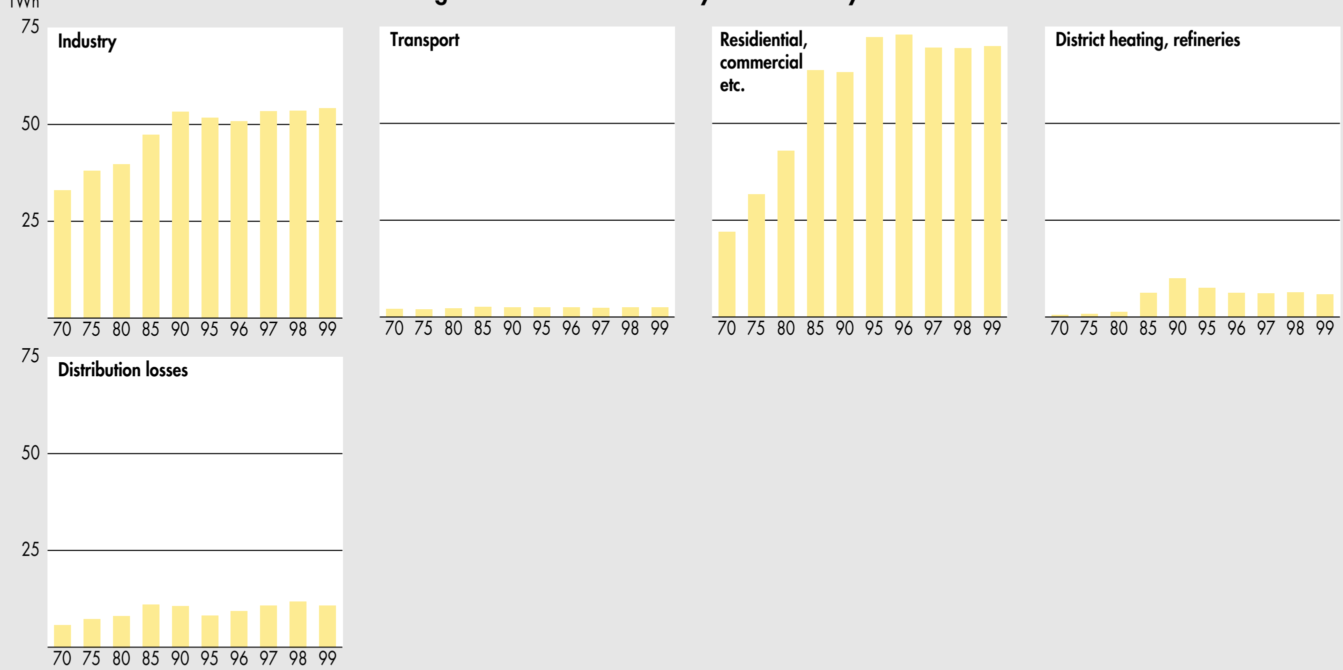


Figure 4b • Use of electricity in Sweden by sectors



Today, most of Sweden's electricity is produced by hydro power or nuclear power, with conventional thermal power production accounting for only about 5 %. Oil-fired cold condensing power plants and gas turbines are used today primarily as reserve capacity during years with low precipitation and resulting low hydro power production. Restructuring of the electricity market has resulted in several reserve power stations being taken out of use for economic reasons.

There are also about 500 wind power plants in the country (as of August 2000). As yet, however, their contribution to the country's electricity balance is still very small, amounting to 0.2 % during 1999.

The total installed capacity of the Swedish electricity production system is somewhat over 30 000 MW. However, 100 % capacity is never available, and transmission capacity between the north and south of the country is limited. The normal transmission capacity means that 6 300–7 000 MW can be transferred from north to central Sweden, and 3 350 MW from central Sweden to southern Sweden.

In 1999, the country produced 151 TWh of electricity, of which 47 % was produced by hydro power and 46 % by nuclear power.

Trade in electricity

Prior to restructuring of the electricity market in the Nordic countries, trade between them was controlled by bilateral agreements between purchasers and sellers. Today, this arrangement has been complemented by a Nordic power exchange, Nord Pool, on which the price of electricity for each hour of the day is determined 24 hours in advance. As a result, pricing of electricity on the Nordic market has become more efficient, as the transaction costs have been reduced. In addition, the exchange price can be used as a reference price for trade under the bilateral agreements. Border tariffs have been removed between Norway, Sweden and Finland, which has also helped to improve the efficiency of trading. Electricity in the →

Figure 5 • Wind power production 1982–1999

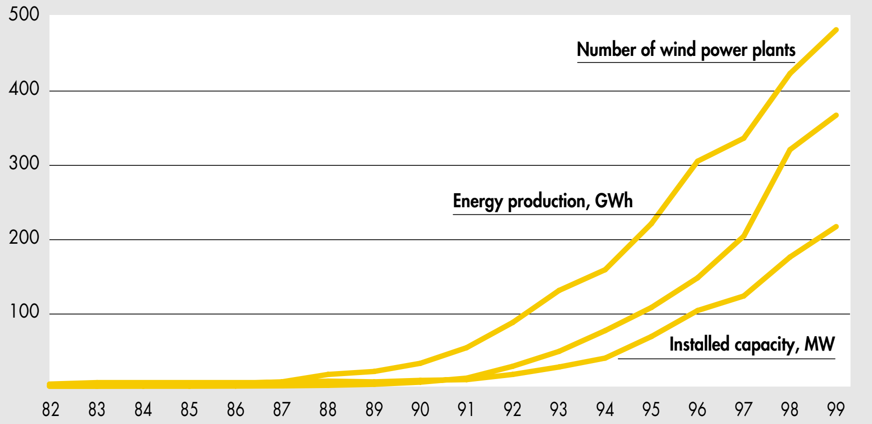


Figure 6a • Electricity production in Sweden 1970–1999

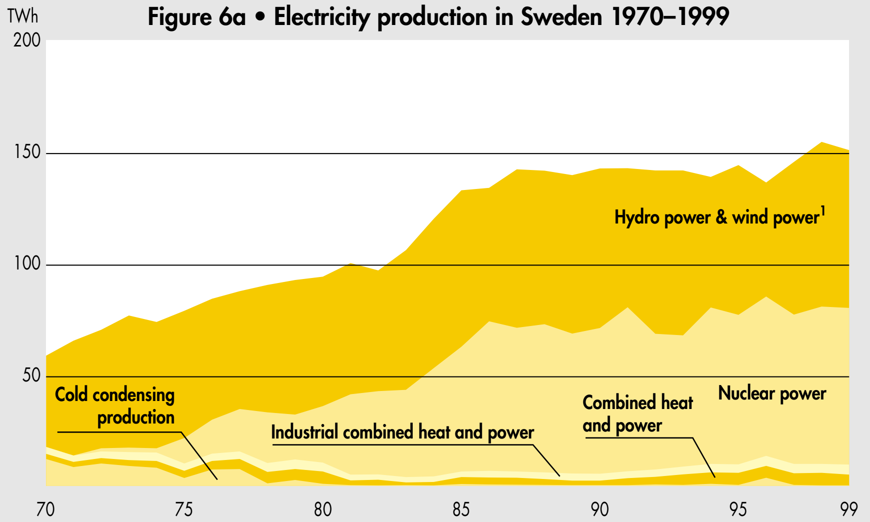
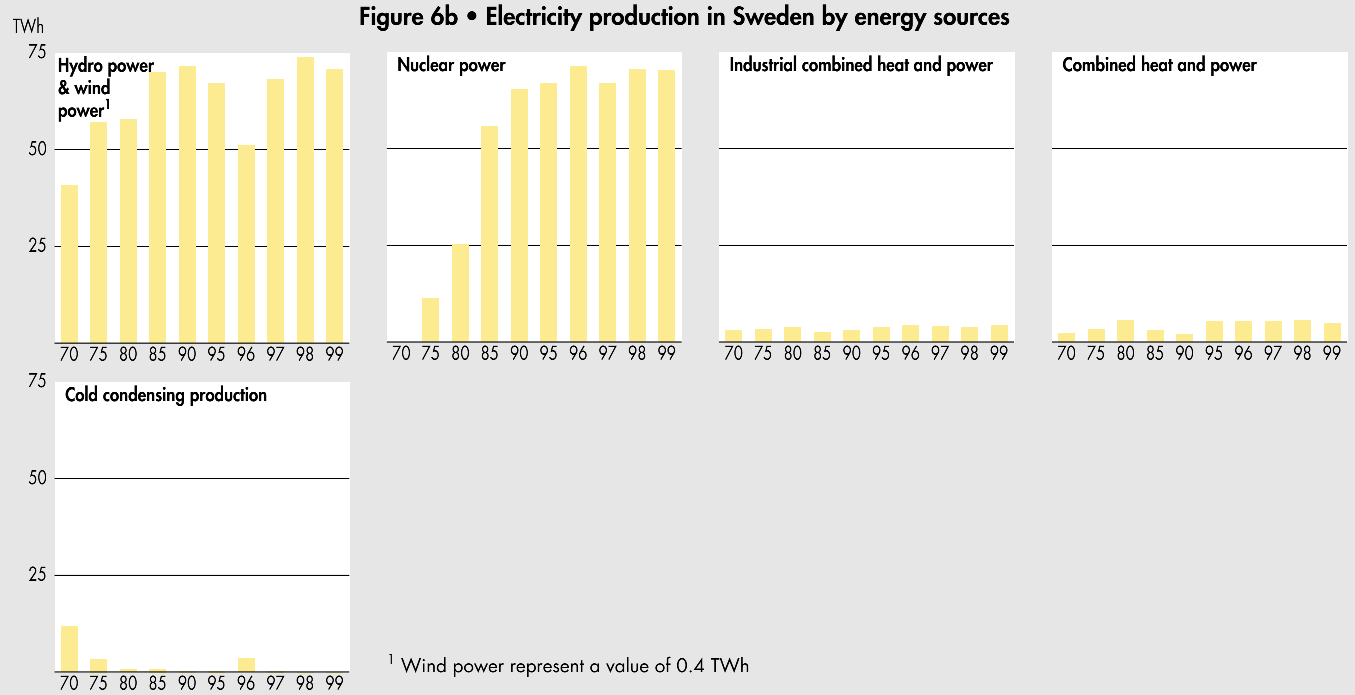


Figure 6b • Electricity production in Sweden by energy sources



[1] Wind power represent a value of 0.4 TWh

Nordic electrical system is produced in those plants having the lowest production costs. This has meant that power stations having high production costs have been closed because they are no longer profitable on an efficient market. Instead, power utilities import electricity from the neighbouring countries in this open Nordic market.

A condition for proper operation of the electricity market is that all parties should have free access to the transmission systems. At the same time, there needs to be a grid operator who, independent of the other parties on the market, ensures that there is a balance of power input and power demand on the grid. In Sweden, the grid operator is Svenska Kraftnät, with responsibility for the country's backbone grid and for most of the links with Sweden's Nordic neighbours. Links between the Nordic countries have been reinforced in recent years, and a cable between Sweden and Poland was commissioned during 2000.

As a result of changes in the electricity markets in the four Nordic/Scandinavian countries, Swedish producers can now sell electricity directly to customers in Denmark, Norway and Finland. In the same way, Swedish customers can purchase electricity from suppliers in other countries wanting to establish a foothold on the Swedish market. Today, several Swedish electrical trading companies have long-term contracts for the import and export of electricity with producers in neighbouring Nordic/Scandinavian countries. Long-term contracts with customers in other countries are also becoming more common.

Trade in electricity between the countries varies not only during the year but also from year to year, depending on the weather and on economic conditions. However, the most significance influence on the overall directions of power flow is the amount of water in the Swedish, Norwegian and Finnish reservoirs, coupled with electricity production costs. German, Russian and Polish utilities also participate in electricity trading with the Nordic countries, although they are not able to trade on the Nord Pool. As yet, trade with these countries is still relatively small.

During the first half of 2000, Sweden's electricity trade changed from a net export to a net import, despite plenty of water in the reservoirs and high availability of the nuclear power plants. One explanation for this could be that the power companies have started to match their production to spot prices. During the spring and summer, for example, the price of electricity on the Nord Pool was so low that it undercut the production costs from most forms of production.

Figure 7 • Sweden´s electricity imports January 1999–July 2000

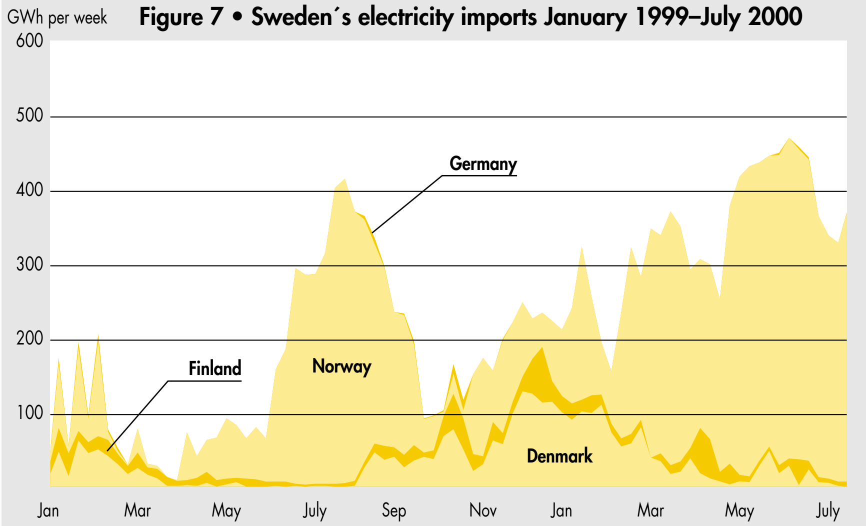
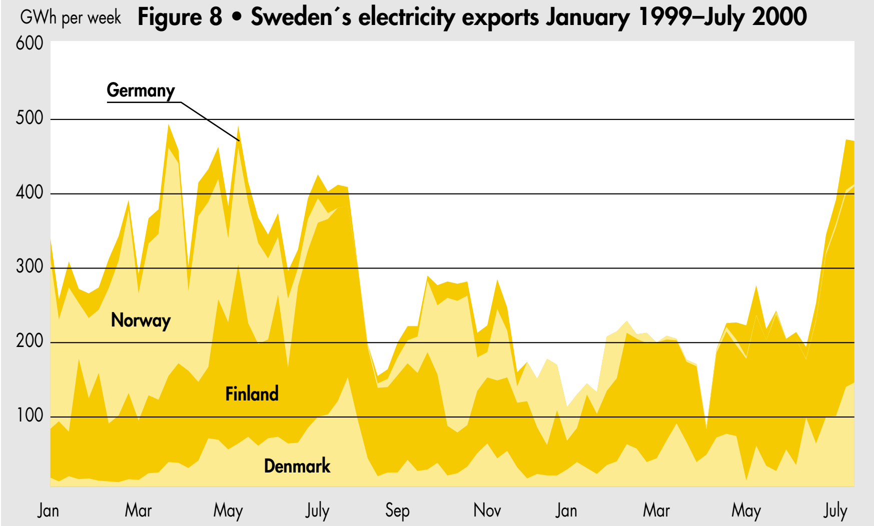


Figure 8 • Sweden´s electricity exports January 1999–July 2000



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 transmission and distribution systems, different taxation regimes, subsidies, national rules and the structure of the electricity market. The spot price of electricity on the power exchange is not the price that private customers see on their electricity bills. The final price of electricity to a customer consists of a grid tariff, a price for the electrical energy itself, various charges and taxes and, finally, the profit margin applied by each link in the chain. The spot price is determined on the basis of an equilibrium price as indicated by the intersection of the supply and demand cost curves, and is used as a reference price for other trading in electricity.

The first year of the restructured electricity market, 1996, was a dry year, which meant that the spot price rose until the end of the year. Since then, it has fallen substantially, due partly to adequate precipitation and partly to increasing competition on the common electricity market. The price varies over the year. Since 1998, these variations have followed a similar pattern, being higher during the winter and lower during the summer. The price variations depend on precipitation quantities, temperatures and available production and transmission capacities.

Due to physical limitations on the links between Sweden and Norway, two different prices, known as area prices, have been applied on occasions. During 1999 and 2000, these differences were greatest during the summer, when the prices in Sweden were higher than those in Norway. In addition, major differences occurred on 24th January 2000, when the Swedish and Finnish area prices rose steeply during the morning, reaching their hitherto highest level. This was caused partly by the fact that it was a cold winter day, and partly by a significant fear of insufficient capacity.

International development

The electricity market is at present undergoing extensive changes in many parts of the world in terms of altered market conditions, new technology and greater environmental awareness. One of the effects of the EU Electricity Market Directive is that at least 25 % of electricity markets in the EU states must be open for competition. The degree of openness varies between states. The electricity markets in Sweden, Finland, Norway, the UK and Germany are fully open to competition, which means that all companies and households are free to choose their electricity suppliers. France, Greece, Portugal and Austria, on the other hand, have merely fulfilled the minimum requirements of the directive. The directive also affects other countries in Europe, and particularly those that have applied for EU membership. Decisions on, or advanced plans for, reform of their electricity markets also exist in several countries outside the EU.

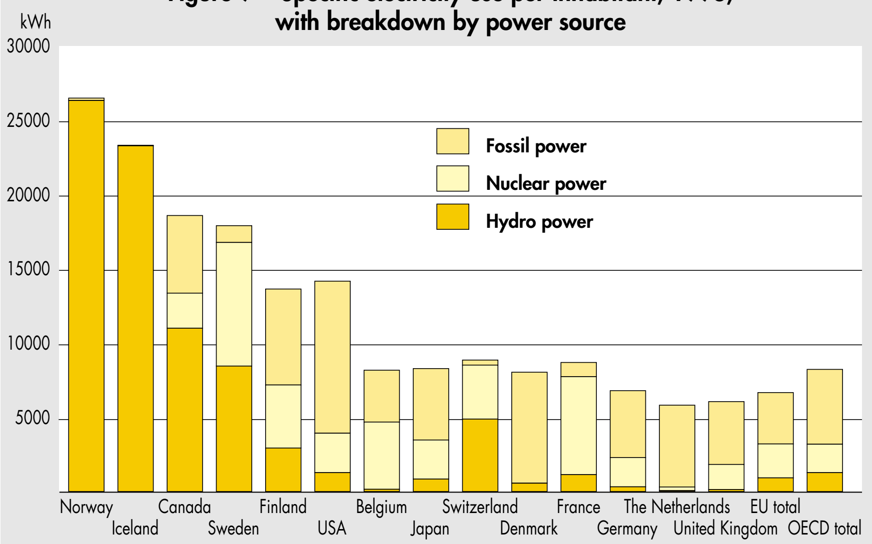
A similar development can be seen in other countries, such as South America, south-east Asia and Oceania. The USA has also started a restructuring process, under which California was the first state to reform its electricity market in 1998.

Restructuring of the electricity markets involves a change from national monopolies, with central planning, to markets exposed to competition. Electricity becomes a form of energy raw material, which can be traded and supplied across borders.

Company takeovers in the electricity markets in the Nordic countries have attracted considerable attention in recent years. Strategic investments are being made by the largest Nordic power utilities, not only in the Nordic countries but in the rest of Europe, while non-Nordic companies, such as the German PreussenElektra and the French EdF, are investing in the Nordic countries.

Import and export of electricity have previously been clear concepts that have been defined on a national perspective. However, as the larger companies increasingly extend their activities across national borders, it becomes less relevant to talk of national electricity markets. Large companies are buying and selling electricity in many other countries besides their original homelands. Development will be towards a common market, with electricity being produced wherever it is physically and economically most appropriate.

Figure 9 • Specific electricity use per inhabitant, 1998, with breakdown by power source



Electricity from renewable sources

Restructuring 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 at present unavoidably higher production costs, electricity from renewable sources may find it more difficult to break into the competitive markets. A draft directive is therefore being prepared at present, with a view to requiring electricity production from renewable sources to have been increased from somewhat less than 14 % to over 22 % by 2010. The necessary financial support for electricity producers using renewable energy sources can be provided by traditional investment support, by fixed price systems[1], 'green certificates' etc. The certificates would provide the producers of electricity from renewable sources with the necessary financial support in order to be able to meet current electricity prices, while also providing an incentive for cost-efficient production.

Electricity use varies between countries

In Sweden, per-capita electricity use is relatively high in comparison with that of other countries. In 1998, Sweden was in fourth place after Norway, Iceland and Canada. Electricity use in the USA was about 15 % less than in Sweden. Among the industrialised European countries, such as Germany, France and the UK, per-capita electricity use was less than half that in Sweden.

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

Sweden is one of the world's countries that have a high proportion of hydro and nuclear power in their electricity production. Only Iceland, Switzerland, Norway and Canada have higher proportions of hydro power, while France and Belgium have higher proportions of nuclear power. Most of the world's electricity is produced by conventional thermal power plants, i.e. CHP plants and cold condensing plants. They are fuelled almost exclusively by fossil fuels, with the proportion of such fuels varying between 90 % and 100 % in most countries. There are a few exceptions: in Finland and Sweden, the use of biofuels and refuse for thermal power production amounts to about 30 %, while in Switzerland 50 % of total thermal power production is based on such fuels. However, in international terms, the proportion of electricity production in Sweden and Switzerland based on thermal power is small, amounting to 6 % and 4 % respectively in 1998. In the EU member states as a whole, over half of electricity production is based on thermal power, with somewhat over 30 % from nuclear power and only 14 % from hydro power etc.

Total electricity production in the European Union is about two-thirds of that in the USA. At the same time, the USA's production of electricity constitutes somewhat over 40 % of the total production of the OECD countries. Electricity production in Sweden accounts for somewhat less than 2 % of OECD production, and 6 % of EU production. ■

[1] Suppliers of electricity from renewable sources receive a fixed payment, determined in advance.

During 1999, the use of biofuels, peat etc. amounted to almost 94 TWh. These fuels are mainly indigenous, and consist of wood fuels (logs, bark, chips and energy forest), black liquors in pulp mills, peat (included in the concept of bioenergy), straw and energy grasses and refuse.

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

The forest products industry

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

Black liquors, which can be produced and used only within the pulp industry, provided almost 34 TWh of energy (excluding electricity production) in 1999. Wood fuels in the form of raw materials residues are used in both the pulp industry and in sawmills. They consist mainly of wood chips, bark and other waste products. Use is also made, although to a lesser extent, of wood fuels produced by on-site forest chipping of felled wood unsuitable for other commercial purposes.

In 1999, the pulp industry used a total of 6.7 TWh of wood fuels in the form of by-products for energy production, while sawmills and other woodworking industries used 9.8 TWh of wood fuels.

District heating plants

A total of over 26 TWh of biofuels, peat etc. were used for heat production in district heating plants in 1999. Of this, wood fuels accounted for 15.7 TWh, unrefined tall oil and black liquors for 1.6 TWh, refuse for 5.1 TWh, peat for 2.8 TWh and other fuels for 1.0 TWh.

The use of wood fuels by the district heating sector has more than quadrupled since 1990. In 1999, use rose by 0.5 TWh relative to the previous year. The main form of these fuels is felling waste and forest by-products. However, processed fuels, such as briquettes and pellets, together with unrefined tall oil, have also been increasingly used in recent years, amounting to a total of 4.1 TWh in 1999.

Refuse has been used for district heating production since the 1970s, and provided 5.1 TWh of energy in 1999. Improved sorting at source may reduce the potential quantity of domestic refuse available for use as fuel, although at present the supply of combustible waste exceeds capacity. There is potential within the industrial sector for increasing the use of (primarily) salvaged wood fuels, which at present are not used for energy production. Some fuels of this type, such as refuse and salvaged timber, have been imported in recent years, but the quantity is difficult to estimate.

The use of peat in 1999 amount to 2.8 TWh, which is 0.3 TWh less than during the previous year. Production is dependent on the weather, and can therefore vary from year to year. Production of peat for energy purposes in 1999 amounted to 2.7 million m^3, which is about the same as average harvests during the 1990s, and represents a substantial increase in relation to production in 1998, when the weather was particularly unsuitable.

Energy crops, such as energy plantations, straw and grass fuels have been used since the beginning of the 1990s, although such use is still relatively limited. About 0.1 TWh of energy plantation fuels were used during the year, complemented by lesser quantities of straw and energy grass. Although there is considerable potential for greater use, the area planted with such crops has remained almost unchanged in recent years, amounting to only about 14 000 hectare in 1999. The amount of land used for energy plantations depends largely on agricultural subsidy rules and the amount of the subsidies.

Figure 10a • Use of biofuels, peat etc. in industry 1980–1999

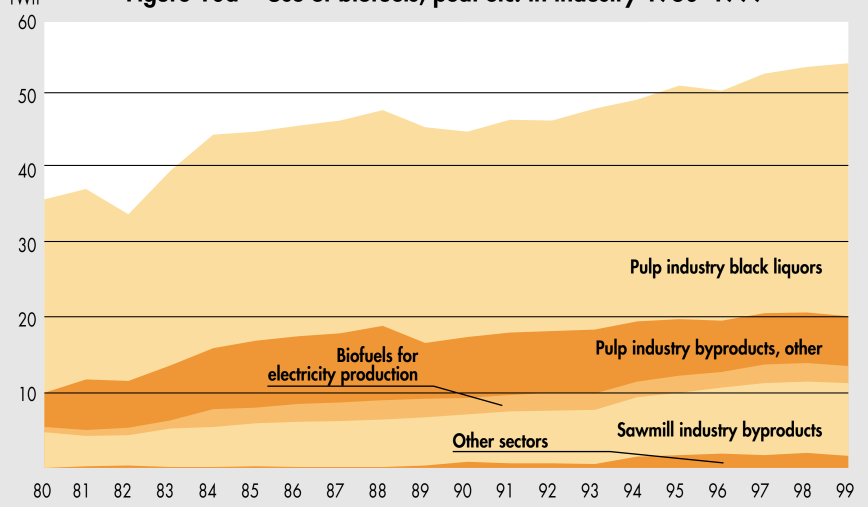
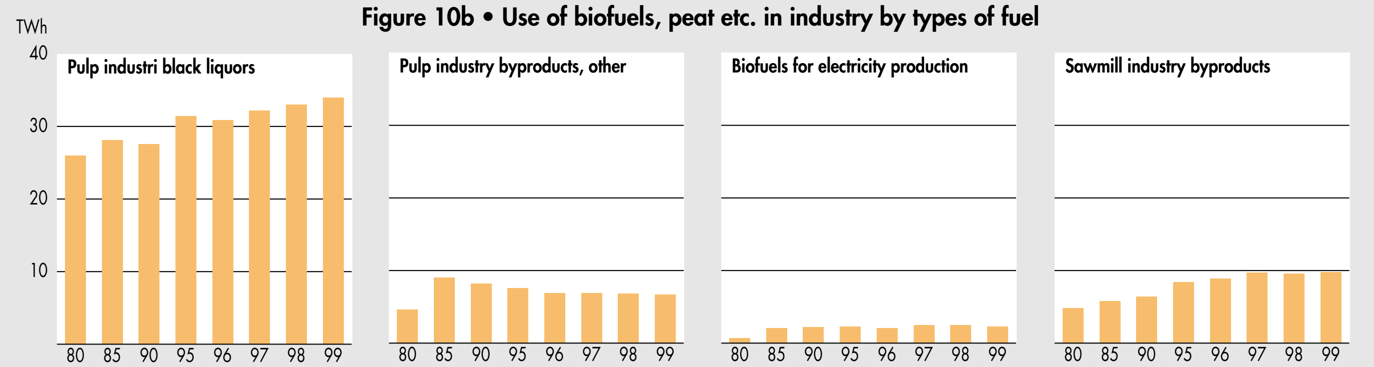


Figure 10b • Use of biofuels, peat etc. in industry by types of fuel



There has been a relatively extensive commercial importation of biofuels during the year, in the form of materials such as wood fuels, salvaged wood, tall oil and peat. Quantities are difficult to estimate, but have increased in recent years, and were estimated in 1997 as amounting to about 7–9 TWh. Imports in that year accounted for about 35–40 % of the supply of biofuels for district heating plants, and nowadays constitute an important source of such fuels. They are imported at prices which are below those on the home market, which means that they exert a certain price press on indigenous fuels. For some individual heating plants, imported fuels can form a substantial part of their fuel supply. The supply of biofuels is good, and there is a significant potential for their use in Sweden. For this reason, the trade in biomass fuels could become increasingly important in future.

The detached house sector

Over 12 TWh of biofuels, peat etc., mainly in the form of logs and chips, were used in detached houses for heating in 1999. Wood-firing is commonest among property-owners with good access to forests, e.g. in agricultural or rural areas. The use of processed biofuels (pellets and briquettes) is still relatively modest in this sector, amounting to about 0.5 TWh in 1999.

Electricity production

3.5 TWh of biofuels were used for electricity production during the year. Of this, about 1 TWh of wood fuels was used for the production of electricity in CHP plants. Of the remainder, 1.1 TWh of wood fuels were used in industrial back-pressure plants and 1.2 TWh in the form of black liquors. Other biofuels, such as agricultural waste, landfill gas, digester gas and peat were sometimes used for electricity production, although such use was very limited.

An international context

Seen in a European perspective, Sweden acquits itself well in terms of its high proportion of biofuels, making up about 15 %, in its energy supply. It is very difficult to find fully comparable details of biofuel use in other countries, but there are factors that have a considerable effect on their use: good availability of forests, an efficient forest products industry and the wide existence of district heating systems. This means that, of the European countries, it is Sweden and Finland that have the highest proportions of biofuels in their respective energy systems. Other countries with potentially high volumes of biofuels, but in which little use is made of them in their energy systems, are Germany, France, the UK, Romania and Austria.

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

Figure 11a • Use of biofuels, peat etc. in district heating 1980–1999

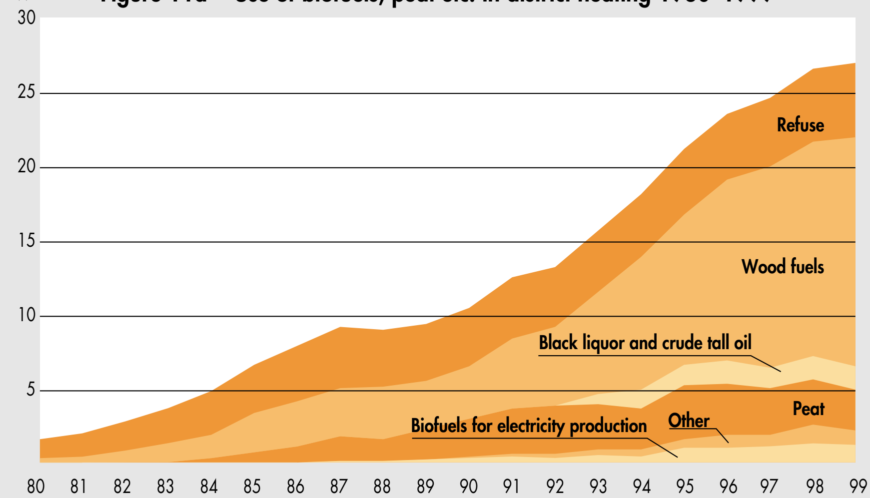
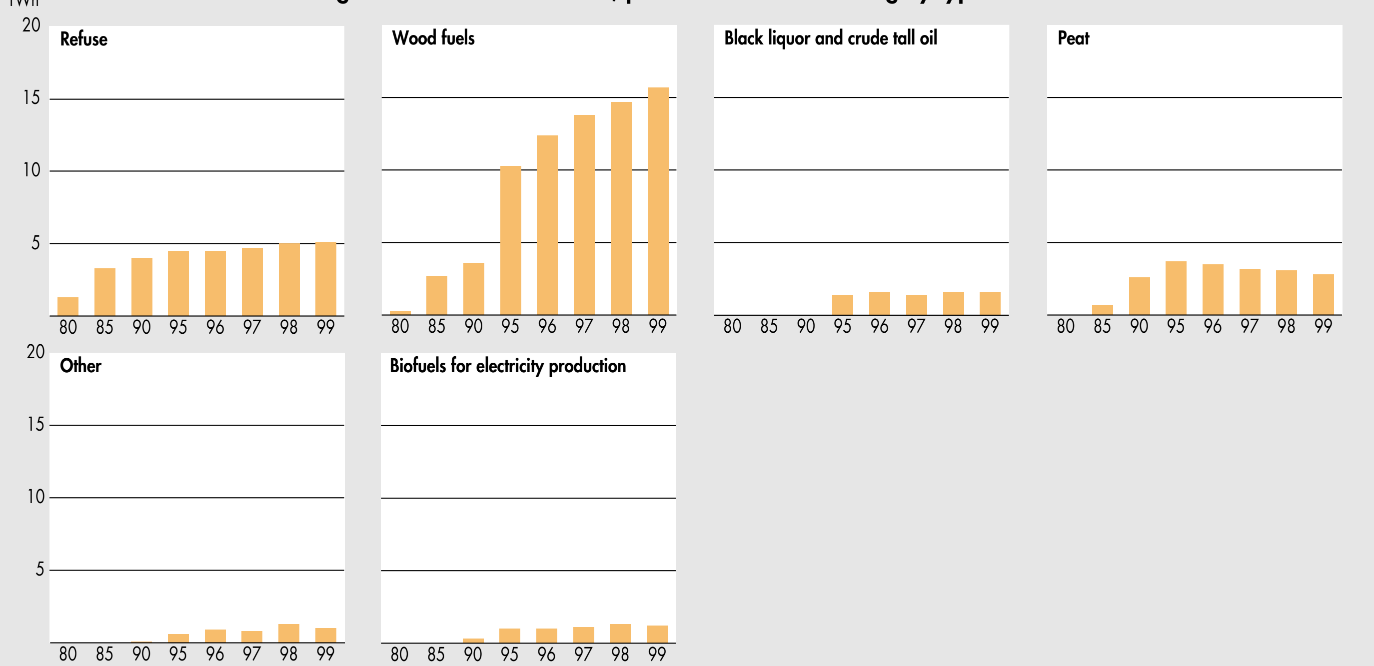


Figure 11b • Use of biofuels, peat etc. in district heating by types of fuel



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

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

Energy policy has favoured district heating through various forms of state support, e.g. grants for the extension of the existing district heating systems and the connection of group heating systems and even individual buildings to existing systems. Replacing a multitude of small individual boilers by district heating enables the heat to be supplied from a much smaller number of larger boilers with high efficiency, reducing both fuel requirements and emissions. Today, investment support is available for biofuel-based combined heat and power production. The 1997 energy policy programme introduced grants for investment in district heating systems. However, take-up was poor, due to the fact that the costs for conversion were too high, and in 1999, the Government withdrew the grants. A decision on their possible restoration is expected in December 2000.

District heating is most competitive in areas of high building density, which means that most systems tend to be found in areas where they are supplying apartment buildings and commercial premises. High capital costs for the mains network mean that it is difficult for systems to achieve viability in low-density detached house areas, where the ratio of mains length to kWh of heat supplied increases. Today, although about 40 % of the total heating requirement for residential buildings and commercial premises in Sweden is met by district heating, only about 6 % of the detached house heating load is met in this way.

At present, the country has about 11 200 km of district heating mains. 42.9 TWh of district heating were supplied in 1999. Of this, over 60 % was used for residential space heating, almost 30 % for heating commercial premises and 10 % by industry.

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

Total energy supply in 1999 was 50.1 TWh, of which biofuels accounted for 26.5 TWh, or somewhat over 50 % of the total energy carriers' input.

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

District heating losses have fallen since the 1980s. Today, distribution and conversion losses account for about 15 % of the total supply of district heating: during the 1980s, when the prime energy input was in the form of oil, losses were about 20 %. Until the beginning of the 1980s, most district heating systems were operated as local authority services. However, during the 1980s and 1990s, most have been restructured as limited companies owned by local authorities. Today, there are about 220 companies supplying heat in Sweden: of them, about

Figure 12a • Use of district heating 1970–1999

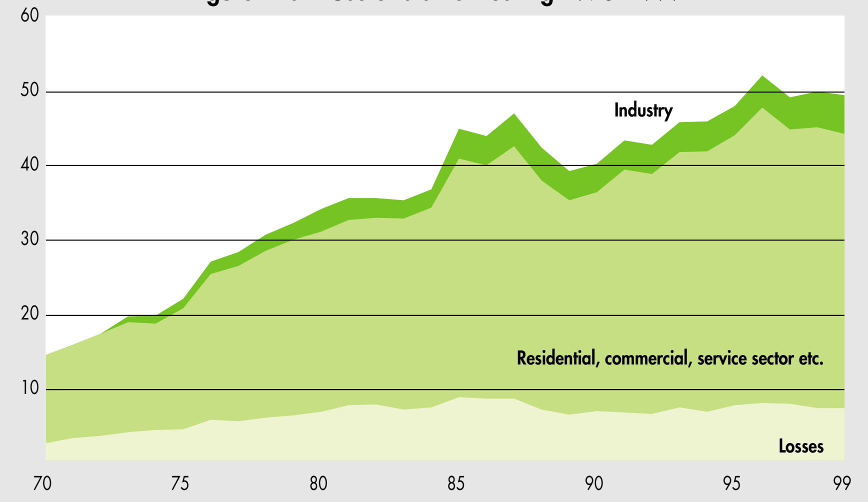
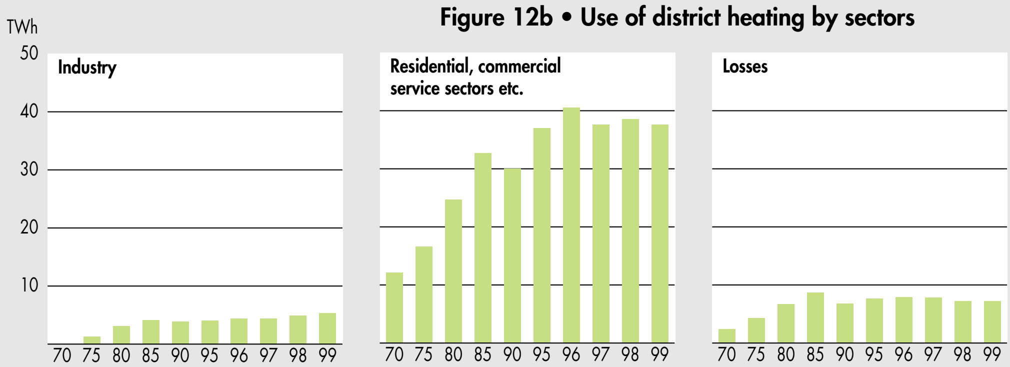


Figure 12b • Use of district heating by sectors



170 are members of the Swedish District Heating Association, an organisation that represents its members' interests. 68 % of the companies are owned by local authorities, 20 % are privately owned, 8 % are owned by the State and 6 % are operated as local authority services.

District cooling

District cooling is used primarily in offices and commercial premises, as well as for cooling of certain industrial processes. Its principle is similar to that of district heating: cold water is produced in a larger central plant and distributed through pipes to customers.

The country's first district cooling system was started up in Västerås in 1992. In 1995, Stockholm Energi started to supply district cooling to central Stockholm, taking the cooling from sea water in Lilla Värtan in combination with the evaporators of its district heating heat pumps. The market for district cooling has expanded strongly since its introduction, powered by such factors as new building regulations, the greater use of computers, more awareness of the importance of good working conditions, expansion of the distribution system and the entry of new suppliers to the market.

In 1999, there were 19 producers of district cooling, supplying a nominal load of 262 MW through 85 km of mains and supplying about 0.3 TWh (281 GWh) of district cooling. It is expected that, within 5–10 years, deliveries will have risen to about 0.5 TW. ■

Figure 13 • District cooling supplied 1992–1999

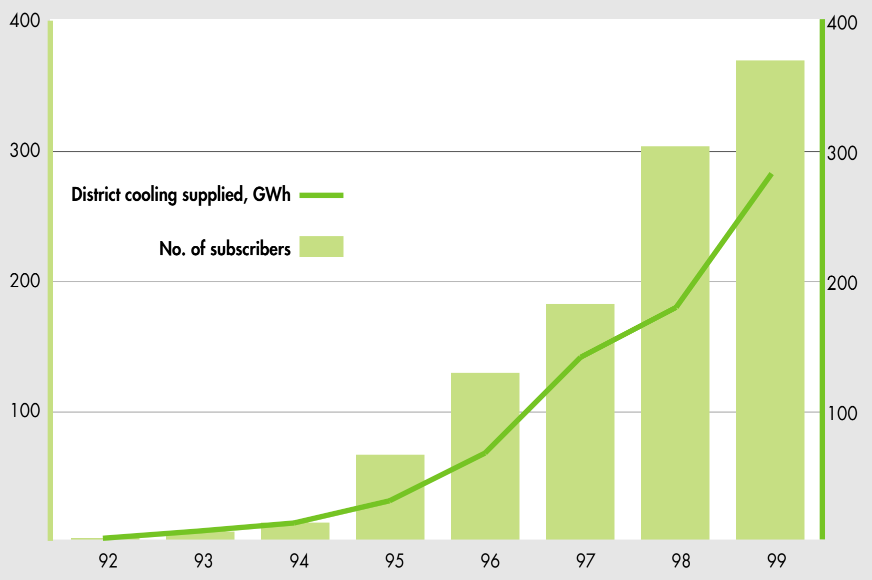


Figure 14a • Energy supplied to district heating 1970–1999

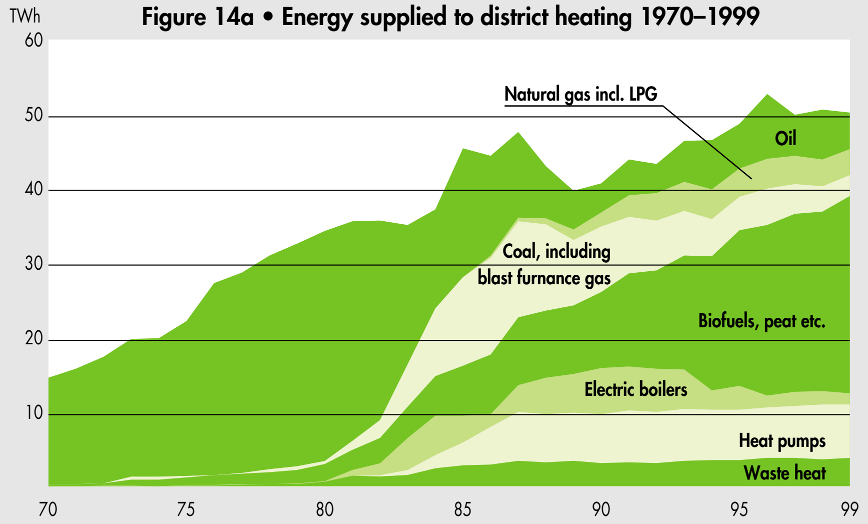
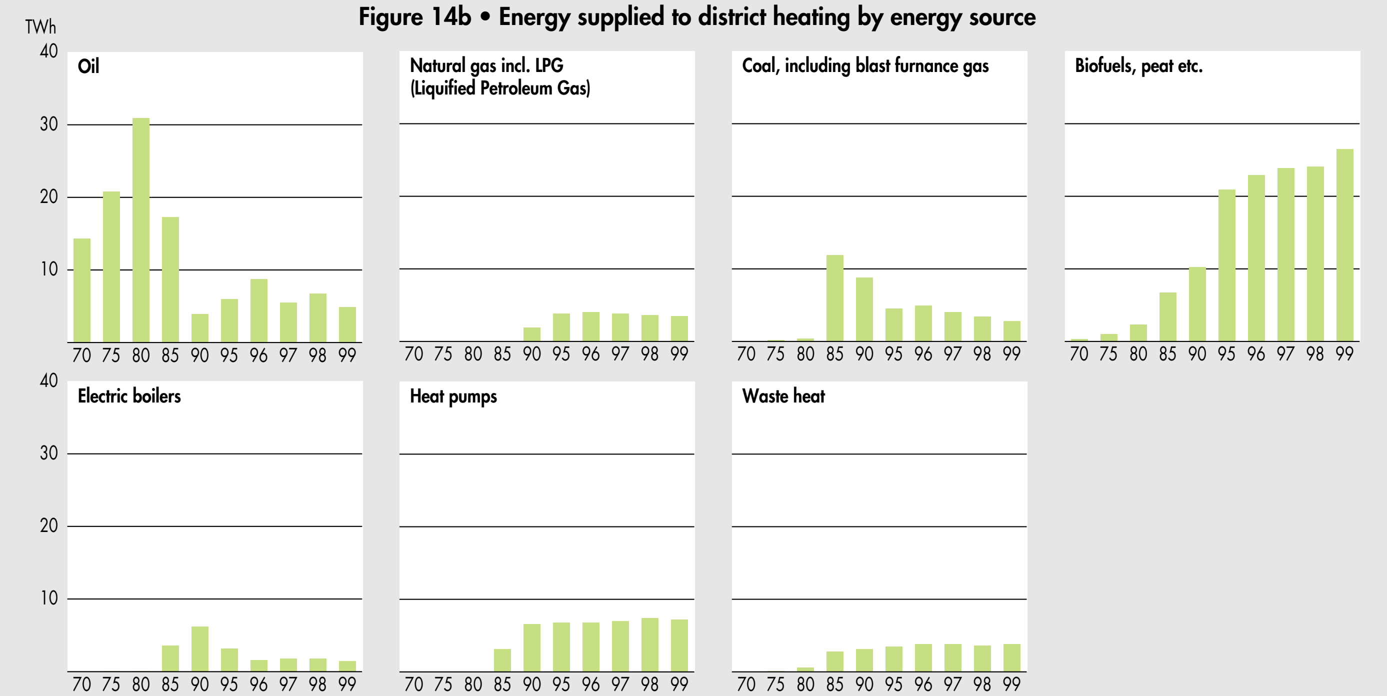


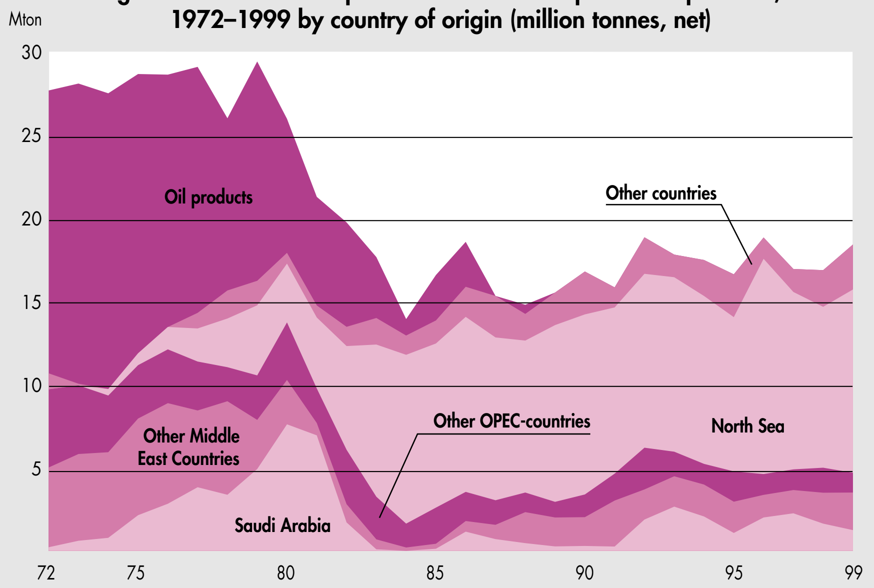
Figure 14b • Energy supplied to district heating by energy source



In recent years, the international oil market has experienced major price swings. From the record-low levels of 1998, average prices rose by 50 % during 1999 to amount to US$18 per barrel. Seen over a 20-year perspective, the 1999 prices were more or less normal. What is noticeable is the fact that, after having fallen substantially in 1998, oil prices have risen just as much during 1999 and 2000, now to over US$30 per barrel.

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

Figure 15 • Swedish imports of crude oil and petroleum products, 1972–1999 by country of origin (million tonnes, net)



Note: Sweden has been a net exporter of refined oil products since 1987.

Figure 16a • Swedish use of oil products 1970–1999

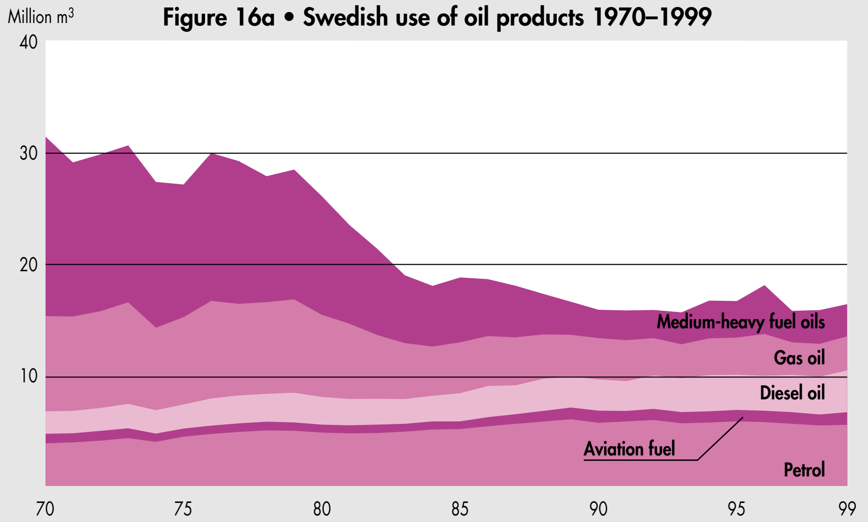
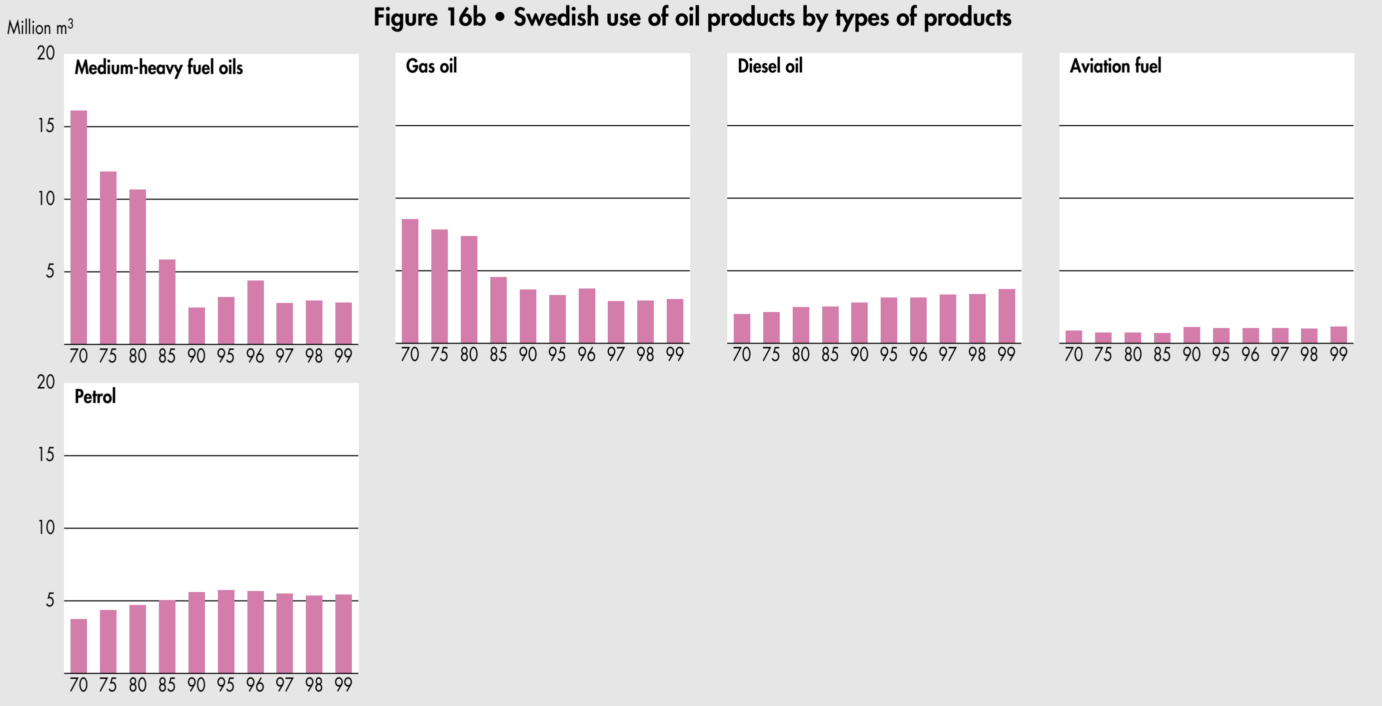


Figure 16b • Swedish use of oil products by types of products



which indicates that the market is expecting future price reductions. This also creates signals to reduce stocks in expectation of lower prices.

Oil production

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

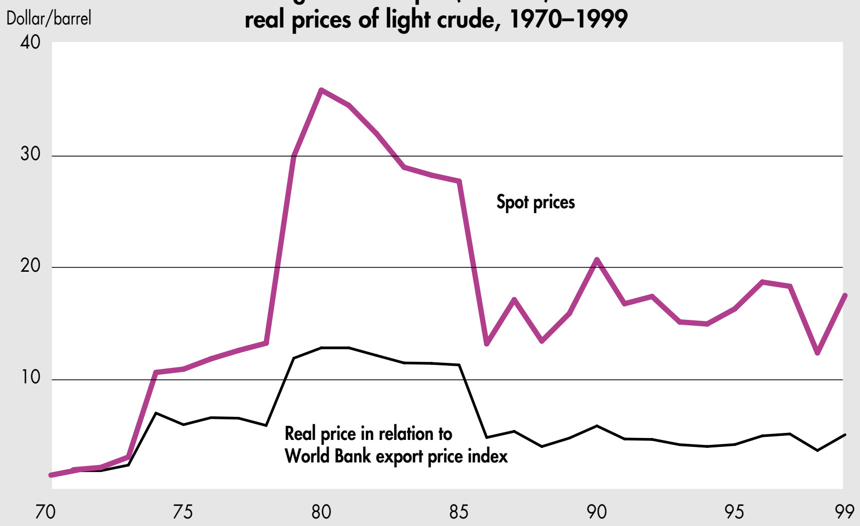
Between 1990 and 1999, world oil production increased by 12 %, amounting to 74 million barrels per day. OPEC's member states account for about 40 % of the world's oil production, and 77 % of its reserves, which thus gives them a considerable hold over the oil market. Other major oil producers are Norway, Mexico, Russia and Egypt. Having failed in 1998 to reach agreement on production cutbacks in order to push up prices, OPEC did succeed in March 1999 in agreeing to reduce the agreed production quota by 1.7 million barrels per day, relative to earlier agreements. In addition, a number of non-OPEC oil-producing countries undertook to reduce their production by 0.4 million barrels per day. Today, the OPEC states have reached agreement on raising their output by 3.2 million barrels per day. The latest agreement on increased output was on 10th September, providing for an increase of 800 000 barrels per day. It is expected that the overall production figure for 2000 will exceed that for 1999 by 2.6 million barrels per day. Much of this increase will come from the OPEC countries, partly because Iraq has increased its output as it has got its production facilities working again. Total production from the OPEC countries now exceeds the 1998 levels.

The demand for oil

In 1999, the economic situation in Asia improved, resulting in the demand for oil approaching normal levels again. Total demand during the year was 74.8 million barrels per day, and this value is expected to increase in 2000. However, the increase in demand in 2000 has hitherto been less than the increase in output. The quantity available has therefore exceeded demand during the three first quarters, and is expected to continue to do so for the rest of the year.

Future total demand for oil will depend largely on world economic developments. In this respect, Asia is the region that is most difficult to assess in terms of demand, due to the rapid economic growth in certain countries.

Figure 17 • Spot (nominal) and real prices of light crude, 1970–1999



Swedish use of oil

As with all other countries, Sweden is affected by the high world market prices of oil. However, as Swedish energy policy since the oil crises of the 1970s has been to reduce the country's oil consumption, use of oil has declined by 50 % since 1970. It is, in particular, the use of oil for heating that has fallen: oil has been replaced by electricity and district heating, although the expansion of nuclear power production and the natural gas distribution network have also played their parts. Total Swedish use of oil in 1999 amounted to somewhat over 16.3 million m^3, of which about 65 % was used for transport. Although the low level of oil use in Sweden makes the country less sensitive to high oil process, it also means that much of the viable conversion from oil to other forms of energy carriers has already been made.

Sweden's import trade in oil products is approximately twice as large as the country's actual use of the products. 40 % of Sweden's total input of oil products comes from Norway, which also supplies about 60 % of the country's crude oil imports. Sweden's significant import of oil is due to the fact that much of the oil is processed in the country and then re-exported. The export proportion has risen from 25 % of Sweden's production of oil products in 1986 to 50 % in 1999. ■

OPEC – *Organisation of Petroleum Exporting Countries* – was founded in 1960 as a counter to the power of the major oil companies and the resulting influence of their home countries on the world oil market. It has 13 members: Saudi Arabia, Iran, Kuwait, Iraq, the United Arab Emirates, Qatar, Libya, Algeria, Nigeria, Gabon, Ecuador, Venezuela and Indonesia. Important oil-exporting countries that, although not members of OPEC, have worked with the organisation at times, include Mexico and Norway.

Since the middle of the 1980s, the coal industry has been suffering from surplus capacity, which has resulted in a fall in the price of coal. In 1998, for example, the price fell from US$ 46 per tonne to US$ 32 per tonne in Northern Europe, in step with falling oil prices. Prices rose again in 1999, initially as a result of rising oil prices, but then fell again to a final average price of US$ 28.8 per tonne.

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

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

About half of all the coal that is mined is used as fuel, which means that it accounts for almost one-third of the world's energy supply. Black coal is a relatively high-value coal, while brown coal has a lower calorific value. Coal is divided traditionally into two categories: coking or metallurgical coal, which is suitable for use in the iron and steel industry, and steam coal, which is sometimes also referred to as energy coal. Estimates put the amount of black coal and brown coal in the earth's crust at about 11 000 billion tonnes, although only a small fraction of this – somewhat over 1 000 billion tonnes – can be recovered. If production continues at the present rate, proven and economically recoverable reserves would last for more than 200 years. The largest accessible reserves of black coal are in Russia, the Ukraine, China and the USA, while the largest reserves of brown coal are in Russia, the USA, Eastern Europe and Australia.

Sweden's coal supply

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

District heating and CHP production

About 50 % of the coal is used in the district heating sector, and the rest in industry. The use of coal for district heating has fallen considerably, particularly during the 1990s when the carbon dioxide and sulphur taxes were introduced. Plants that supply only heat have abandoned coal almost entirely as a fuel due to the high taxes. CHP plants, however, still use some coal, as coal used for electricity production is exempt from the carbon dioxide tax. The use of coal for electricity production is closely linked with hydro power production. During years with high hydro power production, less coal is used for electricity production. During extremely dry years, such as 1996, the use of coal for electricity production can be more than double the normal amount.

The use of coal in industry

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

Figure 18a • Swedish use of energy coal 1985–1999

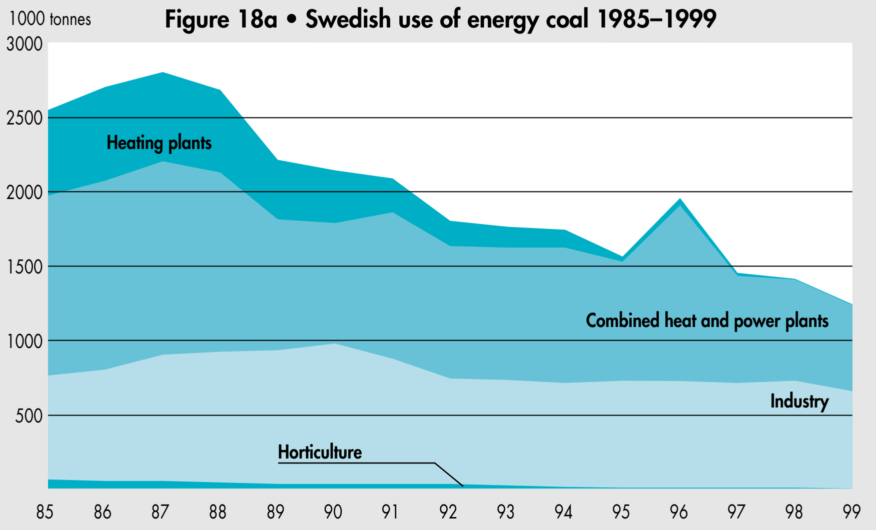
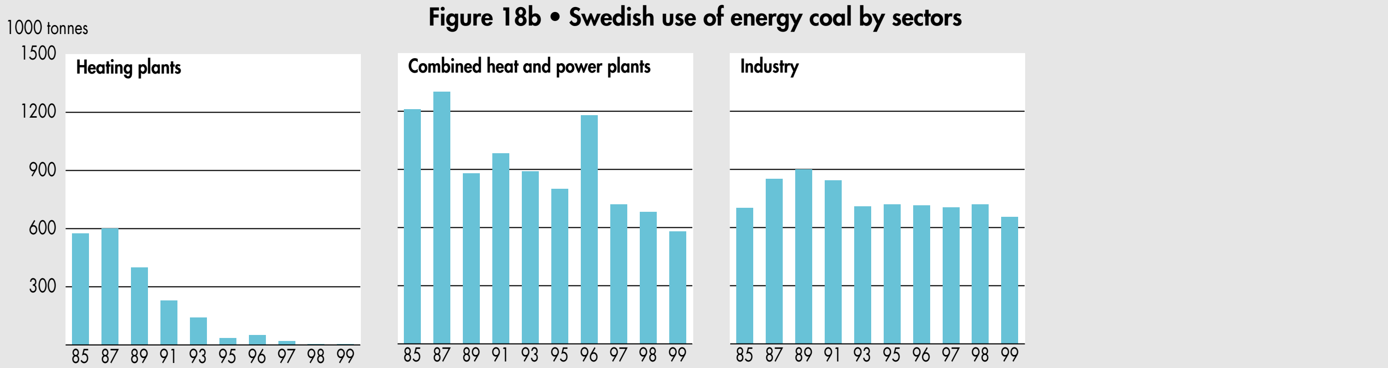


Figure 18b • Swedish use of energy coal by sectors



Natural gas

Sweden's interest in natural gas was awakened by the oil crises of the 1970s. Its use then gradually increased since its introduction to Sweden in 1985, but then stabilised at the present level in 1992. However, interest in natural gas as an alternative, primarily to oil and coal, has reawakened as a result of the restructuring of the Swedish energy system.

The gas comes from the Tyra field in the Danish sector of the North Sea. After transiting Denmark, a pipeline under Öresund brings the gas ashore at Klagshamn outside Malmö. A 300 km trunk main extends from Trelleborg in the south to Gothenburg. Vattenfall Naturgas AB is responsible for operation of the existing trunk main and for importation of the gas to southern and western Sweden. Sydgas AB is responsible for the distribution system in southern Sweden. Today, natural gas meets about 20-25 % of energy requirements in most of the areas to which it is supplied, or about 1.5 % of the country's total energy needs.

In 1999, imports of natural gas amounted to 854 million m^3, equivalent to about 8.3 TWh[1]. It is supplied to about 25 towns and 55 000 consumers, made up of a large number of industries, CHP and heating plants and about 8000-10 000 private customers. A small amount of gas is also used as motor fuel and as fuel for heating greenhouses. Gas has primarily replaced oil in industry, CHP plants and heating plants, with industry accounting for 41 % and CHP/heating accounting for 39 % of Swedish natural gas consumption in 1999.

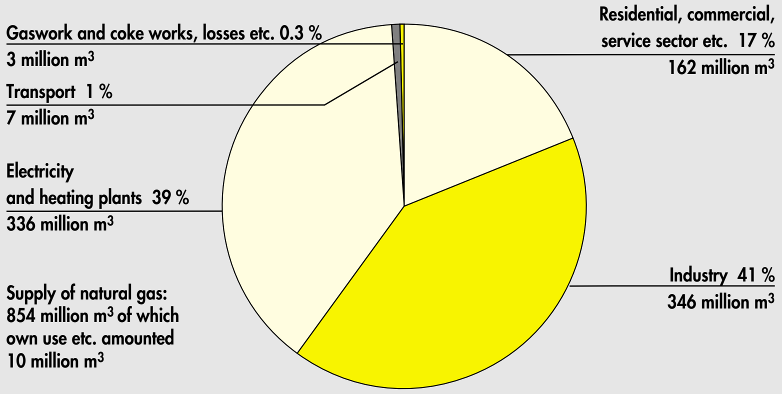
Natural gas is a combustible mixture of gaseous hydrocarbons, consisting mainly of methane, and – unlike oil and coal – is almost completely free of sulphur and heavy metals. Combustion also produces no solid residues such as ash or soot. As the gas contains hydrogen as well as carbon, the quantity of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

LPG

Imports of LPG to Sweden in 1999 amounted to 708 000 tonnes, while 193 000 tonnes were exported. 403 000 tonnes were supplied to the Swedish energy system, equivalent to 5.2 TWh, which was 36 % less than in the previous year. LPG is used mainly in industry, as well as in the restaurant trade and in agriculture. As LPG and oil and also, to some extent, biofuels are interchangeable fuels in these applications, the use of LPG is sensitive to changes in energy taxation or fuel prices. Nevertheless, for certain industrial processes, such as where cleanliness of the fuel and/or accurate temperature control are important, LPG has qualitative advantages over other industrial fuels. During 1999, 0.45 TWh of LPG were used in industry and 0.04 TWh in district heating.

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

Figure 19 • Supply and use of natural gas by sectors in Sweden 1999



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 a hundred biogas plants in operation, most of them in sewage treatment plants and landfill sites, producing digester gas and landfill gas respectively. Most biogas is used either for local or district heating, or for electricity production. In 1998, 27 GWh were used for electricity production and 298 GWh for heat production. Biogas can also be cleaned and distributed via the natural gas network as 'green natural gas'. It is also used for powering vehicles: interest in the gas for this application has increased in recent years. Biogas is used primarily in local bus fleets and for urban distribution vehicles.

Gasworks gas

Gasworks gas is produced by cracking naphtha. SE Gas AB in Stockholm is the only producer of such gas in the country. The gasworks gas used in Malmö and Gothenburg nowadays consists of natural gas mixed with a small proportion of air. Gasworks gas is used for heating detached houses, larger properties and industries, as well as for cooking in restaurants and homes. 0.51 TWh of gasworks gas were used in 1999.

Hydrogen

Pure hydrogen does not occur naturally, but must be produced from sources such as methanol, LPG, natural gas or by electrolysis of water. Production of hydrogen is an energy-intensive process: to produce hydrogen with an energy content equivalent to 100 kWh requires about 125 kWh of electricity. The remainder is converted into heat. Research is in progress, with the aim of improving production technology and developing effective means of storage. When hydrogen technology has been sufficiently developed, it will be possible to use the existing natural gas network for transport of hydrogen. Hydrogen can also be used as a fuel in fuel cells, where it is converted to electricity and heat.

Sweden produces about 135 000 tonnes of hydrogen per year. AkzoNobel operates four of the five largest industrial plants that produce surplus hydrogen. The gas is used internally to produce hydrogen peroxide, which is used for bleaching.

Natural gas internationally

In Sweden, natural gas is a marginal energy source. In the Nordic countries as a whole,

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[1] Since the fourth quarter of 1998, and in accordance with international practice, Statistics Sweden has used a revised value for the effective calorific value of natural gas, of 9.72 MWh/1000 m^3, instead of 10.8 MWh/1000 m^3.

it meets about 11 % of primary energy supply. In the world as a whole, this proportion rises to about 20 %, while about 22 % of energy supplied in the European Union are met by it.

The world's natural gas reserves are substantial: in 1999, commercially viable reserves amounted to 146 000 billion m³, which would last for over 62 years at the present rate of use, with present technologies and present prices. The reserves are concentrated in the former Soviet Union (39 %) and in the Middle East (34 %). The world proportion of total energy supply met by gas has grown rapidly over the last decade, so that it is nowadays the fastest growing primary energy source in the world.

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

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

Only 3.4 % of the earth's natural gas reserves lie within the EU, even if this is also taken to include Norwegian natural gas. At the present rate of use, this would last for only 15 years. However, with rising demand, dependence upon imported supplies will increase substantially, rising from the present 28 % to 70 % in 2020[2]. Over the last decade, natural gas supplies to the EU states have been increasingly based on production from the North Sea and imports from Russia and Algeria.

Figure 20a • World production of natural gas, 1999, million m³

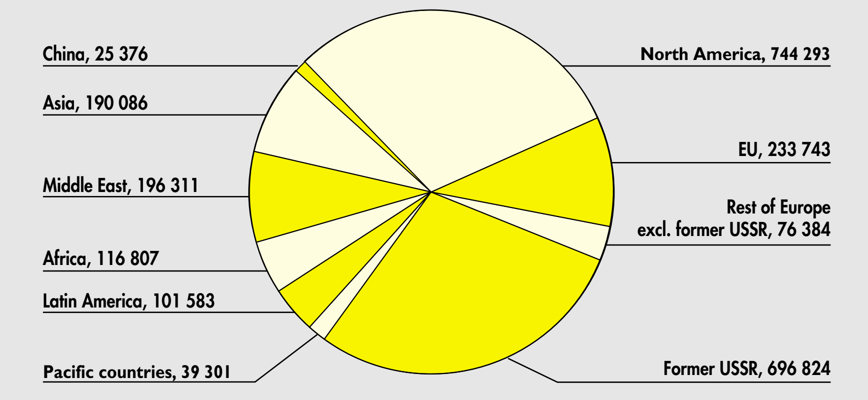
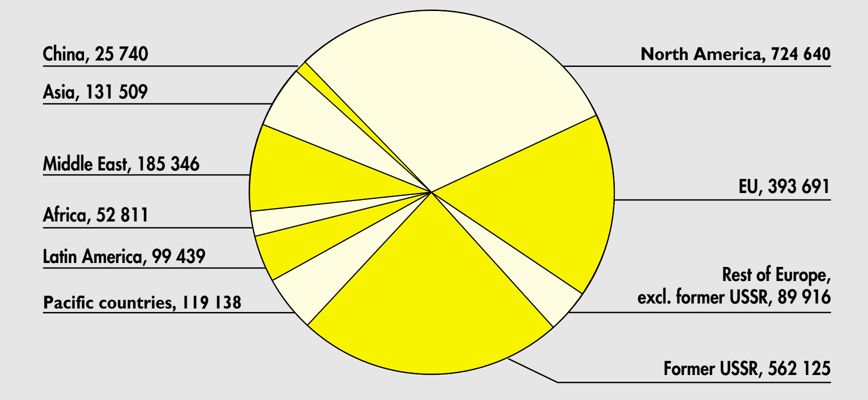


Figure 20b • World use of natural gas, 1999 million m³



In order to increase the security of supply, there is European interest in increasing the number of links between the Russian and Norwegian natural gas fields and the continent. Several studies have investigated the commercial feasibility of creating a Nordic natural gas network, and whether natural gas can assist the reduction of greenhouse gases.

The *Nordic Gas Grid* (NGG) project was carried out on behalf of seven energy utilities, with funding assistance from the EU *Transeuropean Energy Networks* (TEN) funds. It showed that there was sufficient market potential for a Nordic natural gas network to be economically viable. Fully built out, NGG would be able to supply the Nordic countries and the Baltic countries with their needs of natural gas and, in particular, be able to transport large volumes of natural gas to EU markets. With this system in full operation, the transit volumes were estimated to account for between 38 and 68 % of system capacity.

The *North Transgas* project, which was carried out jointly by Finnish Fortum and by Gazprom, looked at three routes for building a gas pipeline from Finland to Germany. One of the alternatives involved routing the pipe via Sweden. However, in 1999, the decision was taken to route the pipe under the Baltic.

Nordleden is a project that has been carried out by Chalmers University of Technology. One of its results indicated that it should be possible to reduce the cost of reducing emissions of greenhouse gases in the Nordic countries by SEK 5–25 000 million by building a trans-Nordic natural gas pipe. Further cost reductions could be effected if a Nordic natural gas pipe could be combined with cooperation in other areas, e.g. greater coordination of the use of electricity and district heating. ■

[2] Eurogas, 'Natural gas in Western Europe', 2000.

In 1999, energy use in this sector amounted to 151.2 TWh, or almost 40 % of the country's total final energy use. This amount was 2.3 TWh less than that of the previous year.

About 86 % of the energy use in this sector is for space heating, domestic hot water production and the powering of domestic appliances. Energy used in land use applications accounts for about 5 % of total energy use in the sector, holiday homes account for another 2 % and other service applications account for 7 %. These latter applications consist of energy use in the building sector, street lighting, waterworks, sewage treatment plants and electricity works.

Over 60 % of the energy use in the sector is used for space heating and domestic hot water production. As this is affected by temperature conditions, there can be considerable random variations in energy demand from one year to another. To enable proper comparisons to be made, it is necessary to correct for climatic conditions. 1999 was almost 10 % 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 1999 amounted to 157.3 TWh; a reduction of 0.2 % relative to 1998.

Reduced use of oil

Figures 21a and 21b show that the total temperature-corrected use of energy has remained relatively stable between 1970 and 1999, although the relative proportions between the different energy carriers have changed. Oil crises, rising energy prices, changes in energy taxation and investment programmes have all affected the move from oil to other energy carriers. In 1999, total use of fossil fuels in the sector amounted to 30.6 TWh, as against 113 TWh in 1970. Much of this reduction is due to a shift from the use of oil for heating to electricity and district heating.

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

Figures 22a and 22b show the growth of temperature-corrected electricity use, classified by application. Use of electricity has grown uninterruptedly from 1970 until the middle of the 1990s, but has since stabilised at about 70 TWh.

Lower final energy use

Several factors have helped to offset increased energy use in the sector. On the heating front, there has been a change from oil to other energy carriers. In detached houses, the change has been mainly to the use of electric heating, while in apartment buildings it has been to district heating. Both these changes have resulted in a reduction in 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 indicate how great a proportion of the thermal energy content of the energy carrier is actually utilised by the consumers in the form of thermal energy. They 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, contributing to a reduction in the actual use of energy for space heating and domestic hot water production. Heat pumps abstract heat from rock, earth, air or water and supply it to the building's heating system. Those abstracting heat from rock, the ground or lake water can supply 80–90 % of the annual space heating and domestic hot water requirements of a detached house, with the remaining 10–20 % usually being supplied by electric immersion heaters or an oil-fired boiler.

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Figure 21a • Final energy use within the residential, commercial, service sector etc. 1970–1999

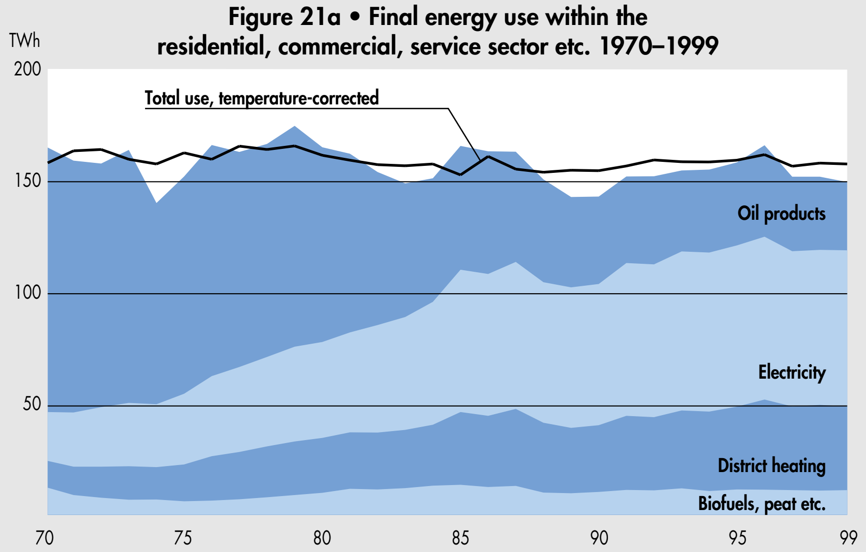
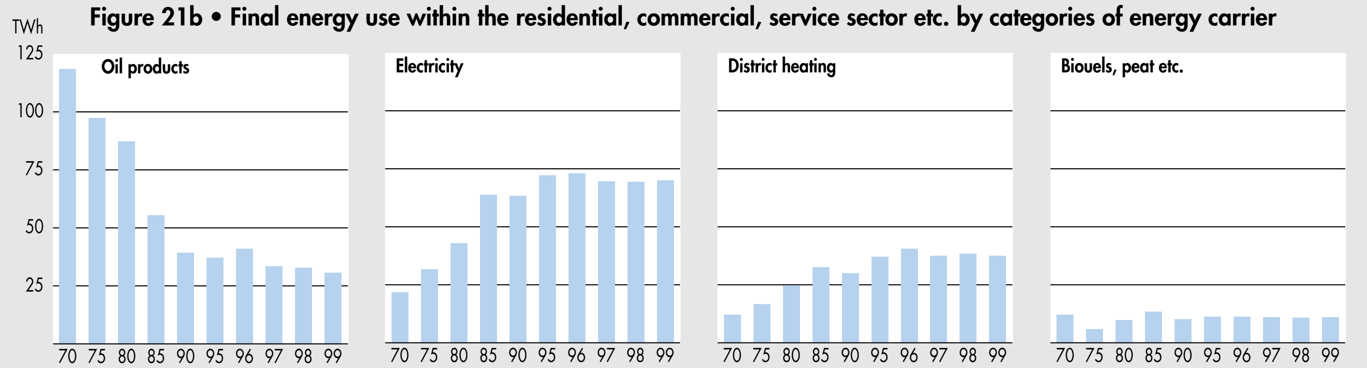


Figure 21b • Final energy use within the residential, commercial, service sector etc. by categories of energy carrier



Heat pumps normally supply 2–3 times as much thermal energy as they use in the form of electrical energy for powering them. This 'free' heat is not included in the approximately 151 TWh of energy used by the sector in 1999.

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 are various types of energy conservation measures, such as retrofitting additional thermal insulation and upgrading of windows in older buildings.

Heating

Of the 97 TWh that were used for space heating and domestic hot water production in 1998, it is estimated that about 45 % were used in detached houses, 29 % in apartment buildings and 26 % in commercial premises and public buildings.

The most common form of heating in detached houses is electric heating, being the main heating source in about 40 % of such dwellings. Approximately 26 % of detached houses have direct-acting electric heating, with the remaining 14 % having waterborne electric heating. The reason for this high proportion of electric heating is that it is cheap to install and simple to run.

Another common heating system in detached houses is electricity in combination with wood and/or oil firing. The proportion of detached houses with such systems increased steadily until 1997, so that almost 30 % of detached houses have such heating systems as their main heating source. In 1998, however, this proportion fell slightly. The total use of electricity for heating in detached houses amounted to 20.5 TWh in 1998. In detached houses with electric heating in combination with some other energy carrier, e.g. oil or wood, the electric heating can easily be replaced by the other energy carrier. This means that such house heating systems are relatively flexible, with the use of electricity being determined by the relative prices of the various energy carriers. About 8 % of detached houses are heated by oil alone, while 7 % have district heating and 4 % are heated by wood.

District heating is the commonest form of heating in apartment buildings, with approximately 73 % of apartments being supplied by it, equivalent to a use of almost 22 TWh of district heating. Oil is used as the sole or main heat source for 13 % of apartments, equivalent to 5 TWh of oil. The use of electric heating in apartment buildings is relatively low, amounting to 2 TWh in 1998.

The main source of heat in offices, commercial premises and public buildings, too, is district heating, with over 50 % of such buildings being supplied, equivalent to 15 TWh of district heating. Electric heating of commercial premises amounted to 5 TWh, which was also the amount of space heating and domestic hot water production energy supplied by oil.

Electricity for household purposes

The use of electricity for household purposes more than doubled between 1970 and 1999, from 9.2 TWh to 19.7 TWh, due to an increase in the number of households and greater ownership of domestic appliances. However, continued improvement in the electrical efficiency of such appliances has tended to offset this increase, as old, worn-out appliances are replaced by new, more efficient ones. This has applied particularly to white goods.

Electricity for common purposes

The use of electricity for common purposes has increased substantially, from 8.2 TWh in 1970 to 26.1 TWh in 1999. 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.

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

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

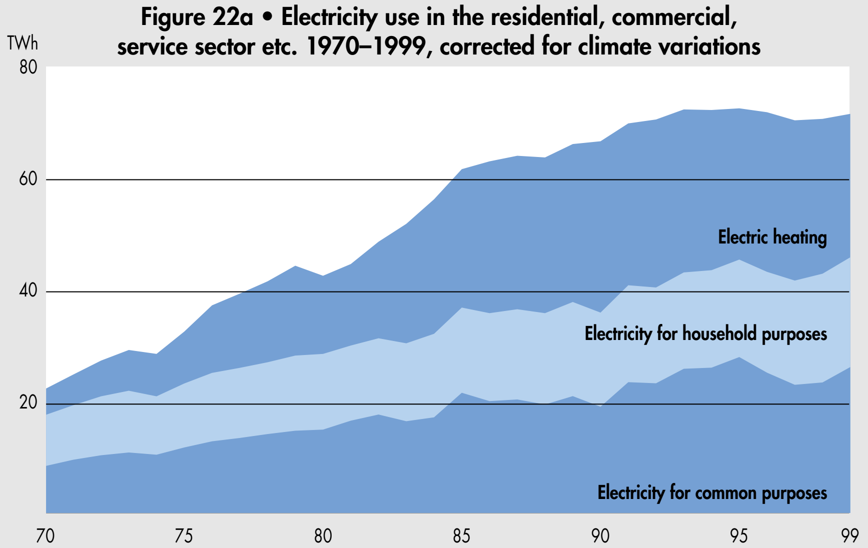
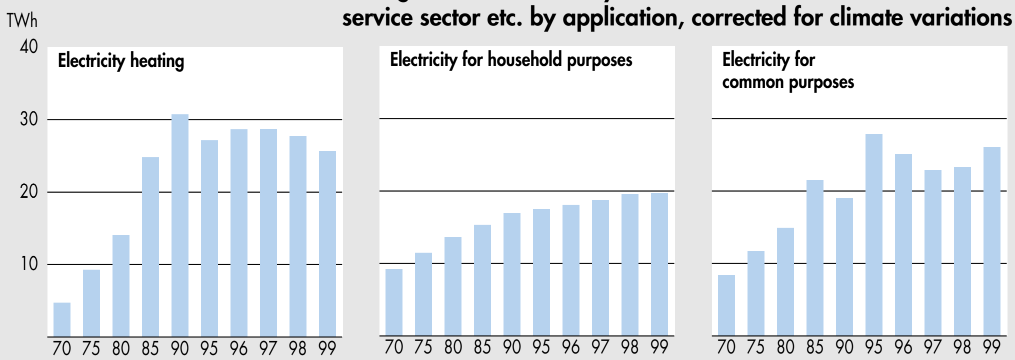


Figure 22b • Electricity use in the residential, commercial, service sector etc. by application, corrected for climate variations



In 1999, industry used 0.3 TWh more energy than during 1998, amounting to 151.2 TWh, or 38 % of the country's final energy use.

Classified by energy source/carrier, this consisted of 20.9 TWh of petroleum products, 14.8 TWh of coal and coke and 54.2 TWh of electricity. Use of natural gas amounted to 3.8 TWh, and that of district heating to 5.3 TWh. Supplies of biofuels, peat etc. amounted to 52.2 TWh. Of this, over 40 TWh was used in the pulp and paper industry, made up in turn mostly of black liquors. Final energy use in industry therefore consisted of 26 % of fossil energy and 35 % of biofuels, peat etc., with the remainder consisting of electricity and district heating.

In Sweden, a relatively small number of sectors accounts for the bulk of energy use in industry. The pulp and paper industry uses about 46 %, the iron and steel industry about 14 % and the chemical industry about 7 %. Together, these three energy-intensive sectors account for two-thirds of total energy use in industry. The engineering industry, although not regarded as energy-intensive, nevertheless accounts for almost 8 % of total energy use in industry as a result of its high proportion of total industrial output in Sweden.

The relationship between output and energy use

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

Between 1990 and 1992, industrial output fell by 6 %, which was reflected by a fall of 5 % in energy use. Electricity use in the sector also fell, but by 6 %, i.e. by more than the fall in total energy use, as the recession tended to hit the electricity-intensive sectors harder than other industrial sectors.

1993 saw an increase in industrial output, which was followed by substantial rises in 1994 and 1995. Output volume in 1999 was over 50 % higher than in 1992, while energy use increased by almost 12 %. During the same period, the use of electricity increased by almost 4 TWh, or nearly 8 %. When comparing the time period from 1975-1997 with that from 1990-1997, it can be seen that the response relationship between energy use and increased industrial output has fallen by about 40 %, due to such factors as technical development and structural changes within the sector.

Changes in oil and electricity use

Despite rising industrial output, the use of oil has fallen substantially since 1970, resulting from the greater use of electricity and improvements in the efficiency of energy use. This trend started in connection with the oil crises of the 1970s, with the ensuing intensive work by both State and business aimed at reducing the use of oil. In 1970, use of electricity constituted only 21 % of industry's total energy use, which can be compared with the present proportion of 36 %. At the same time, the use of oil has fallen from 48 % to 14 % in terms of industry's

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Figure 23a • Final energy use in industry 1970–1999

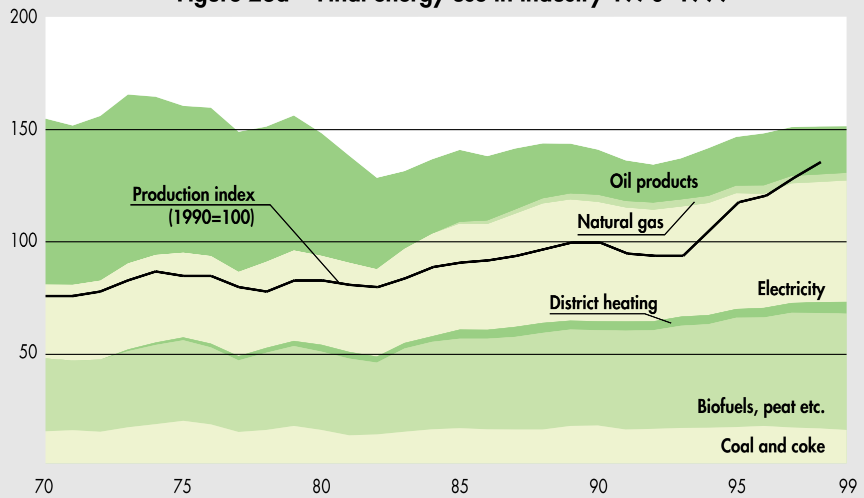
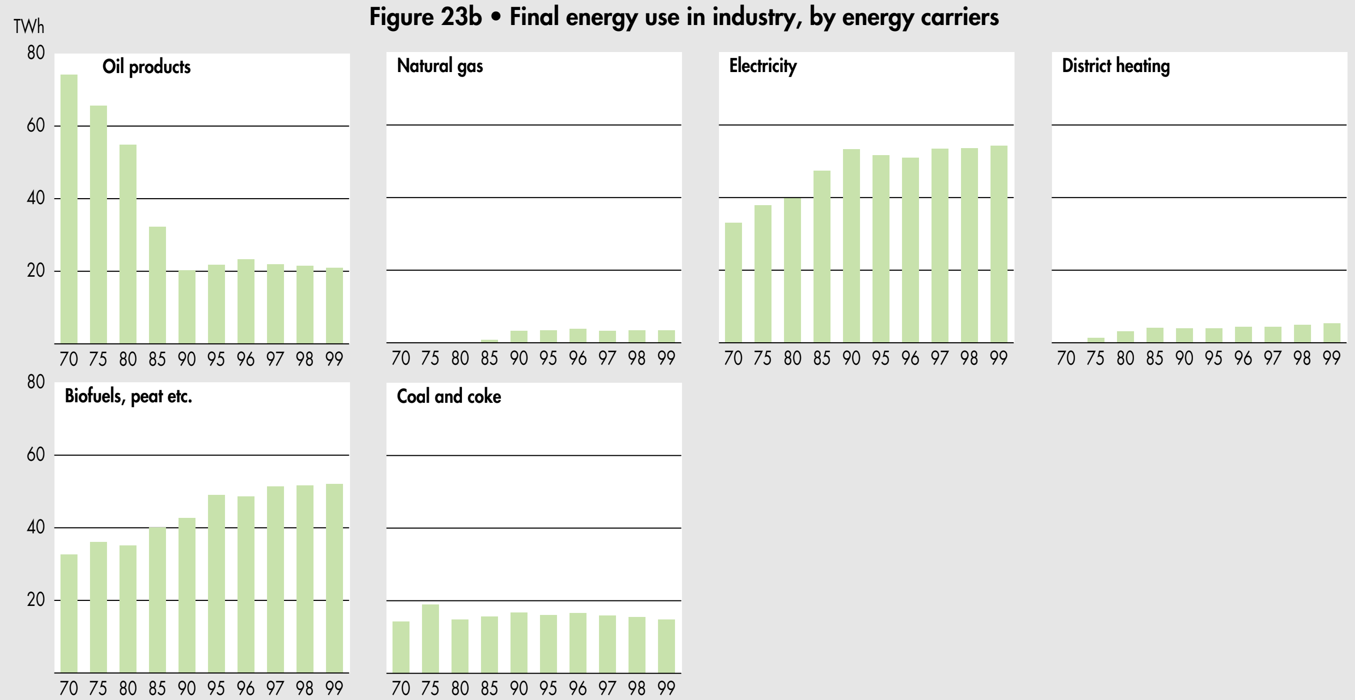


Figure 23b • Final energy use in industry, by energy carriers



energy use. Between 1970 and 1999, the proportion of biofuels, peat etc. has increased from somewhat over 21 % to almost 35 % of total industrial energy use. The change from oil to electricity has meant that primary energy use in the sector has fallen, partly because electrical energy often has a higher efficiency than oil for the majority of applications, and partly because the conversion losses associated with electricity production are now booked to the electricity production sector. Between 1992 and 1999, the use of oil products has increased by 3.5 TWh, or 20 %. Among the factors contributing to this increase have been higher output, lower energy and carbon dioxide taxes and greater use of oil as a replacement for interruptible electric boilers.

Changes in specific energy use

Specific energy use, i.e. the amount of energy used per monetary unit of output 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 1999 it fell by 45 %, showing a clear trend towards less energy-intensive products and production processes, together with changes in the types of industries and products. During this period, industrial output increased by 80 %.

The change from oil to other energy carriers, particularly electricity, is reflected in the specific use of oil and electricity per unit of output value. Specific use of oil fell by 80 % between 1970 and 1992, while specific use of electricity increased by 27 %.

The upturn in the economy over the last few years, coupled with changes in industry's energy taxation structure, is reflected in changes in specific energy use, which continues to fall. Between 1992 and 1999, it fell by 26 %, with specific use of oil falling by 21 % and specific use of electricity falling by 29 %. The recent substantial fall in specific electricity use has been the result primarily of a major increase in the output of the engineering industry, coupled with almost unchanged electricity use.

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

Figure 24a • Specific use of oil in industry 1970–1999, 1991 price levels

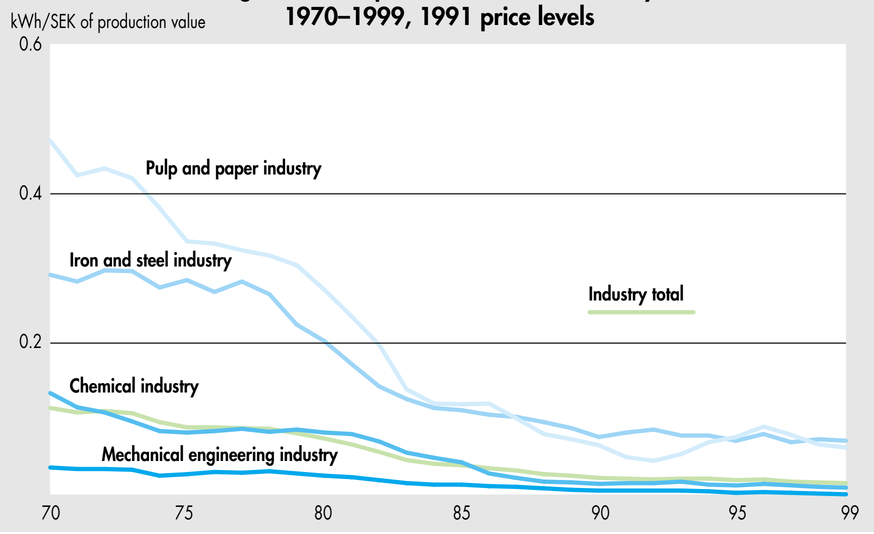


Figure 24b • Specific use of electricity in industry 1970–1999, 1991 price levels

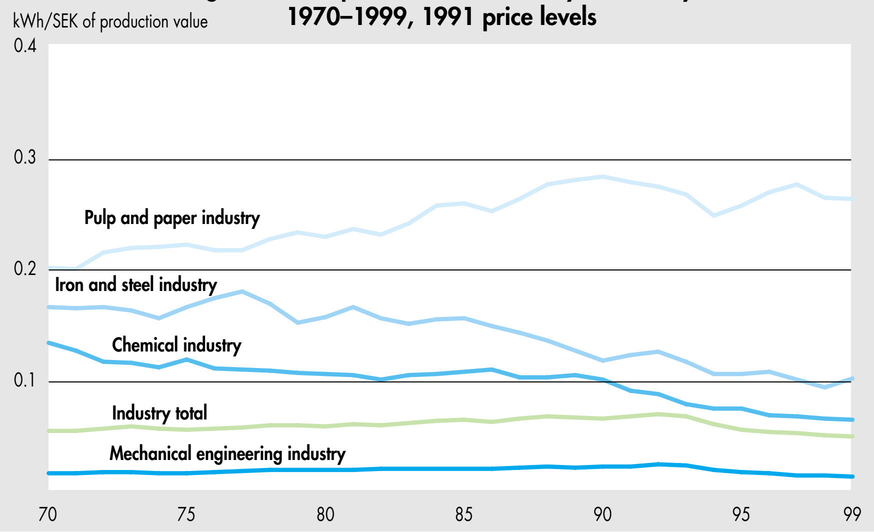
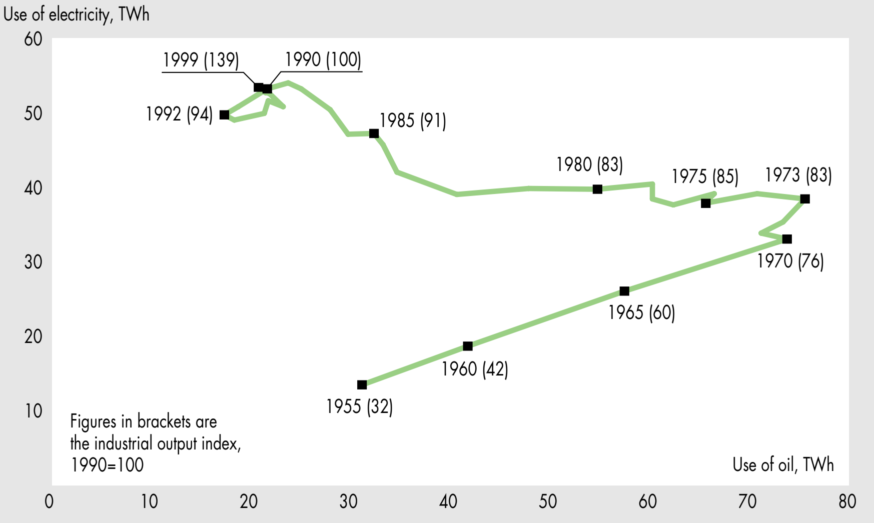


Figure 25 • Use of oil and electricity in industry 1955–1999



Energy use for domestic (internal) transport in 1999 amounted to 91 TWh, or 23 % of the country's total final domestic energy use. International marine bunkers used 17 TWh of bunker oils.

The energy carrier for the transport sector consists almost entirely of oil products, primarily petrol and diesel fuel. In 1999, the use of these two fuels made up 83 % of the country's energy use for domestic transport. In recent years, the use of petrol has declined, while that of diesel fuel and aviation fuel has increased. Use is largely dependent on general economic conditions, although technical development also has a considerable effect on usage patterns. The two main guide measures intended to reduce the use of energy by the transport sector are energy tax and carbon dioxide tax.

Alternative motor fuels

The use of alternative motor fuels, such as ethanol and biogas, is at present marginal: the costs of producing most of these fuels today are higher than the corresponding costs for petrol and diesel fuel. However, this cost differential is being eroded by technical developments and the introduction of environmental levies. A considerable amount of research is being carried out, e.g. within the fields of production technology and vehicle technology. A plant for the production of ethanol, for example, is being built in Norrköping, for an expected output of 50 000 m^3/year.

Modes of transport

Domestic passenger and goods transport in 1998 amounted to 110 billion passenger-km and 60 billion tonne-km respectively. Private cars provide 73 % of passenger transport: bus travel provides 8 %, rail travel provides 4 % and air travel provides somewhat over 4 %. 54 % of internal freight haulage is by road, 32 % by rail and 14 % by water. In recent years, freight haulage by road has increased at the expense of rail and water transport.

Environmental impact

All forms of transport give rise to emissions that are detrimental to the environment and to health. Although the introduction of catalysers has substantially reduced the emission of several hazardous substances, carbon dioxide emissions cannot be reduced in this way, which means that they have continued to increase in step with greater use of fossil fuels.

It has been found difficult to reach agreement on harmonised fuel taxes within the EU. However, the European automotive industry has entered into a voluntary agreement with the European Commission to reduce carbon dioxide emissions from new passenger cars by 25 % by 2008, relative to the 1995 levels. Corresponding agreements have also been reached during the year with Japanese and Korean vehicle manufacturers. In addition, the EU has decided to introduce more stringent requirements in respect of emissions from diesel engines in heavy vehicles, known as EURO standards. The present level of standards are known as EURO-II, but discussions are in progress concerning the introduction of EURO-III standards, which would reduce health-hazardous emissions to 70 % of the EURO-II standards. Directive 1999/94/EU, introduced in December 1999, requires clear statements of vehicle fuel consumptions and emissions in connection with the sales of new passenger cars.

Technical development

Technology advances both through improvements to existing technology and in the form of completely new technology. Of the latter, those that are closest to a commercial breakthrough within the next ten years are hybrid-fuelled 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 are capable of using different fuels simultaneously, e.g. ethanol and petrol. Several of the large vehicle manufacturers have already launched passenger cars with alternative drive systems, or will do so in the next few years. However, looking ahead further than ten years, the automotive industry is pinning considerable hopes on fuel cell technology. Fuel cells, powered by hydrogen and oxygen, produce electricity from two electrodes on each side of an electrolyte. ■

Figure 26a • Final energy use in the transport sector 1970–1999

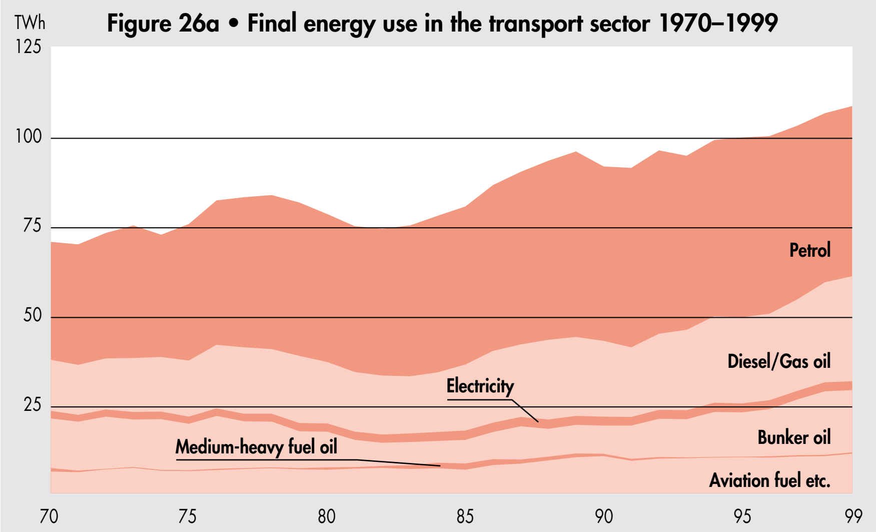
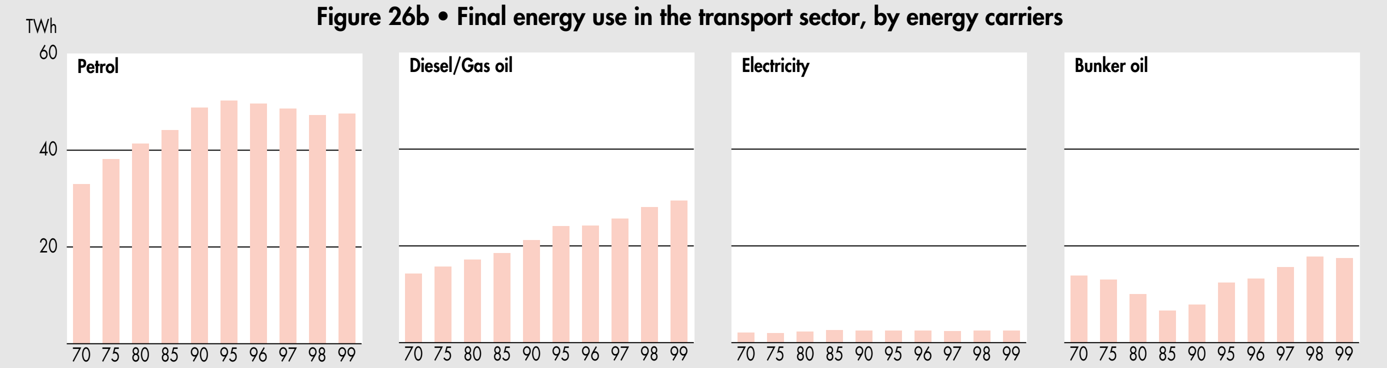


Figure 26b • Final energy use in the transport sector, by energy carriers



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

Sweden takes over the presidency

On 1st January 2001, Sweden will take over the presidency of the European Union for the first time. The main duty of the presidency, which rotates among the EU states every six months, is to direct EU cooperation and to further common points of interest. Sweden will be taking over the presidency from France and handing over at the end of its period to Belgium.

A significant portion of world energy consumption

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

Energy supply today and a look towards 2020

Oil is the dominating energy source in EU energy supply, and its use – particularly in the transport sector – is continuing to rise, so that it nowadays supplies about 45 % of final energy use. On the other hand, the use of coal has fallen considerably, to less than half of its 1985 level, so that it nowadays supplies only 5 % of final energy use. The greatest reduction has occurred in Germany, although its use has also declined considerably in the UK. The use of natural gas continues to rise: since 1985, it has increased by 34 %, so that it nowadays accounts for 23 % of final energy use. The European Commission forecast for developments up to 2020 expects the consumption of natural gas to increase by almost 50 % by 2010, after which it is expected to stabilise. The main reason is a continued increase in the use of natural gas for electricity production. The use of renewable energy sources has been relatively stable since 1985, although there has been an upturn in recent years. The use of wind power is expected to increase substantially by 2020.

Self-sufficiency and dependence on imports

As a region, the EU is the world's largest importer of energy. Despite increased production, self-sufficiency in energy supply has fallen, as the demand for energy is in-

Figure 27 • Total final energy use in the EU, 1985, 1990 and 1997

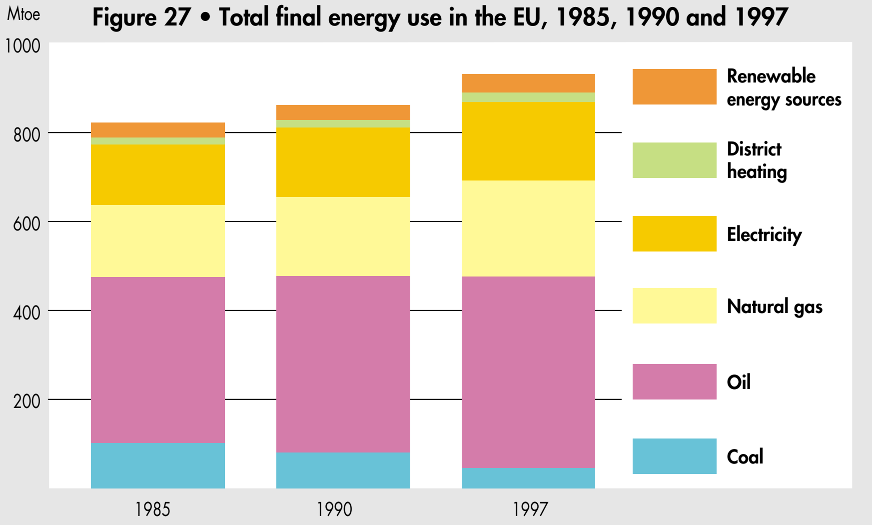
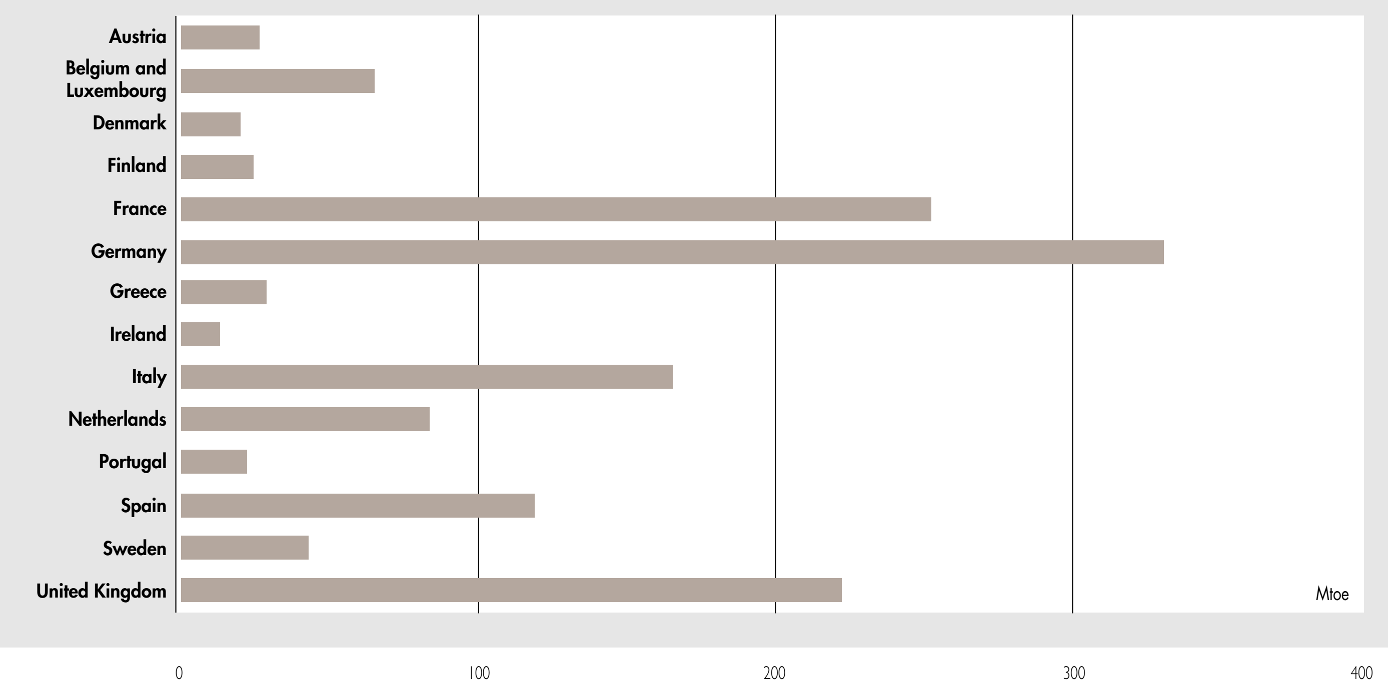


Figure 28 • Total energy use, by EU member states, 1999



creasing even more rapidly. From having been 60 % self-sufficient in energy supply in 1985, the EU was only 54 % self-sufficient in 1997. It had, in other words to import 46 % of its energy requirements. Forecasts indicate that EU production of oil, gas and coal will all decline by 2020. The Commission's forecasts expect dependence on imports to have risen to about 65 % by 2020.

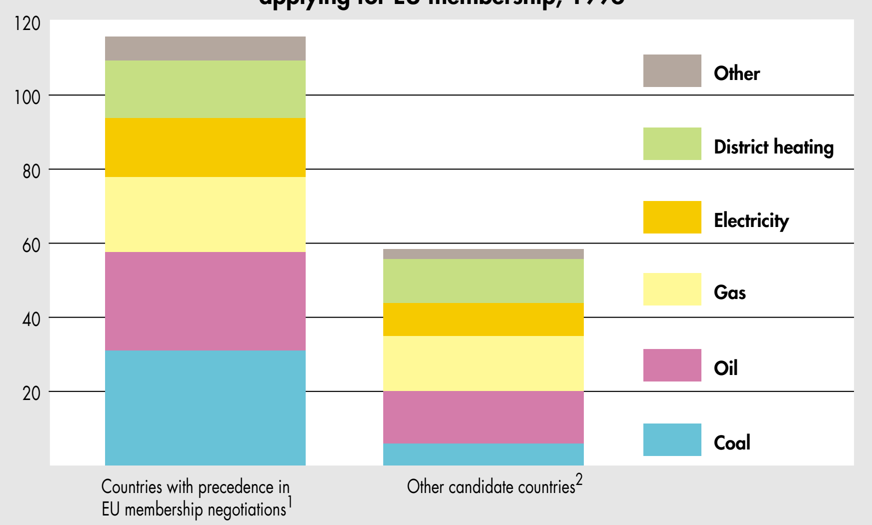
Fifteen states with different conditions

The EU consists of 15 member states with differing conditions. GNPs vary widely, with Germany, France, Italy and the UK having the highest values. On the other hand, countries such as Portugal, Greece and Ireland have GNPs that are only 5–10 % of those of the large states. The climates also differ considerably, which has a considerable effect on energy requirements. Together Germany, France, Italy and the UK account for almost 70 % of total energy use, although this proportion changes somewhat when converted to per-capita energy use. As Sweden and Finland have a relatively high proportion of energy-intensive industries, together with a cold climate, they have relatively high per-capita energy use. Belgium and Holland, too, have high per-capita energy use values. On the other hand, per-capita use is lower in the Mediterranean countries of Greece, Italy, Portugal and Spain.

Enlargement of the European Union

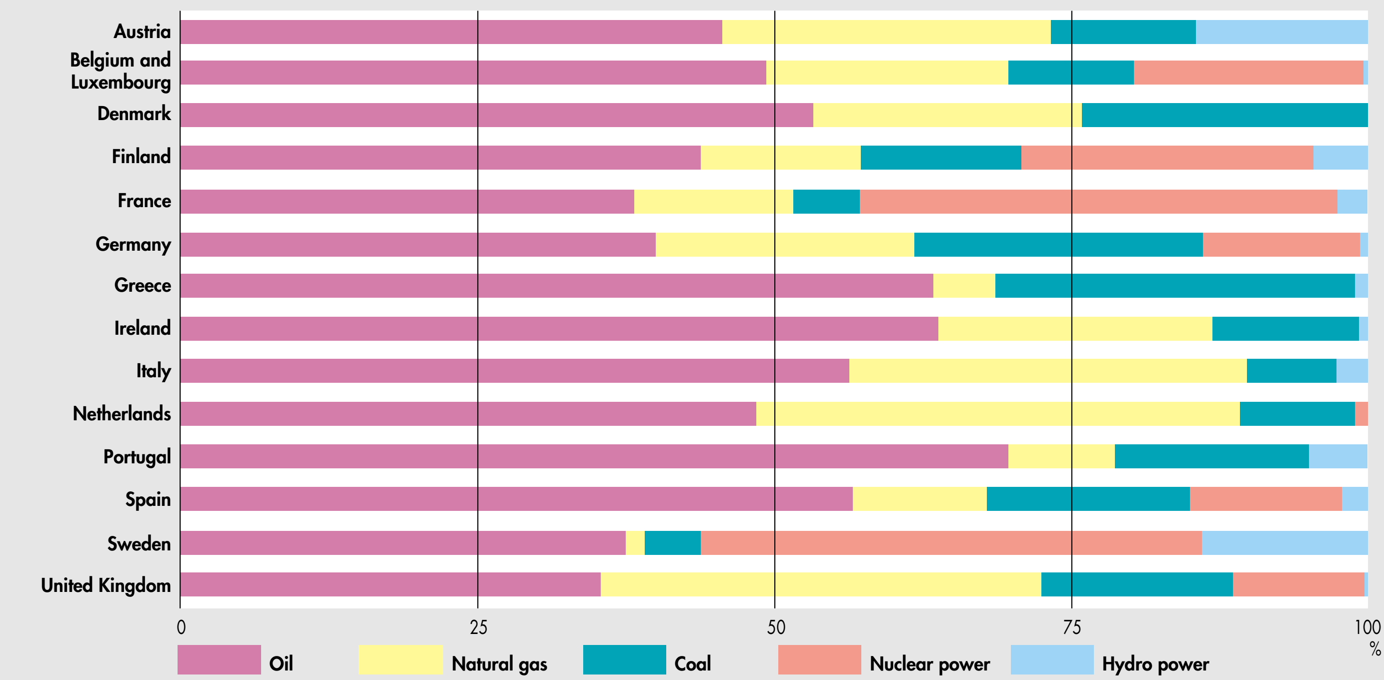
The EU is in the process of preparing for a new enlargement, this time towards Central and Eastern Europe, where a total of ten countries from the former Eastern European states – Bulgaria, the Czech Republic, Estonia, Hungary, Latvia, Lithuania, Poland, Romania, Slovakia and Slovenia – are candidates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

Figure 29 • Total final energy use in central and eastern European states applying for EU membership, 1996



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

Figure 30 • Total energy use, by EU member states, by energy carriers, 1999



Globally, world energy supply is dominated by fossil fuels, which account for about 80 % of total energy supply. Oil is the most important energy source, meeting somewhat over 40 % of demand, followed by coal at over 20 % and natural gas at almost 20 %. Historical development from 1970 until today shows that, in relative terms, it is the use of gas that has increased more than that of either of the other fossil fuels. The use of coal continued to rise until 1990, but has subsequently stabilised. Hydro and nuclear power account for about 2 % and 6 % of world energy supply respectively. According to the energy statistics prepared by IEA – the International Energy Agency – over 10 % of world energy supply is met by biofuels.

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

Resources and reserves

Proven resources of fossil fuels – primarily oil, coal and natural gas – are estimates of the quantities that can be viably extracted with present economic and technical conditions. Expressed in relation to present rates of consumption, they amounted at the end of 1999 to:

- 230 years' production of coal
- 41 years' production of oil
- 62 years' production of natural gas.

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

Energy supplies and international trade

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

Energy use

Since 1990, total world energy use has risen less rapidly than it did during the 1980s, when the average rate of increase was 2 % per annum. The average rate of increase

Figure 31 • World oil reserves 1999 (billion barrels)

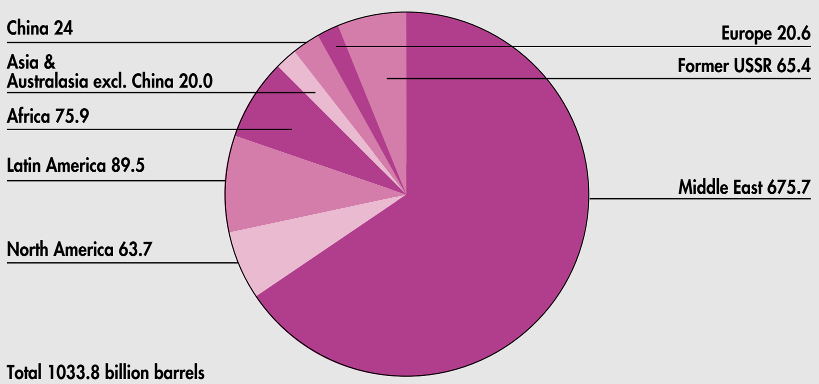
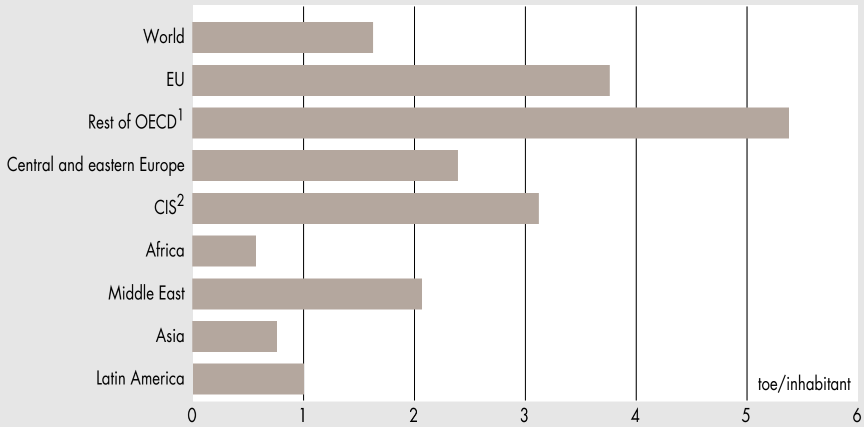
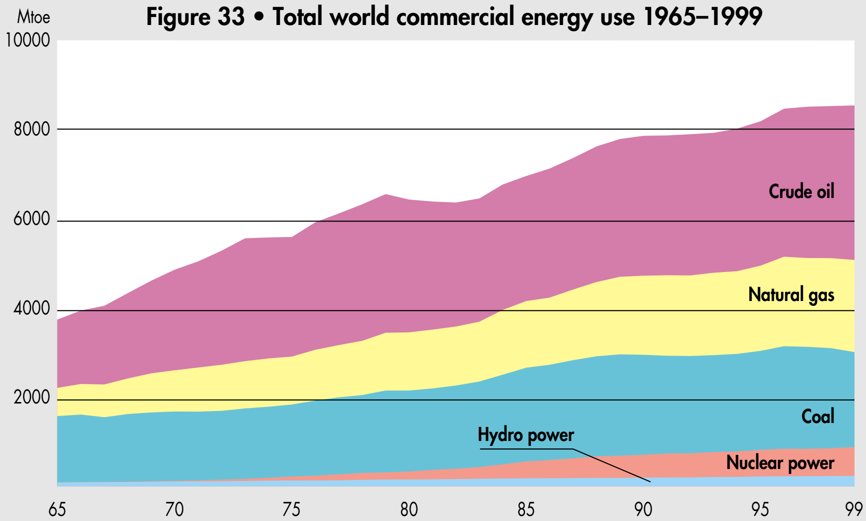


Figure 32 • Total energy use per inhabitant, 1997



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

Figure 33 • Total world commercial energy use 1965–1999



during the 1990s was 0.9 %. Total energy use remained relatively constant during 1998 and 1999. A comparison between regions shows that energy use in the developing countries continues to rise steadily, due primarily to population growth, urbanisation and industrialisation. Energy use in the former Soviet Union fell dramatically during the first half of the 1990s, but has now stabilised. Within the European Union, energy use increased slightly during the 1990s. North America and Japan have shown higher increases.

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

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

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

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

Forecasts

According to the most recent forecast[1] from US Department of Energy/Energy Information Administration (DOE/EIA), world energy demand is expected to continue to rise steadily. Much of this increase will occur in the developing countries, and particularly in China, India, South Korea and Latin America, in which areas consumption is expected to double. Other forecasts of world energy use expect the same magnitude of increase of world energy consumption, of over 2 % per year.[2]

The forecasts differ for certain regions, and this is particularly noticeable for Eastern Europe and the former Soviet Union. Nevertheless, according to DOE/EIA consumption in this region in 2020 is expected to be somewhat less than the 1990 level.

Consumption in Western Europe is expected to increase by almost 1 % per annum until 2020. In the case of North America, the expected increase is 1.2 % per annum, while that for Japan and Australia is 0.9 %.

Oil is still the world's major fuel. The rate of increase of use is expected to be somewhat higher than during the last few decades: in particular, it is the transport sector that will continue to increase. The use of oil in the developing countries is increasing in parallel with their rapidly increasing level of energy use. Natural gas is the fuel of which use is expected to grow the most rapidly, largely due to greater use for electricity production in the industrialised countries. The use of coal is expected to decline significantly in Western Europe, as well as in Eastern Europe and the former Soviet Union. However, reduced use in these areas will be more than offset by greater use in the developing countries, and particularly in China and India. Together, these two countries account for over 90 % of the expected increase in the use of coal during the period. The use of nuclear power is expected to decline in the industrialised countries, Eastern Europe and the former Soviet Union between 2010 and 2020 as a result of the closure of old reactors without replacing them with new ones. World use of hydro power and other renewable energy is expected to grow at almost 2 % per year.

Forecasts for emissions of carbon dioxide

The Kyoto Protocol, which has been formulated as part of the work of international climate negotiations, contains undertakings for the countries in Annex 1 (the industrialised countries, together with the former Soviet Union and the countries in Eastern Europe) to reduce their emissions of greenhouse gases by 2008-2012. (Read more in the section entitled 'Energy and the Environment'.) According to the calculations in the DOE/EIA forecast, the industrial countries will need to reduce their carbon dioxide emissions by 24 % in relation to those given in the forecast if they are to fulfil their Kyoto Protocol undertakings, which call for a reduction of 7 % by 2010. However, the forecast calculations paint a completely different picture for the former Soviet Union and the Eastern European countries, which can increase their emissions of carbon dioxide by almost 40 % in relation to the forecast values for 2010. Under the terms of the Kyoto Protocol, this group of countries may not increase their carbon dioxide emissions by more than 2 % by 2010. In total, according to the forecast, the countries in Annex 1 must reduce their carbon dioxide emissions by 12 % in relation to the forecast results for 2010 in order to fulfil their Kyoto Protocol undertakings. ■

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

	1980	1990	1997	1990/1980 % per year	1997/1990 % per year
World	553	505	477	-1.0	-0.8
EU	291	247	237	-1.6	-0.6
Rest of OECD[1]	447	369	357	-1.9	-0.5
Central and Eastern Europe	1 630	1 472	1 392	-1.1	-0.8
OIS[2]	2 010	1 869	2 180	-0.8	2.2
Africa	790	909	926	1.4	0.3
Middle East	356	704	797	7.0	1.8
Asia	1 813	1 382	1 124	-2.7	-3.0
Latin America	462	490	493	0.6	0.1

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

Note. Development in the Middle East is closely linked to revenues from oil production: between 1980 and 1990, GNP fell by 35 %. GNP in the OIS has fallen by over 40 % between 1990 and 1997.

Source: European Commission, '1999 – Annual energy Review'.

[1] International Energy Outlook 2000, www.eia.doe.gov.
[2] IEA – International Energy Agency, 'World Energy Outlook 2000'. Platt's 'World Energy Service: World Outlook 1999' from Standard & Poor, and Petroleum Economics Ltd. and Petroleum Industry Research Associates, PIRA.

The use of energy has been taxed in Sweden since the 1950s. The objectives have varied over the years: originally, the objective was to finance the State's public spending requirements, but in later years the emphasis changed to the need to control the production and use of energy in order to achieve various energy and environmental policy objectives. The environmental element of energy taxation was given greater importance at the beginning of the 1990s, and the green line continues in the budget for 2001.

There are different taxes on electricity, energy, carbon dioxide, sulphur and NO_x, and they can vary, depending on whether the fuel is being used for heating or as a motor fuel, whether electricity is being used in northern Sweden or the rest of Sweden, whether it is being used by domestic consumers, industry or the energy sector, and so on. In 1999, revenues from energy and environmental spot taxes raised over SEK 52 billion or about 2.6 % of GNP.

Greentax reform

It was decided in the spring of 2000 that about SEK 30 billlion of taxation revenue should be transferred over a ten-year period. During 2001, this will involve about SEK 3.3 billion in higher energy tax, which will be balanced by reduced tax on work.

Sweden's carbon dioxide emissions are to be cut in accordance with the country's commitments under the Kyoto Protocol. Carbon dioxide tax will be increased by 40 % from 1st January 2001, which will be partly balanced by a reduction of 8 % in the energy tax. This will have the effect of increasing the environmental pressure of the taxes when users are choosing between fossil fuels.

Higher carbon dioxide taxes mean that electricity will become cheaper in relation to other forms of energy carriers, and so the tax on electricity will be raised by 1.8 öre/kWh. Within the framework of green taxreform, higher energy taxes will be offset by a higher tax-free allowance and reduced employer's levy.

Types of tax

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

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

		Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax, öre/kWh
Gas oil, SEK/m^3	(< 0.1 % sulphur)	688	1 527	-	2 215	22.4
Heavy fuel oil, SEK/m^3	(0.4 % sulphur)	688	1 527	108	2 323	21.5
Coal, SEK/tonne	(0.5 % sulphur)	293	1 329	150	1 772	23.4
LPG, SEK/tonne		134	1 606	-	1 740	13.6
Natural gas, SEK/1 000 m^3		223	1 144	-	1 367	14.1
Peat, SEK/tonne, 45 % moisture	(0.24 % sulphur)	-	-	40	40	1.5
Crude tall oil, SEK/m^3		2 215	-	-	2 215	21.6
Petrol, environmental class 1, SEK/l		3.26	1.24	-	4.50	
Diesel, environmental class 1, SEK/l		1.51	1.53	-	3.04	
Electricity, northern Sweden, öre/kWh		12.5	-	-	12.5	12.5
Electricity, rest of Sweden, öre/kWh		18.1	-	-	18.1	18.1
Electricity, gas, heat or hot water supply, öre/kWh						
Northern Sweden, öre/kWh		12.5	-	-	12.5	12.5
Rest of Sweden, öre/kWh		15.8	-	-	15.8	15.8
Electric boilers, > 2 MW, 1/11–31/3, öre/kWh						
Northern Sweden		14.8	-	-	14.8	14.8
Rest of Sweden		18.1	-	-	18.1	18.1

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

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

		Energy tax	Carbon dioxide tax	Sulphur tax	Total tax	Tax, öre/kWh
Gas oil, SEK/m^3	(< 0.1 % sulphur)	0	534	-	534	5.4
Heavy fuel oil, SEK/m^3	(0.4 %)	0	534	108	642	5.9
Coal, SEK/tonne	(0.5 % sulphur)	0	465	150	615	8.1
LPG, SEK/tonne		0	562	-	562	4.4
Natural gas, SEK/1 000 m^3		0	400	-	400	4.1
Crude tall oil, SEK/m^3		534	-	-	534	5.2

The electricity tax varies, depending on where, and for what, the electricity is used.

Electricity and heat production

Fuels that are used for electricity production are exempt from energy and carbon dioxide tax, although they are subject to the NO_x levy and sulphur tax in certain cases. Since 1st July 2000 are nuclear power plants taxed on the basis of their gross thermal power output from the reactors. Under a particular set of defined operating conditions, this tax raises the same revenue as the earlier tax rate of 2.7 öre/kWh. In addition, there is a levy of 0.15 öre/kWh for decontamination and decommissioning of the country's previous nuclear facilities at the Studsvik research centre, and a further levy that amounts to about 1 öre/kWh for financing future storage facilities for spent nuclear fuel.

Investment grants are available for the building of wind power plants, biobased CHP plant and small-scale hydro power plants. In addition, wind power production receives an environmental subsidy equal to a rebate of the electricity tax. There is also at present special support for small-scale power production, amounting to 9 öre/kWh.

Fuels used for heat production pay energy tax, carbon dioxide tax and, in certain cases, sulphur tax, as well as the NO_x levy. In principle, biofuels and peat are tax-free for all users, although the use of peat attracts the sulphur tax. Special rules apply for simultaneous production of heat and electricity (CHP). The fuel used for production of the electricity can receive a full rebate of energy and carbon dioxide tax. The fuel used for the net beneficial heat pays only half the normal energy tax rate.

Taxation at the point of use

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

There are various transport tax levels, depending on the environmental class of the fuel, and their effect has been to concentrate use on the least environmentally detrimental classes. Petrol tax has not been raised for 2001, apart from the increase due to indexing: the tax on diesel fuel, however, has been increased by 11.7 öre per litre. This has been offset by a reduction in the rate of value-added tax payable by public transport operators from 12 % to 6 %.

The sales tax on private cars was removed in 1996, with the aim of encouraging the sales of new vehicles and thus reducing the average age of the vehicles in use. The average age of the Swedish vehicle fleet is relatively high, and older vehicles usually produce more exhaust pollution. ■

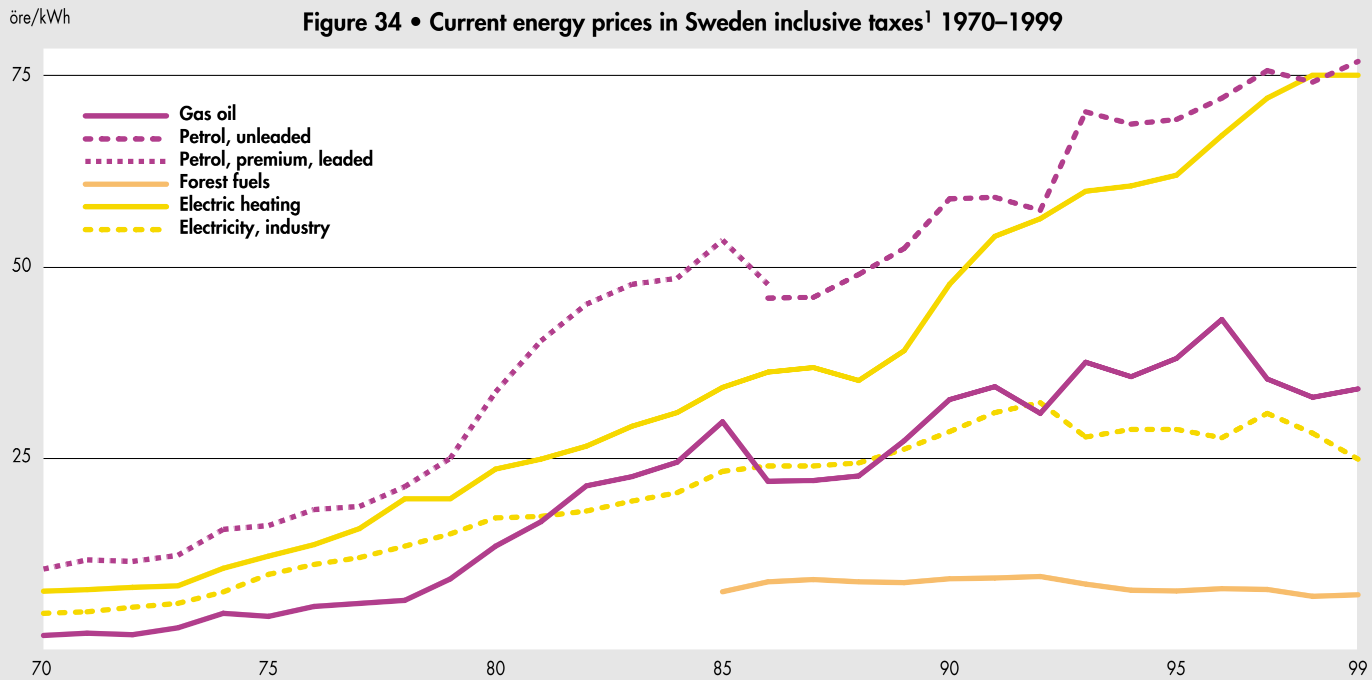
Table 4 • Fuel prices and price of electric heating in Sweden, excluding taxes and value-added tax, actual prices

	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999
Crude oil, US $/barrel	23.81	20.05	19.37	17.07	15.98	17.18	20.81	19.30	13.11	18.25
Gas oil, SEK/m³	2 146	2 131	1 790	2 207	2 004	2 205	2 603	1 759	1 457	1 580
Med.-heavy fuel oil, SEK/m³	1 702	1 535	1 316	1 652	1 525	1 525	1 526	1 014	853	997
Petrol, 95 octane, SEK/l	2.23	2.19	2.06	2.23	2.10	2.02	2.10	2.25	2.01	2.29
Coal, SEK/tonne	358	366	307	309	317	336	340	367	372	327
Forest chips, SEK/m³	92.70	93.50	95.10	87.05	81.40	79.80	82.22	81.8	87.9	85.5
Electric heating, öre/kWh	31.5	36.1	37.9	40.0	39.7	40.7	43.60	45.2	45.0	43.0

Source: EMEP/MSC/W, report 1/00. Note. The price of crude oil is that of Brent crude. Prices of electric heating include value-added tax.

Note. The tables supplement to Energy in Sweden includes the Retail Price Index for 1970–1999, which means that the actual prices can be converted to equivalent prices.

Figure 34 • Current energy prices in Sweden inclusive taxes[1] 1970–1999



[1] A table defining the various environmental classes is included in the tables appendix Energy in Sweden; facts and figures.

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

The negative effects on the environment can be classified into three levels: local, regional, *or* global.

The boundaries between these levels are fluid, being determined not only by the type of emission, but also by how far it spreads. Emissions of dust and soot, for example, are nearly always regarded as local problems, although the material can very well be spread over an area the size of Lapland.

Local environmental problems

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

Regional environmental problems

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

Global environmental problems

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

Acidification

Since the beginning of the 1970s, acidification has been one of the environmental problems in Scandinavia to which the most attention has been paid. As the ability of the

Figure 35a • Emissions of sulphur dioxide (SO_2) in Sweden 1980–1998

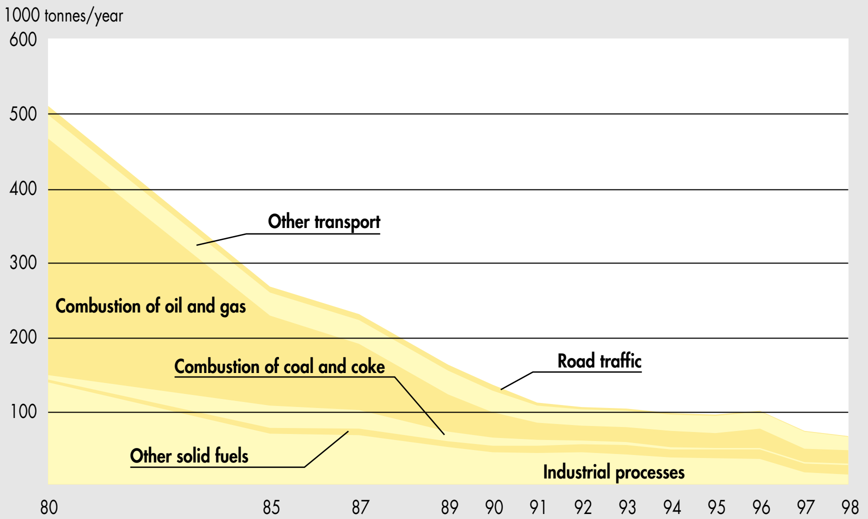
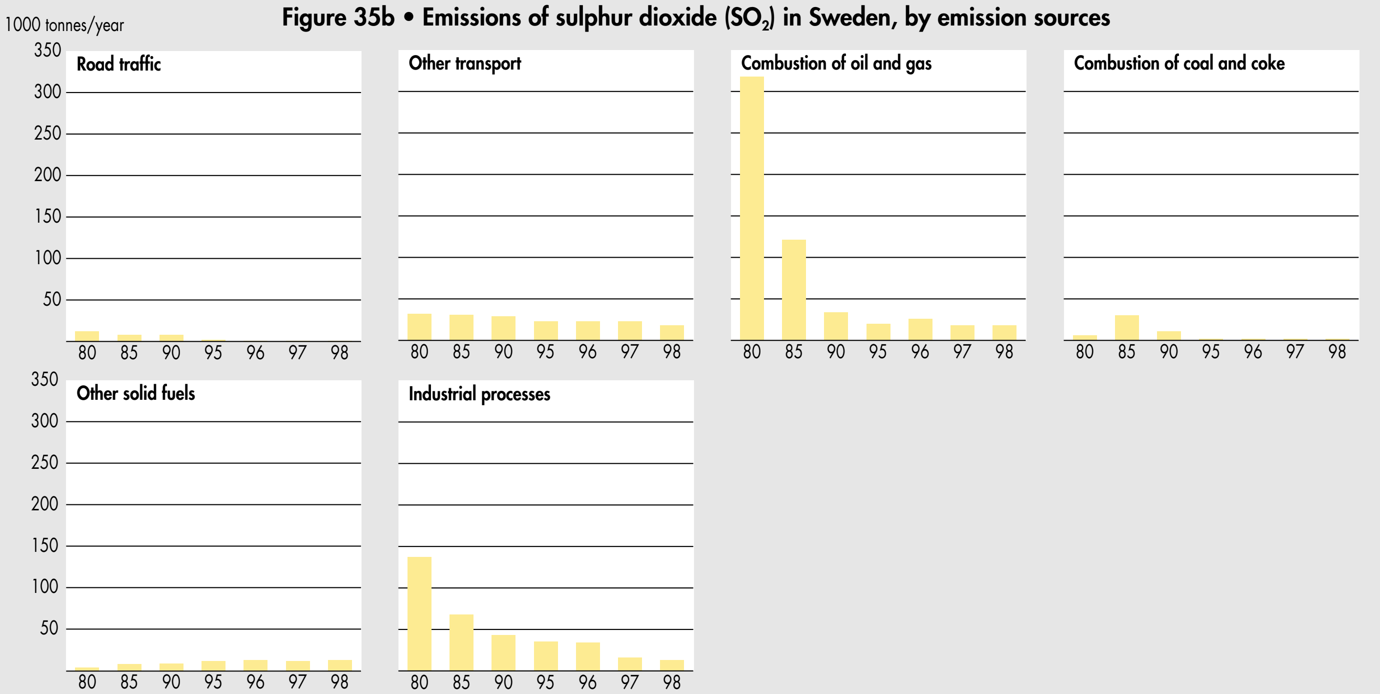


Figure 35b • Emissions of sulphur dioxide (SO_2) in Sweden, by emission sources



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

The main source of this acidification is the emission of sulphur in the form of sulphur dioxide. The sulphur dioxide is oxidised in the atmosphere to sulphuric acid, which is then brought down to the surface of the earth in precipitation, and thus referred to as 'wet deposition'. Sulphur emissions can also be deposited directly in the form of sulphur dioxide, known as 'dry deposition'. As the conversion process of sulphur dioxide in the atmosphere for wet deposition takes a few days - sometimes up to a week - it means that precipitation over Sweden originates primarily from sources in other countries. In 1980, over 17 % of sulphur precipitation in Sweden originated from domestic sources. By 1998, this figure had been reduced to somewhat over 7 %. As the prevailing winds over Sweden are westerly, the country is exposed to depressions and fronts from the west and north-west: large quantities of air pollutants are also carried over Sweden by southerly winds powered by high pressures over the continent. The countries from which about 34 % of today's precipitation in Sweden comes are primarily Germany, Poland and the UK. However, Sweden also exports air pollution to its neighbouring countries, primarily Russia, Finland, Norway, Poland and the Baltic states, although much of the pollution is precipitated in the sea. Swedish emissions come primarily from industrial processes, the combustion of oil and gas and from transport.

Reducing sulphur emissions

Emissions in both Sweden and the rest of Europe have fallen considerably since 1980. Sweden's Parliament has committed the country to reducing its sulphur emissions to only 20 % of the 1980 levels by 2000. This reduction was, in fact, achieved in 1993, partly as a result of less use of oil and partly as a result of lower sulphur contents in the oil. An important step in the work of reducing emissions was taken when a new sulphur protocol was produced by the UN Economic Commission for Europe (ECE) in 1994. Under the terms of the protocol, several European countries have undertaken to reduce their SO_2 emissions by between 30 % and 80 % by 2010, relative to the 1980 levels. The protocol came into force on 5th August 1998, and is legally binding, as it has been ratified by a sufficient number of states. Within the EU, the European Commission has succeeded in setting an emissions limit for the three key pollutants of sulphur dioxide, nitrogen dioxide and ammonia. These limits have been set such that the difference between the actual emission levels and the critical load limits, i.e. what the environment can stand, will be reduced by 50 % for each country.

→

Figure 36a • Emissions of oxides of nitrogen (expressed as NO_2) in Sweden 1980–1998

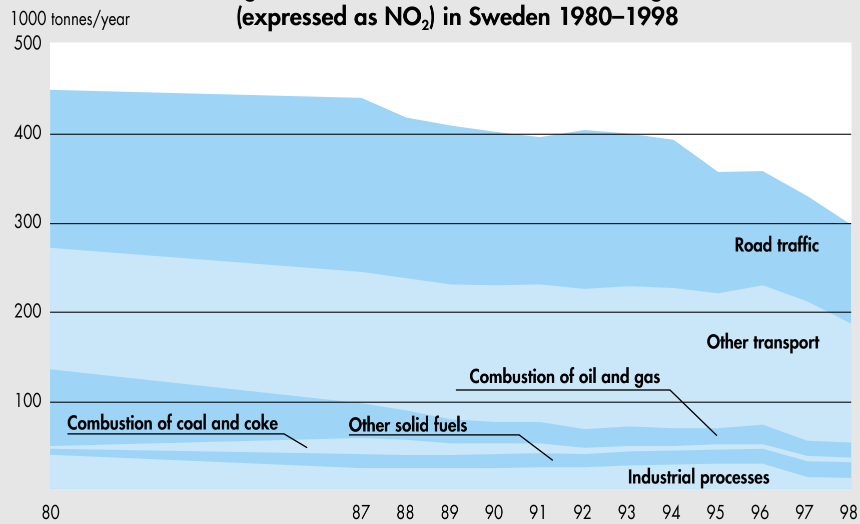
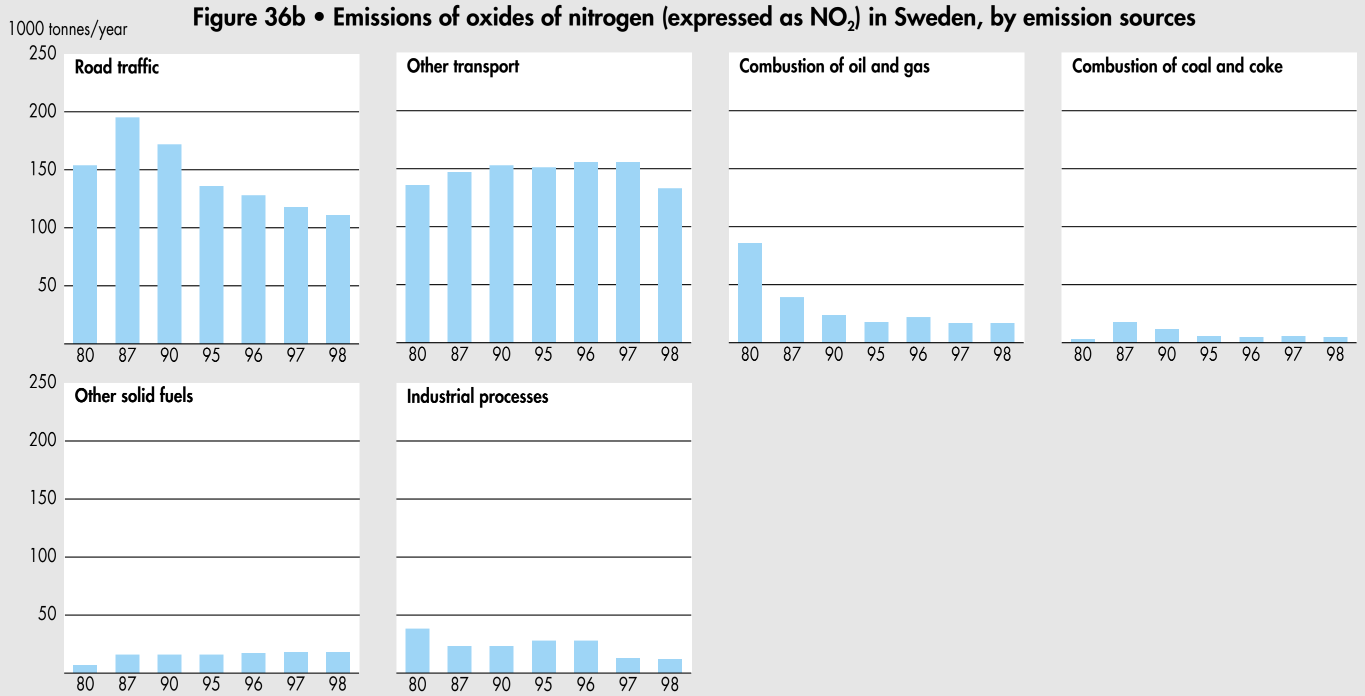


Figure 36b • Emissions of oxides of nitrogen (expressed as NO_2) in Sweden, by emission sources



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

Eutrophication

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

Eutrophication is primarily a problem in water ecosystems. Forest eutrophication is rare, although forests in south-west Sweden do show signs of nitrogen saturation. It is only when nitrogen levels are saturated that nitrogen contributes to acidification. Eutrophication of water ecosystems results in excessive growth of water plants, resulting in cloudiness of the water and reduced depth of visibility. In the longer term, there is a risk of lakes becoming totally clogged by plant growth and turning into marshland. Eutrophication also contributes to oxygen-free bottom environments through the increased demand for oxygen to break down dead plant growth. Oxygen-free bottom zones are a problem in a number of areas, including the Baltic. In fact, the Baltic is perhaps the biotope that has suffered most from nitrogen precipitation, resulting in algae blooms and oxygen-free bottoms. These oxygen-free bottoms make it difficult for fish to reproduce, and also contribute to a serious depletion of bottom fauna.

Figure 37a • Deposition of oxides of sulphur in Sweden 1998 from various sources (%)

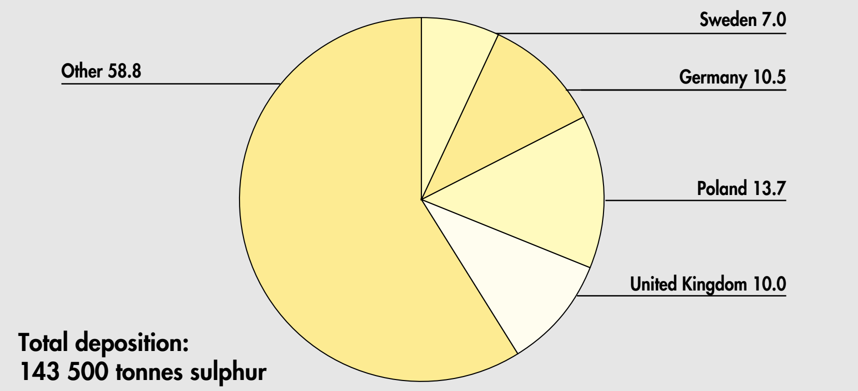


Figure 37b • Deposition of oxides of nitrogen in Sweden 1998 from various sources (%)

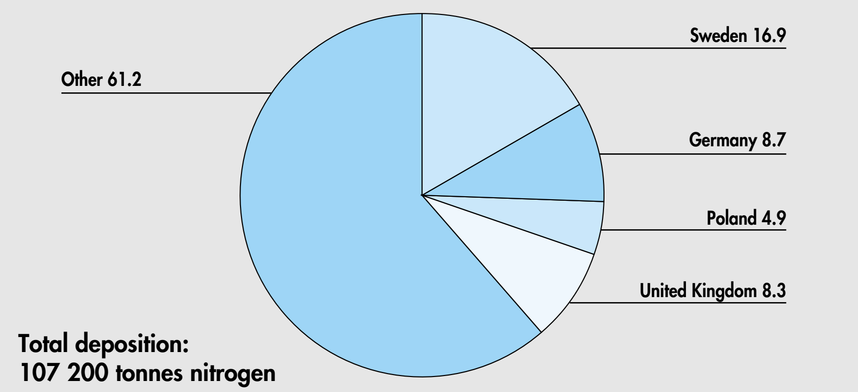


Figure 38a • Emissions of carbon dioxide (CO_2) in Sweden 1980, 1987–1998

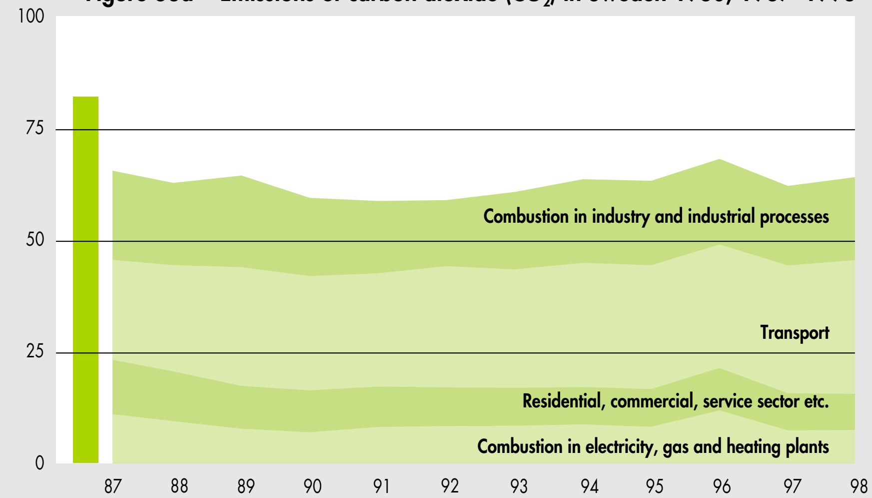
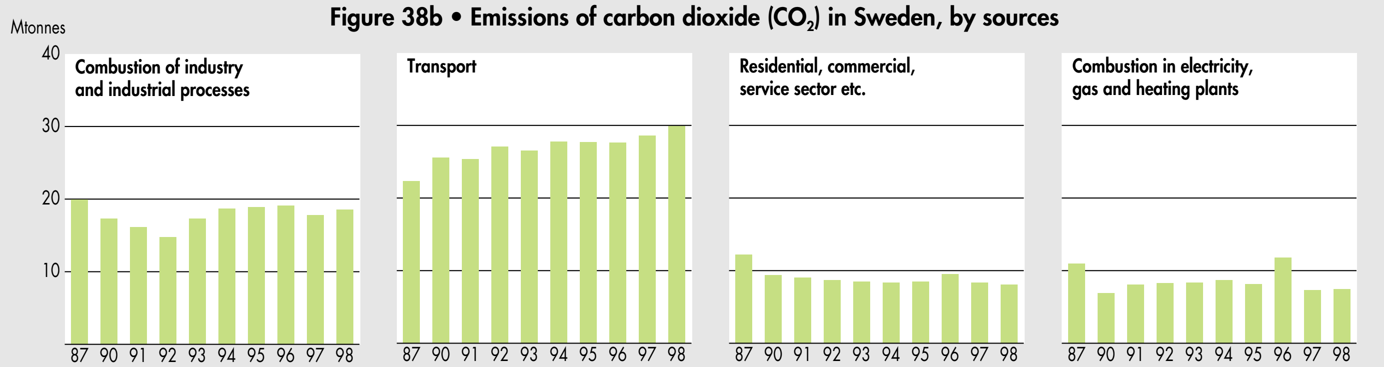


Figure 38b • Emissions of carbon dioxide (CO_2) in Sweden, by sources



Catalytic exhaust cleaning has reduced emissions

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

The greenhouse effect

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

[1] West Germany until 1989.
[2] The part included in EMEPs calculations.

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

The OECD countries emit over half of the total global carbon dioxide emissions, with the USA being responsible in turn for by far the greatest amount, of over 45 %. Other countries with high emissions include Japan, the UK and Germany. In terms of highest specific emissions per inhabitant, we find the USA in top place, equal with Lux- →

Table 5 • Changes in sulphur emissions in a number of European countries

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

Sources: EMEP.

Figure 39a • Emissions of sulphur dioxides (SO_2) in Europe 1980–1998

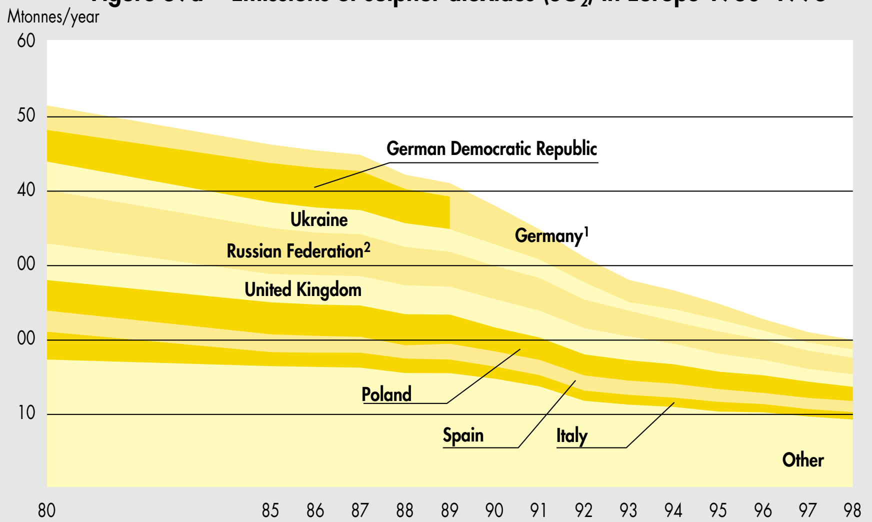
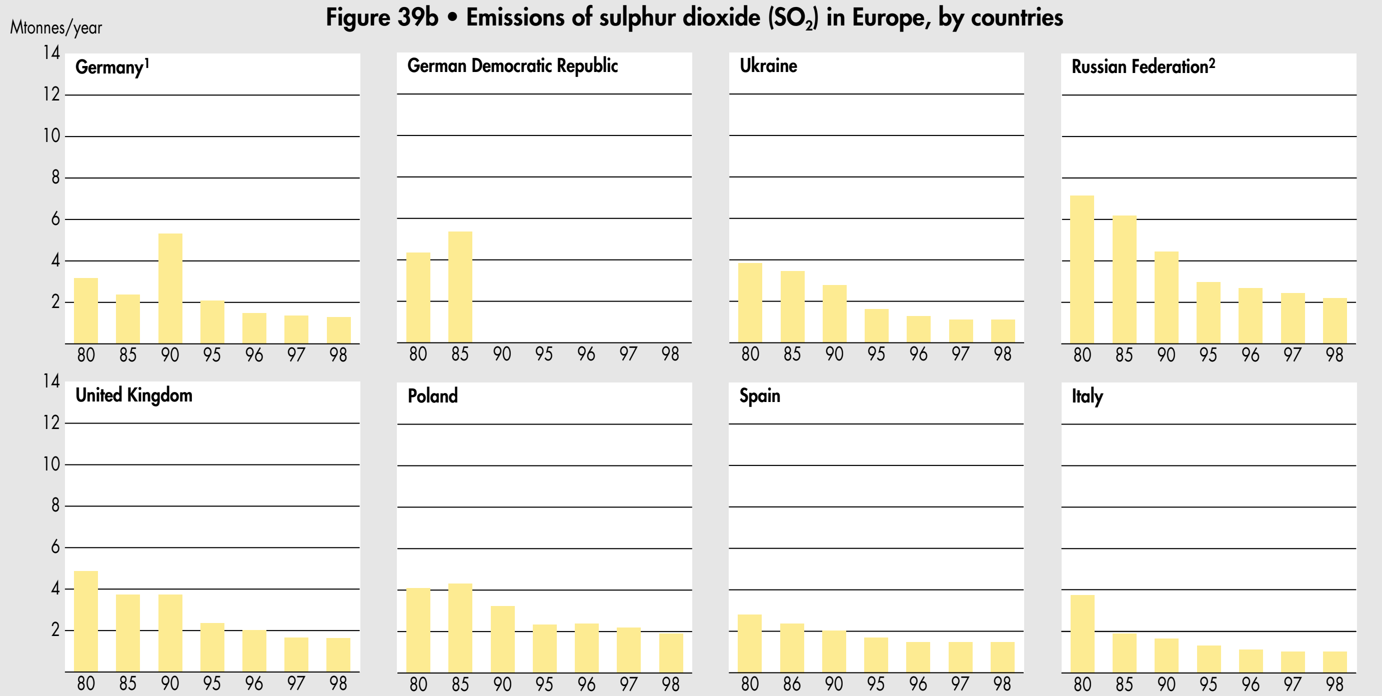


Figure 39b • Emissions of sulphur dioxide (SO_2) in Europe, by countries



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

Sweden contributes a few parts per thousand to the world's carbon dioxide emissions, with specific emissions per inhabitant being below the average for both the OECD countries and for the EU. Carbon dioxide emissions have fallen by about 30 % between 1980 and 1998, although they have risen somewhat during the 1990s.

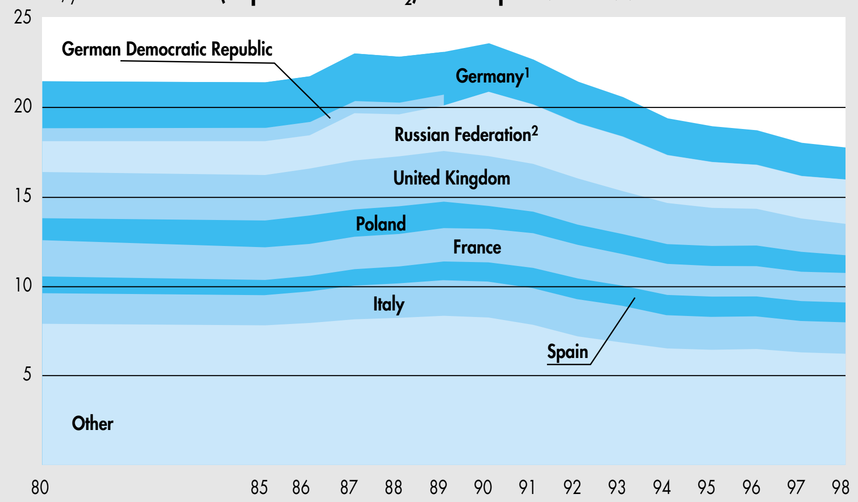
International climate cooperation

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

At the meeting of the parties in Berlin in 1995, it was noted that work to date was inadequate, and a process was started to produce a legally binding document. At the third meeting of the parties in Kyoto in 1997, agreement was reached on a document regulating emissions of carbon dioxide and five other greenhouse gases. The document sets out reductions for all Annex 1 countries, i.e. the OECD countries and the previous Eastern European states, for implementation by 2010. The reductions are expressed as an average over the period 2008–2012, and are referred to the 1990 emission levels. The EU, which negotiated as a single group, is required to reduce its emissions by 8 %. A subsequent agreement has been reached on the internal breakdown of this aggregate reduction, under the terms of which Sweden is in fact permitted to increase its emissions by 4 %. 'Flexible mechanisms', in the form of emission trading and joint implementation, are included in the Kyoto protocol in order to facilitate more cost-efficient reductions.

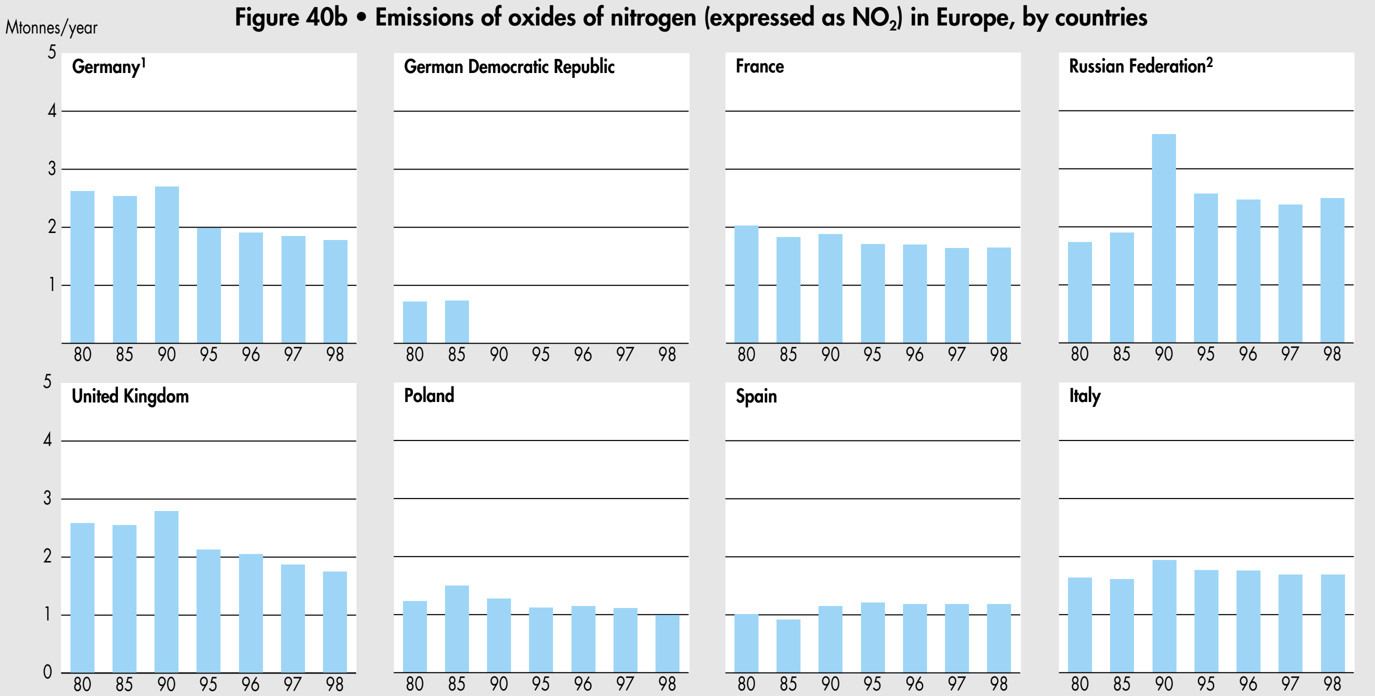
Emission trading involves the trading of emission rights. Countries that have emitted less than their permitted proportion can sell their remaining portion to another country that wants to emit more. Joint implementation involves effecting some improvement in another country and being credited with the resulting reduction in emission. A third mechanism is that of clean development, which involves essentially the same as joint implementation, except that the improvements are carried out in a non-Annex 1 country. Much work remains to be done before these mechanisms have adopted their final form, and it is also necessary for at least 55 states, accounting for at least 55 % of the emissions from the Annex 1 countries, to ratify the protocol.

Figure 40a • Emissions of oxides of nitrogen (expressed as NO_2) in Europe 1980–1998



[1] West Germany until 1989.
[2] The part included in EMEPs calculations.

Figure 40b • Emissions of oxides of nitrogen (expressed as NO_2) in Europe, by countries



Eastward enlargement of the EU

Environmentally, Western Europe is regarded as being far ahead of Eastern Europe with the latter's out-of-date industries, coal-fired power stations and lax environmental legislation. The Eastern European energy sector is characterised by low energy efficiency, dangerous nuclear power stations and a high use of coal, and so there is enormous potential for improvement. As an example, it can be noted that the energy intensity of Estonia, measured in terms of total primary energy supply (TPES) in relation to the country's GNP, was almost five times as high as that of the EU in 1997. The TPES energy intensity in Russia was almost ten times as high. An eastward enlargement of the EU should therefore result in a cleaner environment in the new member states. EU membership involves improved and more relevant legislation, coupled with requirements for reduced emissions. At the same time, higher consumption associated with higher standards of living can result in greater environmental impact, higher energy use and more transport. The work of bringing environmental legislation into line and improving emissions and effluent treatment is proceeding only slowly. The slow progress of the applicant countries (the Czech Republic, Poland, Hungary, Slovenia and Estonia in the first wave) in the environmental sector can delay their admission to the EU.

The prime idea of EU membership is to create better conditions for economic growth. The rapid rate of development in countries such as Estonia and Poland in recent years is likely to continue if they gain access to the single market and to investment support from EU funds. On the other hand, the Western European dependency on road traffic will be extended eastwards, particularly bearing in mind the fact that most of the infrastructure projects receiving EU support are concerned with the building of roads.

In the longer term, eastwards enlargement of the EU should bring positive environmental benefits, although the positive effects are not as certain in the short term. Higher standards of living and greater use of energy usually go together, and there is nothing to indicate that this should not be the case in the previous Eastern European states. The environmental effects of an eastwards enlargement do not depend only on EU requirements and regulations. EU directives are often expressed in terms of general objectives, and it is up to each individual state to decide on the ways and means it will use to achieve them. However, it is clear that they must incorporate EU regulations in their own legislation, which means that there will be a substantial modernisation of such legislation. Nevertheless, it will take time for the changes to work through and have a real effect. In addition, application for membership by some countries can represent a cutback in their present ambitions if they are intending to make the necessary changes at a later date with EU assistance instead of carrying them out today with their own funding. ■

Figure 41a • Emissions of carbon dioxide (CO_2) per inhabitant and BNP 1998 in EU and OECD-countries

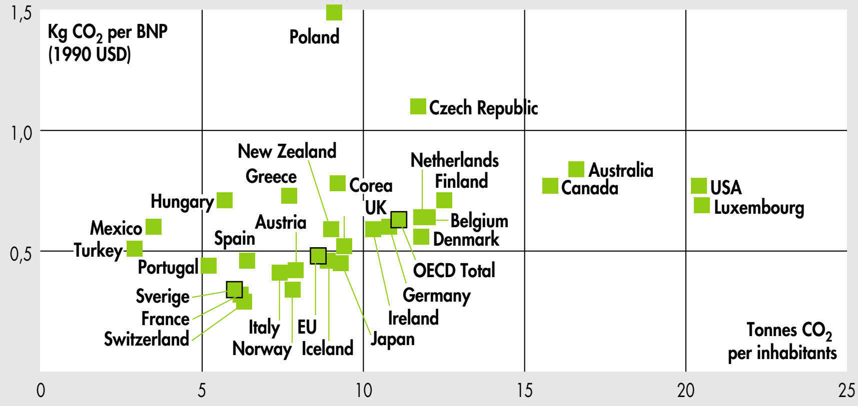
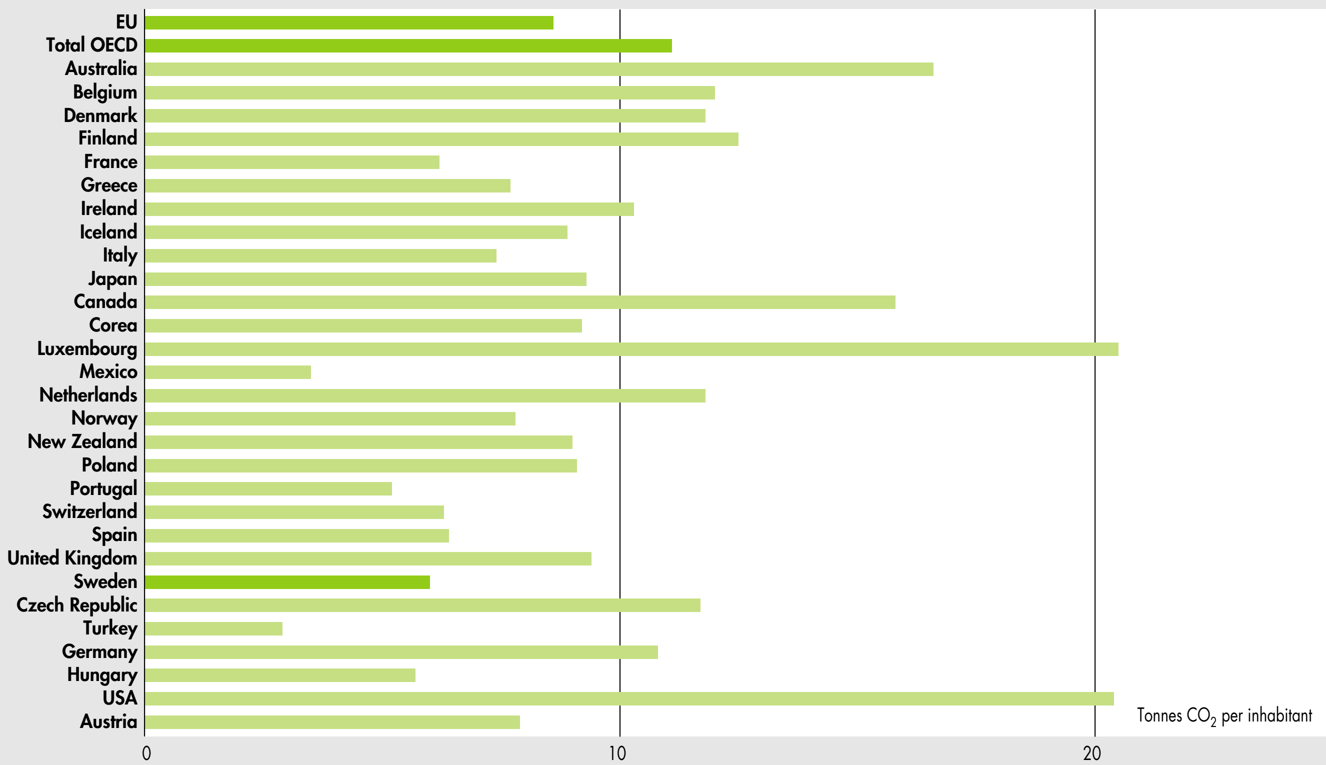


Figure 41b • Emissions of carbon dioxide (CO_2) per inhabitant in EU and OECD-countries, 1998



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

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

Biofuels
Fuels consisting of biomass.

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

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

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

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

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

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

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

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

Coke
The solid residue from the pyrolysis of coal.

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

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

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

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

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

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

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

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

Diesel fuel
A light oil for use in diesel engines.

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

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

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

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

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

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

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

Energy
A measure of work performed in a given time: the product of power and time. Energy is expressed in watt-hours (Wh).

Energy balance
1 The balance of energy supplied and energy used.
2 A presentation of energy supplied and energy used.

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

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

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

Energy crops
Crops grown for use as energy raw materials.

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

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

Sludge gas
See: digester gas

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

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

Steam coal
Coal that is used primarily for burning.

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

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

Toe (tonnes of oil equivalent)
See Oil equivalent

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

Waste heat
Heat released from processes.

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

The international standard unit for measurement of energy is the joule (J), although the watt-hour (Wh) is often used in Sweden. One joule is equal to one watt-second, which means that one watt-hour is equal to 3600 J. International comparisons often use the tonne of oil equivalent (*toe*), which represents the energy obtained by burning one tonne of oil, i.e. 11.6 million Wh.

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

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

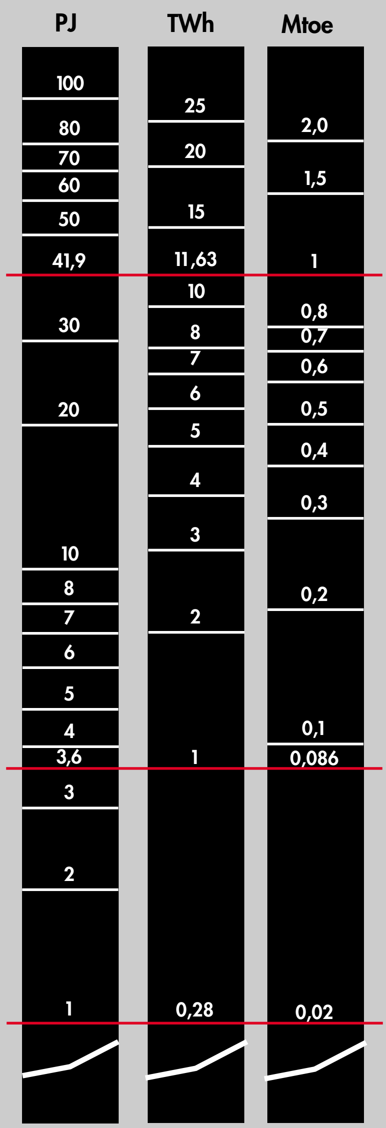
Units commonly used for comparison are the PJ, TWh and Mtoe. See the diagram on the right for conversions between them.

Practical terms

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

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

Conversion scales, energy units (logarithmic scales).



Conversion factors for energy carriers:

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

*Dry solids

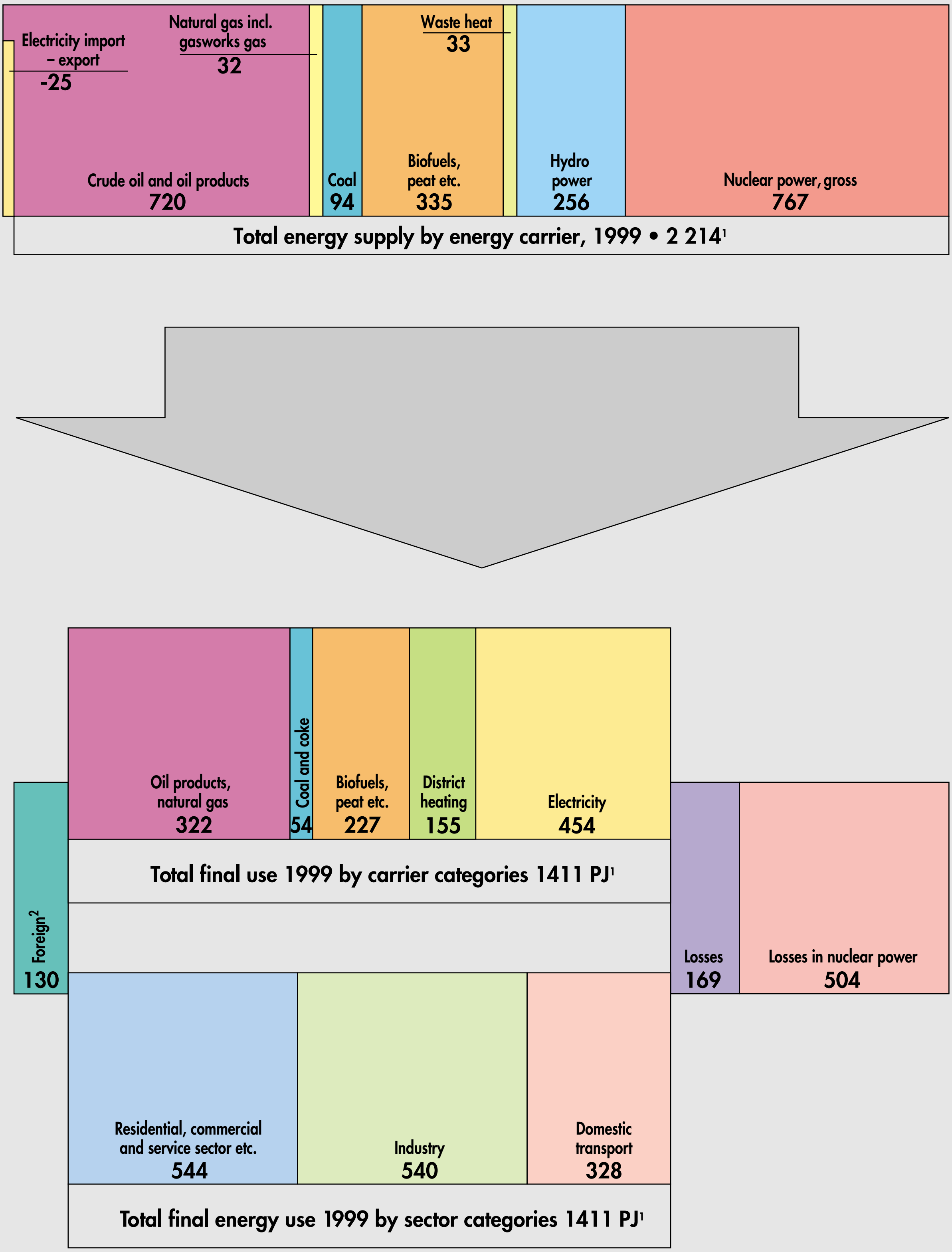
Electricity for household purposes

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

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

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

Figure 1 • Energy supply and use in Sweden 1999, PJ



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

Swedish National Energy Administration

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

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

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

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

Swedish National Energy Administration

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