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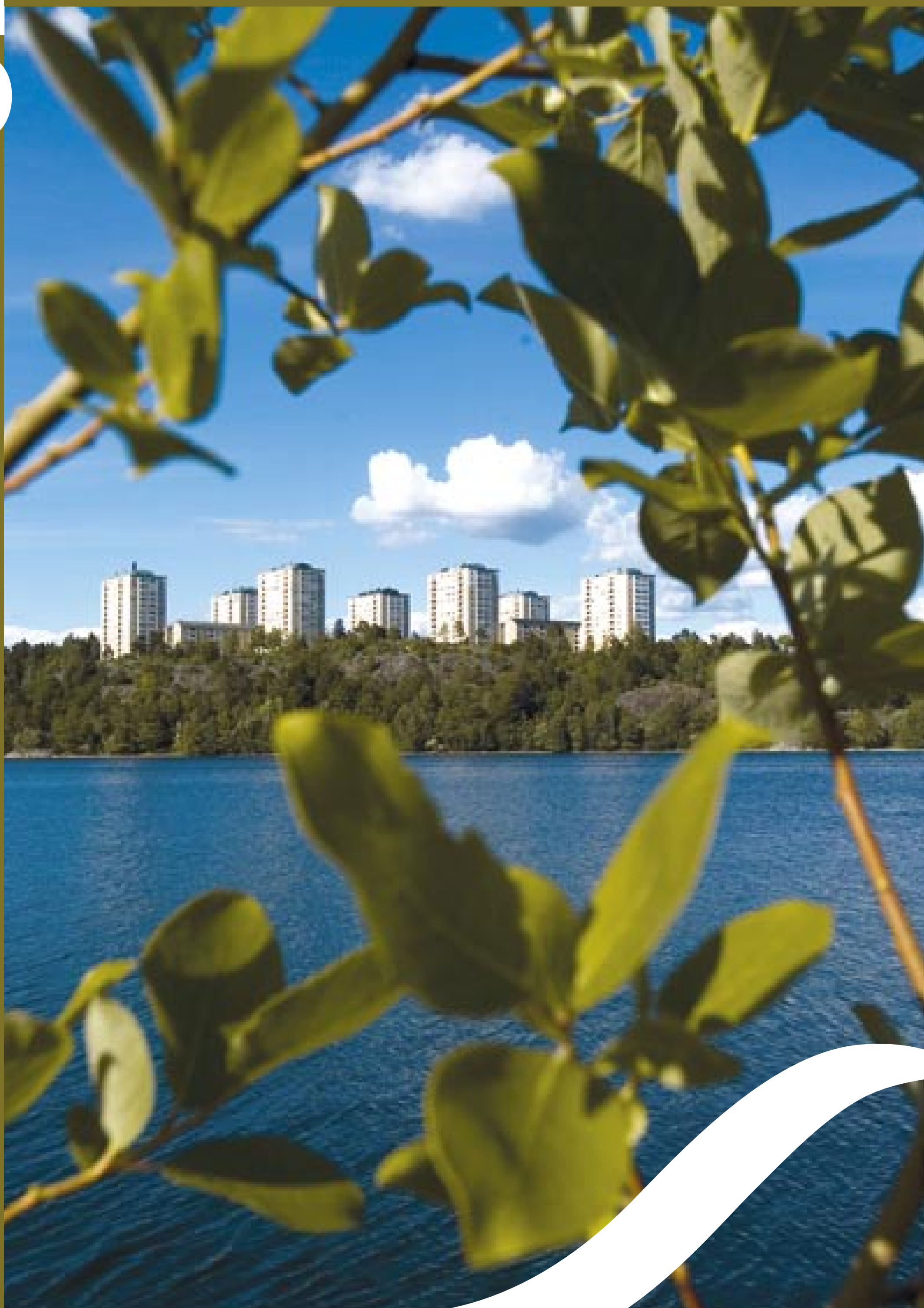

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Preface

The Swedish Energy Agency is Sweden's central public authority for matters relating to energy. It performs its work in conjunction with other public authorities, with business, energy utilities, local authorities and scientists in universities and research institutes. The acquisition and publication of information on the energy system and its development is therefore a central part of the Agency's work.

Everywhere in the world, the challenges that must be addressed by energy policy are more or less the same. Energy supplies are required to be reliable, available at reasonable prices and have as little environmental impact as possible. These three fundamental objectives can complement each other or be mutually opposed, which explains the complexity of energy policy.

Improving the efficiency of energy use and concentrating on the use of renewable energy sources can contribute to all three objectives. These are working areas in which activities are increasing, linked by the EU as an important driving force. The EU also gives priority to the single market in energy, which includes deregulation and trade in energy across national borders. Another very noticeable driving force behind the changes in energy systems is that of international cooperation in the climate sector. Energy policy is also concerned with matters relating to surveillance of the energy markets, crisis preparedness and research, development and demonstration activities. International cooperation is thus of decisive importance for energy policy.

Energy in Sweden is published annually, and is intended to provide decision-makers, journalists, companies, teachers and the general public with a coherent and easily available source of information on developments in the energy sector.

A change in this year's publication is that we have brought together all information on climate policy and Swedish climate strategy in the same chapter. We have also totally revised the content of the 'An international perspective' chapter.

We hope that you will find Energy in Sweden interesting and of value.

Eskilstuna, November 2005

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Current energy and climate policy areas

The framework conditions of energy markets are determined largely by political and legal considerations. In Sweden, the aim of the political decisions is to influence development of energy use and energy production in order to create a sustainable energy system. The markets reflect primarily national and EC decisions, although global agreements are becoming increasingly important. The need for global cooperation is particular marked in the field of climate policy. This chapter discusses a number of areas of current interest in the fields of energy and climate policy

Sweden's energy policy

"Sweden's energy policy, in both the short and the long term, is to safeguard the supply of electricity and other forms of energy on terms that are competitive with the rest of the world. It is intended to create the right conditions for efficient use of energy and a cost-efficient Swedish supply of energy, with minimum effect on health, the environment or climate, and assisting the move towards an ecologically sustainable society." These guidelines for the country's energy policy were set out in the 1997 energy policy agreement[1], together with the strategy for continued restructuring of the country's energy system. The guidelines were confirmed in 2002, when Parliament adopted Bill no. 2001/02:143.

Since January 2005, energy has fallen within the remit of the Ministry of Sustainable Development. Greater political importance has been attached to surveillance and control of the energy markets, with additional emphasis on economic policy measures intended to assist restructuring the country's energy system. Crisis preparedness and measures intended to address vulnerabilities have also become more important.

Measures in the short and medium-long terms

The electricity certificate system was introduced in 2003, with the aim of increasing the use of electricity from renewable sources by 10 TWh/year between 2002 and 2010.

One of the planning objectives for wind power production is that local authorities must have agreed plans for 10 TWh/year of wind power production by 2015. In addition, the 2002 energy policy decision also includes measures to improve the efficiency of energy use, such as those concerned with energy advisory services, technology procurement projects and the market introduction of energy-efficient technology.

January 2005 saw the start of the programme for energy efficiency improvements in energy-intensive industries (PFE). Participating and qualifying companies can be exempted from the new electricity tax that was introduced on 1st July 2004 if they fulfil certain conditions, which include the introduction of a standardised energy management system and application of physical measures to improve the efficiency of electricity use. EU-wide trading with emission allowances also started in 2005, with over 700 Swedish plants in the trading system.

At the beginning of the year, the Government established the Energy Markets Inspectorate as part of the Swedish Energy Agency. The Inspectorate provides a common channel for the collection and analysis of data from the energy markets, and also exercises surveillance over the electricity, natural gas and district heating markets. It has produced a model (the Performance Assesement Model) which indicates whether local network distribution utilities are charging unreasonable tariffs. The model was used for the first time in 2004, producing results which prompted the Inspectorate to carry out further investigations of 43 network utilities. Following on from Storm Gudrun on 8th–9th January 2005, the Government instructed the Inspectorate to put forward proposals for improving the physical security of electricity supply. The results were presented in a report in April 2005.

A new grant system, running from 2004 to 2006, provides a tax reduction for householders who upgrade to high-performance windows in existing detached houses, or who install a biofuelled boiler for heating in new detached houses. In addition, from 15th May 2005 until the end of December 2006[2], the owners of premises used for public activities can apply for grants for conversion or energy efficiency improvement measures in the premises.

[1] Bill no. 1996/97:84. Current energy policy represents an agreement between the Social Democrats, the Left Party and the Centre Party.
[2] Other dates apply for energy surveys and installations of solar cell systems.

The 2005 Environmental Objective Bill[3] referred to a possible expansion of the Repair, Conversion and Extensions scheme grants. In the 2005 finance bill[4], the Government announced its intention of improving the taxation benefits for conversion from direct electric heating in residential buildings. A proposal for doing this, put forward by the Ministry of Sustainable Development, suggests that grants should be available to the owners of detached houses, apartment buildings and residential buildings linked to, or forming part of, commercial premises, who carry out whole or partial conversions from direct electric heating to district heating, heat pumps or biofuels. It has also been suggested that larger petrol stations shall be required to sell renewable motor fuels from 1st January 2006.

Long-term measures

In September 2003, the Commission on Energy Technology and Development submitted its report[5] on evaluation of the long-term elements of the 1997 Energy Policy Agreement. The report stated that although the various research, development and demonstration projects that have been carried out are both relevant and of good quality, they are not alone sufficient as a driving force for restructuring the country's energy system. The report included proposals for a broader, but more focused, long-term energy policy programme, starting in 2005. The Commission also proposed stronger measures to assist commercialisation of new energy technology.

The Government followed this by a new long-term programme for the period 2005–2011, expressed in the 2005 Budget Bill[6], concentrated on research, development and demonstration activities for the development of technology and processes for the conversion to a sustainable energy system. However, the programme represented a halving of grants, from the previous level down to SEK 440 million/year. However, in the 2006 budget bill (Bill no. 2005/06:1), it is proposed that the grants should be returned to their original level of over SEK 800 million. The bill also proposes additional grants for wind power pilot projects.

The energy research programme for the next seven years attached greater importance to linking the work to industry, with a more aggressive ambition level for converting research results to commercial products and services. These changes mean that there will be greater pressure on the focus on, and priorities of, future work. With effect from 2005, there will be two separate, but linked, targets for the new long-term programme. One is to build up the necessary scientific and technical knowledge and competence within the country's universities, research institutes, public authorities and industry as needed in order to facilitate the changeover to a long-term sustainable energy system through application of new technology and new services, while the other is to develop technologies and services that can be commercialised by Swedish industry, thus assisting conversion and development of energy systems not only in Sweden but also in other markets.

There are two research funding councils that are important sources of funding for energy and climate-related research in Sweden: the Swedish Research Council (VR), which provides grants for fundamental research in all scientific areas, and the Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS). There are also several public authorities that finance research and development of this type: they include the Swedish Agency for Innovation Systems (Vinnova), the Environment Protection Agency and the Swedish Energy Agency. Public funding for research and development also includes funding from certain research foundations, such as the Foundation for Strategic Environmental Research (Mistra), which is particularly active in energy and climate research contexts.

The negotiations with the nuclear power companies that were started between the Government and the industry in 2003 were broken off in October 2004 without any agreement having been reached. However, Barsebäck 2 was closed in May 2005, in accordance with the strategy presented by the Social Democrats, the Left Party and the Centre Party. The next stage in the strategy involves consideration of continued operation of the oldest reactors. At the same time, the power companies are planning to increase the output from some of the reactors.

Current investigations

In May 2004, the Government appointed a commissioner to evaluate and review the country's forestry policy of the last ten years. One of the aspects to be considered is that of the increasing and competing pressures for the supply of raw materials. The report is due to be submitted by not later than 31st December 2005.

In June 2005, the Government appointed a commission to investigate The effects of climate changes and how to reduce society's vulnerability to them. An area of particular interest is that of the effects of climate changes on infrastructure, e.g. on roads, railways, telecommunications, building stock, energy production, electricity supply, land use, water supply and effluent treatment. The investigation will also include the possible effects of climate change on human health and biological diversity. The commission is due to submit its final report by not later than 1st October 2007.

In July 2005, the Government appointed a commission to analyse the ability of Swedish agriculture to produce bioenergy crops. This report is due for submission by not later than 1st September 2006.

[3] Environmental Objectives Bill no. 2004/05:150
[4] Bill no. 2004/05:100
[5] Energy research, development and demon stration – one part of restructuring the energy system (SOU 2003:80)
[6] Bill no. 2004/05:1

Investigations concluded during the second half of 2004 and the first half of 2005

The Building Energy Performance Commission was appointed in November 2003, to put forward proposals for necessary amendments to Swedish legislation to bring it into line with the requirements of the EC Energy Performance of Buildings Directive. The work also included a review of application of the National Board of Housing, Building and Planning's Building Regulations. The Commission submitted a report[7] in November 2004, proposing the introduction of legislation concerning energy declarations for buildings on 4th January 2006, with the aim of encouraging the efficient use of energy in buildings. The thinking behind energy declarations is that they should show how energy is used in buildings, and how the buildings can be improved in order to reduce their energy use. The proposed legislation means that property-owners are required to engage the services of an energy expert in order to prepare an energy declaration for a building when it is sold, when a residential building or commercial premises is rented out or when a cooperative leasehold is transferred. Such energy declarations are to be valid for ten years. In practice, for detached houses, the requirement would not apply until the house was sold. Since it was set up, the Commission has received a further instruction, requiring it to put forward proposals for the form of energy declarations, the necessary calculations and the require-ments applicable to those preparing the declarations The final report[7] was delivered in August 2005, with the Government expected to announce its decision during the autumn.

In 2003, the Government appointed the **District Heating Commission** to investigate the competitiveness of district heating in the heating markets, and to put forward proposals for improving consumer protection. The Commission has submitted three interim reports[8]. The final report[9] was submitted to the Government in April 2005, proposing a district heating act that gives greater insight into the activities of district heating companies, gives customers the right to negotiate price and delivery conditions and establishes a board, with members appointed by the parties concerned, to resolve disputes. The Commission also notes that there is a considerable potential for increasing electricity production by converting present-day heat-only plants to cogeneration plants. The Commission also considered the question of continuity of supplies if a district heating utility should become insolvent. These proposals were presented in June 2005, and suggested the establishment of a special fund, financed by the district heating utilities, to guarantee continued operation in such an event.

The **Electricity and Gas Market Commission** was appointed in 2003, with the task of putting forward proposals for harmonising Swedish legislation with the requirements of the EC Electricity and Gas market Directive[10]. An interim report[11] was published in December 2003. In its final report[12] from January 2005, the Commission states that the Swedish electricity market is operating, but that the Nordic electricity market should be strengthened in order to counteract concentration in the electricity sector. Cross-border transmission capacity between the Nordic countries should be increased, and the various national regulations should be harmonised. Consumers' position on the electricity market should be strengthened, to which end the Commission suggests a number of changes to make it easier for consumers to change electricity suppliers.

The Commission regards the natural gas market as immature, although the prospects for establishing an effective competitive Swedish market are improving with the coming into force of new regulations.

At the beginning of 2005, the Government submitted a bill to Parliament concerning a new Natural Gas Act and changes in the Electricity Act. The new Natural Gas Act would require greater access to the natural gas market, legal separation between transmission businesses and those involved in the sale of natural gas, a requirement that transmission companies may not apply their transmission tariffs before the surveillance authority has approved the methods used to determine the tariffs, and the introduction of regulations governing system responsibility and responsibility for maintaining a balance on the natural gas market. Among the effects of the changes in the Electricity Act would be a requirement for separation of grid companies and trading companies, a lower limit for hourly metering of electricity consumption and a requirement for electricity suppliers to indicate clearly on their invoices and advertising material the composition of the energy sources used for production of the electricity that they are selling. These changes came into force on 1st July 2005.

The Renewable Motor Fuels Commission[13] submitted its final report in January 2005. It had been instructed to propose national targets and strategies for continued introduction of renewable motor fuels, and to investigate the feasibility of introducing some form of certificate to encourage their introduction. According to the Commission, green certificates are preferable to tax subsidies or compulsory quotas. It suggests that certificates should be introduced in 2009, at which time the present tax subsidies would be discontinued or phased out. It further suggests that the national objective for the proportion of renewable motor fuels in 2010 should be raised to 5.75%, which is the same as the EU reference level. Sweden's target at present is 3% in 2005. The Commission also states that research into renewable motor fuels should be stepped up.

[7] SOU 2004:109, SOU 2005:67
[8] SOU 2003:115, SOU 2004:136, SOU 2005:63
[9] SOU 2005:33
[10] The European Parliament and Commission's Directive 2003/54/EC of 26th June 2003.
[11] SOU 2003:113
[12] SOU 2004:129
[13] SOU 2004:133

The Flexible Mechanisms 2 Committee submitted its final report[14] in February 2005. It had been asked to investigate the feasibility of including further sectors and further climate gases in the EU's emissions trading scheme. At present, the system covers the iron and steel industry, the minerals industry, the pulp and paper industry and combustion plants for energy production. As far as emissions are concerned, it is only carbon dioxide that is covered by the scheme. The investigation[14] proposes that the system should be expanded to include additional sectors: in Sweden, the transport sector is particularly important, as it accounts for about two-thirds of those carbon dioxide emissions that are at present not included in emissions trading. The report states that Sweden should await the European Commission's response as far as deciding on the inclusion of further climate gases in the trading system is concerned.

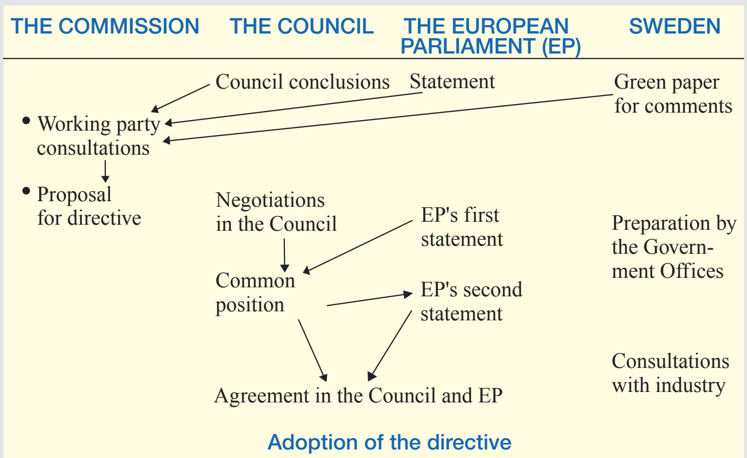
The Regulations Commission submitted its report[16] to the Government in January 2005. It had been asked to analyse the deregulated utility markets. In its report, the Commission states that the various reforms have taken insufficient notice of consumers' interests, and that this is particularly the case for the electricity market. There is therefore a need to strengthen consumers' position on these markets. In addition, the Commission states that surveillance on the electricity market should be stepped up. The Commission feels that it is important to create transparency and clearly to establish the responsibilities of the various parties concerned, and therefore proposes that the network monitoring authority should be given greater independence, and be itself restructured into a public authority on its own.

The BRAS Commission was appointed in 2003 to investigate the present legislation governing tax on waste, and to propose a tax or some other economic policy measure on waste used as a fuel. In March 2005, the Commission submitted an interim report on taxation of waste used as fuel. In it, the Commission suggests that the fossil fraction of waste should be covered by existing energy taxation, which would mean that it would then be taxed on the same bases as other fossil fuels. The Commission submitted its final report in July 2005, in which it stated that the tax on waste is operating well, and needs only slight changes in order to continue its work of supporting achievement of waste policy objectives.

[14] SOU 2005:10
[15] SOU 2004:62
[16] SOU 2005:4
[17] Green Paper – an official Commission document presenting the first drafts or suggestions for possible actions at EU level. White Paper – an official document from the Commission, containing structured proposals for EU regulations. A Swedish Parliamentary bill is similar to a White Paper.
[18] Draft proposal for the Seventh Framework Programme for Research And Development within the European Union.

FACTS: EC Directives

A schematic diagram of how EC directives are prepared, agreed, issued and incorporated in national legislation in member states. In Sweden, this means that the normal response is to set up a committee (SOU), which produces a draft legislation proposal. This then forms the basis of a Governmental parliamentary bill, which is sent to the Council on Legislation before being presented to a Parliamentary standing committee and then voted on by the Parliament. The directive can then be finally incorporated into Swedish legislation



SOURCE: MINISTRY OF INDUSTRY AND COMMERCE

Energy in the EU

In November 2000, the European Commission published a Green Paper[17] for the energy sector. It noted that the EU is still increasing its use of energy, with a need to import increasing quantities of energy. If nothing is done over the next 20–30 years, 70% of EU energy requirements will depend on imported energy, as opposed to 50% today. The Green Paper suggests some bases for a long-term energy strategy.

The common measures that have been taken in the energy sector have been developed primarily within the framework of the single market and as part of the EU's environmental policy. Energy has been included in the draft European constitution, in the form of a new policy area with responsibility split between the EU and the member states.

Work is in progress within the EU on creating a single competitive market for electricity and natural gas. Provided that it is not hijacked by commercial elements, such a single market should be to the benefit of both electricity and natural gas customers and of the energy utilities, not only in Sweden but also in Europe.

The European Commission has proposed that funding for research in the energy sector should be doubled[18].

New directives that have come into force

The Cogeneration Directive (2004/8/EC) was adopted in February 2004. Its purpose is to support and facilitate investment in, and use of, cogeneration plant. The starting point for the directive is not that additional cogeneration capacity is an objective as such, but that cogeneration can provide an efficient means of achieving energy savings and reducing carbon dioxide emissions. Sweden's cogeneration plants easily meet all the criteria in the directive.

2004 also saw adoption of the **Directive Concerning Measures to Safeguard Security of Natural Gas** Supply (2004/67/EC). Under the terms of the directive, member states are required to prepare standards for ensuring security of supply, and to define the divisions of responsibility between the various parties on the market. The directive establishes a crisis mechanism at EU level, which would come into force in the event of significant interruptions to supply. The Directive must have been incorporated in Swedish legislation by not later than May 2006.

The **Ecodesign of Energy-using Products Directive** (2005/32/EC) was adopted in 2005, with the aim of improving the energy efficiency and environmental impact of products throughout their entire life cycle. Common EC regulations for ecodesign are intended to prevent differences in national regulations that could result in barriers to trade on the single market. The directive is also intended to improve product quality and environmental protection and, through improving the efficiency of energy use, to contribute to security of energy supply within the EU. This is a framework directive, which does not set out directly binding requirements for specific products, but instead defines the criteria and conditions to be fulfilled if a product is to be covered by regulations, and how the product requirements are to be structured.

Proposals for new directives, work in progress

The Commission has identified six core areas for the energy sector during the next five years. It wants to:

- increase the efficiency of energy use
- achieve a functioning single market in gas and electricity
- assist renewable energy
- improve nuclear safety
- improve the security of energy supply in Europe, and develop its external energy relationships
- improve the links between energy policy and environmental and research policy.

The directives and initiatives described below address these areas.

At the beginning of the summer, the European Commission published a Green Paper on improving the efficiency of energy use and production within the EU. The Commission is now collecting comments and views from all those concerned, and is expected to process them and probably produce a White Paper on improving the efficiency of energy use and production in the spring of 2006.

In May 2004, the Commission published a Notice concerning the proportion of renewable energy within the EU, containing a list of targets that had been set for the use of renewable energy and a description of the measures that had been taken. The Commission notes that it will be difficult to achieve the objectives on the basis of the measures that have been taken hitherto. It therefore emphasises the importance of further, sustained measures at national level, and gives advanced warning of further measures. In November 2004, the Council adopted conclusions that emphasised the importance of renewable energy and described the areas in which further work is needed in order to achieve the set objectives. Two of the areas considered are biomass and offshore wind power. The conclusions emphasise the need for more long-term approaches.

In 2003, the Commission adopted a package of proposals concerning **energy infrastructure and security of supply.** The package contains proposals for three directives (TEN-e, Energy Services and Energy Supply), together with an ordinance concerning natural gas. The three draft directives and the proposal for a gas ordinance are as follows.

The EU's need for imported energy (mainly natural gas) is growing, while most of the energy sources are outside the EU. As a result, the construction of bulk gas mains to southern and eastern Europe from the previous USSR, Middle East and the Gulf region is important. June 2003 saw the adoption of changed guidelines for trans-European networks **(TEN-e)** in the energy sector (Decision no. 1229/2003/EC), which was followed in December 2003 by publication of a draft for further amendment of the guidelines[19]. The prime objective of the changes is to ensure that the new member states are fully integrated in these projects. Sweden is in favour of this being done now. The Council reached an agreement to do so in June 2005: the European Parliament is now to give a second reading to the matter, after which an agreement should be reached.

An agreement was reached in June 2005 concerning the **Energy Efficiency and Energy Services Directive**[20]. The purpose of the directive is to bring about more cost-efficient and rational end use of energy, and also to avoid barriers to trade in the energy services market. The proposal includes a binding objective of an annual one per cent improvement in the efficiency of final energy use for each member state. Those energy-intensive industries that are covered by the emissions trading scheme are excepted from this requirement, as are aviation and shipping. Matters relating to improvements in the efficiency of energy use have a high priority with the Swedish Government.

The proposal for **security of electricity supply**[21] has been subject of intensive negotiations during 2004, with a general guideline being adopted by the meeting of the Council in November 2004. The directive is concerned with ensuring a high level of security of supply for users of electricity. In the compromise proposal that

[19] Trans-European Energy Networks (TEN-e), KOM (2003) 742, final
[20] The Energy Services Directive, KOM (2003) 739, final
[21] Electricity Supply Directive, KOM (2003) 740, final

was agreed, it is pointed out that it is the parties concerned on a liberalised market that are responsible for ensuring that the demand for electricity can be met. It is also intended that it should be the pricing of electricity on a competitive market that provides the necessary signals for action. Any governmental intervention at national level can interfere with these signals. Sweden is in favour of the draft compromise.

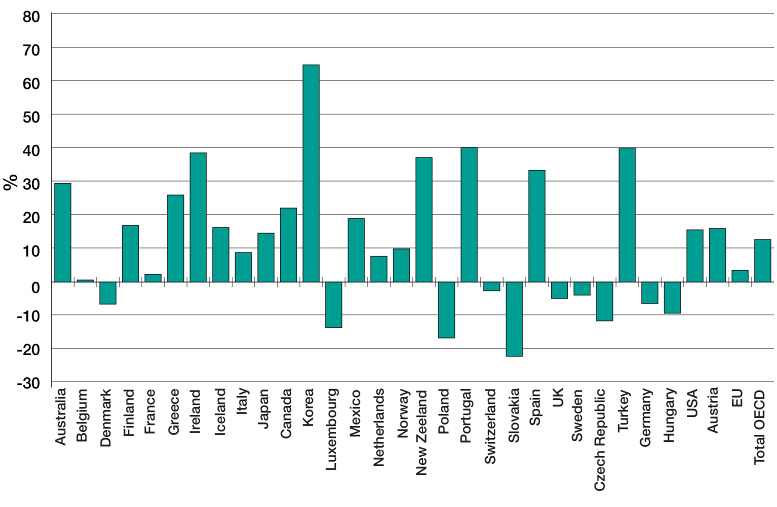
The **Gas Ordinance**[22] should be seen as a further step towards realisation of the single market package for electricity and gas that was adopted in June 2003. The objective of the ordinance is to provide a stable framework to guarantee efficient utilisation of capacity, together with transparency of available capacity and harmonisation of conditions for network and balance services. The proposal is essentially uncontroversial to all the member states. The development of a single market for electricity and gas is an area to which Sweden gives high priority.

Climate policy

International climate cooperation

A major conference on climate change[23] was held by the United Nations in Rio de Janeiro in 1992. The conference resulted in an agreement to jointly tackle the global threat of climate change, with the countries at the conference signing the United Nations Framework Convention on Climate Change (UNFCCC). It came into force in 1994, when it had been ratified by a sufficiently large number of countries (166). Sweden ratified the Convention in 1993, at which time guidelines for the Swedish climate policy was also adopted.

Figure 1: Change in carbon dioxide emissions within the EU and OECD states, 1991–2002



SOURCE: OECD IN FIGURES, 2004 EDITION

The Convention imply among other things that all industrial countries must take steps to reduce their emissions of greenhouse gases, and also to increase the uptake and storage of the gases. The countries must also regularly report details of their progress and the steps that they have taken to the UN.

At the first conference of the parties in Berlin in 1995 (COP 1)[24], it was noted that incentives to take action were not sufficient, and a process was started to produce a legally binding document.

The Kyoto Protocol

At the third conference of the parties in Kyoto in 1997 (COP 3), agreement was reached on a document – the Kyoto Protocol – regulating emissions of carbon dioxide and five other greenhouse gases. The Protocol sets out quantitative reductions for all Annex 1 countries, i.e. the OECD states and the previous Eastern European states, for the period 2008–2012. For the Kyoto Protocol to come into force it was necessary for it to be ratified by at least 55 countries which, in addition, must represent at least 55% of the industrialised countries' carbon dioxide emissions in 1990. The first condition was easily fulfilled many years ago, but as Russia and the USA together were responsible for more than 50% of the total industrialised countries' emissions, it was necessary for at least one of them to ratify the Protocol before it could come into force. Russia ratified the Protocol in November 2004, which meant that countries responsible for more than 61% of the industrialised countries' emissions had then ratified the Protocol. The Protocol therefore came into force on 16th February 2005: by August 2005, 155 countries had ratified it.

Under the terms of the Protocol, the industrialised countries are required to reduce their total emissions of greenhouse gases by at least 5% from 1990 levels during the first commitment period 2008–2012. The EU 15[25], which negotiates as a single group, is required to reduce its emissions by 8%. The EU states reached in 1998 an agreement on internal burden sharing, based on factors such as per-capita emissions and the structure of energy and industry sectors. The new member states (except Cyprus and Malta) have their own commitments to reduce emissions, of between 6% and 8%, under the Protocol. Sweden has a commitment not to increase its emissions by more than 4% within the EU burden sharing agreement.

The Marrakech Accord

The agreement in Kyoto in 1997 set out the basic principles of the Kyoto Protocol, but deciding on a model for implementation remained and was for later conferences of the parties to resolve. Agreement was reached between the parties to the protocol on detailed rules and guidelines at the Marrakech meeting

22 Gas Ordinance, KOM (2003) 741, final

23 Read more about the greenhouse effect in Chapter 7.

24 The Conference Of the Parties (COP) consists of representatives from all the countries that are parties to the Climate Convention, and is the Convention's highest decision-making body. The Conference of the Parties to the UNFCCC serving as the Meeting of the Parties to the Kyoto Protocol (COP/MOP), consists of representatives of all the parties to the Protocol, and is the Protocol's highest decision-making body. Conferences of the Parties are held every year.

25 EU 15 consists of the EU member states prior to the Union's expansion in May 2004.

in the autumn of 2001 (COP 7), converting the Kyoto Protocol to a legally binding text, known as the Marrakech Accord, thus making it possible for the states to assess the consequences of ratification. The points on which agreement was sought related primarily to the conditions and rules for flexible mechanisms (see below), carbon sinks (carbon dioxide absorbation by trees and soil), assistance to developing countries and means of cooperation between industrialised countries and developing countries, and the drafting of sanctions and other responses against countries failing to fulfil their obligations.

Flexible mechanisms

'Flexible mechanisms' are included in the Marrakech Accord in order to facilitate more cost-efficient reductions, and so also quantitatively greater commitments. They consist of emission trading (International Emission Trading, IET), and the project-based mechanisms: Joint Implementation (JI) and the Clean Development Mechanism (CDM). See the Facts panel.

FACTS: Flexible mechanisms

International cooperation is a prerequisite for meaningful measures against climate change. The 1997 Kyoto Protocol includes three flexible mechanisms to enable parties at different levels of development to work together on projects intended to reduce emission of greenhouse gases. The first two of these mechanisms are what are known as project-based mechanisms. All three mechanisms share the feature that one country can benefit from emission reductions achieved in various ways in other countries:

- Joint Implementation (JI) projects enable industrialised countries to implement projects in other countries that have emission reduction commitments under the Protocol, and to credit the resulting reductions against their own commitment reductions.
- The Clean Development Mechanism (CDM) has essentially the same structure as the Joint Implementation mechanism, with the difference that it refers to projects carried out in countries not having quantified commitments under the terms of the Protocol, i.e. generally in developing countries, which therefore requires more tightly drawn regulations. CDM projects are intended also to contribute to sustainable development in the countries in which they are carried out.
- Emission trading permits trading of emission allowances between parties having emission commitments.

Emission trading

A scheme for emission trading within the EU (EU-ETS, Emission Trading Scheme) was introduced on 1st January 2005. It covers all 25 EU member states, and has been developed in accordance with the trading scheme included in the Kyoto Protocol. Its objective is to reduce carbon dioxide emissions in a cost-efficient manner to society, and it is the EU's most important instrument of climate policy against climate changes (ECCP). The overall objective of the scheme is to achieve the EU's commitments in respect of reduced emissions in accordance with the Kyoto Protocol.

The first trading period runs from 2005 to 2007, and is intended to serve as an introductory phase prior to international emissions trading which, under the terms of the Kyoto Protocol, is due to start in 2008. Initially, the Directive (2004/101/EC) applies to a limited number of sectors within the energy-intensive industry, and to electricity producers. This means that it applies to about 46% of EU carbon dioxide emissions. In Sweden, about 38% of the country's emissions are covered by the trading scheme[26]. In the longer term, further greenhouse gases, and further sectors, may be covered by the scheme. In addition to those companies whose plants are covered by the Directive, individual parties and organisations may also participate in the scheme.

The emission trading system is based on each member state setting a ceiling for its emissions prior to each trading period. This is done by the European Commission considering and approving the member countries' national allocation plans, which state the total number of emission allowances that each country intends to distribute, together with details of the principles upon which distribution are based. Each emission allowance represents one tonne of carbon dioxide. The total of all the member states' emission limits represents a common emissions ceiling in line with the EU's commitments under the Kyoto Protocol. The trading system creates a market price for carbon dioxide emissions, with the actual price level being determined by availability of, and demand for, certificates. In absolute terms, the price depends on such factors as companies' marginal costs for reducing their carbon dioxide emissions, the total quantity of emission allowances available on the market, fuel prices and price relationships between different fuels, weather conditions and use of the project-based mechanisms.

For the 2005–2007 trading period, the Swedish state has issued[27] emission allowances equivalent to about 67.3 MtCO_2. For 2005, allowances representing about 22.2 MtCO_2 were allocated to about 530 plants. In addition, there is a reserve of emission allowances equivalent to about 2.1 MtCO_2, available for allocation to new members of the scheme and to existing plants that have increased their capacity.

Each EU member state is required to establish and operate a national registry for the registration of transactions of emission allowances within the trading scheme. The Swedish register, SUS – Svenskt Utsläppssystem, was opened by the Swedish Energy Agency in March 2005. Its purpose is to ensure reliable accounting of the issuance, holding, transaction and cancellation of emission allowances, while the information in the register also provides the basis for surveillance.

The application procedure for allocation of emis-

[26] From data in the Swedish Energy Agency's and Environment Protection Agency's 'Checkpoint 2004'. The figure relates to Sweden's carbon dioxide emissions in 2000.

[27] The number of emission allowances issued is equal to the number of allowances that Sweden intends to allocate to companies included in the trading system.

sion allowances during the Protocol's first commitment period of 2008–2012 will be carried out during the spring of 2006, in connection with the drawing up of a new Swedish National Allocation Plan (NAP) for 2008–2012.

Project-based mechanisms and the linking directive

JI and CDM differ from trading with emission allowances in that they are concerned with concrete projects for reducing greenhouse gas emissions from various plants and businesses, and are therefore referred to as project-based mechanisms. JI and CDM make it possible for one country to contribute to emission reductions in another country, and to credit the reductions against its own commitments. By investing in a project to reduce emissions in a country having lower costs than the country of the first part, the whole becomes cost-efficient. In addition to reductions in emissions of greenhouse gases, the project-based mechanisms also contribute to important technology transfer and capacity building in the recipient countries. Such projects are expected to contribute to modernisation and improving the efficiency of industry and the energy sector in the host countries. In accordance with the Protocol, CDM projects are intended also to contribute to sustainable development.

The Clean Development Mechanism (CDM) is the one operative at present, as the CDM agreement in the Marrakech Accord included a 'prompt start' facility. Under this, an international Executive Board (EB) has been appointed to approve, register and monitor CDM projects. As a result of the Board's activities, a number of detail regulations for CDM projects have been successively developed. JI is not covered by the prompt start arrangement, as it is dependent on the various countries allocated emission allowances being established, which will be the case when the first commitment period starts in 2008. JI includes two tracks[28]. An international Supervisory Committee (SC) for JI Track 2 will be established during the first meeting with the parties to the Kyoto Protocol.

Negotiations on climate cooperation for the period after 2012 started at the first combined convention and protocol members' meeting (COP/MOP 1) in Montreal in December 2005. The aim is to increase participation by bringing large developing countries such as China, India and Brazil into the process, as well as bringing the USA back.

The EU linking directive links the Kyoto Protocol's project-based mechanisms to the EU Emission Trading Scheme (EU-ETS). This means that companies in the trading sector in the EU can be credited with emission reductions from JI and CDM projects. Emission reductions from CDM projects[29] are included in the EU-ETS right from the start, while emission reductions from JI projects[30] will be included in the trading scheme from and including 2008. This is because each country must first have been allocated its emission allowances in accordance with the Protocol[31], which will not be done before 2008. The facility for crediting the results of JI and CDM projects means that there will be a greater number of emission allowances in the EU-ETS than were originally assigned. Nevertheless, environmental benefits are guaranteed, as the greater number of allowances will be compensated by measured real emission reduction. Member states will be required to set a limit to the extent that companies may use CDM and JI to meet their targets.

Swedish climate strategy

Swedish climate strategy has been progressively developed since the end of the 1980s through decisions made within the frameworks of environmental, energy and transport policies. A central element in this strategy is provided by Sweden's signing and ratification[32] of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

Sweden's international commitments became binding in 2002, when Parliament decided to ratify the Kyoto Protocol. Under the terms of the Protocol and the EU burden sharing agreement, Sweden's emissions over the period 2008–2012 may not exceed 104% of the country's emissions in 1990. At the same time, Parliament set the country's national climate strategy[33], with short-term and long-term national objectives. In the short term, the national climate objective requires a reduction of Swedish emissions of greenhouse gases over the 2008–2012 period to 96% of the 1990 emission levels. This objective differs from the EU burden sharing agreement in not being legally binding, but representing a target set by Sweden for itself. In addition, this national objective is to be achieved without using carbon uptake in carbon sinks or through flexible mechanisms. The longer-term climate objective requires Sweden to work towards a stabilisation of atmospheric greenhouse gas concentrations at a level less than 550 ppm[34] carbon dioxide-equivalents. By 2050, Sweden's total emissions should be less than 4.5 tonnes of carbon dioxide-equivalents per year and per inhabitant, to be followed by further reduction. However, it must be borne in mind that Sweden is responsible for only a very small proportion of total global greenhouse gas emissions, and so international cooperation is absolutely vital in attempts to stabilise atmospheric greenhouse gas concentrations.

Swedish measures to reduce climate impact, together with the country's national objectives, are to be constantly monitored and evaluated. Check point report

[28] Joint implementation can be carried out in two ways, known as JI Track 1 and JI Track 2. JI Track 1 projects require the host country to have prepared a national system for emissions recording, together with a national registry, which is not necessary for JI Track 2 and CDM. The two procedures are monitored by international boards; the CDM Executive Board and the JI Supervisory Committee.

[29] CER, Certified Emission Reductions

[30] ERU, Emission Reduction Units

[31] Under the terms of the Protocol, each country is assigned a certain quantity of emission allowances, known as Assigned Amount Units (AAUs), equivalent to the country's permitted emissions for the commitment period concerned. ERUs are converted AAUs.

[32] Ratification represents approval of an international agreement, which thereby becomes binding.

[33] Bill no. 2001/02:55

[34] ppm (parts per million) describes the concentration of a substance.

dates were set for 2004 and 2008. In the 'Check point 2004' report, the Swedish Energy Agency and the Environment Protection Agency[35] proposed that the Swedish national climate objectives should involve that the sum of the assigned quantity of emission allowances to the trading sector, together with the actual emissions from other sectors, must be less than 96% of 1990 emissions. The results from the 'Check point 2004' report evaluation provide a basis for the Climate Bill which is expected to be put before Parliament early 2006.

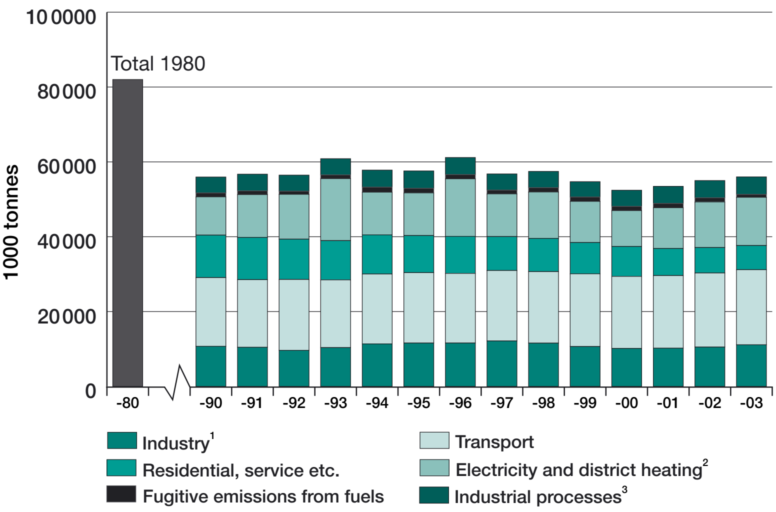
Sweden's climate work is also affected by the country's membership of the EU, in such ways as through the European Climate Change Programme (ECCP) strategy, of which the most important policy measure for reducing total emissions within the EU is that of emissions trading. Other important planks of EU strategy include the Directive for the Promotion of Alternative Motor Fuels (2003/30/EC), the Directive Concerning the Promotion of Electricity Produced from Renewable Energy Sources (2001/77/EC), and the Directive Concerning the Energy Performance of Buildings (2002/91/EC).

In addition to its EU cooperation and its national work on reducing greenhouse emissions, Sweden is also engaged in international climate cooperation. It is involved in the work with the Kyoto Protocol's project-based mechanisms in order to obtain experience of them and to contribute to further development of the mechanisms into effective instruments of climate policy. The Swedish Energy Agency has been instructed by the Government to develop and carry out CDM and JI projects, and has been responsible since 2002 for the Swedish International Climate Investment Programme (SICLIP). Sweden has approved funding of SEK 160 million for projects within the SICLIP framework.

The objective for CDM is to put together a geographically balanced portfolio, concentrating on small-scale projects within the category of renewable energy sources. The Swedish Energy Agency has now entered into agreements concerning the purchase of emission allowances from four projects; three in Brazil and one in India. A further project, in China, is being prepared at present. As far as JI projects are concerned, Sweden has signed bilateral agreements with Romania and Estonia, and is negotiating agreements with Bulgaria and Russia. So far, the Agency has entered into a purchasing agreement for a Romanian project.

The Agency is also the official Swedish Designated National Authority and Focal Point[36] with responsibility for authorising Swedish companies and organisations wishing to participate in project-based mechanisms, and is also responsible for formally assessing and approving climate investment projects involving the purchase of emission reduction units.

Figure 2: Carbon dioxide emissions in Sweden, 1980, 1990–2003



SOURCE, 1980: SCB, STATISTICAL NOTICES NO. 18.
SOURCE, 1990–2003: SWEDEN'S REPORT TO THE UN CLIMATE CONVENTION, ENVIRONMENT PROTECTION AGENCY, 2005.

Note: 1 including industrial back-pressure power production, 2 including coking plants and refineries, 3 including the use of solvents and products.

In total, Sweden's investments in CDM and JI projects up to 2012 are expected to result in emission reductions equivalent to 5 million tonnes of carbon dioxide-equivalents, at a specific price of about 5 öre/kg of carbon dioxide. This can be compared with the cost of quantitatively similar reductions in Sweden, at about 35 öre or more per kg of carbon dioxide. The projects are also cost-efficient in comparison with the EU trading system and its expected prices for emission allowances.

The Agency also participates in the Testing Ground Facility (TGF). This is a fund, of which the purpose is to finance shared JI projects in the Baltic states. The fund was established within the framework of the Baltic Sea Region Energy Cooperation (BASREC), which was in turn an already established regional energy cooperation scheme between eleven countries around the Baltic Sea. The member countries are assigned emission allowances from JI projects in proportion to their contributions to the fund. Sweden's contribution at present amounts to almost EUR 3.5 million, out of a total of EUR 15 million. It is also the intention that private companies can participate in the fund, which should then allow its capital to be doubled.

In addition, Sweden is a member of the World Bank Prototype Carbon Fund (PCF) which has now been operating for a few years, and has assisted the development of climate projects and their necessary regulatory framework. Sweden's share of PCF amounts to USD 10 million. So far, the fund has signed contracts for about 40 projects in both developing countries and transition economies. ■

[35] 'Check Point 2004', Swedish Energy Agency's and Environment Protection Agency's material for evaluation of Sweden's climate strategy.
[36] Designated National Authority (DNA) for CDM projects. Joint Implementation Focal Point (JIFP) for JI projects.

Policy measures and incentives

Several taxes and incentives have been introduced in order to achieve the objectives set out in the country's energy and climate policy: to increase the proportion of renewable energy, to improve the efficiency of energy use, to reduce the overall use of energy and to reduce emissions of carbon dioxide. The most wide-reaching mean of achieving energy policy objectives, and which is also intended to meet several of the objectives, is energy taxation, in the form of an energy tax as such, carbon dioxide tax and sulphur tax. Other important policy measures and incentives described in this chapter are the electricity certificate trading system, the energy efficiency improvement programme, technology procurement, information campaigns, emission trading and the climate investment programme. Research, development and demonstration projects constitute an important element of long-term development strategy.

Energy taxation

The original objective of energy taxes was to finance the State's public spending requirements, but in later years the emphasis has increasingly been on the need to control the production and use of energy in order to achieve various energy and environmental policy objectives. Present energy taxation policy is aimed at improving the efficiency of energy use, encouraging the use of biofuels, creating incentives for companies to reduce their environmental impact and creating favourable conditions for indigenous production of electricity. During the oil crises of the 1970s, the aim was to reduce the use of oil and increase the use of electricity. The environmental element of energy taxation was given greater importance at the beginning of the 1990s while, since Sweden's accession to the EU, there has subsequently been a need to bring taxation into line with EU requirements. The earlier Mineral Oils Directive and the associated Tax Rate Directive have been complemented by new minimum taxation levels as part of the process of harmonisation of taxation of fuels and electricity throughout the EU. A new Swedish taxation model is being developed at present, with the aim of constructing a coordinated and consistent taxation structure for business, while complying with EU competition and public subsidy rules.

The present energy taxation system is relatively complicated. There are different taxes on electricity and fuels, on CO_2 and sulphur emissions, and a levy system on NO_x emissions. The taxes can then vary, depending on whether the fuel is being used for heating or as a motor fuel, whether it is being used by industry, domestic consumers or the energy conversion sector and, in the case of electricity, what it is being used for and whether it is being used in northern Sweden or in the rest of the country. In 2004, revenues from energy taxes raised over SEK 63 500 million, making up about 10% of State revenue or 2.5% of GDP. (See Table 1).

Types of taxes and tax rates

'Energy tax' is an umbrella name for spot taxes on fuels and electricity. They can be roughly divided up into fiscal[37] taxes and those intended to achieve envi-

[37] The main purpose of a fiscal tax is to raise money for the State.

Table 1: Revenue from energy taxes after the 2004 Energy and Tax Act, SEK million

Energy carrier	Energy tax	CO_2 tax	Sulphur tax	Total
Petrol	14 334	11 046		25 380
Oil products	3 700	14 034		17 734
Unrefined tall oil	22			22
Other fuels	107	1 112		1 219
All fuels			93	93
Electricity	17 216			17 216
Electricity from nuclear power plants	1 860			1 860
Total	**37 239**	**26 192**	**93**	**63 524**
Proportion of national tax revenue				10.0%
Proportion of GDP				2.5%

SOURCE: NATIONAL TAX BOARD, NATIONAL FINANCIAL MANAGEMENT AUTHORITY, STATISTICS SWEDEN (SCB)

Table 2: General energy and environmental taxes as at 1st January 2005, excluding VAT

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax öre/kWh
FUELS					
Gas oil, SEK/m^3, (< 0.05% sulphur)	735	2 609	-	3 344	33.6
Bunker oil, SEK/m^3, (0.4% sulphur)	735	2 609	108	3 452	32.6
Coal, SEK/tonne, (0.5% sulphur)	313	2 270	150	2 733	36.2
LPG, SEK/tonne	144	2 744	-	2 888	22.6
Natural gas, SEK/1000 m^3	238	1 954	-	2 192	21.9
Unrefined tall oil, SEK/m^3	3 344	-	-	3 344	34.1
Peat, SEK/tonne, 45% moisture (0.3% sulphur)	-	-	50	50	1.84
MOTOR FUELS					
Petrol, unleaded, env. class 1, SEK/l	2.8	2.1	-	5.0	54.8
Diesel fuel, env. class 1, SEK/l	1.0	2.6	-	3.6	36.6
Natural gas/methane, SEK/m^3	-	1.1	-	1.1	11.1
LPG, SEK/kg	-	1.4	-	1.4	10.6
ELECTRICITY USE					
Electricity, northern Sweden, öre/kWh	19.4	-	-	19.4	19.4
Electricity, rest of Sweden, öre/kWh	25.4	-	-	25.4	25.4
ELECTRICITY, GAS, HEAT OR WATER SUPPLY					
Northern Sweden, öre/kWh	19.4	-	-	19.4	19.4
Rest of Sweden, öre/kWh	22.8	-	-	22.8	22.8
ELECTRIC BOILERS, > 2 MW, 1/11-31/3					
Electricity, northern Sweden, öre/kWh	21.8	-	-	21.8	21.8
Electricity, rest of Sweden, öre/kWh	25.4	-	-	25.4	25.4
INDUSTRY					
Electricity, industrial processes, öre/kWh	0.5	-	-	0.5	0.5

SOURCE: NATIONAL TAX BOARD, SWEDISH ENERGY AGENCY'S PROCESSING

ronmental objectives. This latter group of taxes includes the carbon dioxide and sulphur taxes, while the general energy tax is essentially a fiscal tax. However, there is no hard and fast boundary between the types, as both groups have an environmental effect as well as a fiscal function. The general energy tax, which has existed for several decades, and with varying purposes, is levied on most fuels, and is not dependent only on their energy content (see Table 2). The carbon dioxide tax, which was introduced in 1991, is levied on the emitted quantities of carbon dioxide from all fuels except biofuels and peat. In 2005, the general level of carbon dioxide tax is 91 öre/kg of CO_2. A sulphur tax was introduced in 1991, and is levied at the rate of SEK 30 per kg of sulphur emission from coal and peat, and at SEK 27/m^3 for each tenth of a percent of sulphur by weight in oil. Oils containing less than 0.05% of sulphur by weight are exempted from the tax. The environmental levy on the emission of NO_x was introduced in 1992, at a rate of SEK 40/kg of NO_x, on emissions from boilers, gas turbines and stationary combustion plant supplying at least 25 GWh per annum. However, it is intended to be fiscally neutral, and is repaid to plant operators in proportion to their energy production and in inverse proportion to their NO_x emissions, so that only those with the highest emissions are net payers.

Taxation to encourage greening

It was decided in the spring of 2000 that a total of SEK 30 000 million of taxation revenue should be transferred over a ten-year period. This means that

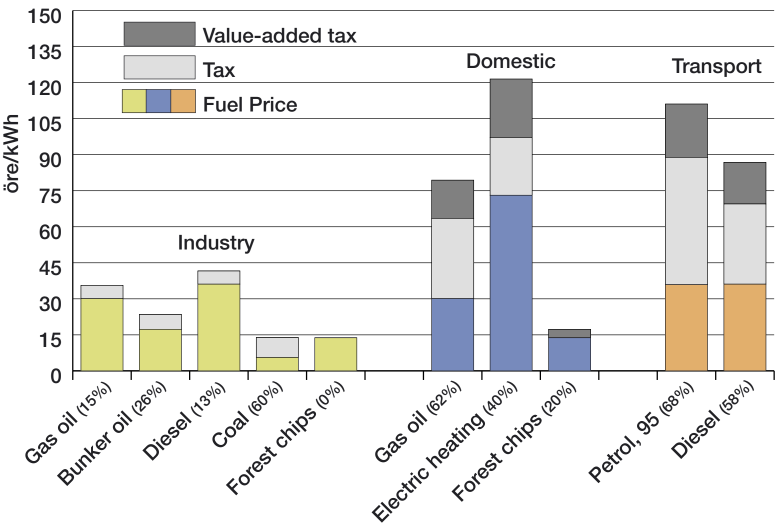
Table 3: Energy and environmental taxes for industry, agriculture, forestry, fisheries and heat production in CHP plants, as at 1st January 2005

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax, öre/kWh
Gas oil, < 0.05% sulphur, SEK/m³	-	548		548	5.5
Heavy fuel oil, 0.4% sulphur, SEK/m³	-	548	108	656	6.2
Coal, 0.5% sulphur, SEK/tonne	-	477	150	627	8.3
LPG, SEK/tonne	-	576	-	576	4.5
Natural gas, SEK/1000 m³	-	410	-	410	4.1
Unrefined tall oil, SEK/m³	548	-	-	548	5.6
Peat, 45% moisture, 0.3% sulphur, SEK/tonne	-	-	50	50	1.84

SOURCE: NATIONAL TAX BOARD, SWEDISH ENERGY AGENCY'S PROCESSING

Note: Manufacturing industry pays no energy tax, and only 21% of the general carbon dioxide tax. The carbon dioxide tax is also reduced for energy-intensive industries. Motor fuels are taxed in accordance with general energy and carbon dioxide taxes. With effect from 1st July 2004, electricity use in industrial manufacturing processes is taxed at a rate of 0.5 öre/kWh.

Figure 3: End-user prices of fuels for various customer categories in 2004, öre/kWh



SOURCE: SPI, STATISTICS SWEDEN, NATIONAL TAX BOARD, SWEDISH ENERGY AGENCY'S PROCESSING

Note: The proportion of the price made up of taxes is shown in brackets.

taxes on energy use and emissions are being increased, balancing a corresponding reduction in taxes on employment. Sweden's carbon dioxide emissions are to be cut, not least in order to comply with the country's commitments under the Kyoto Protocol. The main thrust of the changes for 2005 has been on the transport sector, with increases in the rate of taxation on petrol and diesel fuel. In addition, electricity tax for domestic and commercial users has also been raised: however, there was no further rise in the carbon dioxide tax for 2005.

In the Budget Bill for 2006, the Government proposes to transfer a further SEK 3 600 million, in the form of increases in taxation of light vehicles, electricity from nuclear power plants, natural gravel, waste disposed of in landfill and higher electricity taxes. All these changes are due to come into force on 1st January 2006. In addition, the Government has given notice of a tax on waste used for fuel, as well as on air travel. See the facts panel.

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. However, the use of electricity is taxed, at rates that vary depending on in which part of the country the electricity is used, and on what it is used for. Nuclear power plants were previously taxed on the basis of their electricity production, but since 1st July 2000 the tax has been based on the maximum thermal power rating of their reactors[38]. In addition, there is a levy of 0.15 öre/kWh for sometime decontamination and decommissioning of the country's previous nuclear facilities at the Studsvik research centre[39], and a further levy that amounts to about 1 öre/kWh for financing future storage facilities for spent nuclear fuel[40].

Fuels used for heat production pay energy tax, carbon dioxide tax and, in certain cases, sulphur tax, as well as the NO_x levy. The use of heat, however, is not taxed. In principle, biofuels and peat are tax-free for all users, although the use of peat attracts the sulphur tax. The taxation regime for simultaneous production of heat and electricity (cogeneration) has been changed with effect from 1st January 2004, so that the tax on the fuels used for heat production in such plants is taxed at the same rate as on these fuels when used in industry. However, that portion of the fuel which is used for electricity production receives a full rebate of energy and carbon dioxide tax, although that part of the fuel which is regarded as producing electricity for internal use is subject to full taxation.

38 The tax rate is SEK 5 514 per MW and calendar month. It is proposed that this tax rate should be increased to SEK 10 200 per MW and calendar month from 1st January 2006.

39 The Act (1988:1597) Concerning Financing of Handling of Certain Radioactive Waste etc.

40 The Act (1992:1537).

41 Fisheries cover the raising or cultivation of all types of animals and plants in water.

42 Energy tax is payable, however, on crude tall oil and electricity.

FACTS: Energy taxes in the 2005 Budget Bill

The 2005 Budget Bill (Bill no. 2005/06:1) proposes the following tax changes for 2006.

- Carbon dioxide tax on fuels used in industrial plants covered by the emission trading scheme no longer to be charged.
- Carbon dioxide tax on fuels used in cogeneration plants, covered by the emission trading scheme and having an efficiency of electricity production of at least 38%, and with an overall efficiency of at least 89%, no longer to be charged.
- Carbon dioxide tax on fuels used in other plants in the emission trading scheme to be reduced by an amount equivalent to 13 öre/kg CO_2.
- Energy tax on electricity used in the domestic and service sectors to be increased by 0.6 öre/kWh.
- Tax on the installed thermal power in nuclear power plants to be increased by 85%, i.e. to SEK 10 200/MW and month.
- The energy tax on electricity used for the supply of electricity, gas, heat or water to be raised so that it is equivalent to the level charged on electricity for use in the domestic and service sectors.
- Electricity used by electricity suppliers to be taxed.
- The higher rates of tax on electricity used in larger electric boilers during the winter to be removed.
- An increase in the property tax on hydro power plants from 0.5% to 1.2%. In addition, this tax to be temporarily increased by a further 0.5 percentage points to 1.7% between 2007 and 2011.
- Taxation of the fossil element of waste used as a fuel to be introduced within the framework of the existing energy taxation system.
- Increases in the rates of all energy and carbon dioxide taxes corresponding to changes in the consumer price index over the period June 2004-June 2005.
- In addition, the Bill proposes changes in the following transport-related taxes:
  - an increase in the rate of vehicle taxation on light buses and trucks
  - taxation on air travel
  - reduced rate of vehicle tax on heavy vehicles that fulfil certain exhaust emission quality requirements
  - vehicle tax for light vehicles to be changed to a carbon dioxide emissions basis
  - tax reductions for diesel vehicles having low particulate emissions.

Taxation at the point of use

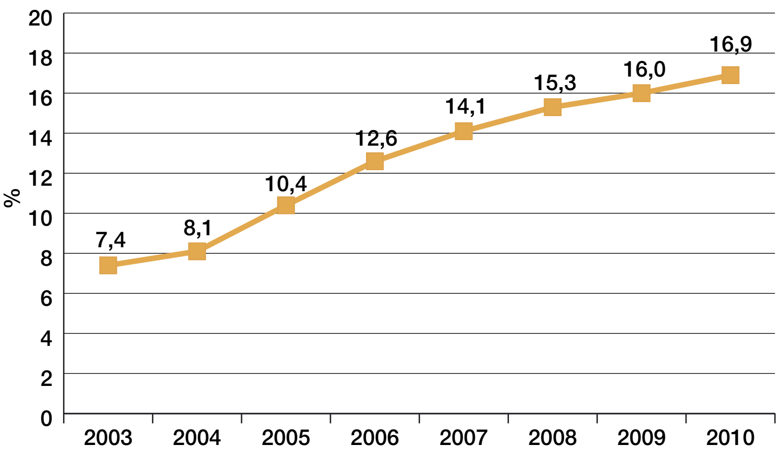
Manufacturing industry, horticulture, farming, forestry and fisheries[41] pay no energy tax on fossil fuels, and only 21% of the carbon dioxide tax[42]. There was no change in the carbon dioxide tax rate for these sectors in 2005. There are special rules for energy-intensive industrial activities, reducing that part of the carbon dioxide tax that exceeds 0.8% of the sales value of the products concerned. There are various tax levels for transport, depending on the environmental class of the fuel, which have resulted in reduced emissions of some pollutants. The tax on petrol was increased by 15 öre/litre, and that on diesel fuel by 30 öre/litre, for 2005. However, the carbon dioxide tax on diesel fuel used in farming and forestry machinery was reduced by SEK 2/litre (200 öre/litre). No energy tax is payable on the use of diesel fuel or fuel oils used in commercial maritime traffic or railbound traffic, or on aviation petrol or aviation paraffin. No energy tax or carbon dioxide tax is charged on ethanol, rapeseed oil methyl ester (RME) or biogas, while natural gas used in the transport sector pays no energy tax. 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, see Table 2. The final price paid by consumers depends largely on taxation. In addition to the various spot taxes on energy, there is value-added tax of 25%, which is not paid by industry. In 2004, the taxes paid by a consumer heating his house with gas oil accounted for 62% of the total cost, while only 20% of the cost for those who heated their houses with wood chips consisted of tax - and that was value-added tax only. For petrol, tax (including value-added tax) accounted for 68% of the total price (see Figure 3).

Electricity certificate system

Since the beginning of the 1990s, several different systems intended to support the production of electricity from renewable energy sources have existed. They have included investment subsidies for the production of electricity from biomass, wind power and small-scale hydro power, as well as what is known as the environmental subsidy for production of electricity from wind power. On 1st May 2003, a new support system for renewable electricity production was introduced, based on trading in electricity certificates for renewable electricity. During a transition period, the certificate trading system is being complemented by targeted support for wind power production in the form of the environmental subsidy which, in 2004, amounted to 12 öre/kWh for onshore production and 17 öre/kWh for offshore production, but which will be progressively phased out by 2009. However, the 2006 budget bill proposes that the environmental subsidy for wind power should be extended.

The aim of the certificate trading system is to bring a greater proportion of electricity production from renewable sources into the country's energy system,

Figure 4: Quota obligation requirement in the electricity certificate system, 2003–2010



SOURCE: THE ACT (2003:113) CONCERNING ELECTRICITY CERTIFICATES

Table 4: Number of plants, installed capacity and renewable electricity production in the electricity certificate system.

	Number of approved plants[1] (st)	Installed capacity (MW)	Renewable electricity production 2003[2] (MWh)	Renewable electricity production 2004 (MWh)
Hydro	1 027	489	963 637	1 968 207
Wind	610	467	455 642	864 546
Biofuel[3]	107	3 171	4 218 276	8 214 740
Solar	1	0.008	4	6
Total	**1 745**	**4 127**	**5 637 559**	**11 047 499**

SOURCE: SVENSKA KRAFTNÄT AND THE SWEDISH ENERGY AGENCY

Note: Total number of approved plants, 1st January 2005. [2] For the period May–December 2003. [3] For 2004, this also includes production from peat, amounting to about 520 GWh of electricity production.

Table 5: Market statistics for the electricity certificate system, 2003 and 2004

	2003[1]	2004
Average certificate price	200.81 kr/st	231.38 kr/st
Quota obligations	4 534 335	7 892 330
No. of certificates cancelled	3 489 984 st	7 832 352
Quota obligation fulfilment	77%	99%
Quota obligation revenue	SEK 183 million	SEK 14 million

SOURCE: SVENSKA KRAFTNÄT AND THE SWEDISH ENERGY AGENCY

Note: [1] For the period May–December 2003.

increasing it by 10 TWh between 2002 and 2010. All electricity users, with the exception of manufacturing processes in energy-intensive industries, are required to buy certificates corresponding to a certain percentage of their electricity use. The system is intended to reduce the production costs of such electricity, and thus increase its proportion in the long term, by creating competition between different types of renewable electricity production. In 2004, users had to buy certificates corresponding to 8.1% of their electricity use. This proportion will be progressively increased year by year, so that it will have reached 16.9% in 2010, by which time the trading system should have resulted in about an extra 10 TWh of electricity production from renewable sources (see Figure 4). Qualifying renewables are electricity from wind power, solar energy, geothermal energy, certain biofuels, wave energy and small-scale hydro power. With effect from 1st April 2004, electricity from peat has also qualified for certificates.

Table 4 shows the number of approved plants, installed capacity and renewable electricity production from each type. During 2004, the average price of electricity certificates was SEK 231, as shown in Table 5. The system covers only electricity produced in Sweden. Norway is at present planning to introduce an electricity trading certificate system, and is holding discussions with Sweden concerning a joint certificate market. An investigation of the expected consequences of a joint Norwegian/Swedish market has been carried out by the Swedish Energy Agency, and was reported to the Ministry of Industry and Commerce in January 2005. During 2004 the Agency also carried out a review of the electricity certificate system. In July 2005, the Ministry of Sustainable Development issued a DS, *A proposal for further development of the electricity certificate system*[43]. The Government is expected to submit a bill for amendment of the electricity certificate system to Parliament in spring 2006.

Programme for energy efficiency in energy intensive industry (PFE)

An energy tax on the electricity used in manufacturing industry was introduced on 1st July 2004, at a rate equivalent to the minimum required tax rate as set out in the Energy Taxation Directive[44]. This means that, where manufacturing industry previously paid a zero tax rate on electricity, it now pays an electricity tax of 0.5 öre/kWh. In June 2004, the Government put forward a bill setting out an energy efficiency improvement programme (PFE), which came into force on 1st January 2005[45]. Companies participating in the five-year programme can receive a full rebate of the energy tax on electricity that they would otherwise have

[43] Ds 2005:29
[44] Directive of the Council, 2003/96/EC.
[45] Energy efficiency improvement programme etc., Bill no. 2003/04:170.

had to pay. In return, they undertake to introduce, within the first two years, an energy management system and to perform an energy audit in order to determine their potentials for improving the efficiency of their energy use. A condition for participation in the programme is that, over the five-year cycle, companies must apply all the energy efficiency improvement measures that have been identified, and which have a payback time of less than three years. Another requirement for participation in the programme is that the company must be an energy-intensive company, as defined in the Energy Taxation Directive, i.e. it must fulfil one of the following criteria:

a) Its costs for the purchase of energy products must amount to at least 3% of its production value, or
b) The total energy, sulphur and carbon dioxide tax for the company must amount to at least 0.5% of its conversion value.

Through the energy management systems and energy audits that form part of the programme, companies will improve their awareness of their potentials for cost-efficient energy efficiency improvements. The underlying intention is that companies should improve their efficiency of electricity use by being relieved of the pressure of taxation that could have an adverse effect on their international competitiveness. The electricity efficiency improvement measures taken as a result of the programme are expected to give more or less the same effect as an energy tax of 0.5 öre/kWh would have done. During the spring of 2005, the Swedish Energy Agency approved 131 companies for participation in the programme. Of these 131 companies, most have entered more than one plant in the scheme. In total, they use about 30 TWh/year of electricity in their manufacturing processes, which means that they will now receive a total tax reduction of about SEK 150 million per year. Most of the companies are in the pulp and paper industry (47), the wood products industry (28) or the chemical industry (19). Other participants include companies in the food industry (11), the iron, steel and mining industry (16), the engineering industry and a few other sectors. The scheme is open to admission of more companies up to and including 2009.

Technology procurement

Technology procurement is a policy measure intended to encourage the development of a new technology. It should be seen as a process, rather than as a project, consisting of a number of phases (stages) and the involvement of several different types of parties. The first phase is a feasibility study, to investigate the potential for efficiency improvement and the feasibility of, or opportunities for, carrying out the procurement, followed by the formation of a purchaser group, production of a performance specification, sending out requests to tender, evaluation of received tenders and dissemination and further development.

Technology procurement is a complete tendering process, with the aim of encouraging and accelerating the development of new technology. As it involves a tendering procedure, it can be seen as a form of competition between manufacturers. When entries have been received, they are tested and evaluated by an independent party and one or perhaps more winners being announced. The winners are given assistance with the market introduction process, and are guaranteed a definite initial order quantity for the new product. In addition, the State provides information via the purchaser group, intended to extend awareness of the the winning technology.

Technology procurement can be seen as a policy measure intended to initiate market changes and to encourage the spread of new, efficient technology in the form of new products, systems or processes. Its main application areas are in the fields of heating and control systems, domestic hot water and sanitary systems, ventilation, white goods, lighting and industry. The Swedish Energy Agency has prepared a list[46] of all technology procurement projects within the energy field that have been carried out by it and by its forerunners. Since the 1990s, 55 different technology procurement projects have been initiated and partly financed. Current technology procurements include demand-controlled ventilation in new apartment buildings, control and monitoring systems for properties, climate screen-integrated systems for solar shading and daylight penetration, industry-standardised information in the sawmill industry, and biogas-powered and hybrid vehicles.

Information activities

The fact that knowledge and understanding affect how we act in given situations when decisions are required means that information campaigns and activities occupy an important and central part among the policy measures available to the State. The part played by information and training is partly to provide knowledge as needed for specific decisions, and partly to increase general awareness of the relationship between energy use and cost, the environment and social aspects. The target groups for information are broad, ranging from energy managers in industry, through such as building contractors and house-owners to those still at school, in the secondary stage and upwards. The existing level of knowledge, and thus the need for information, varies among the various target groups. The potential for improving the efficiency of energy use in industry, for example, is substantial and, in the short term, it is not a lack of new technology that causes the problem, but rather

[46] This list can be downloaded from the Agency's website, www.stem.se

the fact that good and existing technology is not used. In residential buildings and commercial premises, there is a strong link between energy use and the comfort and air quality requirements of the buildings' occupiers.

In the wider perspective of state energy policy, the Swedish Energy Agency is a central provider of information, using many different channels and working with a large number of different parties in order to ensure that information reaches its target groups. One of the more important of these tools is the Agency's website, www.stem.se. Local authority energy advisors constitute a unique network, financed by the Agency, and available in all local authority districts throughout the country. They provide the general public, small companies and organisations with impartial advice, tailored where appropriate to local conditions. The local authority energy advisors are, in turn, backed up by regional energy offices that provide training and coordinate information activities.

Energy research, development and demonstration

In its Budget Bill for 2005[47], Parliament decided on the new long-term programme concentrating on research, development and demonstration activities, with the aim of developing technologies and processes as needed for the long-term objective of transition to a sustainable energy system. This decision means that the objectives of the programme have been expanded, relative to the previous programme, and that the Swedish Energy Agency is given responsibility for administering the entire programme – from support for fundamental research to measures intended to assist the market introduction of new energy technology. The new programme phase puts incresed emphasis on efforts intended to convert the results of energy related research and development activities to commercial products.

The overall objective of the Agency's research, development and demonstration activities is to develop cost-effective energy systems based on renewable energy sources, and to develop system solutions for more efficient use of energy. A holistic approach is important, and special efforts are made to cover the relationships between man, technology, economics and the environment.

The research is structured in six theme areas: *Energy System Studies, Fuel-based Energy Systems, Transport, The Power System, Energy-intensive Industry and The Built Environment.*

Research in the field of **energy system studies** is aimed at improving knowledge of, and competence in, energy systems and international climate policy. Scientists working in these fields, together with their results, constitute important resources for the provision of background material for decisions related to energy and climate policy. Research is concerned with working areas such as energy and climate-related policy measures, the way in which energy markets work, energy-related climate issues, local and regional energy issues, behavioural science and acceptance considerations, as well as areas such as innovation and implementation factors etc.

The **fuel-based energy systems** theme area concentrates on research and development of sustainable biomass fuel production and energy conversion, with the main emphasis on biomass-based systems. Research in the area is intended to contribute to reduced production costs and to utilising a greater proportion of the overall production potential. Sweden is one of the world's leading countries in terms of the production and use of solid processed forest-based fuels, such as pellets. Heating and combined heat and power production are being investigated in order to acquire knowledge that can be used to improve the efficiency of established technologies and to introduce new, more efficient technologies with improved performance.

The **transport** theme area includes research and development of biobased motor fuels, combustion engines and electrical drive systems. Looking ahead, biobased motor fuels should make a valuable contribution to replacing fossil fuels in the transport sector. In the longer term, improvements in combustion engines and electrical drive systems should result in substantial reductions in the fuel consumption of cars and of heavier vehicles. Research into electrical drive systems is concentrated on electrical and hybrid vehicles, and on fuel cells.

The **power system** theme area includes hydro power, wind power, solar cells, wave power, power transmission and energy storage. Training and acquisition of experience are important working areas for future modernisation of existing hydro power production facilities. Research into wind power is aimed at creating the right conditions for increasing the proportion of the country's power supply by wind, and for reducing its cost. The Swedish Energy Agency is also running pilot projects for offshore and alpine wind power production. Research and development in the field of solar cells are concentrated on thin film solar cells and nano-structured cells, as well as on integration, installation and use in buildings. Research into power transmission systems and energy storage systems is concentrated on creating a safe and efficient system suitable for supporting new technologies and means of production, which are expected to be increasingly employed.

The **energy-intensive industry** theme area gives

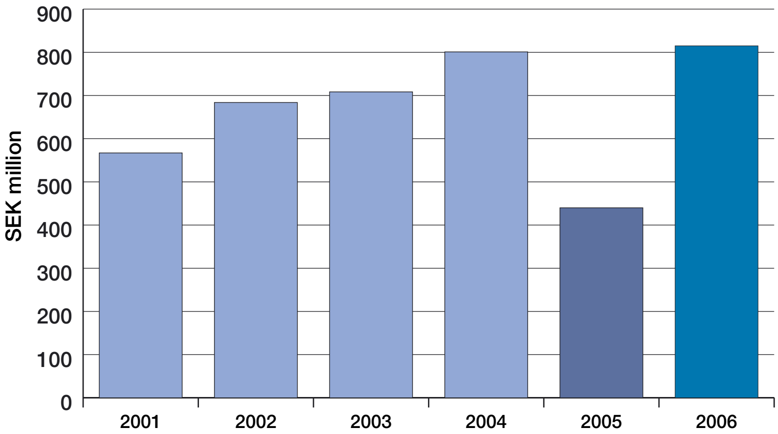
47 Bill no. 2004/05:1, 2004/05 Standing Committee on Economic Affairs (3), Parliamentary Communication 2004/05:120

priority to improvements in the efficiency of energy use, particularly for energy-intensive process stages in the pulp and paper industry and in the steel industry. Gasification of black liquor can provide the forest products industry with a fuel for additional electricity production capacity, and may also provide a means of motor fuels production.

The **energy use in the built environment** theme area includes the supply and distribution of heating, electricity for domestic and building services systems and the underlying design and operation of building services systems. The objective of research into the performance of buildings as climate screens is to achieve substantial improvements in the efficiency of specific energy use for heating, domestic hot water and building services systems. Work in the field of building services systems is concentrated on several different technology areas, such as small-scale combustion of biomass fuels, district heating and district cooling, heat pumps, solar heating and buildings as energy systems.

The Swedish Energy Agency attaches particular importance to the development of three larger bioenergy-related pilot plants, covering the entire chain from research to demonstration. A pilot plant for ethanol production is being built in Örnsköldsvik, while a shut-down gasification plant in Värnamo is to be recommissioned and expanded. This work is being carried out by the Agency in conjunction with industry, with the aim of producing motor fuels from renewable sources in order to replace the use of fossil fuels in the transport sector. Such facilities are regarded as important, when seen against the background of Sweden's favourable conditions for the production of bio-sourced motor fuels from forest raw materials. The Agency is also working with industry in supporting a pilot plant for black liquor gasification in Piteå. Black liquor gasification in the pulp industry would improve the efficiency of chemicals recovery and efficiency of energy processes. Investigations have shown a potential for about 10 TWh/year of electricity production in Sweden through this process. Alternatively, it could be used to produce motor fuels capable of meeting up to about 30% of the present demand for fuels in the transport sector.

Figure 5: Funding for research, development and demonstration activities



SOURCES: THE SWEDISH ENERGY AGENCY'S ANNUAL REPORT, 2004, OFFICIAL DOCUMENT PLACING APPROPRIATIONS AT THE DISPOSAL OF THE SWEDISH ENERGY AGENCY FOR EXPENDITURE AREA 21, ENERGY, FOR BUDGET YEAR 2005, AND BUDGET BILL 2005/06:1

Note: For 2001–2004, the figure refers to approved funding. For 2005 the figure shows appropriations and for 2006 proposed appropriation. The information given is thus not directly comparable between the years.

Emission trading

See chapter 1, Climate policy.

The climate investment programme (Klimp)

The Swedish climate investment programme (Klimp) has run since 2003, and is to some extent a continuation of the local investment programmes (LIP). LIP was a programme under which grants amounting to about SEK 4700 million were awarded between 1998 and 2002 covering all environmental aspects. Klimp provides grants for local authorities and other parties to make investments in measures intended to reduce the emission of greenhouse gases, provide energy savings or represent interesting new technology that can contribute to these objectives. These grants are also available to companies, although they must relate to measures undertaken in more than one Swedish county.

A total of SEK 1040 million has been assigned for Klimp for the period 2002–2006. During the first two tranches of grants in 2003 and 2004/05, SEK 810 million were assigned to 47 programmes, comprising 389 individual projects, mainly in connection with the transport and energy sectors. Grants were also made to six special projects. The 47 programmes cover measures in about 70 of the country's local authority areas, and are expected to result in a reduction in greenhouse gas emissions of about 365 000 tonnes of carbon dioxide-equivalents per year. In addition, they should reduce energy consumption by 570 GWh/year. Experience from LIP shows that bout 75% of the approved projects are actually carried out.

In September 2005, the Government and its two supporting parties proposed that the Klimp grant for 2006 should be increased by SEK 200 million, to a total of SEK 327 million. In addition, it is proposed that the programme should be extended, to provide SEK 320 million/year in both 2007 and 2008. ■

Figure 6: Energy supply and use in Sweden, 2004, TWh [1]

1 Preliminary statistics. Due to rounding of figures there may be differences in the totals.
2 Heat pumps are large heat pumps as used in the energy sector. Input energy for the energy system relates to heat production, 6.4 TWh. Heat collected from the surroundings amounted to over 4.6 TWh, with 1.8 TWh of electrical drive energy input.
3 Nuclear power energy quantities are gross, i.e. as gross fuel energy in accordance with UN/ECE guidelines.
4 Net import of electricity is treated as supply.
5 Use of oil for transport also includes ethanol, amounting to about 1.6 TWh.

SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY.

Sweden’s energy balance

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

The balance is based on statistics from Statistics Sweden (SCB). The statistics are definitive for the period 1970–2002: for the years 2003-2004, they are provisional, and may therefore be changed when SCB has processed additional material.[48]

Figure 6 shows (aggregated and simplified) Sweden’s energy system in terms of the energy flows from supply to final use. Energy is supplied in order to meet users’ demand for energy, which in turn depends on their needs in terms of functions such as lighting, heating, cooling, computer processes etc. It is this use that determines the amount of energy in the form of electricity, heat etc. that needs to be produced. Energy use, as shown in the figure, consists of the total final use, i.e. the use of energy in the residential and service sectors, industry and transport, together with losses, international maritime transport and energy materials used for non-energy purposes. The figure does not show losses that occur in the final energy use stage. Most of the losses shown in the diagram are made up of the thermal energy that is of necessity removed by cooling when producing electricity in nuclear power stations. Other losses include conversion losses in energy plants[49], transmission losses in connection with the supply of electricity, district heating, natural gas and town gas, coke oven and blast furnace gas. However, they do not include the losses in hydro power production. The use of energy products for non-energy purposes is made up of raw materials for the plastics industry, lubricating oils and oils used for surface treatments in the building and civil engineering sectors (asphalt and binders). Sweden’s total energy supply consists of its net import (the difference between imports and exports) of energy carriers such as oil, natural gas, coal and electricity. To this must be added changes that occur in storage, together with the indigenous supply of biofuels, hydro power, heat from rock, lakes, air and the ground to heat pumps, and fuel rods for nuclear power production.

Total energy use

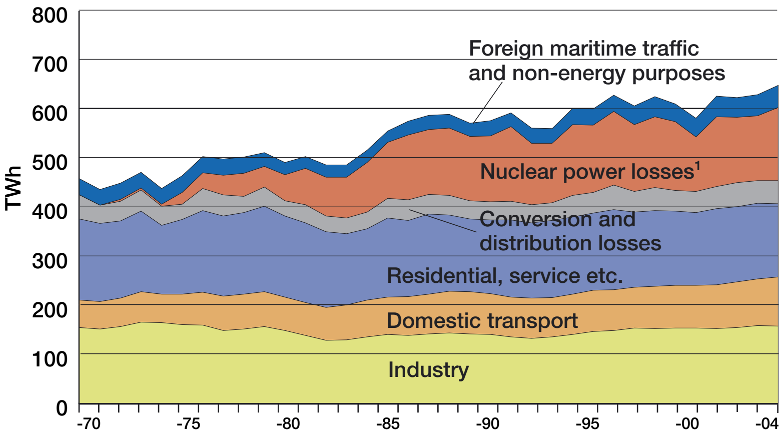
Total energy use in 2004 amounted to 647 TWh. Of this, total final energy use made up 405 TWh, and conversion and distribution losses made up 197 TWh, of which 149 TWh were in nuclear power production. Bunker oils for foreign maritime transport, together with the use of energy products for non-energy purposes, accounted for a further 45 TWh.

Industry, and the residential and service sector, both use more or less the same amount of energy now as in 1970. However, much has changed: the total heated floor area of commercial premises, for example, is greater, population numbers have risen by about 11%, and industrial production is considerably higher than it was in 1970. The move away from oil to electricity as an energy source/carrier has ’transferred’ some of the losses to the supply side of the energy system: see ’System boundaries’ below. However, total energy use by the transport sector (excluding foreign maritime traffic) has increased by 79% since 1970. For the industrial sector, variations in energy use from one year to another are due mainly to economic conditions, while for the residential and service sector they are partly due to differences in the climate from one year to another.

48 This means that there are differences between the statistics in this year’s edition of Energy in Sweden in comparison with those given for 2002 and 2003 in last year’s edition. In the same way, statistics given here for 2003 and 2004 may be changed in next year’s edition of Energy in Sweden.

49 In this context, energy plants are those that produce electricity and/or heat, refineries, gas works, coking plants and blast furnaces.

Figure 7: Total energy use in Sweden, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

1Calculated in accordance with the UN/ECE method for energy supply from nuclear power.

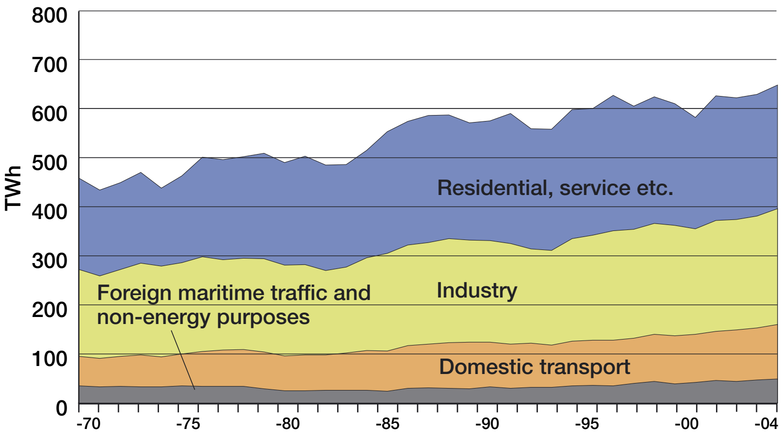
Energy use in the various sectors shows that electricity and district heating are the most important energy carriers for the residential and service sector, that electricity and biofuels are the most important for industry, and that oil products totally dominate energy use in the transport sector.

System boundaries

The concept of system boundaries provides an aid for analysing the country's energy system. Since 1970 the demand for energy[50] has increased by 8%, from 375 TWh to 405 TWh. However, over the same period, total energy supply has increased by no less than 42%, from 457 TWh to 647 TWh. Why is the supply of energy increasing over six times more rapidly than the demand for energy? The answer to this lies in the fact that both the industrial and the residential and service sectors have carried out a major shift away from oil to electricity as the main energy carrier. Although electricity is a very efficient energy carrier as far as users are concerned, it is generally associated with major losses on the production side. As a result, much of the conversion losses were transferred from the end-users to the supply side of the energy system. These losses are not shown as part of the end-users' demand, but as an item of their own. Losses occur, for example, in electricity production, in the production of district heat and in refineries. By assigning all the losses proportionally to the use of electricity, district heating and oil products in the user sectors, we obtain an alternative picture of the development of energy use in the various end-user sectors. Figure 8 shows such an assignment of losses, based on exactly the same statistics as shown in Figure 7, but with the difference that the losses are not shown on their own in Figure 8. The difference between the way in which the information is shown in the two figures is due to where we set the system boundary. If the boundary is set at the factory gate, or at a residential building wall, we obtain a result as shown in Figure 7. If, on the other hand, the boundary is set where the electricity, district heating or oil products are produced, we obtain Figure 8. Other system boundaries can also be considered[52].

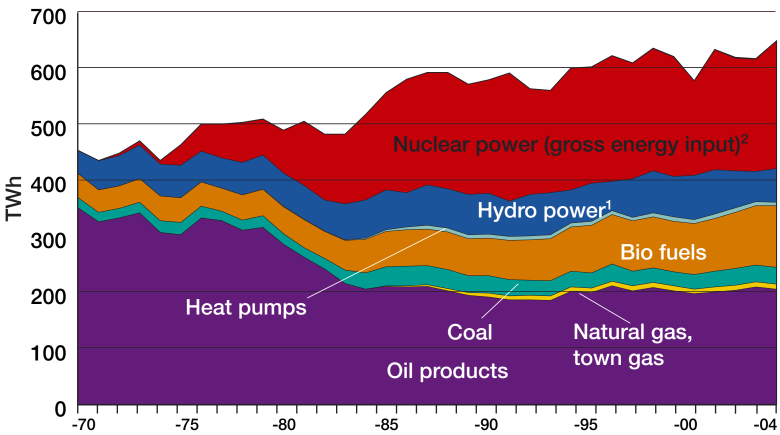
[50] In this context, 'demand for energy' means total final energy use.
[51] Calculated in accordance with the UN /ECE method, which means that the energy conversion losses in nuclear power stations are included.
[52] Source: All or nothing – system boundaries for heating of buildings (in Swedish – Allt eller inget – systemgränser för byggnaders uppvärmning.) www.stem.se – Energy supply – Heat production.

Figure 8: Energy use in various user sectors, 1970–2004, with the conversion sector losses apportioned to the end-users



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 9: Energy supply in Sweden, 1970–2004, excluding net electricity export



Source: Statistics Sweden; additional processing by the Swedish Energy Agency

[1] Includes wind power up to and including 1996. [2] Calculated in accordance with the UN/ECE method for energy supply from nuclear power.

Total energy supply

Sweden's total energy supply in 2004 amounted to 647[51] TWh, excluding a net export of about 2 TWh of electricity (see Figure 9.) The greatest proportions of energy supply were met by oil and nuclear fuel, followed by biofuels and hydro power. Since 1970, the make-up of energy supply has changed. The supply of crude oil and oil products has fallen by over 40%, while the net production of electricity has increased by over 250% as a result of the construction of nuclear power stations and expansion of hydro power production. The supply of biofuels has more than doubled. During the 1980s, local authority energy utilities installed large heat pumps for supplying district heating. In the middle of the 1980s, natural gas was brought to towns along the west coast, while wind power construction started in the middle of the 1990s. Nuclear power used 227 TWh of fuel energy input in 2004, to produce 75 TWh of electricity. Hydro power produced about 60 TWh of electricity, a little less than the 65 TWh of a climatically statistically average year. Hydro power production varies widely, depending on the amount of precipitation during the year. Fuel-based thermal power production produced 12.9 TWh of electricity, while wind power supplied 0.8 TWh. About 54 TWh of fuels were used for district heating production. 26% of the country's energy in 2004 was provided by renewable energy sources. ■

Energy use

Modern society is very dependent on energy: for heating and cooling, for lighting and domestic equipment, for travel and for the production and distribution of goods and services. The amount of energy used is affected by many factors, including economic conditions, technical development, prices and policy measures and incentives employed in energy and environmental policy. The use of energy can be divided up into three sectors: the residential and service sector etc., industry and transport. This chapter describes energy use in 2003/2004, against the background of developments in energy use since 1970

The residential and service sector etc.

In 2003, energy use in this sector amounted to 153.7 TWh, which was about 0,4 TWh more than during the previous year, and represented about 38% of Sweden's total final energy use. According to preliminary data, corresponding energy use in 2004 amounted to 148.8 TWh. The residential and service sector consists of residential premises, commercial premises and public buildings (excluding industrial premises), holiday homes, land use, and other service activities, which include the construction sector, street lighting, sewage treatment plants and waterworks.

About 86% of energy use in the residential and service sector is used in residential and commercial/public premises, where it provides space heating and domestic hot water and powers appliances and building services systems. Energy used in land use applications accounts for about 5% of total energy use in the sector; holiday homes account for another 2%, and other service applications for 7%.

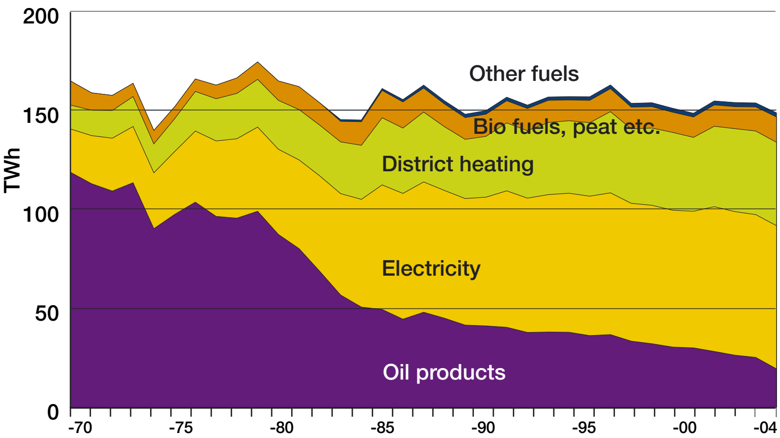
Over 60% of the energy use in the sector is used for space heating and domestic hot water production. As this is affected by temperature conditions, there can be considerable variations in energy demand from one year to another. To enable proper comparisons to be made, it is necessary to correct for climatic conditions in order to arrive at a statistically average year regarding the climatic conditions[53]. 2003 was somewhat warmer than a statistically average year, so that the amount of energy used for space heating and hot water was about 4% less than normal. After applying such correction, energy use in the sector in 2003 amounted to 156 TWh, which is 2% less than in the previous year. The heating energy requirement in 2004 was about 6% less than in a statistically average year, with a preliminary usage figure of about 152 TWh. The number of dwelling units (single-family houses and apartments in apartment buildings) in the country increased by almost 40%, to about 4.4 million, between 1970 and 2004. However, the rate of new building during the 1990s was very low, amounting on average to 14 300 dwelling units per year. The rate of building picked up during the 2000s, to the extent that work started on 28 350 dwelling units in 2004. Floor areas of commercial premises increased substantially from 1970 until the beginning of the 1990s, but the rate of construction has fallen to very low levels in recent years.

From oil to electricity and district heating

The relative proportions of the different energy carriers have changed: see Figure 10. Oil crises, rising energy prices, changes in energy taxation and investment policies have all affected the shift from oil to other energy carriers. In 2003, total use of fossil fuels in the sector amounted to 27.3 TWh, as against 118.6

[53] With effect from 2003, the reference period for determining normal temperatures is from 1970 to 2000. Until 2002, this reference period was 1961/62 to 1978/79.

Figure 10: Final energy use in the residential and service sector, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

TWh in 1970. Much of this reduction is due to a move away from the use of oil for heating to electricity and district heating.

Although the population has risen, and heated floor area has increased, total energy use in the sector has remained relatively stable since 1970. The main reason for this is primarily because different energy carriers have different distribution losses and different conversion loss characteristics when used by consumers for heating. Electricity and district heating have lower losses at the consumer than have fuels such as oil. This means that if electric heating or district heating replace oil heating, the effect will be to reduce final energy use in the residential and service sector. However, at the same time, there will be an increase in losses in the conversion sector. (See also chapter 3 ’Total energy use – System boundaries’.)

A contributory reason is also the fact that there has been a considerable increase in the number of heat pumps in recent years. Their use reduces the actual use of energy for space heating and domestic hot water production in buildings. Heat pumps deliver 2–3 times as much thermal energy as they use in the form of energy for driving them. This ’free’ heat is not included in the statistics of the amount of energy used in the sector.

Other factors that have helped to prevent an increase in energy use for space heating and domestic hot water production in residential buildings and commercial premises include various energy conservation measures, such as retrofitting additional thermal insulation or upgrading windows in older buildings. While the use of energy for heating has decreased, its use for building services systems[54] and domestic purposes[55] has increased. Greater use of, for example, electric floor heating in buildings not otherwise having electric heating has contributed to this growth, in that this electricity is shown in the statistics as domestic electricity rather than as for electric heating. Technical development is steadily improving the efficiency of equipment – particularly white goods in the domestic environment – that replaces older products having higher energy consumptions. Commercial users constantly replace equipment, the energy efficiency of which is steadily improving, although this is countered by the general parallel increase in the number of items used. The low rate of new residential building during the 1990s can also be assumed to have helped slow the rise in energy use.

The use of electricity grew continuously from 1970 until the middle of the 1990s, stabilising at about 70 TWh in recent years. The corrected values for 2000 and 2001 showed an increase, but declined somewhat in 2002 and 2003. A contributory reason for this was the price of electricity, which was low in 2000 and 2001, but which rose in 2002 and 2003. The use of electricity has risen slightly in 2004, possibly because the high price of oil meant that those who could choose between the use of oil and the use of electricity for heating exercised this choice in favour of electricity. Electricity use is divided among electric heating, domestic electricity and electricity for building services systems. After correction, use of electricity for heating increased from 4.7 TWh in 1970 to 29 TWh in 1990, but has subsequently fallen, to 22.6 TWh in 2003.

Space heating and domestic hot water production

Of the 94.7 TWh that were used for space heating and domestic hot water production in residential and commercial premises[57] in 2003, it is estimated that about 42% were used in detached houses, 31% in apartment buildings, 2% in holiday homes and 25% in commercial premises and public buildings. Electricity used for such applications as floor heating and fan heaters – ’hidden’ electric heating – also contributes to the heating of a building, but is partly accounted for in the statistics as domestic electricity.

In 2003, over a third of all detached houses in the country were heated by electricity alone[58]. Approximately 17% of detached houses have only direct-acting electric heating, with a further 12% having water-borne electric heating. About 6% of detached houses are heated by oil alone, almost 8% by district heating[59] and about 5% by biofuels alone. Common heating systems in detached houses are dual-fuelled boilers, or such boilers in combination with direct electric heating. The proportion of detached houses with systems of this type was about 40% in 2003, with dual-fuelled boilers accounting for about 27% (of the total number of detached houses). These boilers allow households to change between electricity, oil and/or biofuels. They are therefore fairly flexible in their choice of fuel, with the selection being largely determined by the relative price levels of the different energy carriers. Other households, not having this ability quickly to change their energy carriers, are more vulnerable to changes in the relative prices. The main reason for the high proportion of electric heating is that it is cheap to install and simple to run. The use of electric heating increased substantially in the sector from 1970 to the middle of the 1980s, after which a slight decline began in its use in detached houses. The total use of electricity for space heating and domestic hot water production in detached houses in 2003 amounted to 15,8 TWh.

District heating is the commonest form of heating in apartment buildings, with about 77% of apartments being heated by it in 2003[60], equivalent to a use of about 23 TWh. Oil is used as the sole heat source for 4% of apartments, and as a partial heat

54 *Operational electricity* is a statistical combination of *electricity for building services systems* and *business electricity. Electricity for building services systems* is used for the building’s in-built equipment for internal climate control, as well as for lifts, escalators and lighting in common areas. *Business electricity* is used for the activity carried out in the building, such as for computers, office equipment and lighting.
55 *Domestic electricity* is the electricity that is used for lighting, white goods, domestic appliances and other electrical equipment in a home.
56 i.e. corrected for a statistically average climate year.
57 Excluding industrial premises.
58 If larger heat pumps that are used in combination with some other form of heating are included, this proportion rises to over 40 %.
59 District heating in combination with some other form of heating in detached houses accounts for about 0,4 TWh. Including them means that about 9 % of detached houses use district heating for heating.
60 In addition, distric heating is used in combination with other forms of heating for 5% of the area.

source for another 8%, equivalent to 2.4 TWh of oil. The use of electric heating in apartment buildings is relatively low, amounting in 2003 to 2.1 TWh.

The main source of heat in offices, commercial premises and public buildings is also district heating, with about 60% of such buildings being supplied solely with district heating, and a further 8% being partly heated by it, equivalent to 15.3 TWh. The use of electricity for space heating and domestic hot water production in commercial premises amounted to 3.9 TWh, while 3.2 TWh of oil were also used for this purpose.

Domestic electricity and electricity for building services systems

The use of electricity for domestic purposes[54] doubled between 1970 and 2003, from 9.2 TWh to 20.1 TWh. Although most of this increase occurred during the 1970s and 1980s, it has continued over the last few years. This rising use can be explained by an increase in the number of households, greater ownership of domestic appliances and greater ownership of electronic equipment. To some extent, it can also be explained by an increase in the 'hidden' use of electric heating. In 2003, average domestic electricity use amounted to about 6 100 kWh in detached houses, and in apartment buildings to about 40 kWh/m^3 [61] and year which, for a 75 m^3 apartment, means an annual electricity use of 3 000 kWh/year. To refine this data, the Swedish Energy Agency is carrying out a metering investigation over the period 2005–2007, to break down electricity use into more detailed purposes.

The use of electricity for building services systems[53] has increased substantially, from 8.4 TWh in 1970 to 30.2 TWh in 2003. The reasons for this development include rapid growth in the service sector and greater use of office machines. The high growth rate of private and public services has also resulted in a relatively substantial increase in the total floor area of offices and commercial premises, which has increased the need for lighting and other services. Lighting and ventilation which, at the beginning of the 1990s, accounted for about 70% of the use of electricity in building services systems, have become more efficient as a result of improved light sources, more sophisticated operational control and correct sizing of systems at the time of installation. Never-the-less, there is still regarded as being considerable potential for further improvements in the efficiency of electricity use in offices, commercial premises and public buildings.

Industry

In 2004, industry used 0.5 TWh less energy than during 2003, amounting to 157.4 TWh, or 39% of the country's final energy use. Classified by energy source/carrier, industry's use of energy was met by 21.8 TWh of petroleum products, 14.9 TWh of coal and coke and 56.0 TWh of electricity. Use of natural gas amounted to 4.2 TWh, and that of district heating to 5.3 TWh. The use of biofuels, peat etc. amounted to 52.6 TWh: (see Figure 12). Final energy use in industry therefore consisted of 28% of fossil energy and 32% of biofuels, peat etc., with the remainder consisting of electricity and district heating.

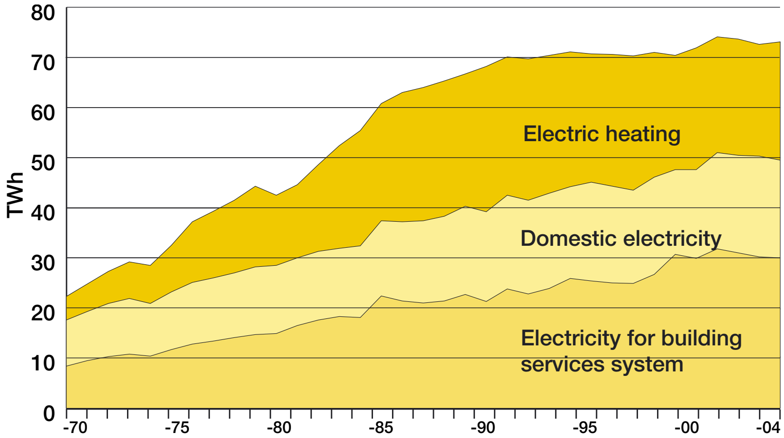
Energy and fuel use in various sectors

In Sweden, a small number of sectors accounts for the bulk of energy use in industry. The pulp and paper industry uses about 49%, primarily as elec-

[61] This guide value was developed from the results of a questionnaire survey of energy use by those living in apartments, carried out by SCB over the period 1997–1999. Prior to 1999, the figure was 50 kWh/m3 and year.

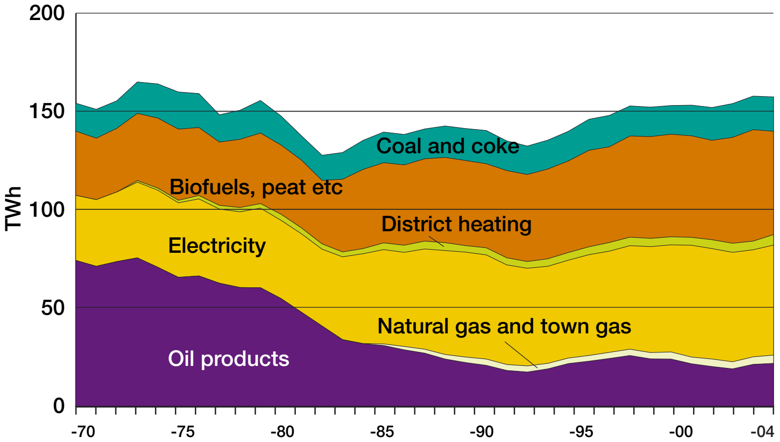
[62] Black liquors are a by-product of pulp manufacture. They are used as a fuel to produce energy: after burning, the residue is processed to recover chemicals for re-use in the process.

Figure 11: Electricity use in the residential and service sector, 1970–2003, after correction to statistically average climate conditions



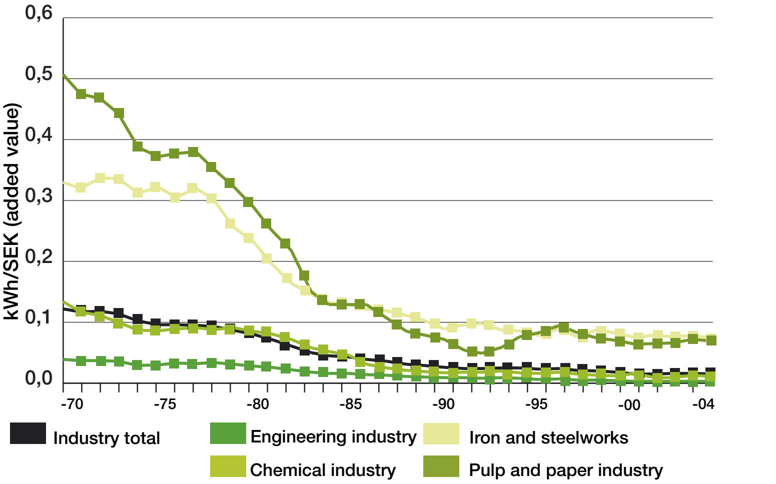
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 12: Final energy use in industry, 1970–2004



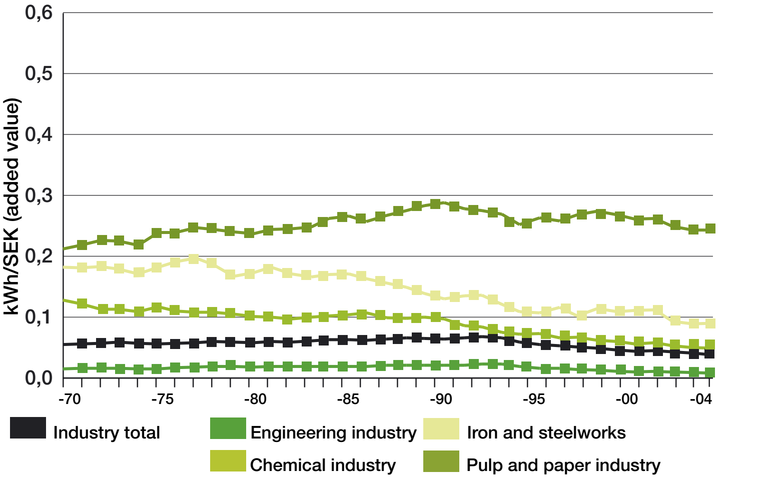
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 13: Specific use of oil in industry, 1970–2004, 1991 price levels



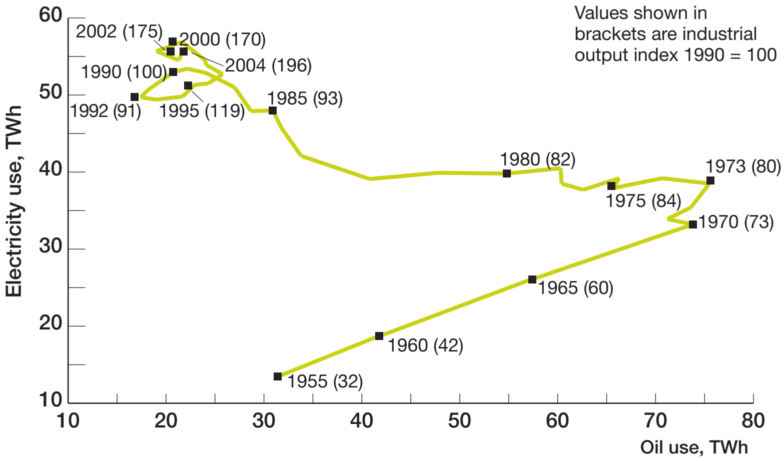
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 14: Specific use of electricity in industry, 1970–2004, 1991 price levels



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 15: Use of oil and electricity in industry, 1955-2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

tricity or from black liquors[62]. The electricity is used mainly for grinders producing mechanical pulp, while the black liquors provide fuel for soda recovery boilers in sulphate mills. The iron and steel industry uses about 15% of industry's energy, primarily in the form of coal, coke and electricity. Coal and coke are used as the reducing agents in blast furnaces, while the electricity is used chiefly for arc furnaces for melting steel scrap. The chemical industry uses 6.9% of industrial energy use: here, electricity is used mainly for electrolysis processes. Together, these three energy-intensive sectors account for over two-thirds of total energy use in industry. The engineering industry, although not regarded as energy-intensive, nevertheless accounts for over 7% of total energy use in industry, as a result of its high proportion of Sweden's total industrial output.

The relationship between industrial output and energy use

In the short term, energy use in industry essentially follows variations in industrial output. In the longer term, it is affected also by such factors as taxation, changes in energy prices, improvements in the efficiency of energy use, investment, technical development, structural changes in the sector and changes in the types of goods produced. Between 1990 and 1992, industrial production declined by 6% per annum, which was reflected by a fall of almost 6% in energy use over the period. Output recovered in 1993, and continued to rise substantially until 2000, during which period it increased at nearly 8% per annum. This was reflected in energy use, which increased by 13% over the period, with electricity use increasing by 15%. This was followed by an economic downturn in 2001, and a recovery over the period 2002-2004. Over the period 2000–2004, industrial output increased by almost 4% per annum. Energy use increased by almost 3% over the whole period, although the use of electricity fell by 1.6%. In total, industrial output has increased by 100% between 1992 and 2004, for an increase of about 19% in total energy use and about 13% in electricity use.

Changes in use of the most important energy carriers

Despite rising industrial output, the use of oil has fallen substantially since 1970, due to greater use of electricity and improvements in the efficiency of energy use. This trend started in connection with the oil crises of the 1970s, which resulted in both state and business starting intensive work aimed at reducing the use of oil. In 1970, the use of electricity constituted only 21% of industry's total energy use, which can be compared with the present proportion of 36%.

At the same time, the use of oil has fallen from 48% to 14% in terms of industry's energy use. Other forms of energy carrier, such as electricity, have therefore replaced the use of oil. One reason for this is that the cost of fossil fuels has risen. Nevertheless, despite this, the use of oil products increased by over 4 TWh, or 25%, between 1992 and 2004. Contributory factors for this have included increased industrial output, lower energy and carbon dioxide taxes and a greater use of oil as a replacement for disconnectable electric boilers[63]. Between 1970 and 2004, the proportion of biofuels, peat etc. has increased from 21% to 33% of total energy use in industry.

Changes in specific energy use

Specific energy use, i.e. the amount of energy used per monetary unit of output 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 2004, it fell by 58%, reflecting a clear trend towards less energy-intensive products and production processes, together with structural changes in the sector. During this period, industrial output value has more than doubled.

The change from oil to other energy carriers, particularly electricity, is reflected in the specific use of oil and electricity per unit of output value. Specific use of oil fell by 81% between 1970 and 1992, while specific use of electricity increased by 23%. Changes in the economy between 1992 and 2004, coupled with changes in the energy taxation of industry, are reflected in changes in specific energy use, which has continued to fall. Over this period, it fell by 41%, with specific use of oil falling by 38% and that of electricity by 44%. More generally, the reduction in specific energy use is due to the fact that production value has increased considerably more than has energy use. For several reasons, we can expect a continued fall in specific energy use. Over a longer period of time, specific energy use has been reduced by technical development and structural changes.

Transport

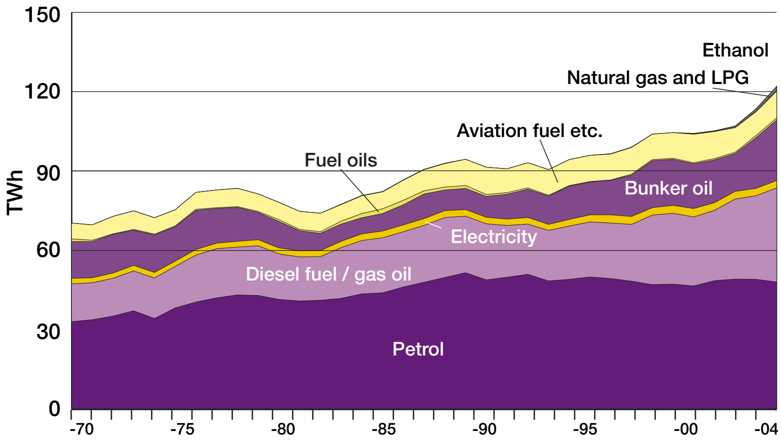
Total energy use for transport (excluding bunkering for foreign maritime traffic) in 2004 amounted to 99 TWh, equivalent to about 25% of the country's total final domestic energy use. Foreign maritime traffic used almost 23 TWh of bunker oils.

Energy use in the transport sector consists mainly of oil products, primarily petrol and diesel fuel. In 2004, the use of these two fuels provided 84% of the country's energy requirement for domestic transport, i.e. excluding bunkering for international maritime traffic. The use of petrol declined somewhat between 2003 and 2004, which can be explained by increased use of ethanol admixture. Including the use of this low admixture ethanol, the use of petrol has remained at about the same level over the last ten years. The use of diesel fuel increased steadily over the period 2000–2004, while that of aviation fuel decreased over the period 2000–2003, and then increased in 2004. This increase is due partly to improved economic conditions and partly to competition giving rise to a greater number of cheap flights. Bunkering for international maritime traffic increased in 2004, partly due to the production by the Swedish oil refineries of low-sulphur fuel oils that meet stringent environmental requirements.

About 1.9% of energy use in transport (excluding foreign maritime traffic) in 2004 was met by renewable motor fuels (ethanol, RME and biogas). Expressed in proportion to the quantity of petrol and diesel oil used, renewable motor fuels amounted to about 2.2%. At present, the costs of producing most of the alternative motor fuels exceed the corresponding costs for petrol and diesel oil. However, the difference in cost is falling as a result of technical development, the introduction of environmental taxes and a general rise the price of petrol/diesel oil. On 15th July 2005, a litre of 95 octane unleaded petrol cost about SEK 11.70. The corresponding price of a litre of E85 fuel (consisting of 85% ethanol and 15% petrol) was about SEK 7.80. However, as ethanol has a lower energy content than petrol, it takes about 1.25–1.35 litres of E85 to provide the same energy as 1.0 litres of petrol. Allowing for this, the cost of E85 today is about SEK 1.20 less than the cost of petrol. LPG as a motor fuel is cheaper today than is petrol, with a difference of about SEK 3.50/litre (petrol-equivalent). The relatively high price of pet-

[63] Electric boilers that enable a user to change between electricity and some other fuel. This is done, for example, at times of high electricity prices.

Figure 16: Final energy use in the transport sector, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

rol has improved the competitive situation of the renewable motor fuels.

Energy use in the transport sector is largely dependent on economic conditions and technical development. The two main policy measures, intended to reduce the use of energy by the transport sector, are energy tax and carbon dioxide tax, but other measures – such as green certificates – are being investigated.

Transport work

Since 1990, domestic passenger transport work has increased by 18% so that, excluding pedestrian, cycle and moped travel, it amounted to about 122 x 10^9 person-km in 2004. Road traffic dominates this, with about 88% of passenger transport work in 2004. About 71% of long-distance passenger travel (i.e. over 100 km) was provided by car traffic. For short-distance travel, car and motor cycle use accounted for about 79% of journeys, which is the same as in 2002 and 2003. Railways carried about 9% of passenger traffic, and aviation almost 3%.

Domestic goods transport has increased by 21% since 1990, amounting to over 93,5 x 10^9 tonne-km in 2004[64]. Of this, 40% were carried by road, 22% by rail and 38% by ship. Since 1990, road transport of goods has increased by 29%, maritime traffic by 21% and rail traffic by 8%.

Development and use of alternative motor fuels

A strategy for the introduction of biobased motor fuels has been developed by the Swedish Energy Agency in conjunction with VINNOVA (the Swedish Agency for Innovation Systems), the National Road Administration and the Environmental Protection Agency. It recommends that biobased motor fuels should be introduced by means of a low admixture of between 5 and 25% in existing motor fuels. This approach has several important advantages, in that it does not require the development of new types of engines, modification of older engines or any expansion of the present distribution infrastructure. Nor does it face vehicle-owners with having to make a choice, as they will be able to utilise the mixed fuel wherever it is available. On the other hand, a risk of the low admixture approach is that it could reduce the incentive for development of, and investments in, new motor fuels and new vehicle technologies.

Low admixture (5%) of ethanol in petrol expanded considerably in 2004: a similar admixture, of 2% RME in diesel fuel, has also increased. RME is not regarded as having a development potential for use as a biobased motor fuel, due primarily to the fact that the potential volumes are too small.

A total of 277 700 m^3 of ethanol was used in the transport sector in 2004. Sweden has at present two factories that produce motor fuel ethanol. The factory in Norrköping produces about 50 000 m^3 of ethanol per year from grain, while that in Örnsköldsvik produces about 18 000 m^3 from by-products from various processes in an adjacent pulp mill. The balance of the ethanol is imported from a number of countries, including Brazil, which has an annual production of about 15 million m^3 of ethanol from sugar cane[65]. A pilot plant for the production of bioethanol from forest raw materials was opened in Örnsköldsvik in May 2004, primarily as a research facility for developing the production of bioethanol from forest raw materials.

Infrastructural and technical development

Technical development occurs both in the form of improvements to existing technology and in the form of completely new technical solutions. The new solutions that are thought to be likely to achieve commercial breakthroughs during the next ten years are hybrid vehicles, 'bi-fuel' vehicles and flexible fuel vehicles (FFV). A hybrid vehicle has two alternative drive systems, generally an electric motor and a combustion engine. Development of what are known as plug-in hybrid vehicles, which are electric hybrid vehicles that can also be recharged off the mains, is also in progress. It should be possible to drive vehicles of this type about 50–80 km on one charge, which would mean that the ordinary combustion engine in them would not need to start during a typical commuting journey. Looking further ahead than ten years, the automotive industry is pinning its hopes on fuel cell technology.

At the end of 2004, there were about 5 300 LPG-powered vehicles in Sweden, of which 4 519 were private cars, 554 were buses and 225 were waste collection vehicles or distribution vehicles[66]. At the beginning of 2005, there were over 13 000 FFV vehicles in Sweden.

Development has not stood still, either, in rail, air or maritime traffic. An autopilot will be tested in LKAB's ore train locomotives in August 2005[67]. The system will provide the driver with information so that he/she can drive in such a way as to avoid unnecessary stops. Potential savings with this technology can be up to 25%, or about 200 GWh/year.

Trials of a new policy measure will be started in Stockholm on 3rd January 2006, in the form of a congestion charge for vehicles entering central Stockholm. This will be accompanied by the introduction of 14 new bus routes, operated by 197 new buses. In addition, new bus lanes will be provided, and additional parking facilities at the entrance points to the congestion zone.

[64] SIKA
[65] Swedish Board of Agriculture, 2004:21
[66] The Swedish Gas Association
[67] National Rail Administration, Rallaren no: 6/2005

Examples of vehicle projects using renewable motor fuels

Trials of various public transport systems powered by renewable or alternative fuels are being held in a number of Swedish towns. The need to provide fuel for public transport vehicles also helps to increase the availability of such fuels for other users. Landskrona has been running what is at present Sweden's only trolley-bus line since September 2003. The route is served by three trolley buses, powered by green electricity from wind and hydro power. Two buses running on EcoPar (also known as Fischer-Tropsch fuel, after its inventor) started service in Sundsvall in April 2004. EcoPar is a synthetic motor fuel: it is at present manufactured from natural gas, but could also be made from woodchips and other biomass. Since the summer of 2001, buses in Malmö have been powered exclusively by natural gas. The city now wants to take a further step, testing the admixture of hydrogen in the natural gas. The advantages of this method include reduced fuel consumption and the fact that no new technical developments are required for the vehicle. Disadvantages include higher fuel prices[68].

In addition to the above-named projects, several Swedish towns have invested in biogas as a renewable vehicle fuel. Biogas buses are at present in traffic in ten Swedish towns, with the numbers increasing constantly. June 2005 saw inauguration of the world's first biogas-powered train in Linköping. The project was a new environmentally friendly alternative for passenger traffic on non-electrified railways. At present, the cost of powering a train by biogas is about twice as high as doing so with diesel fuel. Stockholm has also invested in four biogas-powered boats (also known as water buses), which should come into service in 2006. ■

[68] SGC

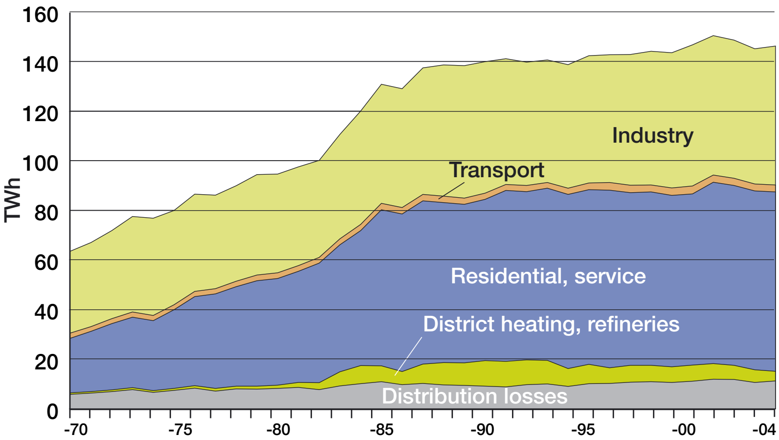
Energy markets

The energy markets are changing in step with world-wide growth in energy demand, developments in technology and with awareness of the effects of energy systems on the environment, society and the economy. Electricity markets in several countries have been opened to competition in recent years, and the same process is now occurring in the natural gas markets. Work on reducing emissions of greenhouse gases is in progress in most countries of the world, and is affecting the markets for fossil fuels and biofuels. With the growing world-wide demand for energy, any sudden changes or unexpected events can have repercussions on many energy markets. This chapter describes the present situation in the markets for electricity, district heating and district cooling, energy gases, oil, coal and biofuels.

The electricity market

Major changes have occurred in the electricity markets in the Nordic countries and the EU over the last few years. These changes have resulted in a move away from national or regional monopolies to international markets, subject to competition, where electricity users can choose their electricity suppliers. Today, all the Nordic countries except Iceland trade on the Nordic electricity exchange, Nord Pool. The Nordic electricity market is becoming increasingly integrated with the electricity markets on the south of the Baltic (particularly Germany and Poland), and there is already trade in electricity between Finland and Russia and the Baltic states. The price of electricity in the Nordic countries is determined largely by hydro power availability in Sweden and Norway, availability of the nuclear power stations in Sweden and Finland, international price levels of various fuels and government policy measures and incentives. In recent years, too, increases in taxation have increased the price of electricity to consumers.

Figure 17: Sweden's electricity use, by sectors, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Use of electricity

Between 1970 and 1987, electricity use increased at an average rate of almost 5% per annum. However, this rate of increase has since declined, to less than 0,5% per annum on average. In 2002 and 2003, electricity use in Sweden actually fell, before turning upwards again slightly in 2004. Economic and technical development, changes in energy prices, business conditions, population changes and the weather all affect electricity use. In 2004, total electricity use in Sweden amounted to over 146 TWh, with the residential and service sector accounting for about half of this, and industry for almost 40%.

Per-capita electricity use in Sweden amounts to almost 17 000 kWh per year. Only Norway, Finland, Iceland and Canada have higher per-capita uses. Conditions in all these countries are similar to those in Sweden: a relatively cold climate and a high proportion of electricity-intensive industries. The high electricity use in Sweden is also due to a high proportion of electric heating and historically low electricity prices. Per-capita electricity use in the USA is about 15% lower than in Sweden, while average use in EU-15 is about 56% less than that in Sweden.

Electricity production

Over the last 30 years, there have been considerable changes in the production mix of the country's electric power. At the beginning of the 1970s, hydro power and conventional oil-fired cold condensing power produced most of the electricity in Sweden. The oil crises of the 1970s coincided with Sweden's construction of nuclear power plants. In 2004, nuclear power supplied over half of the country's electricity, hydro power supplied about 40% and the remaining proportion (less than 10%) was made up of fossil-fuelled and biofuelled production and wind power. Total production amounted to 148.2 TWh, which was 16 TWh more than in 2003.

Over the year as a whole, hydro power production was somewhat below that for a statistically average year, amounting to 59.5 TWh. On the other hand, by the end of the year, the reservoirs had been refilled to a more normal level, after several years of substantial under-capacity. The country's nuclear power stations produced 75 TWh in 2004, which is the highest annual production figure that has ever been achieved by Swedish nuclear power stations. Combustion-based electricity production amounted to 12.9 TWh, with over half of the fuel input being in the form of biofuels, 22% consisting of coal, 16% of oil and 4% of gas. Today, it is CHP and industrial back-pressure production that dominate combustion-based electricity production, with oil-fired cold condensing power plants and gas turbines serving primarily to provide reserve capacity. Wind power production increased by over 20% from 2003, contributing 0.8 TWh. Barsebäck 2 was finally shut down on 31st May 2005, as the result of a parliamentary decision.

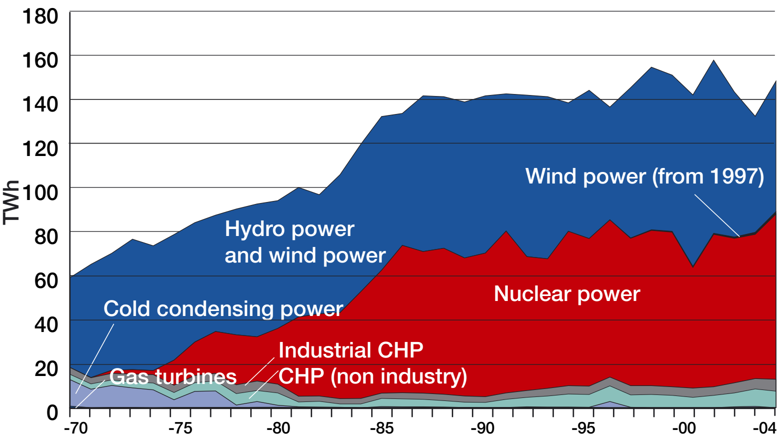
99% of electricity production in Norway is based on hydro power. In Denmark, most electricity production is based on thermal power, although the country also has a relatively high proportion of wind power (17%). In Finland, over half of the country's electricity is produced by non-nuclear thermal power, with a further 27% being produced by nuclear power and 18% by hydro power. Sweden belongs to the group of countries having the highest proportions of hydro power and nuclear power used for electricity production: only Iceland, Norway, Canada, New Zealand, Austria and Switzerland produced a greater proportion of hydro power than did Sweden in 2003, and only a few countries – including France, Belgium and Slovakia – had a higher proportion of nuclear power.

Transmission of electricity and maintenance of system balance

Electricity cannot be stored. When we turn a light on at home, the necessary electricity is produced in a power station at the same instant. In order to ensure that demand and production are in balance at all times, there must be a party responsible for overall operation of the system. In Sweden, it is Svenska Kraftnät that is responsible for maintaining this balance: in addition, it is also responsible for operation of the country's bulk power transmission grid and for most of Sweden's cross-border links with other countries.

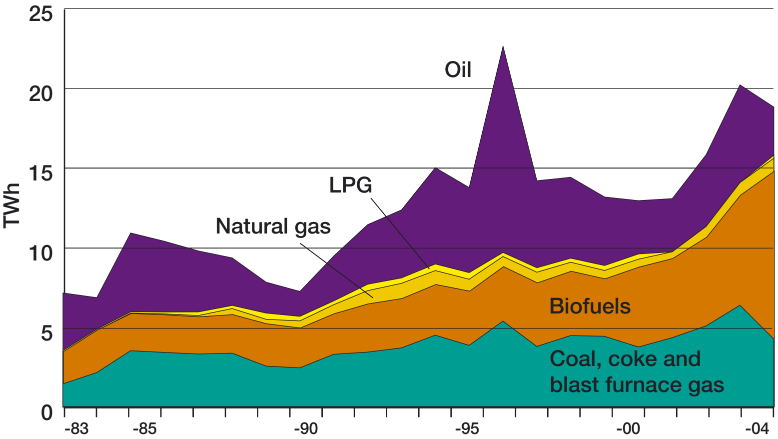
The electricity transmission and distribution net-

Figure 18: Power production in Sweden, by energy source, 1970–2004



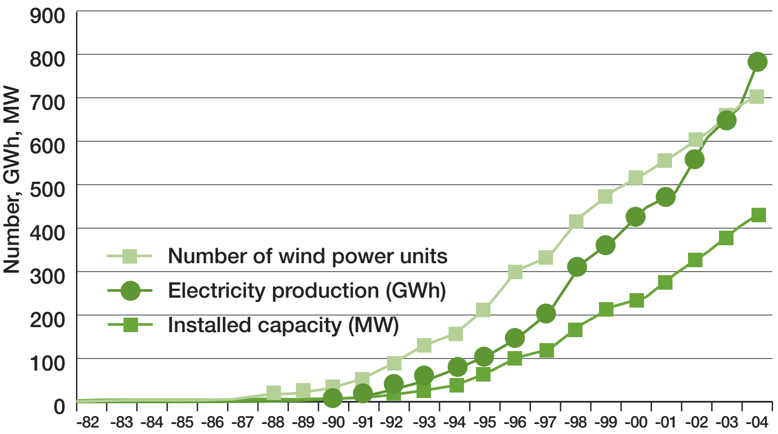
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 19: Fuel input for electricity production (excluding nuclear fuel), 1983–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 20: Wind power production in Sweden, 1982–2004



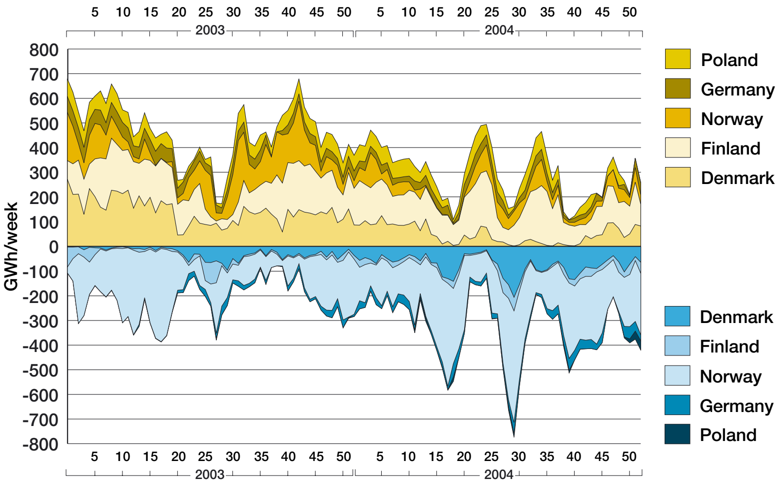
SOURCE: SWEDISH ASSOCIATON OF ELECTRICAL UTILITIES AND THE SWEDISH ENERGY AGENCY

Note: Differences in the number of plants as shown in this diagram and in Table 4 are due to the fact that the electricity certificate system presents its data by metering points, which means that several wind power plants can be included in each metering point, while the Swedish Association of Electrical Utilities presents its data on a plant-by-plant basis. In addition, the electricity certificate system provides statistics only for producers who have submitted applications.

work in Sweden is divided into three levels: the backbone grid, regional grids and local distribution networks. The backbone grid is a high-voltage transmission system, carrying electricity over long distances and to neighbouring countries. The regional grids, which consist of about 35 000 km of lines, are owned mostly by the three larger electricity utilities. They carry electricity from the backbone grid to the local distribution networks and, in some cases, directly to larger electricity users. The local distribution networks, amounting to about half a million km of lines, are owned primarily by the large electricity producers and by local authorities. Security of supply over the various grids and networks has become increasing important in step with the growing dependence on electricity. Storm Gudrun, which struck Sweden on 8–9 January 2005, destroyed over 2 000 km of overhead lines, plunging over half a million domestic consumers and thousands of businesses into darkness. Many had to wait for days or even weeks before their supply was restored.

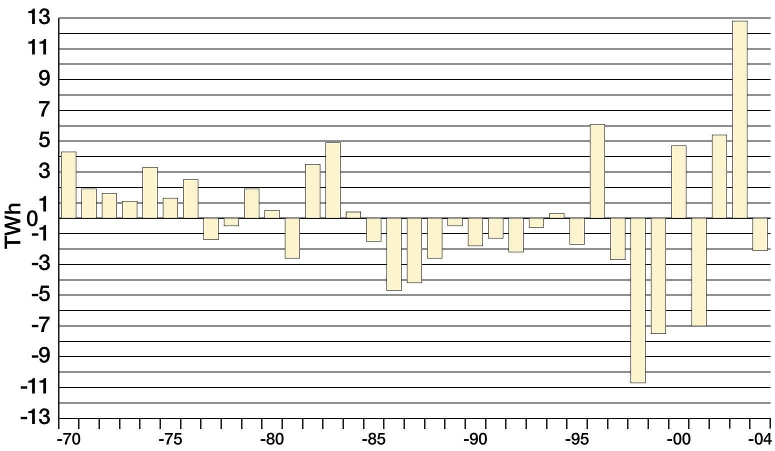
69 Nordel

Figure 21: Sweden's electricity import (+) and export (-), January 2003–December 2004, GWh/week.



SOURCE: SWEDENERGY; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 22: Sweden's net import (+) and net export (-) of electricity, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

A condition for proper operation of the competitive electricity market is that all parties should have unrestricted access to the power grid, which is regarded as a natural monopoly. The Swedish Energy Agency is the network authority, with responsibility for surveillance of the tariffs of the grid owners, ensuring that they comply with regulations concerning metering and that they provide a good delivery quality. In order to improve its surveillance of tariffs, the Agency has developed the Grid Benefit Model, as one means (among several) of assessing the fairness of a tariff. The model was used for the first time in 2004.

There are at present links between Sweden and Norway, Finland, Denmark, Germany and Poland. Nordel has presented five investments for which it recommends priority, including a new cable between Sweden and Finland, and a new grid connection between central and southern Sweden. Neither of these links could be commissioned before 2010. They are needed in order to eliminate bottlenecks in the system and to improve overall security of supply. At present, the total transmission capacity between Sweden and other countries amounts to about 9000 MW.

At the end of 2004, Sweden's total installed capacity was 33 551 MW. Maximum demand in 2004 occurred on 22nd January[69], and amounted to 27 300 MW. As a result of deregulation of the electricity market, electricity producers took a considerable amount of peak load capacity out of operation, as plants that were seldom used did not justify their costs. In 2003, legislation was therefore brought in to require a certain amount of reserve capacity. Svenska Kraftnät has been given temporary responsibility for negotiating a maximum reserve capacity of 2 000 MW per year. This has been done by entering into agreements with electricity producers and users to make additional production capacity (or reduction in demand) available. This solution applies until the end of February 2008, at which time a market-based solution is to take over.

Electricity trading

Trading of electricity generation is vital in order to ensure a properly operating electricity market. Since deregulation, this has been provided by a joint Nordic electricity power exchange, Nord Pool. It facilitates the economic use of Nordic power plants, and offers transparency of pricing. It has two main market places: one for trading in physical electricity, and one for trading in financial instruments. In 2004, 43% of the electricity used in the Nordic countries (apart from Iceland) was traded on Nord Pool's electricity spot market. The remaining physical electricity was traded under the terms of bilateral agreements outside Nord Pool. However, Nord Pool prices are used as references for the determination of prices in bilateral agreements. During the year, Nord Pool's financial market traded 590 TWh (one and a half times the underlying physical need), partly as a means of ensuring prices and partly for speculative purposes. The exchange nowadays also trades in Swedish electricity certificates and EU carbon dioxide emission allowances, both of which are also traded bilaterally. Members of Nord Pool consist of power producers, power distributors, larger end-users and portfolio managers. The majority of all electricity consumers purchase their power from suppliers on the end-user market.

As a result of an improved hydro power production situation and record nuclear power production in 2004, the country was a net exporter of power, in contrast to a substantial import of power in 2003. Trade in electricity between the Nordic countries varies during the year and from year to year, with the prime factor in determining power trading being annual precipitation to the Swedish and Norwegian reservoirs, coupled with the marginal production costs of electricity and the demand for it in the different countries. During 2004, Sweden was a net importer of electricity, primarily from Finland and Germany, and a net exporter to Norway and Denmark. Over the year, imports from and exports to Poland more or less cancelled each other out. The Nordic countries as a whole imported 3% of their electricity in 2004, mainly from Russia and Germany.

Table 6: Total price of electricity (excluding electricity certificates) for different customer categories, including taxes and value-added tax, öre/kWh

Date	Light industry[1]	Detached house with electric heating[2]	Detached house without electric heating[3]
1st Jan. 2002	43.8	87.9	111.3
1st Jan. 2003	59.9	111.4	135.4
1st Jan. 2004	62.4	117.9	143.6
1st Jan. 2005	55.2	109.9	135.9

SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Note: These prices are average prices from the electricity companies, available to each customer category from 1st January. [1] Annual consumption 350 MWh, [2] Annual consumption 350 MWh, [3] Annual consumption 5000 kWh.

Electricity price makeup and development

The spot price of electricity on the Nord Pool market is not the same as the final price that a domestic customer sees on his or her bill. The total price to the customer consists of the price for the electricity itself, the price of electricity certificates, the network price, energy tax and value-added tax. Of these, it is the price of the electricity itself and that of the electricity certificates that are subject to competition. In January 2005, the total price of electricity to domestic customers without electric heating was made up of about 31% for the electricity itself, 29% for the network charge, 2% for green certificates, 18% for tax and 20% for value-added tax. The price of electricity may be fixed for (typically) one, two or three years in advance, or it may be variable, depending on such factors as the average monthly price on the power exchange. However, most customers have what are known as open-ended contracts, and have not renegotiated their contracts with their suppliers. The network price depends on where in the country the electricity is used and on the nominal supply rating. The average price of certificates charged to customers by the electricity companies was 2.6 öre/kWh. For most domestic customers, electricity tax has increased by 5.6 öre/kWh since 2002, an increase of 28%. Harmonisation of regulations with the EU Energy Taxation Directive has meant that the zero rate of tax on electricity used in industrial manufacturing processes has been replaced by a tax rate of 0.5 öre/kWh.

The spot price has varied widely since deregulation of the market in 1996, partly due to variations in precipitation from one year to another. The hitherto highest price occurred at the end of 2002 and the beginning of 2003, reaching a record spot price of 104.1 öre/kWh on Nord Pool. Over 2004 as a whole, the average spot price was 26.4 öre/kWh, down from 33.5 öre/kWh in 2003, with the reduction being due mainly to higher precipitation. The rising world market prices for coal during the year affected the Nordic price of electricity. The price is also affected by the recently introduced emission trading scheme.

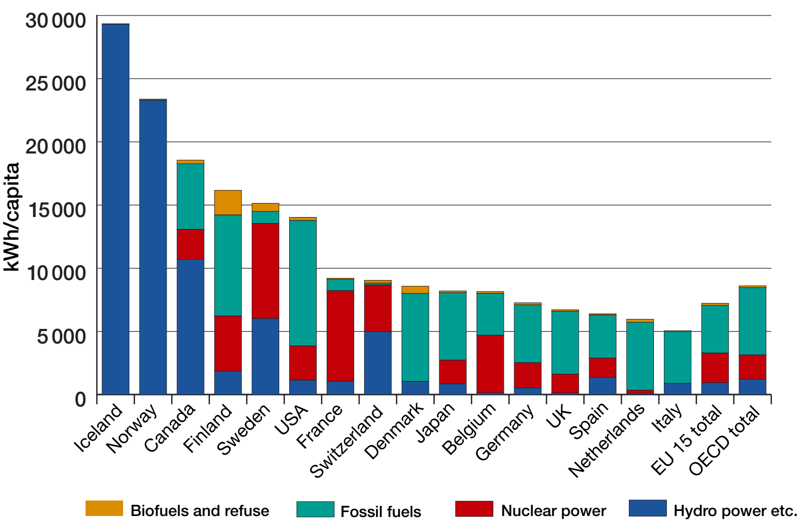
Development of the single electricity market

The electricity market in many parts of the world is at present undergoing extensive changes in terms of changing market conditions, new technology and more stringent environmental requirements. Within the EU, policy is concerned largely with deregulation and harmonisation in order to achieve a competitive market, to ensure the security of energy supply and to bring about sustainable development and environmental conditions. Directive 2003/54/EC *concerning common rules for the internal market in electricity* sets out common rules for production, transmission, distribution and supply of electricity. It sets a time plan for deregulating the electricity markets, under which all non-domestic customers must be able freely to choose from among competitive suppliers by July 2004, with this freedom extended to domestic con-

Figure 23: Nord Pool's spot prices. Monthly and mean annual values of system prices and prices for the Swedish price area

SOURCE: NORD POOL, FTP SERVER

Figure 24: Per-capita electricity production from different sources, 2003



SOURCE: IEA, ELECTRICITY INFORMATION 2005

Note: Hydro power includes other renewable energy, except biofuels. Fossil fuels include mainly coal or gas.

sumers by not later than July 2007. However, up to now, the degrees of openness and deregulation vary between EU states.

Reform of the electricity markets means that electricity can be traded and supplied across national borders. The power utilities are developing into larger and more integrated energy utilities, operating in several countries. In a trans-national market, electricity is produced where it is technically and economically most favourable to do so. The ordinance from 2003 concerning conditions for access to cross-border connections for trade in electricity is intended to ensure fair conditions for such trade, and thus to improve competition on the single market for electricity.

Electricity from renewable energy sources is at a disadvantage on competitive markets due to its high production costs. Directive 2001/77/EC is intended to encourage the production of electricity from renewable sources. It requires the production of electricity from renewable sources in the EU to be increased from somewhat less than 14% at present to over 22% by 2010. Each state is free to choose whatever method it prefers to encourage the production of renewable electricity. Sweden has chosen a certificate trading scheme, which has been in operation since May 2003.

The district heating and district cooling markets

District heating has been used in Sweden since the 1950s, but district cooling did not appear until the 1990s. District heating supplies residential buildings, commercial premises and industries with heat for space heating and domestic hot water production. District cooling, on the other hand, finds a market almost exclusively in the commercial sector for air conditioning of shops and offices, and in industry for process cooling and cooling large computer centres. District heating systems are geographically much larger than district cooling systems, which are confined to the centres of urban areas.

District heating

District heating can be defined in technical terms as the centralised production and supply of hot water, distributed through a piping system and used for the space heating of buildings. It is the commonest form of heating in apartment buildings and commercial premises, supplying about half of the country's end use of heating. It is the main form of heating in the centres of 232 of the country's 290 municipalities[70]. Local authorities began to look at district heating during the latter half of the 1940s, when it was seen as a good way of increasing electricity production in Sweden by providing a heat sink for CHP production. Its use spread during the 1950s and 1960s as a result of the extensive investments in new housing 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[71] were gradually linked up to form larger systems, which were then in turn connected to district heating systems. There was a particularly substantial expansion of district heating over the period from 1975 to 1985, partly due to its ability to replace oil through its flexibility of

[70] From the 2004 results of an annual survey by five large housing organisations, monitoring local authority charges for heating, domestic hot water, water, sewage treatment, electricity and public cleaning.

[71] Heating plants supplying a small number of blocks, usually in a single development. A common feature of the 1960s' Million New Homes programme.

fuel use. This was also the period of expansion of nuclear power generation, and the continued expansion of district heating resulted in it becoming a net user of electricity, in disconnectable boilers and large heat pumps, rather than a net producer of electricity, which is more common in most other countries with substantial district heating systems. However, in recent years, interest in CHP (now mainly biofuel-fired) has again revived in Sweden due to such factors as carbon dioxide taxation, changes in the taxation regime for CHP and the electricity trading certificate scheme.

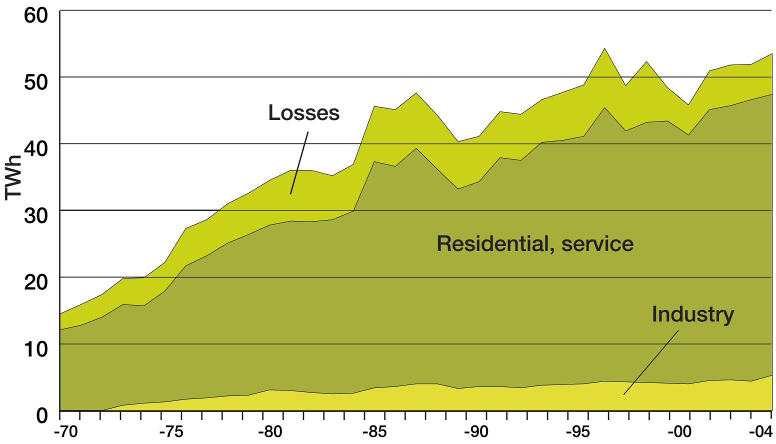
Energy policy has favoured district heating through various forms of state support, e.g. grants for the extension of existing district heating systems and the connection of group heating systems and even individual buildings to existing systems. Replacing a multitude of small individual boilers by district heating has reduced emissions from heating of residential buildings and commercial premises. The urban environment in most Swedish towns has been significantly improved as a result of the expansion of district heating and improved flue gas treatment, which have reduced emissions of SO_2, particulates, soot and NO_x.

District heating is not price-controlled, although the regular price comparisons by the Public Service Fee Group[72] and the Swedish Energy Agency's annual surveys of the heating markets provide information on price differences between areas. A more in-depth review of district heating in the heating markets has been carried out by the District Heating Commission. Among the proposals in the Commission's report are separate accounting of district heating activities, legal and functional separation of district heating and electricity market activities, the presentation of key performance indicators and the establishment of a board for arbitration and the resolution of conflicts. The Commission, which submitted its final report in June 2005, proposes that these measures should be realised through a special district heating act. The amendments to the Electricity Act that came into force on 1st July 2005 include requirements for separate accounting of district heating activities.

Today, district heating supplies about 47% of the total residential and commercial premises heating requirement. It is the commonest form of heating in apartment buildings, supplying heat to about 77% of the heated floor area, while about 60% of commercial and similar premises are heated by it. In detached houses, on the other hand, the proportion is only about 9%. (See also 'Residential and service sector' in the 'Energy Use' chapter.)

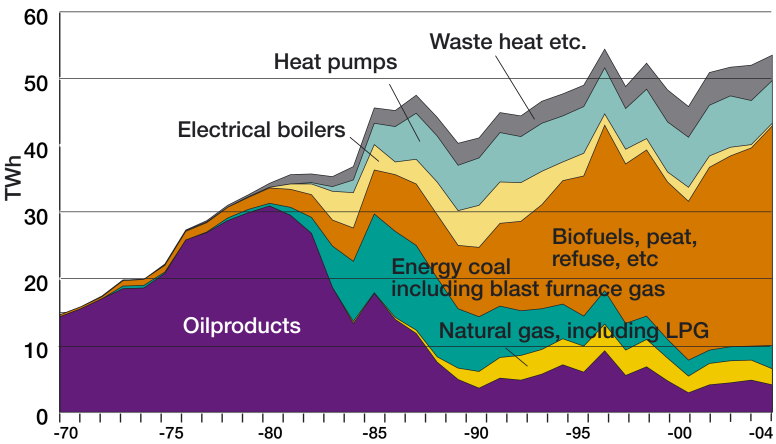
Over 47 TWh of district heating were supplied in 2004, which was an increase of almost 2% over 2003. Of the total quantity, about 57% were for residential heating (apartment buildings and detached houses), about 32% for commercial premises and 11% for in-

Figure 25: Use of district heating, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 26: Energy input for district heating, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

dustry. Some industries have sold their own heat production facilities to district heating utilities, and then buy the heat back from the utility. This then appears in the statistics as district heating, despite the fact that it is actually district heating without distribution pipes. The effect is to distort the preliminary statistics for industrial use of district heating. However, corresponding decreases can be found in the use of biofuels by industry for heating.

One of district heating's advantages is its flexibility in respect of choice of fuel. 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. Total energy supply to the district heating sector in 2004 was just under 54 TWh, of which biofuels, waste and peat accounted for 33 TWh, or over 61%. The supply of biofuels, waste and peat to district heating utilities

[72] Formed by five large housing organisations, and monitors local authority charges for heating, domestic hot water, water, sewage treatment, electricity and public cleaning. Also known as the Nils Holgersson Survey.

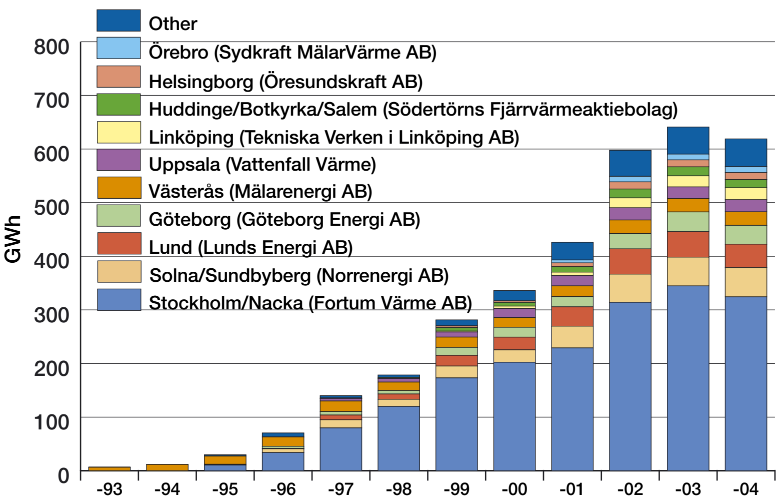
increased by almost 11% from the previous year. This was due to the effects of the introduction of the green electricity certificate system in 2003, the inclusion of peat as a certificate-qualifying fuel for electricity production in CHP plants in 2004, the ban on landfill disposal of waste and the high world market prices of fossil fuels during the year.

The use of electricity in the sector, with most of it being accounted for by electric boilers, has fallen substantially since market deregulation in 1996. The electrical energy input to heat pumps, however, has remained relatively constant. District heating losses have fallen since the 1980s as a result of improved technology and higher load factors. In 2004, distribution and conversion losses amounted to somewhat over 11% of the total energy input, as against about 20% during the 1980s. Some of the reduction, however, is due to the greater use of heat buyback, as described above, which requires no network distribution.

Until the beginning of the 1980s, most district heating systems were operated as local authority services. However, since then, most have been restructured as limited companies, owned by the local authorities. Today, there are about 220 companies supplying heat in Sweden, although many have common owners. After deregulation of the electricity market, there has been a considerable consolidation of ownership as a result of some of the larger electricity utilities buying up local authority energy companies, including their district heating operations. Nevertheless, about 60% of the country's district heating utilities are still owned by local authorities, although many of the really large systems, such as Stockholm, Malmö, Uppsala, Norrköping and Örebro, are partly owned by private or state[73] interests.

[73] The Swedish state through Vattenfall, and the Finnish state through Fortum.
[74] Energy gases are natural gas, LNG, biogas, town gas and hydrogen.

Figure 27: Supplies of district cooling, by supplier, 1992–2004



SOURCE: SWEDISH DISTRICT HEATING ASSOCIATION

District cooling

District cooling is used mainly in offices and commercial premises, as well as for cooling various industrial processes. Its principle is similar to that of district heating: cold water is produced in a large central plant and distributed through pipes to customers. The statistics provide data only for commercial district cooling, i.e. with the supplier and consumers being different parties. It is primarily existing district heating suppliers that have established commercial district cooling systems in Sweden. The commonest means of production in Sweden is to use waste heat or lake water as the heat source for heat pumps, with the cooled water from which heat has been abstracted then providing the district cooling water, while the heated output water from the heat pumps is generally used for district heating. Another common method of production is simply to use cold bottom water from the sea or a lake, i.e. free cooling. A further alternative is to install absorption refrigerant plant, powered by district heating, in or near a customer's premises, which increases the load factor of the district heating system in the summer.

One of Europe's largest district cooling operations has been built up in central Stockholm since 1995. The market for district cooling has expanded strongly since the first system was started up in Västerås in 1992, powered by such factors as higher internal heat loads in offices and shops, greater awareness of the importance of good working conditions and the phase-out of ozone-destroying refrigerants. The progressive prohibitions on the use of such refrigerants have meant that property-owners have been forced to convert existing equipment or invest in replacement systems. In 2004, there were 28 commercial district cooling suppliers, some operating more than one system. 619 GWh of district cooling were supplied.

The energy gases market

Sweden uses a relatively small quantity of energy gases[74] in comparison with many other European countries. However, the distribution network for natural gas in Sweden is being extended. The rest of Europe is covered by an extensive natural gas distribution network. The use of natural gas in Europe has increased over the last couple of decades, primarily by replacing coal and oil.

Natural gas in Sweden

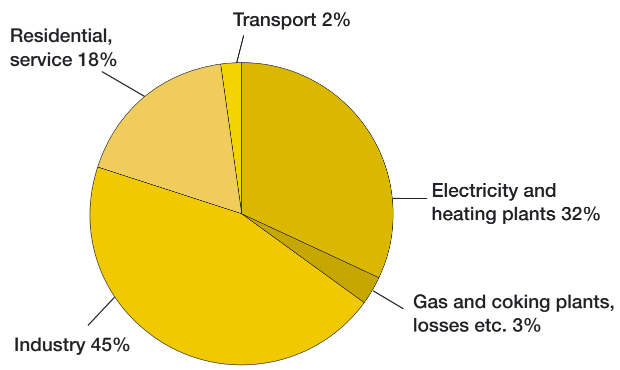
Natural gas is a combustible mixture of gaseous hydrocarbons, consisting mainly of methane. Unlike coal or oil, it contains no heavy metals and is almost completely free of sulphur. Combustion also produces no solid residues, such as ash or soot. For a given quantity of thermal energy, the amount of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

Natural gas was introduced to Sweden in 1985. Its use increased rapidly until 1992, after which growth continued at a more modest rate. In 2004, imports amounted to 927 million m^3, equivalent to 9.3 TWh. Industry accounts for about 45% of total use, with CHP and district heating plants accounting for over 30%. Domestic consumers use almost 20%, and a small amount of natural gas is also used as motor fuel. Natural gas is distributed at present to about 30 districts, where it provides about 20% of energy use. On the national level, it supplies a little over 1% of total energy use.

With effect from 1st July 2005, the state utility Svenska Kraftnät has the system responsibility for the national supply of natural gas. This means that it has overall responsibility for short-term maintenance of the balance between supply of natural gas to the national system and delivery of gas from it.

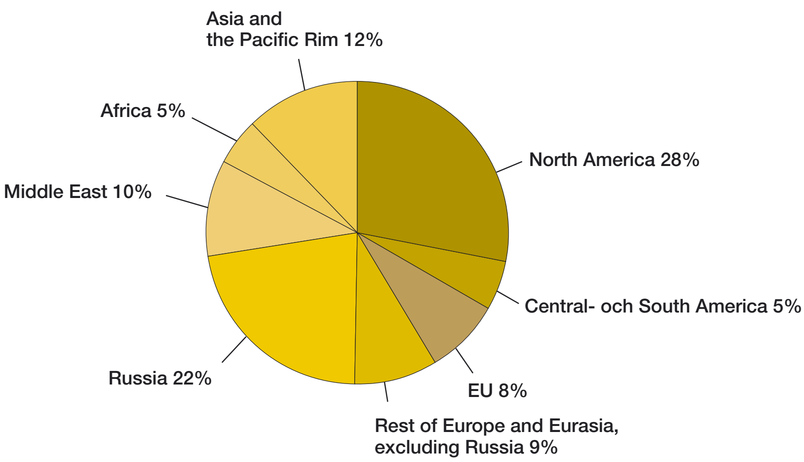
The natural gas network extends from Trelleborg in the south to Gothenburg, with a number of branches, such as to Gislaved in Småland and Stenungssund, north of Gothenburg. Nova Naturgas AB owns much of the trunk main. Its trading activities were sold in 2004 to the Danish Dong Natural Gas A/S. E.ON Gas Sverige AB is responsible for the branch mains in southern Sweden. A concession application has been submitted for extension of the existing main from Gislaved/Gnosjö to Oxelösund via Jönköping and Boxholm. In conjunction with Verbundnetz Gas, Sjællandske Kraftværker and Norsk Hydro, E.ON Gas is planning to build a transmission pipeline between Germany and Sweden, via Denmark, under the name of the Baltic Gas Interconnector. Permission for construction of the Swedish part of the project was granted by the Government in October 2004. In May 2004, Nova Naturgas AB concluded construction of the west coast distribution main from Gothenburg to Stenungssund and Bohus.

Figure 28: Use of natural gas in Sweden in 2004, by sectors. Total, 927 million m^3



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 29: World natural gas production, 2004. Total 2 692 x 10^9 m^3



SOURCE: THE STATISTICAL REVIEW OF WORLD ENERGY 2005, WWW.BP.COM

International production and use of natural gas

Although natural gas is a marginal energy source in Sweden, it provides somewhat over 20% of energy supplies in the EU states and in the world as a whole. The world's natural gas reserves are substantial: at the end of 2004, commercially viable reserves amounted to almost 180 000 x 10^9 m^3, which would last for almost 70 years at the present rate of use, with present technologies and present prices. Most of the reserves are to be found in the former Soviet Union (33%) and in the Middle East (41%). Less than 2.0% of the world's natural gas reserves lie within the EU states. At the present rate of use, this would last for only 13 years. Over the last decade, natural gas supplies to the EU states have been increasingly based on production from the North Sea and imports from Russia and Algeria. In order to increase the security of supply, there is European interest in increasing the number of links between the Russian and the Norwegian natural gas fields and the continent. Today, the world's major producing countries are Russia, the USA and Canada. Within the EU, the major producers are the UK and Holland. The proportion of total global energy supply met by natural gas has increased rapidly during the last decade, by over 30% between 1992 and 2004. Consumption of natural gas is highest in the USA, Russia and the UK. Within the EU, natural gas has a part to play in reducing environmentally hazardous emissions, primarily by replacing coal and oil.

Natural gas transport

Pipeline transportation of natural gas is the main way of transporting natural gas between producers and consumers. The physical transport system can be approximately divided up into transmission and distribution. Transmission pipes carry the gas over long distances under high pressure: the quantities of energy represented by the gas can be very significant. At the reception points, the pressure is reduced in metering and pressure regulation stations, before the gas is supplied to local distribution networks for delivery to the end-users. Several Asiatic countries, particularly Japan and South Korea, are far from their sources of supply. Gas is delivered to them by ship in liquid form, having been liquefied by extreme cooling. Liquefied natural gas (LNG) has historically been unable to compete to any greater extent with pipe-borne natural gas, due to its high cost. However, recent reductions in the cost both of production and transport have partly changed this situation.

Deregulation of the natural gas markets

The underlying purpose of deregulation of the natural gas markets around the world has been to create the right conditions for effective utilisation of resources, thus keeping down the prices of gas. Several structural regulatory changes have been introduced in order to ensure smoother operation of the markets. Some of the most important of these are unbundling and third-party access. Unbundling involves separation of transport and sales of the gas, and can operate at various levels. In the most extreme case, it involves a complete separation of ownership between the transport activity and the sales activity. This is required in order correctly to assign the costs for each and to prevent cross-subsidisation. (Cross-subsidisation is the practice of applying the revenue from one activity to support another.) This is unacceptable, as otherwise revenues from the monopoly transport activity could be used to subsidise sales prices on the competitive market, thus distorting competition.

Third-party access requires the owners of transmission and distribution networks to allow other parties to use the networks. The UK provides an example of a country with third-party access to both its transmission network and its distribution networks. One of the reasons for its introduction has been to create competition in the sale of natural gas: in practice, if it is to work properly, it must also be accompanied by unbundling.

The USA and Canada were the first countries to begin restructuring their gas markets at the end of the 1970s. Similar reforms were launched in the UK during the middle of the 1980s, so that, since 1998, the market there is completely open. All customers, regardless of size, have a free choice of supplier.

The EU Natural Gas Directive was issued in February 1998, with the aim of increasing competition on the European natural gas markets. It was incorporated in Swedish legislation on 1st August 2000, in the form of a new Natural Gas Act. A new Natural Gas Directive (2003/55/EC) was issued in June 2003, with the aim of accelerating deregulation of the natural gas markets, and setting a timetable for opening the markets. In addition, it includes requirements for unbundling and third-party access of and to transmission and distribution networks.

The new Natural Gas Directive necessitates significant changes to Swedish legislation, reflected by the coming into force of a new Natural Gas Act on 1st July 2005. One of the effects of the act is that transport and sales of gas in Sweden must be carried out by separate legal parties (unbundling). The new act also specifies dates by when the market must be fully open to competition. By not later than 1st July 2005, all non-domestic customers must be able freely to choose their gas suppliers. With effect from 1st July 2007, this freedom must be extended to all customers, thus fully opening the gas market to competition by 2007. (See Chapter 1, Energy and climate policy.)

Other energy gases

LPG is a petroleum product, consisting of the hydrocarbons propane, propene and butane, or mixtures thereof. Its environmental characteristics are very similar to those of natural gas. It is used mainly in industry, as well as in the restaurant trade and in horticulture. As LPG and oil and also, to some extent, biofuels are interchangeable fuels in these applications, the use of LPG is sensitive to changes in energy taxation or fuel prices. In 2004, 5.1 TWh of LPG were used in industry, 0.4 TWh in the residential sector and over 0.4 TWh for electricity and district heating production.

Biogas consists of methane, formed by the breakdown of organic materials such as sewage sludge, domestic or industrial waste under anaerobic (oxygen-free) conditions. The process, known as digestion, occurs spontaneously in nature, e.g. in marshes. Today, Sweden has about 100 biogas plants in operation, most of them in sewage treatment plants or at landfill sites, producing digester gas and landfill gas respectively. Most biogas is used for electricity and heat production. In 2003, 41 GWh were used for electricity production, 374 GWh for heat production and 108 GWh in the transport sector. Biogas can also be cleaned and distributed via the natural gas network as ’green natural gas’.

Town gas (gasworks gas) is produced by cracking naphtha. Fortum Värme AB in Stockholm is the only producer of such gas in the country: the town gas used in Malmö and Gothenburg nowadays consists of natural gas mixed with a small proportion of air. It is used for heating detached houses, larger properties and industries, as well as for cooking in homes and restaurants. 0.5 TWh of town gas were used in 2004.

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

The oil market

Crude oil makes up about 40% of the trade in raw materials for the world's commercial energy markets. For over 140 years now, oil has been one of the most important energy raw materials, on the back of which industrialisation, motor traffic and economies have grown. Oil products as energy carriers are best used in less densely populated areas, and over long distances as motor fuels or for heating where no piped or wired energy carriers are available. Recent decades have seen a rapid expansion of the oil markets in the new industrialised countries in the Far East and Pacific rim, particularly in China, as well as in the major oil-producing countries of the Middle East. The use of oil is at present increasing rapidly in the developing countries.

Oil in Sweden

In 2004, oil provided over 32% of Sweden's energy supply. On the user side, it is the transport sector (including bunkering supplies for international maritime transport) that is most dependent on oil, using over twice as much oil as do the industry and residential/service sectors together. The use of oil has been substantially reduced since 1970, falling by almost 45% since 1970. It is particularly the use of fuel oils that has been reduced (and especially in the detached house sector): instead, Sweden has become more dependent on electricity, although district heating has also replaced a considerable quantity of oil for heating supplies. (See Figure 30.) Another important change since before the oil crises is the fact that Sweden nowadays exports, rather than imports, refined oil products. Prices of refined products rose steeply during the 1970s oil crises, and so an increase in refinery capacity was an important means of helping to protect the Swedish economy against excessive price rises.

In 2004, Sweden imported over 20.5 million tonnes of crude oil, and net-exported 4.5 million tonnes of refinery products. About 60% of Sweden's total crude oil imports come from the North Sea. Overall, 29% of imports come from Denmark, 27% from Russia, 26% from Norway, 8% from Iran, 6% from the UK and 4% from Venezuela, as shown in Figure 31 and Figure 32. This substantial importation of oil is due to the fact that much of the oil is processed in Sweden before re-export[75]. In accordance with international agreements and its membership of the EU, Sweden is required to maintain stocks of oil as a buffer against crisis situations. The Swedish Energy Agency is the surveillance authority for this, deciding who is required to maintain such stocks and how large they are to be.

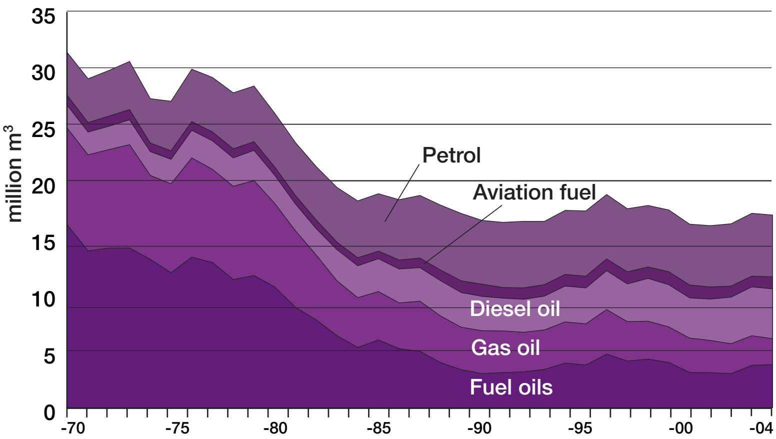
Production and reserves

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

Production methods for crude oil have become more efficient, with technical development resulting in both improved prospecting for oil and improvements in production from the wells. New reserves can be found, thus increasing total known reserves. New technology has also made it possible to extract more oil from each well. This has reduced the cost of recovering the oil, thus giving a certain theoretical potential for lower oil prices. Longer periods of higher crude oil prices can also provide an incentive to increase production. However, as long as output restrictions are applied by producers, oil prices are maintained at higher levels. Other factors, such as shortage of refinery capacity, can increase the prices of oil products. It is difficult to put a figure on total oil reserves, and there are many different assessments thereof. The same applies to attempts to determine how long supplies will last with present technology and rates of use. (See also Chapter 6, World Energy Situation).

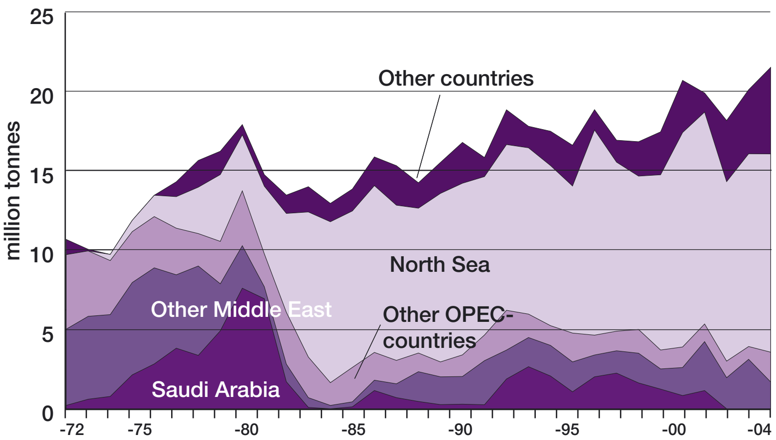
[75] Further information and statistics from the oil industry can be found in 'The Oil Year, 2004' (In Swedish – 'Oljeåret 2004'), www.spi.se, and elsewhere.

Figure 30: Use of oil products in Sweden, including foreign maritime traffic, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 31: Net Swedish imports of crude oil, by country of origin, 1972–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

OPEC and other oil producers

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

Outside OPEC, the largest oil-producing countries are Russia, the USA, Mexico, China, Norway, Canada, the UK and Oman, together accounting for most of the rest of the world's oil production. However, with the exception of Norway and Oman, these countries have large home markets, and therefore make little contribution to net world exports. Abstraction rates in the non-OPEC countries are high in relation to their remaining reserves, which means that the oil market will become more dependent on oil production from the OPEC countries in the longer term. In general, the cost of crude production is higher in non-OPEC countries, due to the size of the fields and their accessibility. Offshore production, for example, is more common in the non-OPEC countries. Since the oil assets in the OPEC countries were nationalised during the 1970s, OPEC has acted as a cushion on the world market. Crude oil outputs are regulated by a quota system. OPEC has attempted to maintain price levels by persuading its member states not to utilise their full production capacity, although this policy has had somewhat varied success.

The price of oil

There are many factors that affect the price of oil: expectations of future economic trends, for example, political conditions in the Middle East, armed conflicts in high-output regions, refinery capacity, terrorist threats and the strength or weakness of the dollar are some of the more important. In recent years, there have been substantial price changes on the international oil market as a result of these factors and of production restrictions by OPEC. Figure 33 shows the roller-coaster ride of oil prices over the last 30 years, both in real terms and in relation to 1990 prices. OPEC has tried, for some years, to maintain the price level in the range USD 22–28 per barrel, aiming to achieve an average price of USD 25 per barrel. This price range represents a balance between a high price of oil, which gives high revenues for the producers, and the braking effect of this price on world economy and thus on the demand for oil, but has now been abandoned.

Crude oil and oil products are the biggest single group of commodities or goods in global trade. As a result, the price of oil has a major effect on global economies, although there is also a corresponding reverse effect, by which economies affect demand, and thus the price of oil. The price has risen from USD 13 per barrel in 1998 to between USD 25 and USD 29 over the period 2000–2002. In 2003, the average price was almost USD

29 per barrel which, in nominal terms, was the highest for 20 years. World oil consumption in 2004 increased by 3.4%, or 2.5 million barrels/day, which is the greatest increase in 20–25 years. It is, in fact, more than twice as large as the average year-on-year increase during the last ten years. Oil consumption in China alone increased by almost 900 000 barrels/day, which is an increase of about 16%. The average price of crude oil in 2004 was USD 28.30 per barrel: in October 2004, prices reached a maximum of about USD 55 per barrel, after which they fell somewhat. Prices in 2005 have continued on an upward trend, reaching between USD 50 and USD 70 per barrel at peak.

The coal market

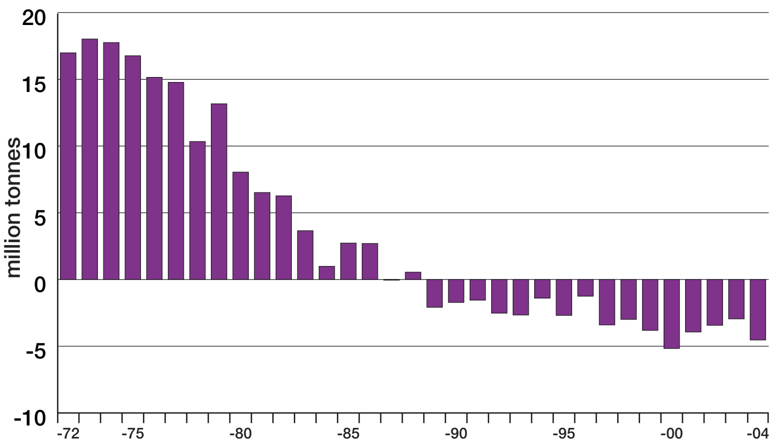
Carbon is one of the elements, and occurs in nature in the form of combinations in various minerals. Some of these minerals can be burnt, and are referred to in everyday language as coal. By tradition, coal is divided into hard coal and brown coal, depending on its calorific value. This division is not particularly precise, as no two coalfields produce coal with exactly the same properties. They can differ in respect of properties such as ash content, moisture content, the proportion of flammable constituents (calorific value), volatile elements, sulphur content etc. Quality differences between coals vary on a continuous scale. Hard coal is a relatively high-value coal, while brown coal has a lower energy content and a higher moisture content. Sweden uses almost exclusively only hard coal, which is divided traditionally into two different categories: coking or metallurgical coal, which is used in the iron and steel industry, and steam coal, which is sometimes also referred to as energy coal, and is used for energy purposes. Between 1991 and 2002, the spot price of coal in north-western Europe has varied between USD 26 per tonne[76] and USD 46 per tonne. The price started to rise steeply in April 2003, reaching USD 78/tonne in July 2004, which is a record. A year later, in August 2005, the price had fallen back to USD 59/tonne.

The largest producers of hard coal are China and the USA, which together account for 62% of world production. The major exporting countries are Australia, Indonesia and China, together accounting for about 55% of world trade in hard coal. Coal production in Europe is falling, while imports are rising somewhat. If production continues at the present rate, proven and economically recoverable world reserves would last for about 165 years[77].

Sweden's coal use

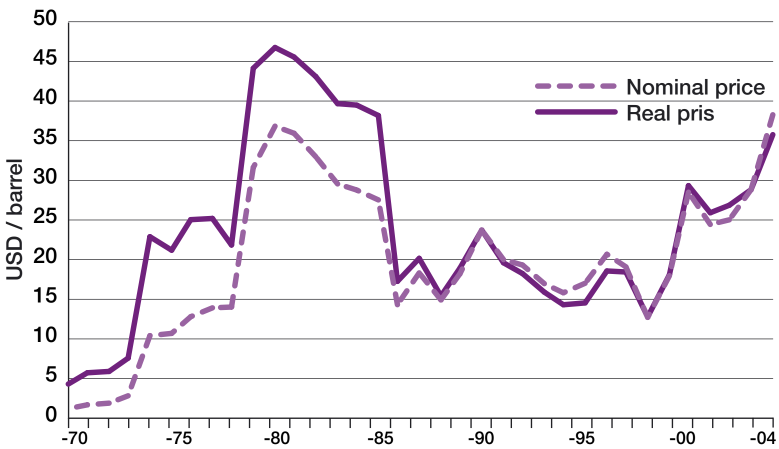
Coal played an important part in Sweden's energy supply up to the 1950s, when it lost ground to the cheaper and more easily handled oil. The oil crises of the 1970s meant that coal again became an interesting alternative fuel for reasons of price and security of supply. During the 1990s, the increasingly stringent environmental standards imposed on coal firing, together with rising taxation, meant that the use of coal for heat production stagnated. A total of 3.6 million tonnes of hard coal was used in Sweden in 2004. 2,0 million tonnes of this were coking coal, leaving 1.6 million tonnes for energy purposes. To this must be added a net import of 0,4 million tonnes of coke.

Figure 32: Net import plus net export of refinery products, 1970–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 33: Nominal and real prices of light crude oil, 1970–2004



SOURCE: WWW.BPAMOCO.COM AND THE WORLD BANK

The use of coal in industry

Industry uses energy coal, metallurgical coal, coke and smaller quantities of other coal products such as graphite and pitch. Coke is essentially pure carbon,

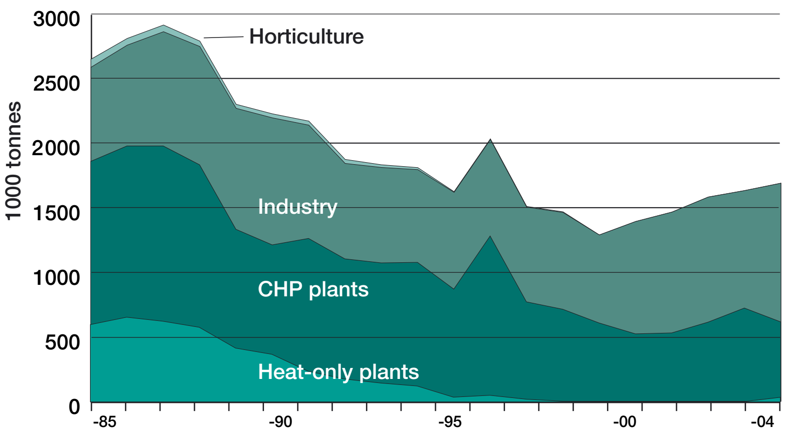
[76] Coal with a standardised calorific value of 6 000 kcal/kg.
[77] IEA, Coal information 2005

produced in coking plants from metallurgical coal. The country's two coking plants, at steelworks in Luleå and Oxelösund, also produce coke oven gas as a result of the process. The gas is used for heat and electricity production in the steelworks, and for district heating production. The coke is used in the iron and steel industry for reduction of the iron ore and as an energy input to the process. Some of the energy content of the coke is converted to blast furnace gas, which is used in the same way as the coke oven gas. In addition to metallurgical coal and coke, ordinary energy coal is also used in industry. 2.0 million tonnes of metallurgical coal were used in industry in 2004, together with 1,0 million tonnes of energy coal and the country's entire net import of 0,4 million tonnes of coke. The quantity of energy coal provided an energy input of 7.8 TWh.

District heating and combined heat and power production

The use of coal for district heating fell considerably during the 1990s, when the carbon dioxide and sulphur taxes were introduced. Plants that supply only heat have abandoned coal almost entirely as a fuel due to the high taxes, replacing it by biofuels. However, CHP plants still use some coal, as that proportion of the coal regarded as providing the energy for electricity production is exempt from energy and carbon dioxide tax. However, to improve the competitiveness of CHP production, this treatment has been changed with effect from 2004, so that the coal is taxed on the basis of the proportions of electricity and heat produced by the plant, with the heat production portion being exempt from energy tax and paying only 25% of the carbon dioxide tax. The electricity production portion pays no tax. SSAB's steel mill in Luleå supplies gas to the town's district heating cogeneration plant for the production of heat and electricity, while its mill in Oxelösund supplies heat from its coke oven gas and blast furnace gas to the town district heating system. In 2004, the district heating sector used 0.6 million tonnes of energy coal (4.5 TWh) and 2.5 TWh of coke oven and blast furnace gas for electricity and heat production.

Figure 34: Use of energy coal in Sweden, 1985–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Electricity production

0.24 million tonnes of coal (1.8 TWh), together with 1.6 TWh of coke oven and blast furnace gas, were used for electricity production in 2004, giving a total of about 2.1 TWh of electricity.

Biofuels, peat and waste

The proportion of bioenergy used in the Swedish energy system has steadily increased, from a little over 10% in the 1980s to about 17% in 2004. Most of the increase has been by industry and district heating plants.

The total use of biofuels, peat and waste in 2004 amounted to 110 TWh, of which about 53 TWh were used in industry, 13 TWh in the residential and service sector, and somewhat over 1.6 TWh in the transport sector, with about 33 TWh being used for district heating production. District heating cogeneration plants used 5.6 TWh for electricity production, while industrial back-pressure plants used 4,7 TWh of such fuels.

With the exception of a certain import contribution, the biofuels, peat and waste used in the Swedish energy system are indigenous, consisting mainly of:

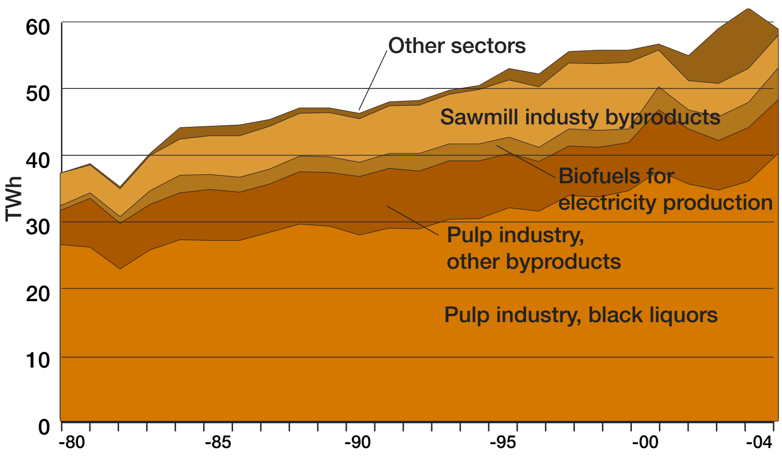
- wood fuels (logs, bark, chips and energy plantations),
- black liquors and tall oil pitches (intermediate and secondary products in chemical pulp mills),
- peat
- waste (from industries, domestic waste etc.)
- ethanol (100% for use in industry and as a 5% admixture in 95-octane petrol).

They are used mainly in the forest products industry, in district heating plants and the detached house sector, primarily for the production of heat, but also for electricity production. Availability of raw materials for biofuels is good, due to the country's substantial forest areas. Large quantities of by-products and waste products are generated from wood raw materials by the Swedish forest products industry. Most of the wood fuels used in the energy sector come directly from the forest in the form of felling residues, small branches and tops etc., from by-products from the sawmill industry and from the pulp and paper industry.

Unprocessed biofuels are used mainly at regional and local levels, as their high bulk and low price means that it is not viable to transport them. Biofuels can be converted to pellets, briquettes or powder in order to improve their energy density, simplify handling and reduce the cost of transport. By mixing various types of raw materials, and with suitable additions of small quantities of chemicals, it is possible to produce reasonable consistency in the qualities of the fuels. In 2004, the Swedish energy system used a total of over 1.25 million tonnes, equivalent to about 6 TWh, of pellets, making up almost 1% of the country's total energy supply. About one-third of this quantity was delivered to the detached house market, which has exhibited strong growth in demand in recent years. Deliveries of pellets to the Swedish market have more or less doubled between 1999 and 2004.

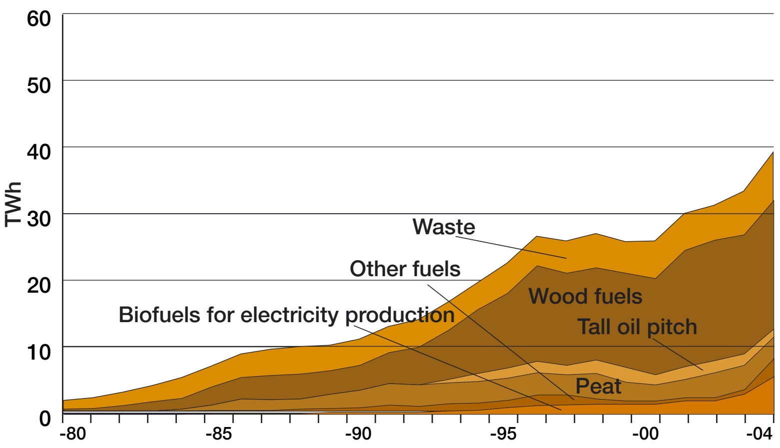
Each year, there is a relatively extensive commercial importation of biofuels. However, no reliable import or export statistics are at present collected, and so it is difficult to estimate quantities. Imports are therefore included in the country's energy balance as indigenously produced, calculated from the statistics of use. The investigations that have been carried out into the import quantities indicate a figure in the range 5–9 TWh, which means that the importation of biofuels represents a significant raw materials source. Most of the imported material is used for the supply of district heating.

Figure 35: Use of biofuels, peat etc. in industry, 1980–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 36: Use of biofuels, peat etc. for district heating, 1980–2004



SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

The forest products industry

The forest products industry uses the by-products and waste from various manufacturing processes, together with raw materials that do not meet quality standards, for the production of heat and electricity. As part of the overall process of producing chemical wood pulp for paper making, pulp mills recover chemicals used in the process by burning the liquors extracted from the process, known as black liquors, and containing the digester chemicals, lignin and other substances extracted from the wood. Crude tall oil is a by-product of recovery of the digester chemicals. It is separated by refining into tall oil and tall pitch (oil). Raw tall oil and refined tall oil can be used as fuels, but are taxed as other fuel oils and are therefore used primarily as industrial raw materials. Tall pitch (oil) is treated as an untaxed biofuel, and is therefore being increasingly used as a fuel. Black liquors are produced and used only within the pulp industry: in 2004, they provided over 39 TWh of energy (excluding electricity production). Wood fuels, in the form of raw materials residues, are used both in the pulp industry and in sawmills. They consist mainly of wood chips, shavings, bark and other waste products. In 2004, the pulp industry used a total of almost 8 TWh of wood fuels in the form of by-products for energy production, while sawmills and other woodworking industries used about 5 TWh of wood fuels. Other industry sectors used almost 1 TWh of biofuels. In total, the forest products industry used about 57 TWh of various types of biofuels in 2004.

District heating plants

About 33 TWh of biofuels, peat etc. were used for heat production (i.e. excluding electricity production) in district heating plants in 2004. Of this, wood fuels accounted for over 19 TWh, waste for over 7 TWh, black liquors and tall oil pitch for about 1 TWh, peat for over 3 TWh and other fuels for over 2 TWh. The use of wood fuels by the district heating sector has increased by more than five times since 1990, as shown in Figure 36. The main form of these fuels is felling residues and by-products from the forest products industry, although processed fuels such as briquettes, pellets and powder have also been increasingly used in recent years.

Waste

Waste has been used for district heating production since the 1970s. The quantity increased by about 3 TWh to over 7 TWh between 1990 and 2004, and is expected to continue to increase. Combustible waste must now be separated from other waste, and it has been prohibited since 2002 to dispose of unsorted combustible waste in landfill. Waste sent for combustion is exempted from the landfill disposal tax, but the ash is taxed. Landfill disposal of waste has been taxed since the beginning of 2000, and the rate is since January 1 2006 SEK 435 per tonne. A Commission was appointed in the autumn of 2003 to evaluate the effect of the Landfill Tax and to put forward a proposal for a tax on waste used as a fuel. See Chapter 1. Sweden's Energy Policy'.

Some quantities of waste, demolition timber and similar fuels have been imported in recent years, but the amounts are difficult to estimate. The extent of import is affected by a number of factors, such as the regulations concerning taxation of sorted and unsorted waste both in Sweden and the exporting countries, as well as by the relative levels of taxation on different forms of waste. Trading in emission allowances may also affect the scale of the trade. It is likely that the use of waste as a fuel in Sweden will increase over the next few years. With effect from 1st January 2005, it has been forbidden to dispose of other organic waste in landfill. There is at present a substantial shortage of capacity for dealing with waste banned from landfill disposal, with the result that incineration plants are being built at a number of sites.

Peat

The use of peat in district heating systems amounted to 3.2 TWh in 2004. The harvest in 2004 amounted to about 1.9 million m^3, i.e. somewhat under the average for the past few years. Imports were somewhat higher than in 2003, and today provide about 30% of the use of peat for energy purposes.

Peat is a substance that consists of dead plant and animal residues which, due to lack of oxygen in the decomposition process, have been incompletely broken down by the biological and chemical processes in peat bogs. The formation of peat started about 10 000 years ago as the inland ice from the last ice age retreated, and is still in progress. Sweden works peat partly for fuel purposes (energy peat), and also as a soil improver etc. (horticultural peat). Its properties when used as fuel are important when it is burnt together with wood fuels, particularly in reducing the risks of slag formation, sintering, the build-up of deposits and corrosion in boilers, and so increasing the availability and reducing the running costs of the plant.

With effect from 1st April 2004, the use of peat in approved CHP plants entitles electricity producers to Green Certificates. Electricity production from peat amounted to about 520 GWh in 2004. The EU Commission approved peat as an effective fuel for cogeneration production on the grounds of its environmental properties and due to the fact that there was a risk of it losing out to coal for this purpose on competitive grounds. The role of peat in the Swedish electricity certificate system has been investigated by the Swedish Energy Agency in 2004 as part of Part 1 of the first review of the certificate system. The Part 1 Report was submitted to the Government on 1st May 2004, followed by the Part 2 Report on 1st November 2004.

An EU-wide emissions trading scheme for carbon dioxide emissions was introduced on 1st January 2005. For the purposes of the trading scheme, emissions from the combustion of peat are treated in the same way as emissions from combustion of fossil fuels. This has the effect of changing the competitive situation of energy peat in Sweden, as it previously paid only sulphur tax. Now, those in the emissions trading scheme who burn peat must also obtain emission allowances for it.

The detached house sector

Almost 13 TWh of biofuels, peat etc., were used in detached houses for heating in 2004. Most of this was in the form of logs, but a smaller proportion was provided by wood chips and a growing proportion by pellets and briquettes. Wood firing is commonest among property-owners with good access to forests, e.g. in agricultural or rural areas. The use of pellets in the detached house sector has almost quintupled since 1999, so that about 60 000 houses are today heated by pellets-fired boilers. Industry figures show that the use of pellets in this sector increased by about 12% between 2003 and 2004.

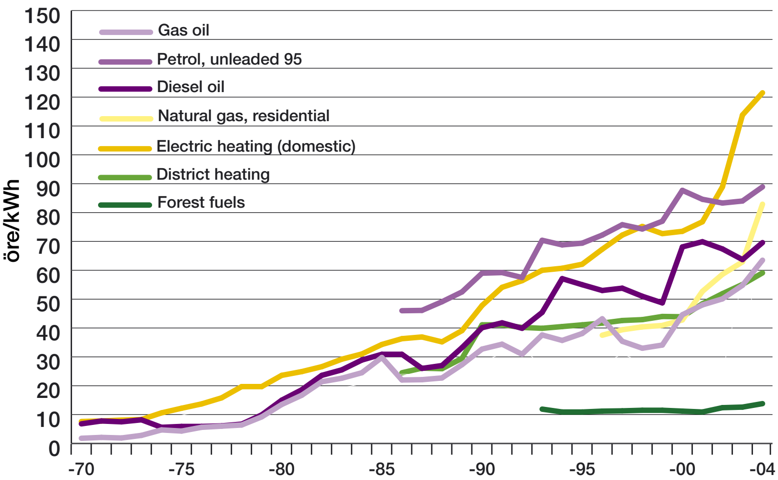
An international comparison

About 17% of Sweden's energy is supplied by biofuels, which is a good level by European standards. It is difficult to find fully comparable details of biofuel use in other countries. In a global perspective, biofuels are the most important fuels for most of the Third World's populations. The following factors have a considerable effect on their use in energy systems: good availability of forests and raw materials, a developed forest products industry, wide existence of district heating systems and good transport systems. This explains why, of the European countries, it is Sweden and Finland that make use of the highest proportions of biofuels in their respective energy systems.

Energy prices

Commercial energy prices consist of the price of the fuel, taxes and value-added tax. For electricity, the price also includes that of the necessary electricity certificates if the consumer is required to purchase them. The EU emission trading scheme was introduced on 1st January 2005, and means that the emission allowances price will in future be added to the price of fuel for use in those sectors covered by the trading scheme. Figure 37 shows the commercial energy prices. Table 7 shows the prices of fuels net of taxes, electricity certificates and value-added tax. See Chapter 2, Policy Measures and Incentives, for a description of the taxes and fees that are involved in making up the end-user price of the various energy carriers. Taxes and fees can vary, depending on how and where the fuel is used. A more complete picture is given in the table to Figure 37 in Energy in Sweden in Figures 2005. ■

Figure 37: Commercial energy prices in Sweden, 1970–2004 (including tax)



SOURCE: SPI, STATISTICS SWEDEN, EUROSTAT, SWEDISH ENERGY AGENCY'S PROCESSING

Table 7: Fuel prices for industry and the price of electricity for industry in Sweden, excluding taxes and VAT, current prices, öre/kWh

Energy carrier	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004
Gas oil 1 [1]	20.3	22.3	26.3	17.8	14.7	16.0	26.4	25.7	25.0	25.7	30.1
Heavy fuel oil [1]	15.5	14.1	14.1	9.4	7.9	9.2	17.1	20.5	17.0	16.8	17.3
Coal [2]	4.2	4.4	4.5	4.9	4.9	4.3	4.7	5.9	5.3	4.9	5.6
Wood chips [3]	10.9	10.9	11.2	11.3	11.5	11.5	11.2	10.9	12.4	12.6	13.8
Diesel oil [1]	28.6	25.8	22.4	22.2	18.6	21.9	38.6	39.3	36.2	31.9	36.1
Natural gas, used in industry [4]	-	-	12.8	15.0	14.4	11.0	15.7	29.7	19.2	24.1	24.5
Electricity, used in industry [5]	28.8	28.8	27.7	30.9	28.3	24.9	24.9	22.2	24.5	57.1	47.5

SOURCE: [1] SWEDISH PETROLEUM INSTITUTE. FUEL OILS EXCLUDING ANY QUANTITY DISCOUNTS. MOTOR FUELS AT PUMP PRICES. THE PRICE FOR HEAVY FUEL OIL WAS FOR NORMAL SULPHUR UP TO 1978, AFTER WHICH IT WAS FOR LOW-SULPHUR OIL. 1979 PRICE DIFFERENCE WERE 58 SEK/M^3 IN CURRENT PRICES, CALCULATIONS BY THE SWEDISH ENERGY AGENCY. TODAY ABOUT 95% OF THE PETROL ARE MIXED WITH 5 % ETHANOL WITH LOWER THERMAL VALUE THEN PETROL. THIS HAS NOT BEEN TAKEN INTO ACCOUNT.

[2] STATISTICS SWEDEN, CALCULATIONS BY THE SWEDISH ENERGY AGENCY.

[3] SWEDISH COMPETITION AUTHORITY, NUTEK (1992–1997) AND SWEDISH ENERGY AGENCY (1998–). MOIST CONTENT 45%. WITH EFFECT FROM 1993, THE PRICE RELATES TO SOD PEATS, DELIVERED TO A HEATING PLANT.

[4] EUROSTAT. INDUSTRIAL COST BASED ON ANNUAL DEMAND OF 11.63 GWH, 200 DAYS AND 1600 HOURS, CALCULATIONS BY THE SWEDISH ENERGY AGENCY.

5 SOURCE: VATTENFALL (1970–1995) AND EUROSTAT (1996–). PRICES FOR AN INDUSTRY, 10 MW AND 50 GWH PER ANNUM, CALCULATIONS BY THE SWEDISH ENERGY AGENCY.

An international perspective

World energy supply is dominated by fossil fuels, with oil being the most important of them. However, there are major differences in the use of energy between regions, due largely to countries' economic situations, coupled with industrial structure and climate. Increasing globalisation means that any problems in the energy markets spread quickly and can have world-wide effects.

A general overview

Global energy use increased by 4.3% in 2004, which is twice the average rate of increase over the last ten years. At the same time, according to the International Monetary Fund (IMF), the global economy increased by over 5%, which in turn is the highest rate of increase since the 1960s. China alone was responsible for more than 40% of the increase in the demand for energy. The USA and the rest of south-east Asia each accounted for 10% of the increase, followed by the former USSR, the EU 25 and Latin America with about 5% each.

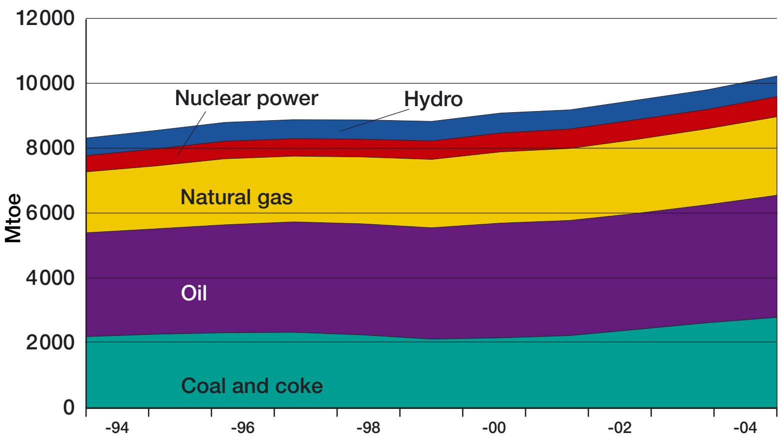
The rapid economic upturn that followed the Asian crisis of 1998, and the subsequent recession in 2001, meant that even in 2003 the global energy markets were finding it difficult to increase capacity quickly enough to meet the demand for energy. 2003 and 2004 also suffered from more extreme weather conditions in the northern hemisphere, in the form of longer and colder winters, followed by hotter and drier summers. This particularly affected the demand for oil, although it also affected the demand for all other forms of primary energy, and particularly that for raw materials input for electricity production. The hot and dry weather, particularly in Europe, affected the production both of thermal-based electricity and of hydro power.

In addition, political instability in many oil-producing regions, coupled with difficulties in increasing production outside OPEC, has had a substantial effect on international oil prices.

The combined effects resulted in severe interruptions to the pattern of trade and to substantially increased prices, which in turn affected energy carrier logistics and resulted in higher transport costs for maritime transport. The cost of carrying coal, for example, from South Africa to Europe rose from USD 10/tonne to USD 30/tonne. This in turn provided incentives for changing to different energy carriers. It is not possible to obtain a complete picture of the effects as yet, due to the delay in obtaining confirmed statistics - particularly for bioenergy, but also for other renewable forms of energy based on solar or wind power. However, it can be said that the competitiveness of alternative energy carriers has been improved during the year. The costs of producing alternative energy are falling, while the prices of supplying fossil energy have increased.

Interest in geopolitics has again increased in recent years. The rapid economic growth, particularly in Asia, has meant that this region as a whole is now experiencing a rapidly growing shortage of energy, while at the same time Europe and North America are also suffering from deficits. Africa and Russia are looking increasingly attractive as trading partners, not only for Europe and North America, but also for Asia. However, as their own internal economies grow, the surpluses available in these regions will also decline.

Figure 38: Global supplies of primary energy



SOURCE: BP STATISTICAL REVIEW OF WORLD ENERGY, JUNE 2004

Energy supply

Oil

The proportion of oil used in the global energy balance has fallen slightly, in step with oil price increases since 2000, when oil made up 38% of the world energy balance. In 2004, it had fallen to about 36%. The rate of increase in oil production did not keep step with the increase in demand, which at times resulted in very low stocks and high prices.

Prices rose substantially in 2004, from an average of USD 30/barrel in January for Brent crude to over USD 40/barrel in December. However, as the value of the dollar was falling at the same time, the actual effect of the price rise was reduced for countries whose currencies are not linked to the dollar, e.g. the EU states.

The historical trend, of the increase in demand for motor fuels being greater than the increase in demand for fuel oils, has continued. 70% of the increase was accounted for by the motor fuels sector, while the demand for heavy fuel oils fell by almost 5%. This was also reflected in product prices: on an annual basis, the price of petrol rose by about 50%, and that of diesel oil by about 55%, while the price of heavy fuel oil rose by only about 30%. The USA accounted for about a half of the increase in the demand for petrol, while China accounted for about half of the increase in the demand for diesel oil. As far as the increase in demand for heavy fuel oils was concerned, almost all the increase was accounted for by south-east Asia.

Coal

The price of coal, together with its freight costs, rose rapidly during 2003 and did not level out until 2004. In Europe, the price of hard coal increased from an average of just under EUR 40/tce in 2003 to over EUR 60/tce[78] in 2004.

In recent years, coal has been meeting a slightly greater proportion of global energy demand, so that it now accounts for about 27%. It is China, in particular, that is responsible for the major increase in the use of coal. Between 2000 and 2004, China increased its use of coal by 500 million toe. The amount of coal used in other parts of the world has essentially remained constant over this period.

Natural gas

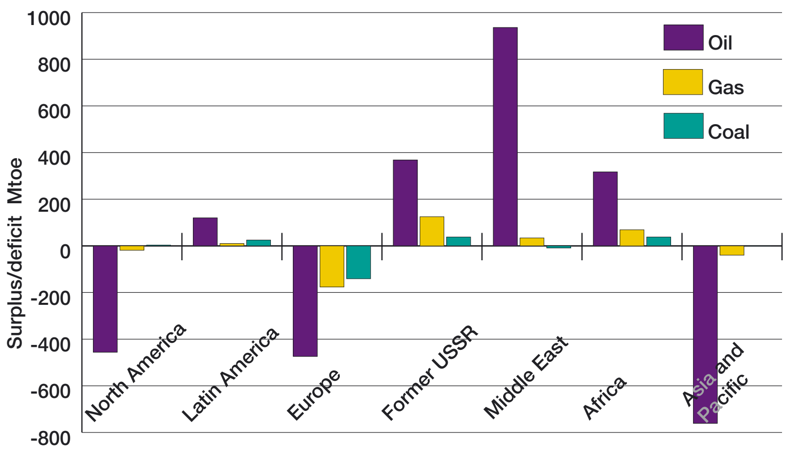
The proportion of the world's energy supply met by gas has fallen slightly over the last five years (by about 0.1%), amounting now to about 24%. However, in terms of volume, gas consumption has increased by a total of over 10% over the last five years, with 3% occurring during 2004.

The greatest rises in the use of gas in recent years have occurred in Latin America, Africa and the Middle East, where the growth rate has been about 4.5% per annum, as compared to a little over 1% in the rest of the world.

The price of natural gas is linked to the price of oil, as shown in Figure 41 below[79]. It can be seen that the price of long-term contracts for natural gas is linked to the development of the price of oil. The price rise has continued in 2004, although no official figures are as yet available. The actual result is therefore that gas has lost out in terms of competitiveness against coal, despite the substantial price rises on the international coal market.

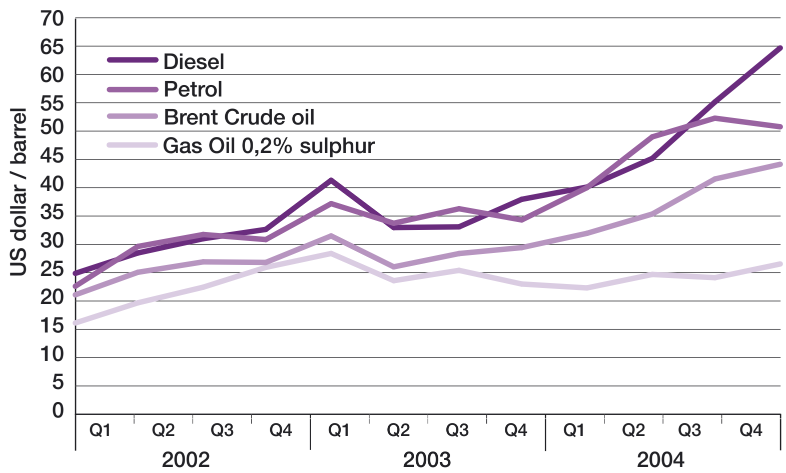
The market for liquefied natural gas (LNG) has grown substantially in recent years, in step with the

Figure 39: The regional balance for fossil fuels, 2004



SOURCE: BP STATISTICAL REVIEW OF WORLD ENERGY, JUNE 2004

Figure 40: Oil prices in Europe, 2002–2004



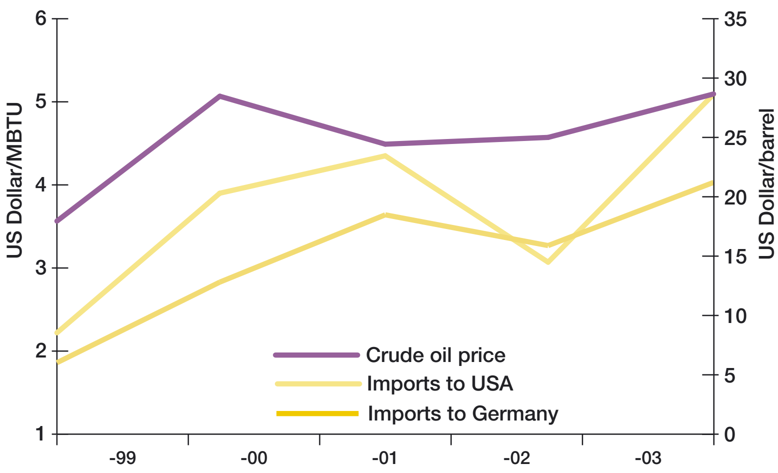
SOURCE: CERA AND PLATTS

78 Tce, Tonnes of coal-equivalent

79 MBTU, Million British Thermal Units. 1 MBTU is equivalent to about 0.29 MWh. One barrel of oil contains 159 litres of oil.

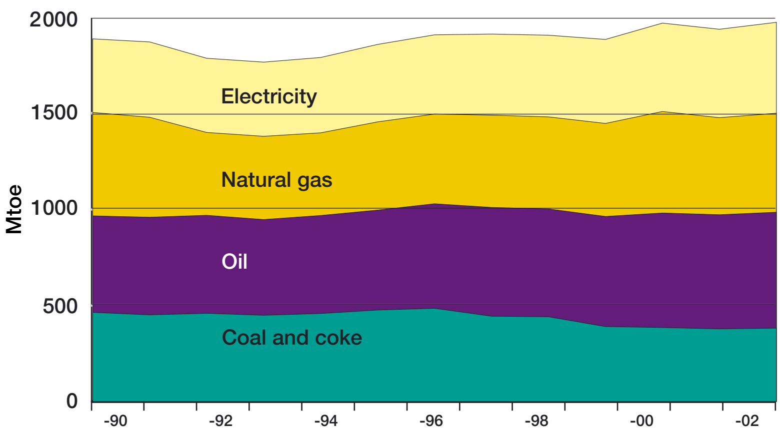
80 In this document, we have used the classification of 'Domestic and service sector'. IEA uses a different classification, treating 'Commercial sector' and 'Households' separately. Nevertheless, unless there is special reason to the contrary, we have in this report combined these two sectors in order to facilitate comparison with other Swedish statistics.

Figure 41: Import price of natural gas



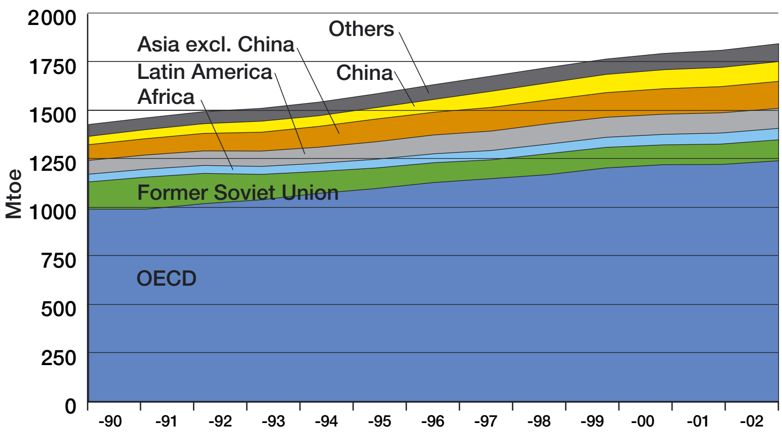
SOURCE: IEA, NATURAL GAS IMPORT COSTS, JUNE 2005

Figure 42: World use of energy by industry



SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

Figure 43: World energy use in the transport sector



SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

growing shortage of natural gas in the USA. According to preliminary calculations by Cedigaz, about 500 x 109 m3 of natural gas were traded internationally via pipelines, and almost 200 x 109 m3 in the form of LNG. However, the proportion of gas carried between countries in international trading is only a small part of the total production of 2.4 x 1012 m3. An expected surge in the use of LNG can have major consequences on international energy trade and on regional gas prices.

Other energy

Other forms of energy sources and carriers include hydro power, nuclear power, biofuels, wind power, geothermal power, solar cells etc. Statistics for nuclear power and hydro power are available for 2004, but those for other forms of energy are not yet available beyond 2002. In 2002, production in nuclear power plants provided about 6% of total world energy supply. Renewable energy, including hydro power, accounted for somewhat over a further 6%, at about 600 Mtoe each. Although there was further growth in 2003 and 2004, it is unlikely that it was sufficient to increase the actual proportion of energy supply provided from renewable energy.

Energy use

Industry

Energy use in industry picked up again during 2002, and is now back at the same level as in 2000.

The use of energy by industry is another parameter that follows the general trend, i.e. that of using proportionally less coal and proportionally more electricity. However, oil is still the main energy carrier, taking a share of 30%.

Transport

The transport sector increased its use of energy in 2002 by 2%, which is equal to the average since 1990. Energy use is dominated by oil (95%), with natural gas providing 3% and coal and electricity together providing 2%. As yet, the use of biofuels and other alternatives is negligible.

The rate of increase of consumption of motor fuels is greatest in the transition economy countries, although it is also growing more rapidly than in the OECD countries in development countries such as Africa.

Both in Asia, including China, and Africa, the use of motor fuels increased by over 3% from 2001, which is twice the rate of increase of the OECD countries.

Domestic and service sector[80]

Over the last decade, energy use in domestic households has increased at about 1% per annum, and this rate also applied for 2002.

The general trend – that the proportion of coal as an energy source is declining, while the proportions of electricity and gas are increasing – is particularly strong in the domestic and service sector. Together, these two energy carriers supply over 70% of total energy use in the residential and service sector (38% for electricity and 34% for natural gas). Oil has largely maintained its share, with only a slight decrease from 23% in 1990 to 22% in 2002.

Electricity production and use

World electricity production increased by more than 3% between 2001 and 2002, amounting to over 16 000 TWh. The average rate of increase in electricity use has remained at a little over 2% per annum since 1990.

Coal is still the predominant source of energy input for electricity production, providing 39% of all electricity in 2002. At 7%, oil is steadily losing its share of electricity production to natural gas at 19%. Nuclear power production remains constant around 17%, with hydro power providing about 16%. Over ten years, the proportion of electricity produced from renewable sources has increased from 1.5% to 2.0%.

Although the rich countries still produce the greater share of world electricity, Asia in particular is rapidly increasing its production. In general terms, production of, and demand for, electricity are increasing more rapidly in the transition economies and developing countries than in the industrialised countries.

The major user of electricity is still the industrial sector, although use within the commercial sector and by households is increasing rapidly. In 1990, the industrial sector used as much electricity as total use in the household sector and the commercial sector. By 2002, industry was using 43% of electricity, as against 30% used by households and 25% used by the commercial sector. The household and commercial sectors are, in other words, constantly increasing their share of electricity use in relation to that used by industry. This trend has been particularly strong in China, with household use of electricity having quadrupled since 1990. Transport uses somewhat less than 2% of world electricity, although this proportion has increased in recent years.

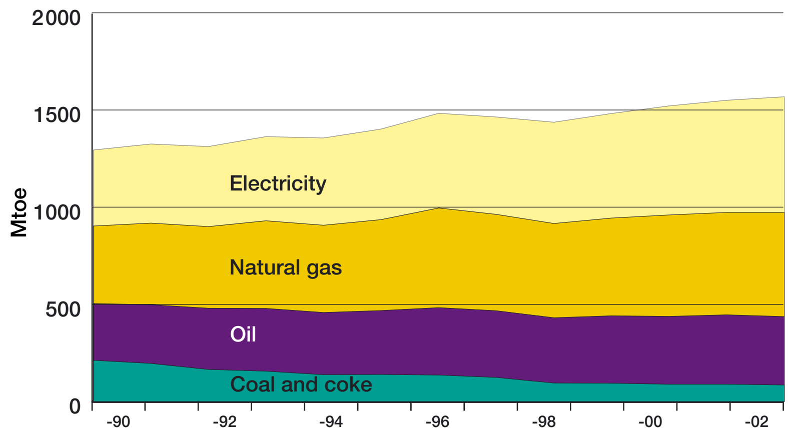
Some regional presentations

North America

The geographical concept of North America consists of Canada, the USA and Mexico. In this group, the USA is the dominant user, accounting for 85% of energy supply.

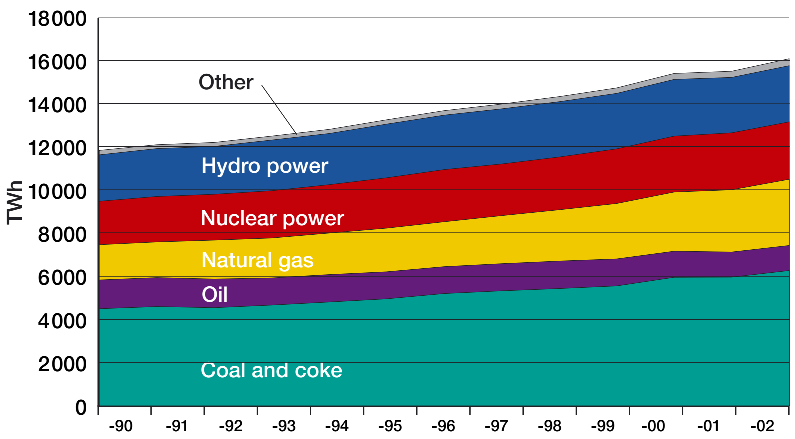
In 2003, total energy supplied to North America

Figure 44: World energy use in the household and commercial sector



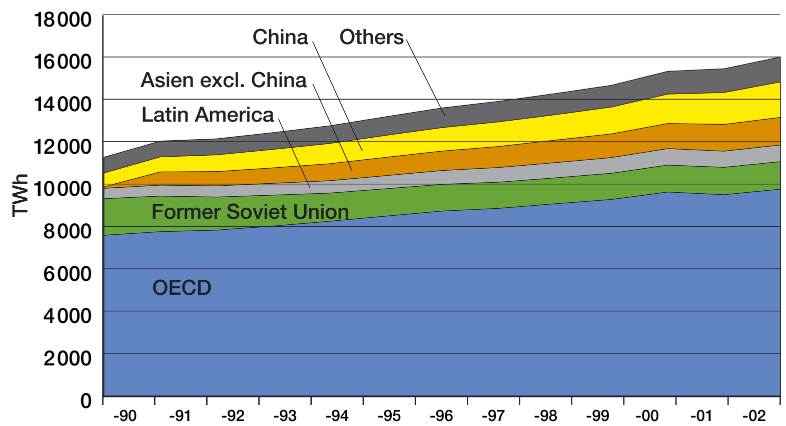
SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

Figure 45: World electricity production by energy sources



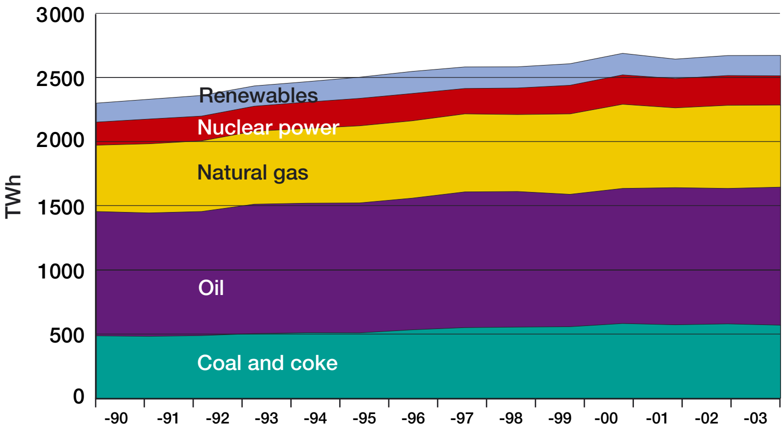
SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

Figure 46: Regional world electricity production



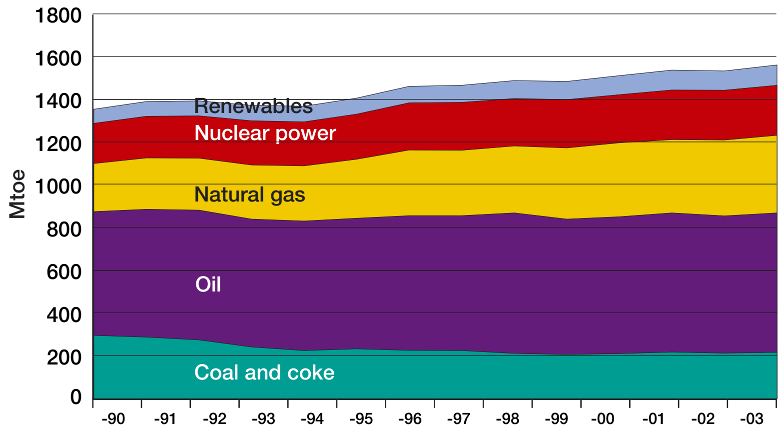
SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

Figure 47: Energy supply in North America



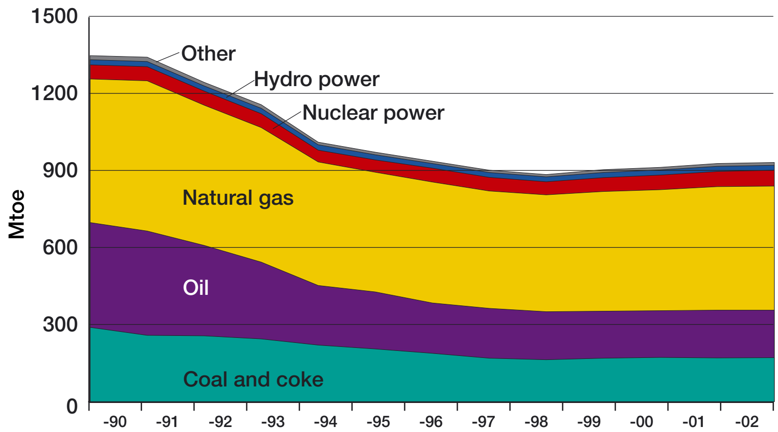
SOURCE: IEA, ENERGY BALANCES OF OECD COUNTRIES (2005 EDITION)

Figure 48: Energy supply to EU 15



SOURCE: IEA, ENERGY BALANCES OF OECD COUNTRIES (2005 EDITION)

Figure 49: Energy supply in Russia and OSS



SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

amounted to 2672 Mtoe, which was only 2 Mtoe higher than in 2002. 2003 was remarkable, in that the total supply of coal, natural gas and nuclear power actually fell by a total of over 20 Mtoe. The decline in the supply of natural gas was due mainly to the fact that production in the USA fell, and could not be replaced in the short term by imports. The only energy carriers that increased in volume were oil and renewable energy. The supply of oil increased by 20 Mtoe, or somewhat less than 2% increase, while the supply of renewable energy increased by 3 Mtoe, equivalent to an increase of over 2%.

Energy use increased by over 1.5% in 2003, which is the same as the average over ten years. Total energy use declined in the industry sector, but increased by about 2.5% in both the transport and residential and service sectors. This means that the transport sector nowadays accounts for about 40% of final energy use, with the industry sector on its way down to a 25% proportion of total energy use.

EU 15

Energy supply in Europe increased by almost 2% in 2003, which is twice as much as the trend for the last ten years. All energy carriers increased by proportionally the same amount, which means that their relative proportions are unchanged. Oil still has 42%, natural gas 23%, nuclear power 15%, coal 14% and renewable energy sources 6%. Nevertheless, seen over a longer period, natural gas is continuing to replace coal in the overall energy balance. However, the steady downward trend for coal seems to have been interrupted, with a bottom level of 207 Mtoe in 1999 as against 217 Mtoe in 2003.

In 2003, energy use increased by almost 3%, or twice the rate of the ten-year average. The biggest rise, of 5%, occurred in the residential and service sector. The transport sector continues to increase its use of energy, using as much energy in 2002 as the industry sector. Within EU 15, the industry sector and the transport sector each account for about 30% of energy use, with the residential and service sector accounting for 40%.

Electricity use increased by 3%, from about 2 300 TWh to almost 2370 TWh. The biggest increase, at 3%, was in the residential and service sector, which means that this sector now accounts for 55% of electricity used in EU 15.

EU 25

The accession of a further ten countries on 1st May 2004 means that the EU now consists of countries differing considerably in terms of size, geographical conditions and economic conditions. Poland, which is the largest of the new member states, has a GDP of about 6% of that of Germany. Germany, the UK, France and Italy together account for 71% of GDP and 66% of energy use in the old EU 15. Energy use in the new member countries is about one-tenth of that in EU 15, which is largely explained by the fact that these countries are relatively small in comparison with those making up EU 15. In comparison with the case in EU 15, coal is more important for final energy use in the new member states, with oil and gas being less important.

Russia and allied states (OSS)

The decline in Russian energy supply began to stabilise in the middle of the 1990s, starting a slight rise in 1998. It is worth noting how important natural gas is in the energy system, providing over 50% of energy supply, in comparison with the world average of somewhat over 20%. Of equal note is the low proportion of energy supplied by oil, amounting to only 20% of energy supplied, as against a world average figure of 36%.

It can be worth noting that domestic gas consumption amounts to over 75% of the countries' total production: no other major gas exporting region uses such a high proportion of its own production.

Energy use in the OSS has stabilised at about 600 Mtoe per annum. It should be noted that, at 42% of total energy use, the residential and service sector accounts for a very high proportion. Part of the reason for this is that household energy consumption is still strongly subsidised. Prices are gradually being brought into line with world prices, and particularly in the industrial sector, but attempting to change prices to domestic users is politically highly sensitive.

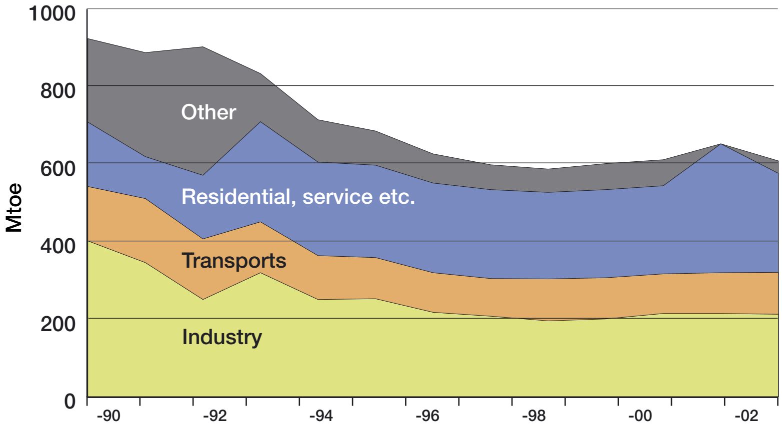
China

Energy supply in China is dominated by coal, making up 58%, although this is almost a 5% reduction since 1990. For some years now, the traditionally next largest energy source, biomass and waste heat, has been overtaken by oil. In 2002, oil accounted for 20% of energy supply, which is low in an international perspective. Since the beginning of the 1990s, the use of biofuels has decreased from 23% to 18%.

Nuclear power and natural gas still play only minor parts, although everything indicates that the proportions of energy supply provided by oil, natural gas and nuclear power will increase at the expense of both coal and biofuels.

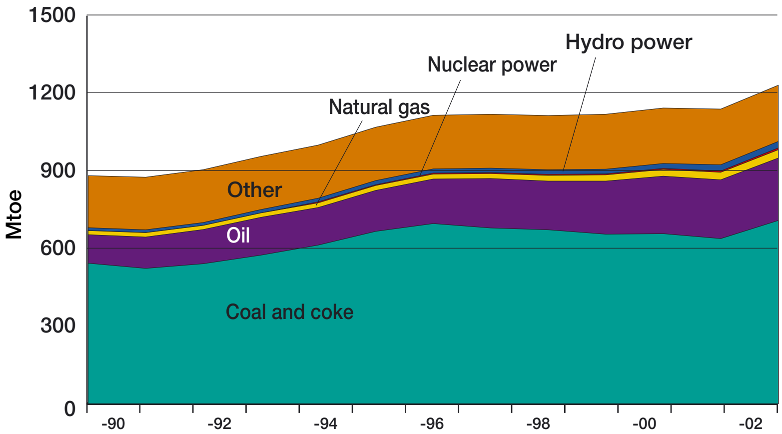
The demand for energy took off in 2002, increasing by over 4%. As far as can be told, this rate of increase has since further risen in both 2003 and 2004. At 40%, the proportion of energy used by the industrial sector is approximately the same as that used by the residential and service sector. Transport accounts for only 10% of energy use, but it is in this sector that demand is growing most rapidly. ■

Figure 50: Energy use in Russia and the OSS



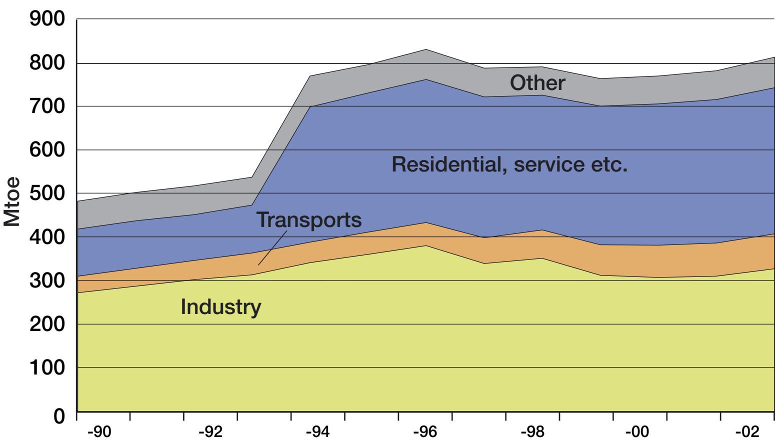
SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

Figure 51: Energy supply in China



SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

Figure 52: Energy use in China



SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES (2004 EDITION)

Note: The apparent substantial increase in energy demand for the residential and service sector from 1994 is probably merely the result of statistical errors.

The environmental situation

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

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

Local and regional environmental problems

Local environmental problems include point source emissions of pollutants to air or water. Examples include those resulting from various forms of combustion, such as particulates, volatile organic compounds and low-level ozone. Problems of this type generally have an immediate effect on their surroundings and are easy to detect, so steps to deal with them can generally be taken at an early stage.

Regional environmental problems include acidification and eutrophication. The damage that they cause becomes apparent only after a longer time and they are generally more difficult to deal with than local environmental problems. They often have many different sources, and spread over large areas. Environmental problems are regarded as being regional if they afflict large areas, countries or, in some cases, continents.

Acidification

At the beginning of the 1970s, acidification was one of the environmental problems in Scandinavia to which the most attention was paid. The ability of Scandinavian soils to neutralise acidity is less than in most other parts of Europe. It was in the Scandinavian countries that the problem was first noticed, with the result that it was long regarded as an essentially Scandinavian problem. One of the effects of acidification is the release of metals such as aluminium in the ground and water, making them available for uptake by plants and organisms. This adversely affects the growth of forests and leads to damage to many sensitive species of plants and animals, both on land and in water. The main cause of acidification is the emission of sulphur in the form of sulphur dioxide, with ammonia and oxides of nitrogen (NO_x) also contributing to the effect. 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 2002, Swedish emissions of sulphur dioxide amounted to about 50 000 tonnes in total. Sweden’s ’import’ of sulphur on wind streams from other countries is therefore much greater than the contribution from indigenous sources. On the other hand, Sweden ’exports’ about 60% of its own emissions to other countries: only about 11 000 tonnes fell back to Swedish soil in 2000. The export and import quantities shown in Figure 53 are expressed as quantities of pure sulphur: each tonne of sulphur produces about two tonnes of sulphur dioxide.

Reduced sulphur emissions

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

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

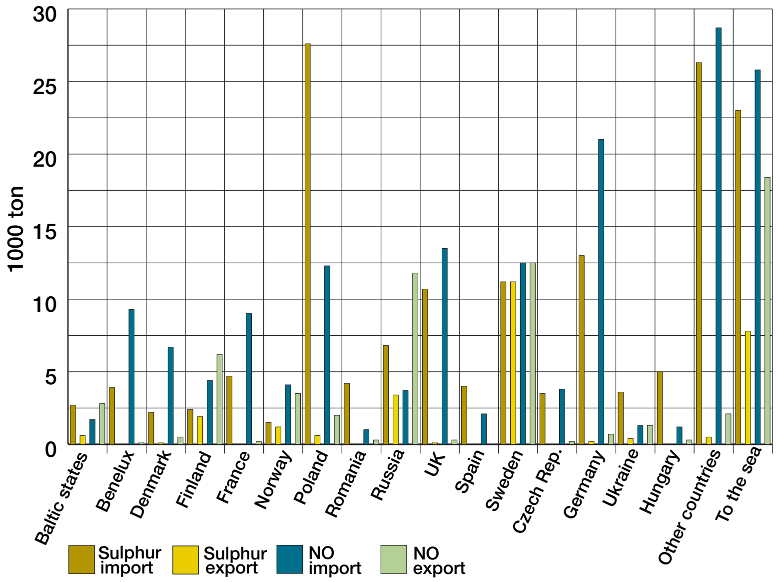
Eutrophication

The main cause of eutrophication is an excess of nitrogen. Most nitrogen compounds are deposited on the ground, but if plants cannot utilise it all, the surplus is leached off into waterways where it contributes to excessive aquatic plant growth, algae blooms and oxygen-free sea or lake bottoms. Most of the nitrogen run-off comes from the use of manure and fertilisers in agriculture, but the energy sector is the main origin of most of the excess nitrogen in the atmosphere.

Reduction of NO_x emissions

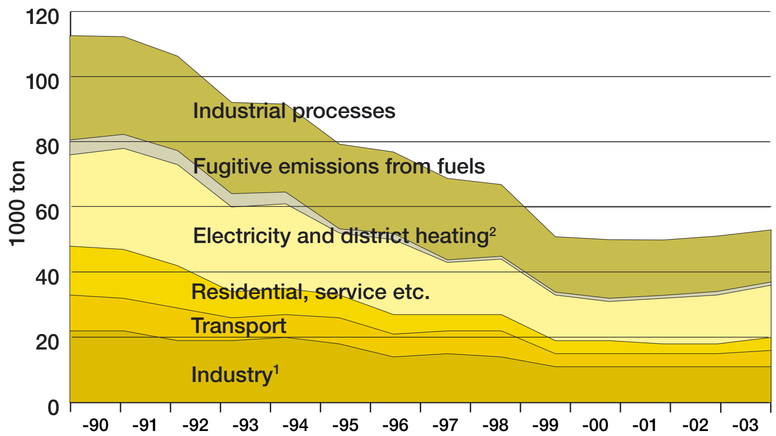
By far the greatest proportion of NO_x emissions comes from road traffic, see Figure 55. Emissions of NO_x are being reduced by the introduction of catalytic exhaust cleaning in petrol driven vehicles, but are not diminishing to the same extent as sulphur dioxide. Emission requirements for both petrol and diesel cars and for heavy goods vehicles were progressively tightened up during the 1990s. Emissions of NO_x have been reduced by over 25%, to 206 000 tonnes/year, between 1990 and 2003, despite a rise in transport work. Under the 'Zero Eutrophication' banner, there is a sub-objective of reducing airborne emissions of NO_x in Sweden further to 148 000 tonne/year by not later than 2010. The largest contributors to NO_x precipitation in Sweden from other countries are Germany, the UK and Poland. Solving eutrophication problems requires international cooperation, and it is here that the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and various EU directives have an important part to play. Emissions of NO_x are treated in the same way as those of sulphur dioxide in the Convention, in the Oslo Protocol and the Gothenburg Protocol (the Protocol to Abate Acidification, Eutrophication and Ground-level Ozone) and elsewhere. The EU Directive on National Emission Ceilings has also set emission ceilings for NO_x and ammonia by 2010.

Figure 53: Swedish imports and exports of sulphur and NO_x (expressed as NO_2) in 2000



SOURCE: PROCESSING BY THE ENVIRONMENTAL PROTECTING AGENCY OF BASIC DATA FROM TRANSBOUNDARY ACIDIFICATION AND EUTROPHICATION AND GROUND- LEVEL OZONE IN EUROPE, EMEP STATUS REPORT 1/2003

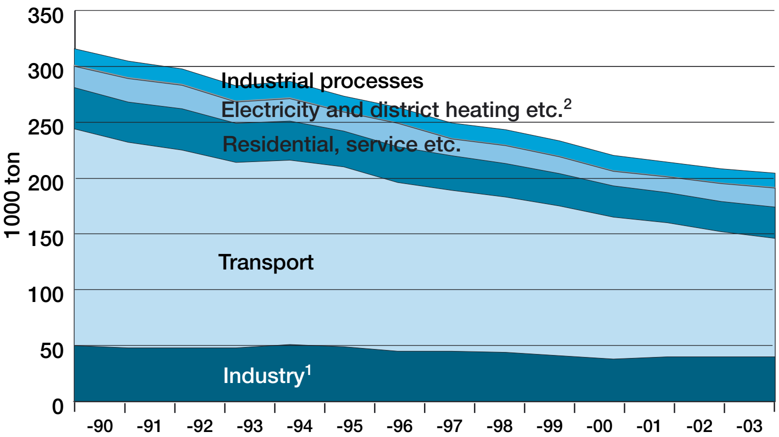
Figure 54: Sulphur dioxide (SO_2) emissions in Sweden, 1990–2003



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

SOURCE: SWEDEN'S STATUS REPORT TO THE UN AIR POLLUTION CONVENTION; SWEDISH ENVIRONMENTAL PROTECTION AGENCY 2005; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY.

Figure 55: NO_x emissions (expressed as NO_2) in Sweden, 1990–2003



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

SOURCE: SWEDEN'S STATUS REPORT TO THE UN AIR POLLUTION CONVENTION; SWEDISH ENVIRONMENTAL PROTECTION AGENCY 2005; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY.

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

Depletion of the ozone layer

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

Tackling depletion of the ozone layer is the first global environmental problem that has been successfully reduced by strong measures at international level. The use of ozone-destructive chemicals has been regulated by a number of international agreements (the Vienna Agreement and the Montreal Protocol). Production is declining, and it is expected that the ozone layer will be back to normal by about the middle of the next century.

The greenhouse effect

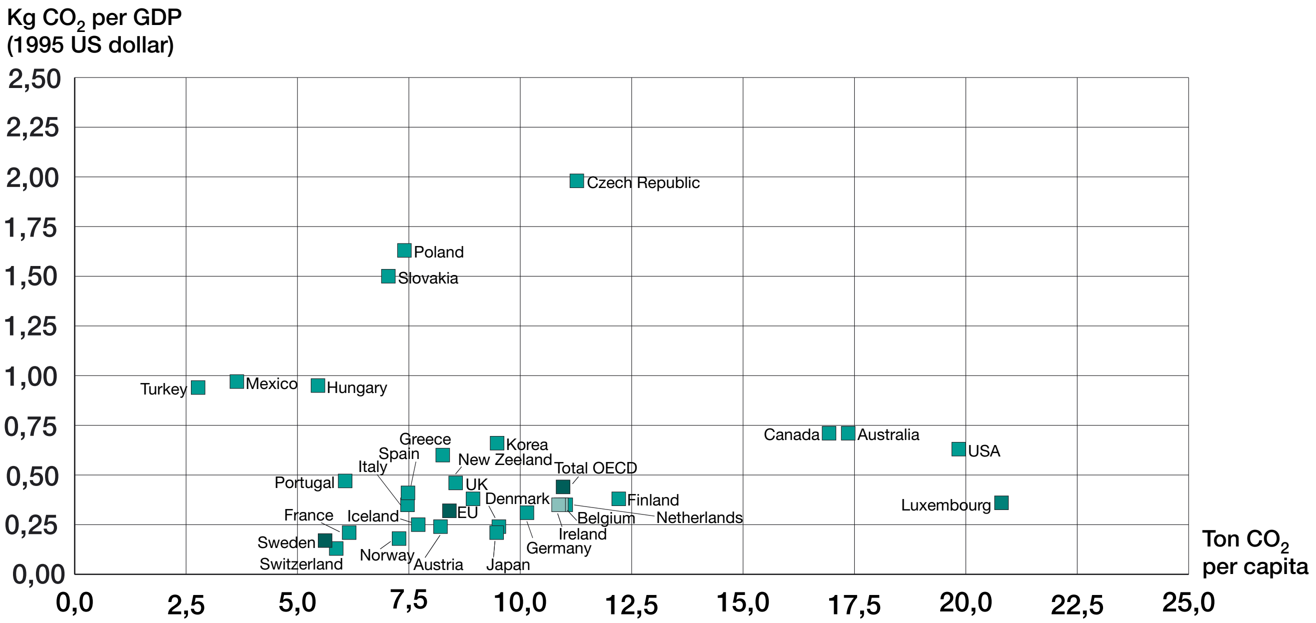
Strictly, the greenhouse effect is not an environmental problem: it is, in fact, an essential factor for the existence for life on earth. Without carbon dioxide and water vapour in the atmosphere, the average temperature of the earth would be about 33 °C lower than it is today (i.e. about -18 °C), and the planet would be frozen. It is, however, the increase in the greenhouse effect, resulting from the emission of greenhouse gases, that is an environmental problem.

Over the last 150 years, anthropogenic[81] activities have increased the concentration of carbon dioxide in the atmosphere by about 30%: if the oceans were not also a major sink for carbon dioxide, this increase would have been closer to 60%. The average temperature of the earth has risen by about 0,5 °C during the 20th century, but has accelerated particularly during the last 25 years. Carbon dioxide is the most important anthropogenic greenhouse gas, but other gases that contribute to the effect include methane, nitrous oxide (laughing gas – N_2O), low-level ozone, HFCs and PFCs (refrigerants) and sulphur hexafluoride (an electrical insulator). Per molecule or per kilogram, these gases actually have a more powerful greenhouse effect than carbon dioxide 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 OECD emissions, over 45%. Other countries with high emissions include Japan, the UK and Germany. In terms of highest per-capita emissions, the USA is in top place, followed by Luxemburg, Australia and Canada. These countries also have high emissions in relation to their GDPs, although the old Eastern Bloc countries such as Poland and the Czech Republic have even higher levels. (See Figure 56.) Sweden contributes a few parts per thousand to the world's carbon dioxide emissions, with per-capita and GDP-

[81] Anthropogenic: originated by man (OED).

Figure 56: Per-capita and GDP-proportionate emissions of carbon dioxide from combustion in EU and OECD countries in 2002.



SOURCE: OECD IN FIGURES, 2004 EDITION

proportionate emissions being below the average both for the OECD countries and for the EU. Carbon dioxide emissions in 2003 were less than in 1990. The reason for the low emission level is that much of its electrical energy system is based on nuclear power and hydro power, which have no net emissions of carbon dioxide.

According to the IEA reference scenario[82], carbon dioxide emissions will continue to increase steadily, at a rate of somewhat over 1.8% per annum until 2030. Of this, about two-thirds will come from the developing countries. By 2030, emissions are expected to have increased to about 38 x 10^9 tonnes, which is 70% more than today. Electricity production and transport are expected to contribute to more than three-quarters of the increase in emissions. Geographically, it is expected that the proportion of global CO_2 emissions from the developing countries will have increased from 34% to 47%, while that of the OECD states will have fallen from 55% to 43%. China is expected to account for a quarter of the increase in emissions. The IEA points out in its forecast that the OECD states will have difficulty in fulfilling their Kyoto commitments, particularly if it is assumed that the USA does not intend to ratify the Kyoto Protocol. ■

[82] IEA – World Energy Outlook

Energy facts

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

Table 8: Conversion factors for effective calorific values, as used by Statistics Sweden and The Swedish Energy Agency.[1]

Fuel	Physical Quantity	MWh	GJ
Wood chips	1 tonne	2.0–4.0	7.2–14.4
Peat	1 tonne	2.5–3	9–11
Pellets, briquettes	1 tonne	4.5–5	16–18
Coal	1tonne	7.56	27.2
Coke	1 tonne	7.79	28.1
Nuclear fuel	1 toe	11.6	41.9
Crude oil	1 m^3	10.1	36.3
Topped crude oil	1 m^3	11.1	40.1
Petroleum coke[2]	1 tonne	9.70	34.9
Asphalt, road dressing oils	1 tonne	11.6	41.9
Lubricating oils	1 tonne	11.5	41.4
Road fuel petrol[3]	1 m^3	9.04	32.6
Virgin naphtha	1 m^3	8.74	31.5
Light virgin naphtha	1 m^3	7.91	28.5
Aviation petrol	1 m^3	8.51	30.6
Other light oils	1 m^3	8.74	31.5
Petroleum naphtha	1 m^3	9.34	33.6
Aviation paraffin	1 m^3	9.58	34.5
Other paraffin and intermediate oils	1 m^3	9.54	34.3
Diesel fuel[4] and gas oil	1 m^3	9.96	35.9
Heavy fuel oils and bunker oil[5]	1 m^3	10.6	38.1
Propane and butane	1 tonne	12.8	46.1
Town gas, coking oven gas	1 000 m^3	4.65	16.7
Natural gas[6]	1 000 m^3	9.99	36.0
Blast furnace gas	1 000 m^3	0.930	3.35

Notes: [1] Specific energy contents are expressed to three significant digits. More significant digits have been used in the calculations.The following values were used prior to 2001:

[2] 9.67 for conversion to MWh and 34.8 for conversion to GJ.
[3] 8.72 for MWh and. 31.4 for GJ.
[4] 9.89 for MWh and 35.6 for GJ.
[5] 10.8 for MWh and 38.9 for GJ.
[6] 9.72 for MWh and 35.0 for GJ.
The value for natural gas is the net (lower) calorific value. The gross (upper) calorific value for conversion to MWh is 11.1 from and including 2001: prior to 2001, it was 10.8.

Energy quantities and conversion factors

Conversion factors are revised when changes in fuel energy contents have occurred. During the latest such revision, for statistics from and including 2001, the specific energy contents of petroleum coke, petrol, diesel fuel, gas oil, all grades of heavier fuel oils and natural gas were changed. Note that these conversion factors are averages for various fuels, and that there are differences between qualities, not least for various wood fuels and coal.

The international standard unit for energy is the joule (J). However, this is a small unit (1 J = 1 watt-second), and so for convenience the watt-hour (Wh) or kilowatt-hour are generally used. International comparisons and statistics often use the unit of toe (tonne of oil equivalent). In some applications, calories (cal) are still used. All these units are impractically small for dealing with large energy quantities in national contexts: instead, larger units are used through the additions of prefixes, such as petajoule (PJ) or terawatt-hour (TWh). ■

Table 9: Conversion between energy units as used in *Energy in Sweden.*

	GJ	MWh	toe	Mcal
GJ	1	0.28	0.02	239
MWh	3.6	1	0.086	860
toe	41.9	11.63	1	10 000
Mcal	0.0419	0.00116	0.0001	1

Table 10: Prefixes used with energy units in *Energy in Sweden*.

Prefix	Factor		
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

A little energy reference book

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

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

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

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

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

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

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

Efficiency improvement
All energy use processes (e.g. lighting, electric motor drive, petrol motor drive etc.) involve some loss, i.e. not all of the energy supplied is turned into the desired form.

In the case of lighting (for example), some of the electrical energy ends up as heat, rather than light. If we can improve the process, we can get more light and less heat for the same amount of energy: i.e. we have improved the efficiency. Progressive improvements in the case of lighting are from incandescent bulbs (hot wire filaments), to fluorescent tubes, to high-frequency fluorescent lamps. The next stage is still under development: to white light-emitting diodes.

Electricity certificate system
The electricity certificate system is a market-based support system to assist the growth of renewable electric power production (electricity from solar energy, wind power, hydro power and biofuels) in Sweden. The target is to increase the amount of such power by an additional 10 TWh/year by 2010. All producers of such renewable power receive one certificate unit per MWh of electricity. These certificates can then be sold, as the system requires all electricity users (with a few exceptions) to buy a certain number of certificates, determined by their quota obligation.

By raising this quota each year (i.e. by requiring users to buy a greater proportion of electricity from renewable sources), demand for such electricity will be increased, thus stimulating the expansion of production from renewable energy sources.

Energy
Is measured in joules, which equal 1 watt-second. One kilowatt-hour (kWh) therefore equals 3 600 kilojoules, as there are 3600 seconds in an hour.

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

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

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

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

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

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

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

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

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

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

as propane, ammonia or fluorocarbons, and at lower temperatures than for water. In this way, they can absorb heat from their surroundings.

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

Gasification
Gasification is a very important process in energy technology, as no fuel can burn without first being converted to gas. Gasification of a fuel generally occurs when the fuel is actually burnt. However, combustion losses can be reduced by first gasifying the fuel before combustion, and then delivering it in gaseous form. Another reason for doing this is that it makes it easier to remove various contaminants. Solid fuels can be converted to gaseous form either by pyrolysis or by partial combustion. In addition, organic non-fossil materials can be gasified by biological processes, to produce biogas. Pyrolysis (dry distillation) involves heating the solid organic material in the absence of oxygen, causing it to release volatile substances (mainly various hydrocarbons) without burning them. Light hydrocarbons released in this way (e.g. methane) remain in the gas phase even if they are then cooled, but other hydrocarbons condense to pyrolysis oil, leaving most of the fuel in solid form as carbon powder or sinter and ash.

Partial combustion involves supplying steam and limited quantities of air to glowing carbon in a special reactor vessel, to produce a gas consisting of a mixture of hydrogen, carbon monoxide, carbon dioxide and nitrogen. The combustible constituents of this gas, known as water gas, are hydrogen and carbon monoxide. Generator gas consists mainly of carbon monoxide, carbon dioxide and nitrogen. Water gas is widely used in the chemical industry as a feedstock for the production of more high-value fuels and chemical products, such as methanol.

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

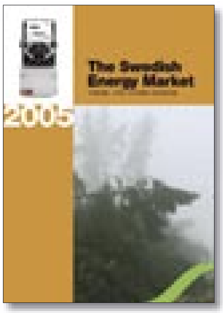
Oil equivalent
A common unit for comparing the energy contents of various fuels with each other and with a standardised measure of the energy content of fuel oil. The unit is generally that of tonne of oil equivalent (toe), which provides 41.9 GJ or 11.63 MWh.

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

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

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

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



The Swedish Energy Market 2005

The Swedish Energy Market 2005 is an annual publication from the Swedish Energy Agency that presents data and statistics on the piped and wired energy markets in Sweden, i.e. the markets for electricity, natural gas and district heating. It also provides an overall picture of the energy market events, or factors affecting or with a potential to affect the energy markets, that occurred during the second half of 2004 and the first half of 2005. The 2005 edition includes a theme chapter on the effects of the Storm Gudrun, that struck southern Sweden in January 2005.

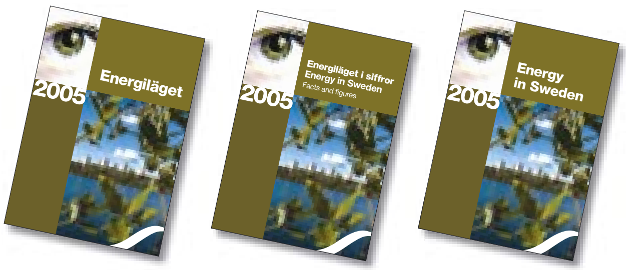
An efficient and low-environmental-impact energy system

The Swedish Energy Agency is the central Swedish public authority for energy. Our work is aimed at assisting the strategic transformation of the Swedish energy system to a low-environmental-impact, reliable and efficient energy system. Although Sweden's energy system is our prime objective, we also extend this work to co-operation on an international level.

We promote more efficient energy markets, with increased production from renewable energy sources. We are the regulatory authority for Sweden's gas and electricity grids, and are also responsible for the country's strategic energy preparedness for crisis situations. We support a large number of research and development programmes in the energy sector in conjunction with universities, research institutes and industry.

Energy in Sweden is published annually, and is intended to provide decision-makers, journalists and the public with coherent and easily available information on developments in the energy sector.

Energy in Sweden is available in Swedish and English, in the following formats, all of which can be ordered or downloaded from the Swedish Energy Agency's web site at www.stem.se – Publications.



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