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Preface

Everywhere in the world, the challenges presented by energy policy are more or less similar. Energy supplies need to be reliable, environmentally friendly, and the energy needs to be available at reasonable prices. These three fundamental objectives can complement each other or be mutually opposed, which shows the complexity of energy policy, a complexity which is further compounded by the close links between energy, environmental and climate policies.

Improving the efficiency of energy use and supporting the use of renewable energy sources can contribute to achievement of all three objectives. These are working areas in which activities are increasing, linked by the EU as an important driving force. The EU is also giving priority to the single market in energy, which includes deregulation and trade in energy across national borders. Another clear driving force behind the evolution of energy systems is that of international cooperation in the climate sector, where the Agency's work includes management of Sweden's membership of the emissions trading system, international climate projects and climate research related to energy policy. Energy policy also includes regulatory surveillance of the Swedish energy markets, contingency planning for crises, and research, development and demonstration activities. International cooperation is thus of decisive importance both for development of the energy system and for dealing with cross-border and global environmental problems.

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 academic and applied scientists. The acquisition and publication of information on the energy system and its development are therefore central parts of the Agency's work.

Energy in Sweden and its sister publication, Energy in Sweden – Facts and figures, are published annually, and are intended to provide decision-makers, journalists, companies, teachers and the public with coherent and easily available information on developments in the energy sector.

Most of the publication is based on official statistics up to and including 2005, complemented where possible by input reflecting current events and decisions up to the middle of 2006. However, the change of Sweden's government as a result of the election in October 2006 could result in some changes in the direction of Swedish energy policy. The new government's Statement of Policy and its 2007 Budget Bill are summarised from an energy policy perspective in a facts panel.

Eskilstuna, November 2006

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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 EU decisions, although global agreements are becoming increasingly important. The need for global cooperation is particularly 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 adverse 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[1] energy policy agreement, together with a strategy for continued restructuring of the country's energy system. The guidelines were confirmed in 2002, when Parliament adopted Bill no. 2001/02:143.

Greater political importance has been attached to surveillance and control of the energy markets, and additional emphasis has been put on economic policy measures intended to assist restructuring the country's energy system. Consumer aspects, crisis preparedness and measures intended to address vulnerabilities have also become more important. Renewable energy sources and improvements in the efficiency of energy use are priority working areas.

From January 2005 until the change of government in October 2006, energy fell within the remit of the Ministry of Sustainable Development. The panel on the next page summarises the most important energy policy points in the new government's policy statement and Budget Bill of October 2006.

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 between 2002 and 2010. A number of changes were introduced in June 2006, including extending the certificate system until 2030 and raising the target to 17 TWh of new renewable electricity production by 2016 over the 2002 production level.

One of the planning objectives for wind power production is that local authorities must have agreed plans for 10 TWh of wind power production by 2015.[2] The Government's Wind Power Bill[3] presents proposals for measures to assist achievement of the planning objective, including support for local authority land use planning and continued simplification in order to facilitate the approval procedures for the construction of wind power resources. In addition, the 2002 Energy Policy Decision also includes measures to improve the efficiency of energy use, such as 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 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 their efficiency of electricity use. EU wide trading in carbon dioxide emission allowances also started in 2005, with the aim of reducing emissions of greenhouse gases. Over 700 Swedish plants are included in the trading system.

[1] Bill no. 1996/97:84. Current energy policy represents an agreement between the Social Democrats, the Left Party and the Centre Party.
[2] Read more about details of the national planning target and other matters in ER 16:2003.
[3] Bill no. 2005/06:143, Green Electricity from Wind Power – Measures for viable wind power production.

FACTS: Statement of Government Policy and the 2007 Budget Bill

Sweden's new government took office on 6th October 2006. Energy policy decisions previously made by Parliament remain valid unless and until new policy decisions are made. In the government's Statement of Policy, the Prime Minister sets out the government's intentions for the coming mandate period, with information on certain energy policy matters. In its Budget Bill for 2007 (presented to Parliament on 16th October), the new government sets out its proposals for Parliament's decision on its economic policy, including that for Expenditure Area 21, Energy.

- The government intends to invite all parliamentary parties to agree on a wide-ranging and long-term energy policy accord, based on the existing Alliance for Sweden's energy policy agreement.
- The government's objective is to break the connection between economic growth and greater use of energy and raw materials, by such means as improving the efficiency of energy use.
- Sweden's environmental activities will be determined by ambitious environmental and climate targets, accompanied by clear plans of action. Strong actions will be taken in the transport, residential and industry sectors.
- Environmental and energy taxation will be designed such that it will be in taxpayers' interests to act responsibly in environmental matters. Taxes and regulations that have the effect of opposing more efficient use of energy will be modified. Property tax will be frozen. Energy conservation measures in industry will be encouraged, accompanied by a programme of energy efficiency improvement measures for the country's residential building stock. The government will publish its proposals in due course.
- The transfer to green taxation will be suspended, aviation tax will be discontinued, proposals for harmonisation with the EU Energy Taxation Directive will be published, as will proposals for reduction of the energy tax on electricity in northern Sweden.
- No political decisions on phase-out of the country's nuclear reactors will be taken during the 2006-2010 mandate period. Barsebäck will not be allowed to restart. The ban on constructing new reactors will remain in force, and the government intends to consider the applications for increases in output in accordance with applicable legislation.
- The government is appointing a commission to review the possibilities of reducing the joint ownership of the Swedish nuclear power plants.
- Increased resources will be assigned to the provision of emergency electrical power supplies to electronic communication systems.
- An incentive to encourage the use of environmentally benign vehicles will be introduced. A review of the environmental classification of vehicles and fuels will be carried out, and environmental requirements for public transport negotiations will be tightened up.
- Expansion of combined heat and power generation will be encouraged. The government will publish its proposals in due course.
- Small-scale hydro power will continue to be entitled to green electricity certificates after 2012. The quotas in the system will be adjusted accordingly.
- The government will introduce special funding support for municipalities, regional bodies and country administrative boards for development and acceleration of the planning process for new wind power installations.
- Sweden will press for clear targets for reduction in the use of fossil energy to be set within the EU, and will actively assist reaching these joint targets.
- The EU Emissions Trading Scheme should be expanded in terms of parties covered and of substances, and efforts should be made to bring more countries into the system. The Kyoto Protocol should be extended (i.e. continued) as soon as possible.
- Sweden will press for the establishment of a strategic energy agreement between the EU, China and India. Swedish aid to developing countries will remain at a high level, with greater importance attached to environmental and energy considerations. The government proposes that a Globalisation Council should be established.
- Support for climate investments will be increased, particularly for biobased motor fuels.
- The economic frameworks for research will be increased. A greater proportion of research funding will be channelled through faculty grants to outstanding research environments. SEK 1000 million will be invested in climate research.
- Targets in terms of converting research results into commercial products and services should be raised. The administration grant to the Swedish Energy Agency is therefore being increased.
- Energy matters will be transferred from the Ministry of Sustainable Development to the Ministry of Industry and Commerce. The head of the restructured Ministry of Industry and Commerce is Maud Olofsson, and the head of the restructured Ministry of the Environment is Andreas Carlgren.

Statement of Government Policy and Budget Bill (bill no. 2006/2007:1)

At the beginning of 2005, the Government established the Energy Markets Inspectorate as part of the Swedish Energy Agency. The Inspectorate monitors, analyses and exercises surveillance over the electricity, natural gas and district heating markets. During the year, the Inspectorate decided to investigate the 2004 tariffs of 50 network companies in more detail. In addition, it exercised its powers under the Compulsory Administration Act for the first time, when a network company failed to comply with the Electricity Act. Following on from Storm Gudrun on 8th-9th January 2005, the Government instructed the Inspectorate to prepare proposals for improving the physical security of electricity supply. The results were presented in a report in April 2005, and formed the basis of the changes in the Electricity Act that were introduced on 1st January 2006.

A special conversion grant was introduced on 1st January 2006 in order to reduce the use of oil and electricity for heating purposes in residential buildings and certain commercial premises. The grant is available for conversions to district heating, biofuel fired heating systems, heat pumps or solar heating.

With effect from 1st April 2006, larger petrol stations have been required to sell renewable motor fuels, which has encouraged sales of ethanol. A special programme provides support for other alternative motor fuels during 2006 and 2007.

The climate investment programme (Klimp) has been augmented for 2007 and 2008.

Long-term measures

In June 2006, Parliament set the target[4] that specific energy use in residential buildings and commercial premises should be reduced by one fifth by 2020, further reducing to half of present day levels by 2050. In addition, by 2020, the dependence of the built environment on fossil fuels for energy supplies should have been broken.

The first national energy research programme in Sweden was initiated in 1975, following on from the 1973 oil crisis. This means that Sweden has now had a public policy of research and development in the energy sector for over 30 years.

The 2005 Budget Bill[5] confirmed a new, long-term energy research programme for the period 2005–2011, concentrating on research, development and demonstration activities for the development of methods, technologies and processes for the changeover to a sustainable energy system. Initially, the programme involved a cut in grants from previous levels, but financing was restored to the original level of somewhat over SEK 800 million per year in the 2006 budget. Continued support is provided for pilot projects in the wind power field. The Energy Research Bill[6], which was presented to Parliament during the spring of 2006, proposes guidelines for the continued work. It includes requirements for greater links to business and industry, coupled with ambitious targets for turning research results into commercial products and services.

There are two research funding councils that are important sources of finance 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 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 Swedish Environmental 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.

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 was that of the increasing and competing demands for raw materials. The work was delayed for a number of reasons, including the effect of an additional directive, and was presented on 3rd October 2006.

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 special commission to investigate the ability of Swedish agriculture to produce bioenergy crops. This report is due for submission by not later than 28th February 2007.

A commission has been appointed to investigate what else Sweden should do in order to fulfil the requirements of the Energy Services Directive. The Directive requires each member state to achieve a measurable improvement of 9 % in its efficiency of energy use over a period of nine years. In achieving this, the public sector is expected to take a lead. In addition, energy utilities are required to assist in several ways, so that their customers can make cost efficient improvements in their efficiency of energy use. One of the areas to be investigated is whether it would be justified to introduce requirements for more individual metering, e.g. of domestic hot water consumption in individual apartments. In addition to the final report, which is due on 30th November 2007, the commission is required to submit interim reports in November 2006 and January 2007 on (respectively) how energy efficiency improvements can suitably be measured and monitored, and proposals for a national plan for further improvements in the efficiency of energy use.

An investigation into electricity network tariffs is due for completion on 20th December 2007, submitting proposals for legislation and regulations as needed to enable the surveillance authority to require the network operators to submit their tariffs and connection fees/methods for approval prior to their introduction. The report will also include proposals for how power supplies from other countries connected to the Swedish regional networks shall be dealt with in order to ensure that they are treated in the same way as when they are connected to the national grid. The investigation also includes analysis of the present boundaries between area and line concessions, and their links to the tariff regulations, as well as comparisons with the natural gas market.

Investigations concluded during the second half of 2005 and the first half of 2006

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, Buil-

[4] Bill no. 2005/06:145, National programme for improving the efficiency of energy use in buildings and smart energy construction.
[5] Bill no. 2004/05:1
[6] Bill no. 2005/06:127, Research and New Technology for Future Energy Systems.

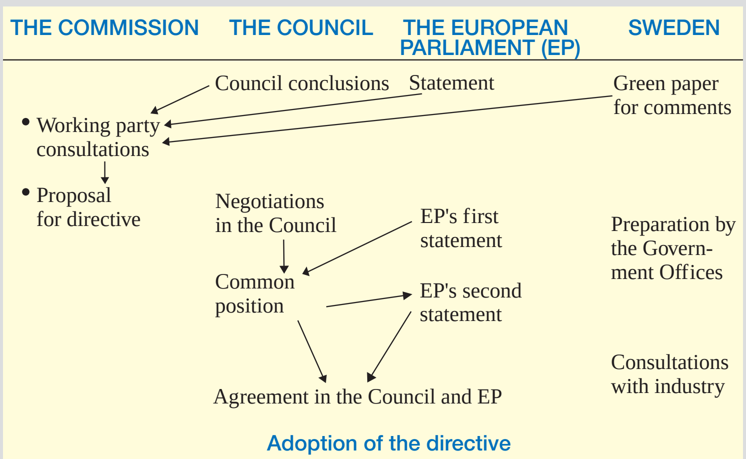
ding and Planning's Building Regulations. The Commission submitted a report[7] in November 2004, proposing the introduction of legislation concerning energy declarations for buildings. This will come into force at the beginning of October 2006, with the aim of encouraging efficient use of energy in buildings. The idea behind an energy declaration is to show how energy is used in the building, and how the building could be improved in order to reduce its energy use. It 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 com-mercial premises is rented out or when an apartment in a cooperative tenant-owners' society is transferred to a new tenant. Such energy declarations are to be valid for ten years. In practice, for detached houses, the requirement will not apply until the house is sold. The final report[8] was delivered in August 2005, with the Commission submitting proposals for the information required in an energy declaration, what calculations are to be made, and the requirements to be expressed in respect of the persons to perform the work.

The Commission on Oil Dependency (the 'Oil Commission'), which was appointed by the Government in December 2005, presented its report[9] in June 2006. The Commission had been asked to present a concrete strategy for breaking Sweden's dependence on oil by 2020. This involves targets of reducing the dependence of the transport sector on oil by 40-50 % in comparison with today, heating residential buildings and commercial premises entirely without the use of oil, and reducing the use of oil by industry by 25-40 %. The efficiency of energy use within society as a whole shall have improved by at least 20 %.

[7] SOU 2004:109
[8] SOU 2005:67
[9] On the way to an oil-free Sweden, June 2006
[10] 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.

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



Energy in the EU

The common actions that have been taken in the energy sector in Europe 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 within the EU is concentrated primarily on creating a single competitive market for electricity and natural gas, and on increasing the security of supply.

Under the leadership of energy policy commissioner Andris Piebalgs, the Commission has hitherto issued new Green Papers[10] and evaluations of existing legislation. This work can result in concrete legislative proposals, which may either be presented, or be ready for decision, in 2009.

New legislation that has come into force

The Ecodesign of Energy using Products Directive (2005/32/EC) was adopted in 2005, with the aim of improving the energy efficiency and reducing the environmental impact of products throughout their entire life cycle. Common EU 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 means that it 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.

A package of Commission documents on **Energy Infrastructures and Security of Supply** was presented in 2003. The proposal for the infrastructure package related to two directives (Energy Services and Electricity Supply), an Ordinance concerning the supply of gas and a decision (TEN-e). All of these have now passed Parliament and become new legislation.

EU import requirements of energy (primarily natural gas) are growing, but most of the energy sources lie outside the EU. This means that gas mains from southern and eastern Europe to previous Soviet Republics, the Middle East and the Gulf region are important. Decision 1364/2006/EC was signed by the Council and Parliament on 6th September 2006, concerning **Guidelines for the Trans European Energy Network** (TEN-e), and came into force on 12th October.[11]

The Directive Concerning Measures to Safeguard Security of Electricity Supply and Infrastructure Investment (2005/89/EC) was adopted in December 2005. It is concerned with ensuring a high level of security of supply to electricity users. The compromise proposal that was put forward emphasises that it is the parties involved on a liberalised market who must be responsible for ensuring that their customers‘ demand for electricity can be met. The pricing of electricity on a competitive market must also provide the parties with signals of the measures that are necessary. Intervention from states on these markets can distort the signals.

The Gas Regulation (2005/1775/EC) was adopted in the autumn of 2005, and is to be seen as a step towards establishment of the single market package for electricity and gas supplies. With certain exceptions, it came into force on 1st July 2006. Its objective is to provide a stable framework to guarantee efficient utilisation of capacity. In addition, it is intended to create transparency of available capacity and harmonisation of network and balance services conditions.

The Directive on Energy End use Efficiency and Energy Services (2006/32/EC) was adopted in March 2006. Its objective is to achieve a more cost efficient and rational final use of energy, and to remove obstacles in the way of the energy services market. It includes an indicative energy conservation target of 9 % over nine years. In order to achieve this, member states will have to prepare and implement national action plans, with the public sector taking a leading role. Member states have two years to implement the directive.

Work in progress and proposals for new directives

The Commission has presented a Green Paper for the energy sector[12]. It notes that the EU is using ever more energy, with a correspondingly increasing requirement for imported energy. If nothing is done over the next 20-30 years, 70 % of the EU's energy requirements will have to be met by imported energy, as against 50 % today. In the Green Paper, the Commission sketches out the bases for a long term energy strategy. The question of substantial European dependence on other countries for its energy supply has come increasingly to the fore in recent years, as a result of rising oil prices and Russia's conflict with Ukraine, which has affected the supply of natural gas to Europe. The Green Paper has been circulated for comments in the member states, and will result in a strategic review of the energy sector, which is expected to be presented in January 2007. The review will, in turn, form a basis for the action plan for energy that the Council of Europe is to present to the spring summit in 2007.

The Commission has identified six core areas for the energy sector during the coming 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.

At the meeting of the Council in December 2005, Council Conclusions related to the Green Paper on improving energy efficiency[13] within the EU were adopted. In October 2006, the Commission presented an action plan for improved efficiency of energy use intended to achieve an energy saving of 20 % by 2020. The plan contains a package of priority measures in areas such as energy-using equipment, buildings, transport and energy production.

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 noted that it will be difficult to achieve the objectives on the basis of the measures that have been taken hitherto, and therefore emphasised the importance of further, sustained measures at national level, with advanced warning of further measures. In November 2004, the Council adopted conclusions that emphasised the importan-

[11] Decision of the European Parliament and of the Council, no. 1364/2006/EU of 6th September 2006, laying down a series of guidelines for trans-European energy networks.

[12] A European Strategy for a Sustainable, Competitive and Secure Energy Supply, COM (2006)105, final.

[13] "Att göra mer med mindre" ["Doing more with less"] COM(2005) 265

ce 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 emphasised the need for more long term approaches. An action plan for biomass[14] was presented by the Council in December 2005, with its conclusions being adopted in June 2006. The Commission also put forward a strategy for bio based motor fuels[15] in February 2006, but yet without Council conclusions adopted. An action plan for forests[16] was presented by the Commission in June 2006.

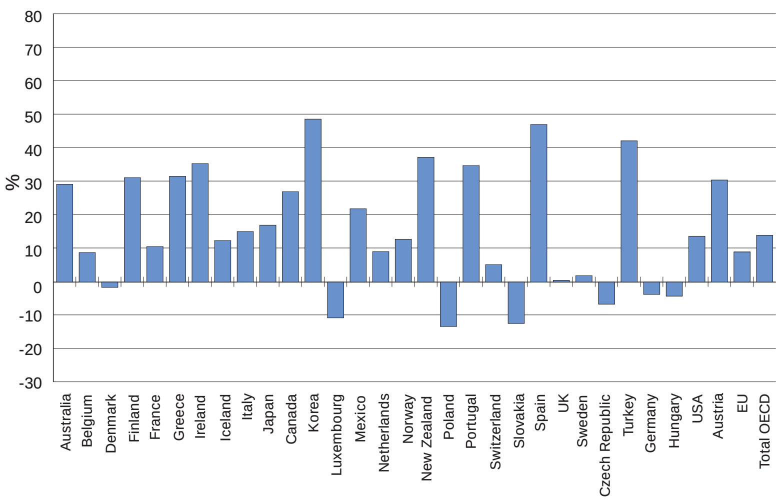
A review of the EU system for trading in emission allowances is in progress at present, and may result in improvements to the system and possibly in new directives. An amendment to the Emission Allowances Trading Directive[17] is in progress of implementation, in the form of additional guidelines for allocation plans for the 2008-2012 trading period.

Climate policy

International climate cooperation

A major conference on climate change was held by the United Nations in Rio de Janeiro in 1992. The conference resulted in an agreement jointly to tackle the global threat of climate change, with the parties to the conference signing the United Nations Framework Convention on Climate Change (UNFCCC). The Convention 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 were adopted. The Convention includes a commitment for all industrial countries to take steps to reduce their emissions of greenhouse gases, and to increase the uptake and storage of the gases. The countries must also periodically report details of their progress and the steps that they have taken to the UN. At the first Conference of the Parties to the UNFCCC in Berlin in April 1995 (COP 1)[18], it was noted that incentives to take action were not sufficient, and a process was started to produce a legally binding document.

Figure 1: Change in carbon dioxide emissions within the EU and OECD states, 1993–2003



SOURCE: OECD IN FIGURES, 2005 EDITION

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 Economics in Transition in Eastern Europe, 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 have been responsible for 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[19], which negotiates as a single group, is required to reduce its emissions by 8 %. In 1998, the EU states reached 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.

14 COM(2005) 628
15 COM(2006) 34
16 COM(2006) 302
17 2003/87/EC
18 COP, Conference Of the Parties, consists of representatives of all parties to the Climate Convention, and is the highest body of the Climate Convention, making its final decisions. 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 parties to the Kyoto Protocol, and is its highest decision-making body. Conferences of the Parties are held every year.
19 EU-15 are the fifteen member states of the EU prior to the enlargement on 1st May 2004.

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 left 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 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 countries to assess the consequences of ratification. The points on which agreement was sought related primarily to the conditions and rules for the flexible mechanisms (see below), carbon sinks (carbon dioxide absorption by vegetation and the ground), assistance to developing countries and means of cooperation between industrialised countries and developing countries. Agreement was also reached on sanctions and other responses against countries failing to fulfil their obligations.

Flexible mechanisms

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

Emissions trading

International trading in emission allowances under the Kyoto Protocol starts in 2008. However, the EU started an EU-wide emissions trading scheme in 2005, as a preparation for global trading under the terms of the Protocol: see below.

Project-based mechanisms

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. They 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 construction of physical capacity in the host 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 as defined by the host country.

The Clean Development Mechanism (CDM) is the one that has been operative for the longest, 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[20]. An international Supervisory Committee (SC) for JI Track 2 was established at the first meeting of the parties to the Kyoto Protocol, in December 2005.

The EU Emissions Trading Scheme and the Linking Directive

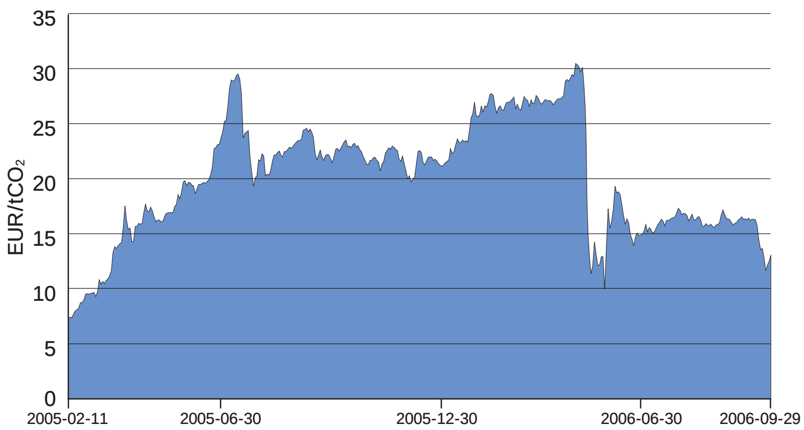
A trading scheme for emission allowances within the EU (EU ETS, Emissions Trading Scheme) started on 1st January 2005. The scheme covers all 25 member states, and has been developed in accordance with the Kyoto Protocol. Its purpose is to reduce carbon dioxide emissions in a manner that is cost efficient in terms of the wider public economy. Emission allowances trading is the most important climate policy instrument within the EU Climate Change Programme (ECCP), the objective of which is to achieve the EU's emission reduction commitments under the Kyoto Protocol.

The first trading period runs from 2005 to 2007, and is intended to act as an trials phase leading up to international trading in emission allowances, due to start under the Kyoto Protocol in 2008. Initially, the directive applies to only a limited number of sectors in energy intensive industries, and to electricity producers, thus covering about 46 % of carbon dioxide emission sources within the EU as a whole. In Sweden, about 38 % of the country's emissions are covered by the trading scheme[21]. Further greenhouse gases, as well as other sectors,

[20] Joint Implementation projects can be carried out in two ways: Track 1 JI projects or Track 2 JI projects. Track 1 projects require the host country to have established a national system of emissions recording and a national register, which are not required for Track 2 projects or CDMs. These are monitored by international boards; the CDM Executive Board and the JI Supervisory Committee.

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

Figure 2: Prices of emission allowances, 2005-2006



SOURCE: NORD POOL FTP SERVER. PRICE DEVELOPMENT FOR THE EUADEC-06 PRODUCT.

could be included in the system in the longer term. In addition to the companies specifically mentioned in the trading directive, other companies, individuals and organisations may also participate in emission allowances trading.

The trading system is based on each member state setting a ceiling for its national emissions during each coming trading period. At the European level, this is done by the Commission checking and approving each member state's national allocation plans, setting out the total number of emission allowances that the country intends to allocate, together with information on the principles it intends to apply for allocation. Each unit of emission allowances represents one tonne of carbon dioxide. The total of the member state's emission limitations forms a joint emissions ceiling, intended to comply with the overall EU undertaking under the terms of the Protocol. The trading system sets a market price for carbon dioxide emissions, depending on supply and demand. The price will depend 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 the relationship between them, weather conditions and use of the project based mechanisms.

Each EU member state is required to prepare and administer a national register of emission allowances transactions under the scheme. The Swedish register, SUS (Svenskt utsläppsrättssystem) was opened by the Swedish Energy Agency in March 2005. Its purpose is to ensure reliable accounting of the issuance, holding, transactions and cancellation of emission allowances, while the information in the register also provides the basis for monitoring.

For the 2005-2007 trading period, Sweden has issued[22] emission allowances equivalent to about 67.3 $MtCO_2$. 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.

Under the national allocation plan for 2008-2012, Sweden intends to issue 22.5 million emission allowances per year to companies covered by the scheme. As before, a reserve of 3 million allowances will be provided for allocation to new members of the scheme and to existing plants increasing their capacity. The allocation principles for the period will be essentially the same as those for the present period.

The Linking Directive links the Kyoto Protocol's project-based mechanisms with the EU emission trading scheme[23]. This means that companies in the trading sector in the EU can use allowances that stem from emission reductions from projects in other countries. Emission reductions from CDM projects have been included in the EU-ETS since 2005, while emission reductions from JI projects will be included from and including 2008. This latter inclusion is because each country must first have been allocated its emission allowances in accordance with the Protocol[24] before credits from JI projects can be converted from AAU Kyoto units. 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 allocated. Nevertheless, environmental benefits are guaranteed, as the greater number of allowances within the EU will be compensated by measured real emission reductions outside the EU.

Member states are required to set a limit to the extent that companies may use CDM and JI in order to fulfil their obligations during the 2008-2012 trading period.

Price variations of emission allowances

During the first four months of 2006, the price of an emission allowance unit varied between about EUR 25 and EUR 30. Statistics of each country's verified emissions during 2005 began to find their way onto the market at the end of April 2006. They showed that many countries had a surplus of emission allowances during 2005, which meant that the price of the allowances fell substantially; between 26th and 28th April 2006, falling from EUR 29.40 to EUR 13.60. At the beginning of July 2006, the EU

[22] 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.
[23] As a result of the Council's and the Parliament's Directive (2004/101/EC) amending Directive 2003/87/EC establishing a scheme for greenhouse emission allowance trading within the Community, in respect of the Kyoto Protocol's project mechanisms (the Linking Directive).
[24] In accordance with the Kyoto Protocol, each country is allocated the quantity of emission allowances (Assigned Amount Units AAUs) corresponding to the country's permitted emissions for the 2008-2012 commitment period.

ETS showed a total surplus of 97.2 million rights for 2005[25]. This can be compared with the total allocation of about 2191 million emission allowances for the entire EU. Poland, Germany and France showed the greatest surpluses, while the UK and Spain had deficits of emission allowances. Despite a surplus of allowances, the market has subsequently partly recovered, with the price of an allowance stabilising at about EUR 16 during the summer of 2006.

The over-allocation can be assumed to be a result of the fact that most EU member states overestimated their expected emissions when working out their national allocation plans. Another explanation may be that companies found it cost efficient not only to reduce their carbon dioxide emissions, but also to improve their efficiency of energy use. A continued move away from fossil fuels to biofuels has also had a positive effect on emissions. In addition, emissions during 2005 were affected by the weather and energy prices. The winter months of 2005 were warmer than usual in many European countries, thus reducing the need for fossil-fuelled peak load or standby capacity in the electricity or district heating sectors. Emissions from the trading sector in Sweden in 2005 were about 3 million tonnes lower than the allocations for the year, which meant that the sector had a surplus of about 15 % of its allocation. This surplus can be partly explained by substantial precipitation in the Nordic countries during 2005.

It is still uncertain as to what extent it is possible to draw conclusions concerning emissions for the entire 2005-2007 period from the verified emissions for 2005 alone. Companies may hold a surplus of emission allowances for the first year, but find that they have a shortage of rights towards the end of the period. Industries may also be unwilling to sell their rights until they have a better picture of their needs for the entire trading period. This means that any surplus held by industry will not find its way onto the market until final verified figures for the period are issued in April 2008. In addition, the price of allowances during the 2005-2007 period will depend on the allocation during the first Kyoto period, which will be published in step with the EU member states submitting their national allocation plans to the Commission for the period 2008-2012.

Negotiations on climate cooperation for the period after 2012

Negotiations on climate cooperation for the period after 2012 were started at the first combined Conference of the Parties and Members of the Parties meeting (COP/MOP 1) in Montreal in December 2005. The process is continuing along two lines: negotiations concerning the industrialised countries' commitments after the Kyoto Protocol first commitment period, and a dialogue under the Climate Convention concerning future international cooperation in the climate sector. The aim is to achieve a global climate regime that includes not only the USA but also large developing countries such as China, India and Brazil.

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[26] of the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol.

Swedish climate strategy was most recently published in the Government's Bill no. 2005/06:172, National Climate Policy in Global Cooperation. This strategy is based on the following Swedish contributions:

- activities intended to promote and create confidence in climate negotiations and climate cooperation
- continued work to reduce national emissions of greenhouse gases,
- a coordinated energy and climate policy, with concentration on research and development,
- expansion of the Kyoto Protocol's flexible mechanisms, and
- measures to protect society against the effects of climate change.

A natural part of the Swedish strategy is to ensure, together with the EU, that the climate agenda is handled on an international level. The Climate Convention makes it clear that the industrialised countries have a particular responsibility to lead the way in climate change. The Government is therefore of the opinion that it is important that industrialised countries can demonstrate by their practical policies that it is possible to combine a policy for reduction of greenhouse gas emissions with continued successful economic development.

As part of the strategy, Parliament has set a Swedish objective for greenhouse gas emission

[25] i.e. equivalent to a surplus of 97.2 million tonnes of CO_2, compared with actual emissions during the period.
[26] Ratification involves approval of an international agreement, which thereby becomes binding.

reductions that goes beyond its agreed allocation under the EU Burden Sharing Agreement. Under the terms of the EU allocation (which is legally binding), Sweden's emissions over the period 2008-2012 may not exceed 104 % of its emissions in 1990. As its target, Sweden has elected not simply to comply with this, but actually to reduce its emissions by 4 %, achieving this without compensation for uptake in carbon sinks (uptake of greenhouse gases in vegetation and ground), or by using flexible mechanisms.

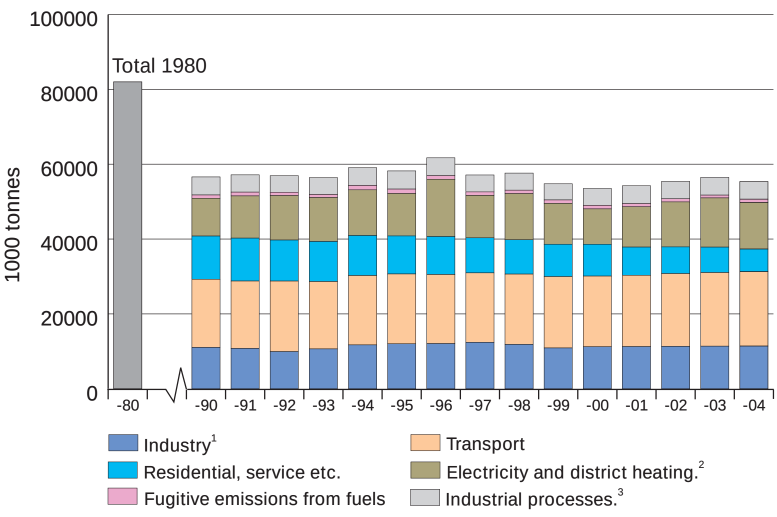
This objective was confirmed by Parliament in 2006, which means that the country is postponing a decision on whether the Swedish target should be based on what is known as a "deduction target". Basing the Swedish target on a "deduction target" would mean that the sum of the assigned quantity in the trading sector, together with emissions from other activities, must be less than 4 % over the period 2008-2012.

The Government is also of the opinion that there should be a medium/long-term objective for greenhouse gas emissions. This means that Swedish emissions in 2020 should be 25 % lower than emissions in 1990. Setting a Swedish target for the medium long-term is dependent on other European countries' national commitments for reducing their emissions, and is based on the declaration by the Council of Europe that emissions in industrialised countries should be reduced by 15-30 % by 2020.

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

[28] Dir. 2005:80

Figure 3: Carbon dioxide emissions in Sweden, 1980, 1990–2004



SOURCE, 1980: STATISTICS SWEDEN, STATISTICAL NOTICES NO. 18.
SOURCE, 1990-2004: SWEDEN'S REPORT TO THE UN CLIMATE CONVENTION, SWEDEN'S NATIONAL INVENTORY REPORT 2006.

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

The long-term climate objective means that Sweden will aim for stabilising greenhouse gas concentrations in the atmosphere at a level less than 550 ppm[27] carbon dioxide equivalents. Globally, this is calculated as equivalent to 4.5 tonnes carbon dioxide equivalents per year and person by 2050. Today, Sweden's per capita emissions amount to about 7.88 tonnes carbon dioxide equivalents per year. The target is that, by 2050, Sweden's total emissions should be less than 4.5 tonnes carbon dioxide equivalents per person and year, with the value continuing to decline. Globally, Sweden is responsible for only a very small proportion of total greenhouse gas emissions. International cooperation is therefore essential in order to succeed in stabilising greenhouse gas concentrations in the atmosphere.

Swedish climate policy has been based on tackling problems on a broad front, but with economic policy measures as the central instruments. Energy supply is a key area for the work of moving Sweden to a sustainable society. Energy supply, energy conservation, improvements in the efficiency of energy use, the use of renewable energy and efficient energy technology are all involved. The carbon dioxide tax, which was introduced in 1991, and other taxes on various forms and uses of energy, have played a considerable part in reducing effects on the climate in a socio economically effective manner. Other important instruments include public support for environmental and climate investments, concentration on renewable electricity production and the use of bio-sourced motor fuels.

As far as the effects of climate changes on various aspects of society are concerned, the Government has appointed a special investigator[28] to identify the potential vulnerabilities of Swedish society to global climate changes, together with the regional and local consequences of such changes.

Swedish climate work and its national objectives will be constantly monitored, with the results evaluated in the form of a number of Checkpoint Reports. The first of these reports was published in 2004, and work is now in progress on the second, to be published in 2008. Material for the reports is provided by the Swedish Energy Agency and the Environment Protection Agency. For the 2008 report, the work includes a re-evaluation of whether the flexible mechanisms should be included in the interim objective, and assessment of the consequences of reducing greenhouse gas emissions by 25 % by 2020. The two agencies will also consider whether the long term target should be replaced by a target based on limiting the atmospheric temperature rise to 2 °C.

Events and policies within the EU have become increasingly important for Swedish climate work, such as the European Climate Change Programme (ECCP), in which the most important policy measure for reducing total EU emissions is the Emissions Trading Scheme. Other important EU policy measures include the Directive on the Promotion of the Use of Biofuels and other Renewable Fuels for Transport, the Directive Concerning Electricity Production from Renewable Energy Sources and the Energy Performance of Buildings Directive.

In addition to its EU cooperation and its national work on reducing greenhouse emissions, Sweden is also engaged in international climate cooperation. 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 200 million for projects within the SICLIP framework.

Sweden's objective for CDM is to put together a geographically balanced portfolio, concentrating on small-scale projects in 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, which have also been registered as CDM projects with the CDM Executive Board (CDM-EB). The Agency has also signed a contract for a project in China, which is being prepared at present. As far as JI projects are concerned, Sweden has signed bilateral agreements with Romania, Estonia and Bulgaria, and is negotiating agreements with Russia and the Ukraine. So far, the Agency has entered into a purchasing agreement for a Romanian project and an Estonian project.

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 Sea Region. The fund was established within the framework of the Baltic Sea Region Energy Cooperation (BASREC), which is in turn a regional energy cooperation scheme between eleven countries in the Baltic Sea Region, established in 1999. Sweden's contribution at present amounts to almost EUR 3.5 million. In the spring of 2006, the Fund's capital was doubled to EUR 35 million after it was opened to private companies. Its work is based on the Testing Ground Agreement (TGA), which was signed by the region's energy ministers in 2003, and of which the objective is to make the Baltic region into a testing ground for climate investments.

In addition, Sweden is a member of the World Bank's Prototype Carbon Fund (PCF) which has now been operating for a few years, and has assisted the development of climate projects within the framework of CDM and JI and contributed to the development of the necessary regulatory framework for such projects. Sweden's share in the PCF amounts to USD 10 million. The fund has signed contracts for about 25 projects in both developing countries and transition economies.

Sweden decided, in June 2006, to participate in the European Development Bank's Multilateral Carbon Credit Fund, with an investment of about EUR 2 million. The Fund will invest in JI projects in such areas as improving the efficiency of energy use, conversions to renewable fuels and renewable energy sources (e.g. biomass and wind power) in those transition economies (e.g. Russia and Ukraine) where the Bank is active and which have ratified the Kyoto Protocol.

It is expected that, as a result of Sweden's international climate investment programme, together with the country's share in multilateral funds and funding that has been earmarked for new projects in the future, the total emissions reduction will amount to about 6 million tonnes of carbon dioxide equivalents, equivalent to about 1.6 % of calculated Swedish emissions of greenhouse gases for the 2008-2012 period. The price of the emission reductions that it is intended to purchase is about 5-10 öre/kg of carbon dioxide, which can be compared with marginal costs for greenhouse gas reductions in Sweden of about 50-200 öre (SEK 0.5-2.0) per kg of carbon dioxide. Even in comparison with the estimated prices for emission allowances in the EU trading system which, in the summer of 2006, were about 15 öre per kg of carbon dioxide, these projects can be seen to be very cost-efficient.

The Swedish Energy Agency is also the official Swedish Designated National Authority and Designated Focal Point[29], 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. ■

[29] Designated National Authority, DNA, for CDM projects. Designated Focal Point, DFP, for JI projects.

Policy measures and incentives

Several policy measures and incentives have been introduced in order to achieve the objectives set out in the energy and climate policy. The overall objectives are to ensure the supply of electricity and other energy, to create the right conditions for efficient use of energy and a cost-efficient Swedish supply of energy having a low negative impact on health, the environment or climate, and to assist the wider changeover to an ecologically sustainable society. For several of these overall objectives, it will be important to increase the proportion of renewable energy, to improve energy efficiency, to reduce the use of energy in absolute terms and to reduce emissions. The most wide reaching means of achieving energy policy objectives, and which is also intended to help 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 scheme, the energy efficiency improvement programme, policy measures for the built environment and transport, technology procurement, the climate investment programme and information activities. Emissions trading is described in Chapter 1, Climate Policy. Research, development and demonstration projects constitute an important element of long-term development strategy.

Various types of policy measures

Policy measures can be divided into a number of main groups, depending on how they are intended to achieve their objectives. **Administrative policy measures** are controls in the form of prohibitions or requirements, issued by political or administrative bodies, and which are mandatory in nature. The control may be quantitative (emission conditions, limit values etc.) or technical. Those issued under the environmental framework code form the basis of Swedish environmental policy. Regulations governing the energy efficiency of buildings are another administrative policy measure. **Economic policy measures** affect the cost and benefit of the choices available to parties concerned. They consist of taxes and fees, transferable emission allowances or certificates, deposits as securities and various forms of grants and subsidies. **Information** can bring about changes in behaviour and attitudes, but differs from controls and economic policy measures in that no compulsion is exercised upon the recipient, and nor is he exposed to any economic pressure, but the desired changes are voluntary. **Research**, development and demonstration activities can also be said to be a form of policy measure. Although research and development may not in themselves bring about a change, technical development and knowledge of the effects of various changes are essential if we are eventually to reach various energy and environmental objectives.

Table 1: Main groups of policy measures

Administrative	Economic	Information	Research
Controls	Taxes	Information	Research
Limit values for emissions	Support, grants, subsidies	Advisory services	Development
Requirements for types of fuels and energy efficiency	Lodging of securities	Training	Demonstration
Long-term agreements	Emission allowances trading	Opinion-forming	Commercialisation
Environmental classification	Certificates trading		Procurement

Table 2: Revenue from energy taxes after types of energy and taxes 2005, SEK million

Energy carrier	Energy tax	CO_2-tax	Sulphur tax	Total
Petrol	14 833	11 140		25 973
Oil products	4 596	13 702		18 298
Unrefined tall oil	21			21
Other fuels	84	969		1 053
All fuels			74	74
Electricity	18 151			18 151
Electricity from nuclear power plants*	1 804			1 804
Total	**39 489**	**25 811**	**74**	**65 374**
Proportion of national tax revenue				9.6%
Proportion of GDP				2.4%

* This tax is a tax on power output at production level. It must not be confused with the energy tax that is paid by users.
SOURCE: SWEDISH NATIONAL TAX BOARD, SWEDISH NATIONAL FINANCIAL MANAGEMENT AUTHORITY, STATISTICS SWEDEN

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 been a progressive alignment of Swedish taxation with EU regulations. 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 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 2005, revenues from energy taxes raised almost SEK 65 400 million, making up almost 10 % of State revenue or 2.4 % of GDP. (See Table 2.) There is also taxation expenditure (taxation relief) on the country's income budget. The definition of taxation expenditure is that the tax received is less than a certain specified standard.[30] Examples of taxation expenditure include energy tax relief for biofuels, peat etc., tax reductions for certain environmentally beneficial improvement installations in detached houses, and the reduction of the carbon dioxide tax for industry. All told, the sum of the energy related items of taxation expenditure amounted to almost SEK 39 000 million in 2005, according to the 2006 Budget Bill[31].

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[32] taxes and those intended to achieve environmental objectives. This latter group of taxes includes the carbon dioxide and sulphur taxes, while the general energy tax is essentially a fiscal tax. However, there is no hard and fast boundary between the types, as both groups have an environmental effect as well as a fiscal function. The general energy tax, which has existed for several decades, and with varying purposes, is levied on most fuels, based on various factors such as their energy contents. The carbon dioxide tax, which was introduced in 1991, is levied on the emit-

[30] If an item of taxation expenditure is discontinued, it results in an increase in taxation revenue and thus an improvement in the public sector budget, in the same way as if some item of expenditure in the public budget had been discontinued.
[31] Bill No. 2005/06:1, Expenditure areas 21, 22, 23 and 24.
[32] The main purpose of a fiscal tax is to raise money for the national exchequer.

Table 3: General energy and environmental taxes as at 1st January 2006, excluding VAT

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax öre/kWh
FUELS					
Gas oil, SEK/m³ (<0,05 % sulphur)	739	2 623	-	3 362	33.7
Bunker oil, SEK/m³ (0,4 % sulphur)	739	2 623	108	3 470	32.8
Coal SEK/tonne (0,5 % sulphur)	315	2 282	150	2 747	36.3
LPG, SEK/tonne	145	2 759	-	2 904	22.7
Natural gas, SEK/1000 m³	239	1 965	-	2 204	20.0
Unrefined tall oil/m³	3 362	-	-	3 362	34.3
Peat, SEK/tonne, 45 % moisture (0,3 % sulphur)	-	-	50	50	1.8
Domestic refuse, SEK/tonne fossil carbon*	150	3 374	-	3 524	14.8
MOTOR FUELS					
Petrol, unleaded, env. class 1, SEK/l	2.9	2.1	-	5.0	55.2
Diesel fuel, env. class 1, SEK/l	1.0	2.6	-	3.7	36.8
Natural gas/methane, SEK/m³	-	1.1	-	1.1	10.1
LPG, SEK/kg	-	1.4	-	1.4	10.6
ELECTRICITY USE					
Electricity, northern Sweden, öre/kWh	20.1	-	-	20.1	20.1
Electricity, rest of Sweden, öre/kWh	26.1	-	-	26.1	26.1
ELECTRICITY, GAS, HEAT OR WATER SUPPLY					
Northern Sweden, öre/kWh	20.1	-	-	20.1	20.1
Rest of Sweden, öre/kWh	26.1	-	-	26.1	26.1
INDUSTRY					
Electricity, industrial processes, öre/kWh	0.5	-	-	0.5	0.5

* From 1st July 2006. The proportion of fossil carbon in domestic refuse is assumed to be 12,6 % of the weight of the refuse.

SOURCE: SWEDISH NATIONAL TAX BOARD, ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

ted quantities of carbon dioxide from all fuels except biofuels and peat. In 2006, the general rate of carbon dioxide tax is 92 öre/kg of CO_2. A sulphur tax was introduced in 1991, and is levied at a rate of SEK 30 per kg of sulphur emission from coal and peat, and at SEK 27/m³ 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, and is applied at a rate of SEK 40/kg of NO_x, on emissions from boilers, gas turbines and stationary combustion plants 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, 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 30000 million of taxation revenue should be transferred over a ten year period. This means that taxes on energy use and emissions are being increased, offsetting 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 emphasis has hitherto been on higher taxes on electricity and fuels used for heating and, in recent years, also on the transport sector. The taxes on light vehicles, electricity from nuclear power plants, natural gravel, waste disposed of in landfills and tax on the use of electricity have been increased in 2006 as part of this policy. A tax on waste used for fuel, and a tax on air travel, have also been introduced[33].

Electricity and heat production

Electricity production in Sweden is exempted from energy and carbon dioxide tax, although it is subject

[33] Budget Bill no. 2006/2007:1 proposes discontinuation of the shift to green-encouraging taxation and abolition of the aviation tax.

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

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. This tax was raised by 85 % in 2006, to SEK 10 200/MW per calendar month. 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[34], and a further levy that amounts to about 1 öre/kWh for financing future storage facilities for spent nuclear fuel.[35] Heat production pays energy tax, carbon dioxide tax and, in certain cases, sulphur tax and 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 sulphur tax. The taxation regime for simultaneous production of heat and electricity (also known as cogeneration or CHP, Combined Heat and Power) was changed with effect from 1st January 2004, so that the tax on the fuels used for heat production in such plants is now taxed at the same rate as on these fuels when used in industry. From 1st January 2006, the previous tax relief on the energy tax on electricity used for electricity, gas, heat or water supply was removed, raising the tax to the general rate for the domestic and service sectors. Taxation of electricity suppliers' internal use of electricity was also introduced, although the higher tax rates on electricity used during the winter in larger electric boilers was removed with effect from 1st January 2006.

With effect from 1st July 2006, combustion of certain domestic refuse was also made liable to energy tax, levied on the basis that 12.6 % by weight of the refuse is assumed to be fossil carbon. The energy tax element amounts to SEK 150 per tonne of fossil carbon, while the carbon dioxide tax element is levied at the rate of SEK 3374 per tonne of fossil carbon.

Electricity production plants are also subject to property tax. For hydro power plants, this tax was raised from 0.5 % to 1.2 %, with effect from the beginning of 2006. In addition, there is a temporary increase in the rate of tax covering years 2007-2011, bringing it up to 1.7 %.

Taxation at the point of use

Manufacturing industry, horticulture, farming, forestry and acquaculture[36] pay no energy tax on fossil fuels, and only 21 % of the carbon dioxide tax[37]. For 2006, the carbon dioxide tax rate for these sectors remains unchanged from 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

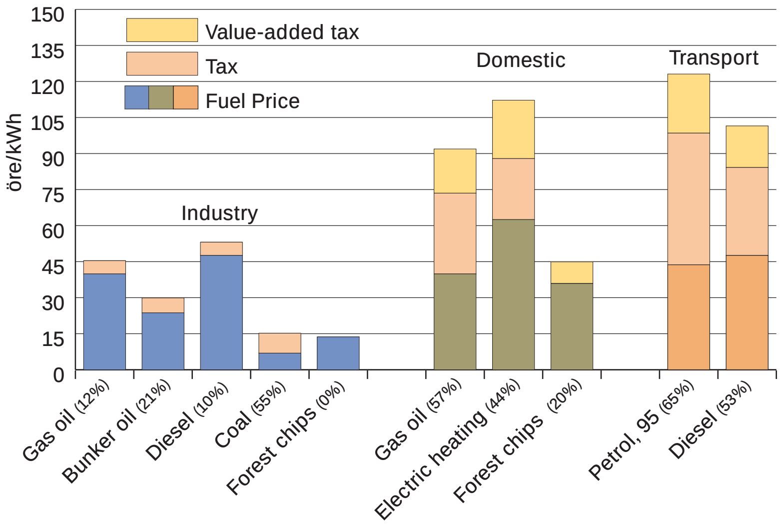
Table 4: Energy and environmental taxes for industry, agriculture, forestry, fisheries and heat production in CHP plants, as at 1st January 2006

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax öre/kWh
Gas oil, < 0.05% sulphur, SEK/m³	-	551	-	551	5.5
Heavy fuel oil, 0.4% sulphur, SEK/m³	-	551	108	659	6.2
Coal, 0.5% sulphur SEK/tonne	-	479	150	629	8.3
LPG, SEK/tonne	-	579	-	579	4.5
Natural gas, SEK/1000 m³	-	413	-	413	3.7
Unrefined tall oil, SEK/m³	551	-	-	551	5.6
Peat, 45% moisture, 0.3% sulphur	-	-	50	50	1.8
Domestic refuse, SEK/tonne fossil carbon *	-	709	-	709	3.0

SOURCE: SWEDISH NATIONAL TAX BOARD, ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

* From 1st July 2006. The maximum carbon dioxide tax relief (79 %) is receivable with an electricity efficiency of 15 %. Energy tax relief is receivable with an electricity efficiency of 5 %.

Figure 4: End-user prices of fuels for various customer categories in 2005, öre/kWh

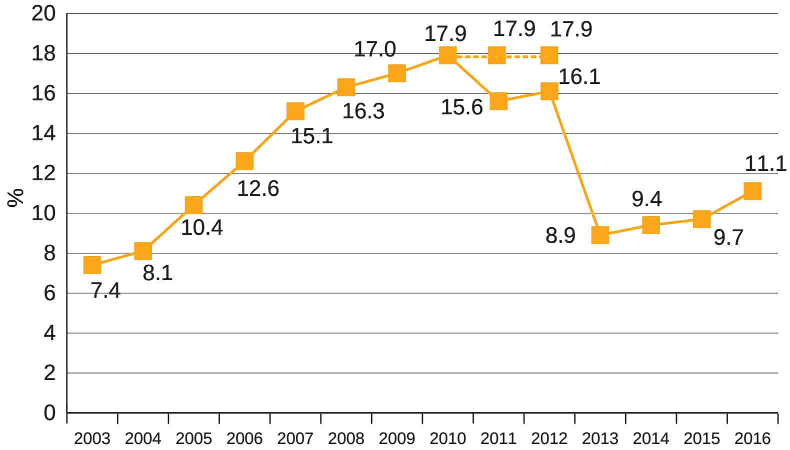


SOURCE: SPI, STATISTICS SWEDEN, NATIONAL TAX BOARD, SWEDISH ENERGY AGENCY'S PROCESSING

Note: Prices for industry are given without consideration to any occurring bulk rebates. The share of taxes are given within brackets.

[35] Act no. 1992:1537
[36] Aquaculture includes the raising or cultivation of all kinds of creatures and plants in water.
[37] Energy tax is, however, charged on raw tall oil and electricity.

Figure 5: Quota obligation requirement in the electricity certificate system, 2003-2016. (As decided by Parliament, 2006)



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

Note: The dotted line shows the proposed requirement as given in the 2006/07 Budget Bill. A decision is expected in December 2006.

Table 5: 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)	Renewable electricity production 2005 (MWh)
Hydro	1 069	516	963 637	1 968 325	1 798 931
Wind	675	529	455 642	864 546	938 548
Biofuel[3]	119	3 363	4 218 276	8 215 561	8 559 696
Solar	1	0.008	4	6	5
Total	**1 864**	**4 408.008**	**5 637 559**	**11 048 438**	**11 297 180**

SOURCE: SVENSKA KRAFTNÄT AND THE SWEDISH ENERGY AGENCY

Note: 1) Total number of approved plants, 1st January 2006.
2) For the period May-December 2003.
3) Includes production from peat, amounting to about 545 GWh of electricity in 2004 and about 631 GWh in 2005.

Table 6: Market statistics for the electricity certificate system, 2003-2005

	2003[1]	2004	2005
Average certificate price	200.81 SEK/st	231.38 SEK/st	216.46 SEK/st
Quota obligations	4 534 335 st	7 892 330 st	10 129 197 st
No. of certificates cancelled	3 489 984 st	7 832 352 st	10 119 869 st
Quota obligation fulfilment	77%	99%	99.9%
Quota obligation revenue	SEK183million	SEK 14 million	SEK 3 million

SOURCE: SVENSKA KRAFTNÄT AND THE SWEDISH ENERGY AGENCY

Note: 1) For the period May-December 2003.

resulted in reduced emissions of some pollutants. Tax rates on petrol and diesel fuel were left unchanged for 2006. 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 is exempted from 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 3. Electricity tax was raised by 0.6 öre/kWh in 2006. 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 2005, the taxes paid by a consumer heating his house with gas oil accounted for 57% 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 65 % of the total price: see Figure 4.

The electricity certificate system

Since the beginning of the 1990s, several different systems intended to support the production of electricity from renewable energy sources have come and sometimes gone. They have included investment grants for the production of electricity from biomass, wind power and small-scale hydro power, as well as an operational subsidy for electricity generated from wind power, known as the environmental bonus. 1st May 2003 saw the introduction of a new support system for renewable electricity production, based on trading in electricity certificates for renewable electricity. The certificate trading system is being complemented by transition rules for wind power production in the form of the environmental bonus which, in 2005, amounted to 9 öre/kWh for onshore production and 16 öre/kWh for offshore production[38]. It is intended that the progressive reduction of this environmental subsidy, which started in 2004, will cease at the end of 2009. In 2009 there will be a 12 öre/kWh subsidy for offshore wind power production and no subsidy for onshore production.

The electricity certificate system is intended to reduce the production costs and support the development of new production in the long-term by creating competition between different types of renewable electricity production. Producers receive one certificate unit for each MWh of renewable electricity that they produce. Qualifying renewables are electricity from wind power, solar energy, geothermal energy, certain biofuels, wave energy and certain hydro power. With effect from 1st April 2004, electricity produced from peat in cogeneration plants has also qualified for certificates. All electricity users, with the exception of energy intensive industries, are required to buy certificates corresponding to a certain percentage of their electricity use. In 2005, users had to buy certificates corresponding to 10.4 % of their electricity use. The proportion of certificates that users are required to buy (their quota obligation) varies from year to year: see Figure 5.

Table 5 shows the number of approved plants, installed capacity and renewable electricity production from each type. During 2005, the average price of electricity certificates was SEK 216, as shown in Table 6. The system covers only electricity produced in Sweden.

The aim of the certificate trading system is to produce a greater proportion of the country's electricity from renewable sources, increasing it by 10 TWh between 2002 and 2010. In June 2006, Parliament decided on changes to the electricity certificate system, in the form of various changes intended to extend the long-term strategy purpose of the system, as well as to increase the target for renewable electricity production. They include raising the target for renewable electricity production to 17 TWh in 2016 (as compared with production in 2002), and extending the life of the scheme itself to 2030. Quota obligations have been set for this entire period, and adjusted for the immediate period of 2007-2010. Limitations on allocations of certificates have been introduced for the plants themselves, with new plants receiving certificates for 15 years, while those plants started up before 1st May 2003 will be phased out of the scheme at various dates in the future. The regulations governing electrically intensive industry have been changed, with the industries being excused on other grounds. The changes will come into force on 1st January 2007.

Programme for energy efficiency in energy-intensive industry (PFE)

An energy tax on 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[39]. This means that, although 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 presented a bill setting out an energy efficiency improvement programme, which came into force on 1st January 2005[40]. Companies participating in the five-year programme can receive a full rebate of the energy tax on electricity that they would otherwise have 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. Companies must also undertake to implement, within the five-year duration of the programme, all the energy efficiency improvement measures that have been identified and which have a payback time of less than three years. A 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, *or* value.

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, with an incentive to do so being provided by relief from 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 have more or less the same effect as an energy tax of 0.5 öre/kWh would have had. In June 2006, there were 124 companies in the programme, operating about 270 separate plants. 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 (25) or the chemical industry (19). Other participants include companies in the food industry (11), the iron, steel and mining industry (14), the engineering industry and a few other sectors. The scheme is open to admission of more companies up to and including 2009. Most of the participating companies submitted their first

[38] The Budget Bill for 2004, No 2003/04:1 proposed a progressive reduction in the tax relief for electricity produced from wind power, known as the environmental bonus.

[39] Council Directive 2003/96/EC restructuring the Community framework for the taxation of energy products and electricity.

[40] The Act (2004:1196) Concerning a Programme for Improving the Efficiency of Energy Use etc.

reports to the Agency during the summer or autumn of 2006, describing the results of their work on energy auditing and the introduction of energy management systems.

Buildings

Building regulations

A whole range of policy measures are used in order to influence energy conservation and management in buildings. The National Board of Housing, Building and Planning's Building Regulations[41] are an administrative policy measure. In general, buildings must be designed and constructed to reduce overall energy use by means of low heat losses, low cooling requirements, efficient use of heating and cooling and efficient use of electricity. The Regulations contain specific requirements for energy use in buildings.

Energy declarations

Another administrative policy measure is that of the Act Concerning Energy Declarations for Buildings[42], which came into force on 1st October 2006. Owners of buildings are required to provide information on the buildings' energy use, together with certain parameters of the indoor environment, in an energy declaration. The regulations will be progressively extended to cover various categories of buildings. This legislation is based on an EC Directive[43]. One of the purposes is that, through the provision of easily accessible, impartial information, consumers will be able to make decisions based on energy use in their buildings, thus reducing their energy costs.

Investment grants for solar heating

The purpose of the solar heating grant is to encourage the use of solar heating technology for heat supplies to detached houses, apartment buildings and certain types of commercial premises. The grant is in the form of a one-off payment to subsidise the cost of installation of solar heating systems for space heating and/or domestic hot water production. Grants, which are administered by county councils and the National Board of Housing, Building and Planning, have been available for projects started since 1st June 2000.

Assistance for conversion of heating systems

The purpose of these conversion grants[44] is to reduce the country's dependence on oil, to encourage efficient and environmentally benign use of energy, and to reduce the use of electricity for heating purposes in residential buildings. Owners of detached houses, apartment buildings or other premises associated with residential premises having direct electric heating can receive a grant for the cost of partial or complete replacement of such heating systems by district heating or rock, earth or lake water heat pumps, or by biofuelled boilers. The grant is also available to those replacing oil-fired heating systems with one of these alternative heating systems. Both grants are available for the period 1st January 2006 to 31st December 2010: again, they are administered by county councils and the National Board of Housing, Building and Planning.

Tax relief

Tax relief is a policy measure that, within the building sector, acts effectively as a grant for the installation of small scale biofuel-fired heating systems and more energy efficient windows[45]. Builders of new detached houses can apply for tax relief for the installation of a biofuel-fired facility, such as a pellets-fired boiler, as the primary heating source. The new boiler must be able to provide both space heating and domestic hot water, and must also be the main source of heating in the house. The owner must live in the house for at least the first year after construction.

Owners of single-family or two-family houses can receive a tax relief for the installation of new windows having a maximum U-value of 1.2. The entire window – glass, frame and casement – must be replaced in order to qualify. In addition, the owner must live in the house. This relief is administered by the National Board of Taxation, and runs from 1st January 2004 to 31st December 2006.

Transport

There are several different types of policy measures that affect the transport sector. Energy and carbon dioxide taxes on motor fuels are indexed upwards each year, following cost developments. The energy tax is mostly fiscal in its purpose, while the carbon dioxide tax is intended to reduce carbon dioxide emissions from fossil fuels. See Table 3 for details of tax rates.

The tax exemption for biofuel-based motor fuels means that biofuel-based motor fuels are exempted from energy taxation[46]. This is intended to encourage the introduction of new motor fuels, as well as to improve their security of supply in the longer term, by supporting the use and indigenous pro-

41 Latest edition: BFS 2006:12.
42 The Act (2006:985) Concerning Energy Declarations for Buildings.
43 Directive 2002/91/EC concerning the energy performance of buildings.
44 Ordinances (2005:1255) and (2005:1256).
45 The Act (2003:1204) Concerning Tax Reduction for Certain Environmental Improvements in Detached Houses.
46 Bill no. 2005/06:160

duction of such fuels. Supporting indigenous production and increasing the security of supply is also the purpose of the customs duties on imported ethanol intended for low admixture (about 190 öre/ litre), which was introduced on 1st January 2006.[47] The Act requiring larger petrol stations to sell at least one renewable motor fuel since 1st April 2006 is also intended to have a considerable effect on the growth of biofuel-based motor fuels. A special measure during 2006 and 2007 provides support for other alternative motor fuels in the form of a grant for public petrol stations selling renewable motor fuels other than ethanol[48].

Motor vehicle tax is primarily a fiscal tax, although it also includes an environmental objective element. October 2006 saw the introduction of a new taxation basis for newer vehicles, based on vehicles' carbon dioxide emissions instead of, as previously, the weight of vehicles[49].

In addition to the above, there are several other policy measures in the transport sector, such as taxation of vehicle benefit and free fuel, subsidised public transport, tolls for certain heavy traffic, congestion charge[50] and the vehicle scrapping deposit.[51]

Technology procurement

Technology procurement is a policy measure intended to encourage the development of new energy-efficient 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 are announced. The winners are given assistance with market introduction, and are guaranteed a definite initial order quantity for the new product. In addition, the State provides information via a purchaser group, intended to extend awareness of the winning technology.

Technology procurement can be seen as a policy instrument 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[52] of all technology procurement projects within the energy field that have been carried out by it and by its forerunners. Since the 1990s, 56 different technology procurement projects have been initiated and partly financed. Current technology procurement projects 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 pellets stores for detached houses.

Energy research, development and demonstration activities and commercialisation

Responding to the proposals in the Government Bill on Research and New Technology for a Future Energy System[53], Parliament has decided on a 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. The budget for research, development and demonstration activities in the energy sector for 2006 was considerably increased over that for 2005, when it had been severely cut. In the Bill, the Government states that an annual budget on the same level as that for 2006 is reasonable if the results are to assist development and restructuring of the country's energy system. The objectives of the programme have been expanded, relative to the previous programme, and the Swedish Energy Agency has been given responsibility for administering the entire programme – from financing of fundamental research to measures intended to assist the market introduction of new energy technology. Current guidelines call for greater focus and concentration of resources on energy research, development and demonstration activities, with more ambitious targets for commercialising the results of research and development in the energy sector. Support has been provided for helping the programme to look further ahead. Regular monitoring and evaluation reviews will assist the work of the programme.

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, society, technology, economics and the environment.

Activities are structured in six theme areas: Energy System Studies, Energy Use in the Built Environment, Transport, Energy-intensive industry, the

[47] Swedish Environmental Protection Agency
[48] Report of the Traffic Commission, 2005/06:TU6
[49] Bill no. 2005/06:65
[50] See the chapter on transport for more details.
[51] See the Agency's report on economic policy measures, ER 2006:34, for a complete presentation of economic policy measures in the transport sector.
[52] The list can be downloaded from the Agency's web site, http://www.energimyndigheten.se/.
[53] Bill no. 2005/06:127

Power System and Fuel based Energy Systems.

Research in the field of **energy system studies** is aimed at improving knowledge of, and competence in, energy systems and international climate policy. The 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 of energy and climate related policy measures, the function of the energy markets, energy-related climate issues, local and regional energy issues, behavioural science and acceptance considerations, as well as innovation and implementation factors etc.

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.

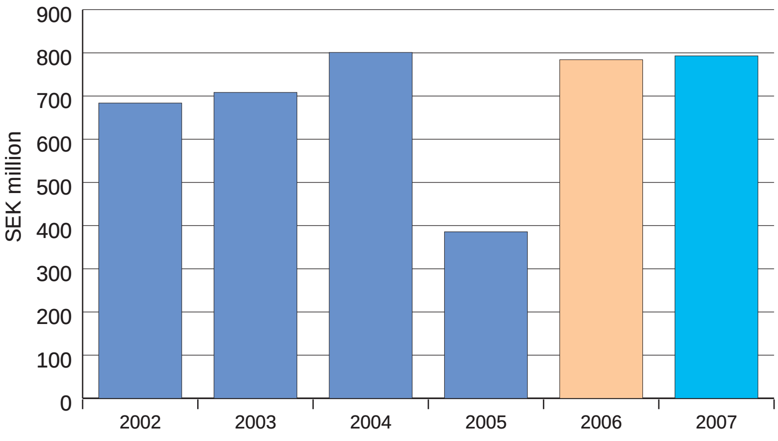
The **transport** theme area includes research and development of biofuel-based motor fuels, combustion engines and electrical drive systems. Looking ahead, biofuel-based motor fuels have the potential for making a valuable contribution to replacing fossil fuels in the transport sector. In the longer 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 **energy-intensive industry** area gives priority to improvements in the efficiency of energy use, particularly for energy intensive processes 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 **power system** area includes hydro power, wind power, solar cells, wave power, power transmission and energy storage in the power system. 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 from wind, and for reducing its cost. The Agency is also running pilot projects for offshore and highland wind power production. Research and development in the field of solar cells are concentrated on thin-film solar cells and nano structure cells, as well as on integration, installation and use in buildings. Research into power transmission systems and energy storage in power 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 **fuel based energy systems** working area includes 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 help to reduce production costs and to utilise 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 technologies are being investigated in order to acquire knowledge that can be used to improve the efficiency of established technologies and to introduce new technologies with improved performance.

Figure 6: Funding for research, development and demonstration activities



SOURCES: THE SWEDISH ENERGY AGENCY'S ANNUAL REPORT 2005, OFFICIAL DOCUMENT PLACING APPROPRIATIONS AT THE DISPOSAL OF THE SWEDISH ENERGY AGENCY FOR EXPENDITURE AREA 21, ENERGY, FOR BUDGET YEAR 2006, AND BUDGET BILL 2005/06:1

Note: For 2002–2005, the figure refers to approved funding. For 2006 the figure shows appropriations and for 2007 proposed appropriation. The information given is thus not directly comparable between the years.

The 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 in operation in Örnsköldsvik, while a demonstration plant that was previously owned by Sydkraft in Värnamo, gasifying biomass for production of electricity and heat, will be recommissioned after a major conversion. This work is being carried out by the Agency in conjunction with industry, with the aim of producing motor fuels from renewable sources to replace fossil fuels in the transport sector. These plants 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 the 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.

The climate investment programme (Klimp)

The Klimp climate investment programme allows local authorities and other parties to apply for grants for measures intended to reduce the emission of greenhouse gases in Sweden or assist the restructuring of the energy system, or which include interesting new technology that can contribute to these objectives.

Klimp has run since 2003, and is to some extent a continuation of the local investment programmes (LIP).

A climate investment programme consists of measures that are mostly in the form of physical investments. The main criterion for evaluating the success of the programme is how effective greenhouse gas emission reductions have been in relation to their costs and to the grants applied for under the scheme. However, the overall perspective, strategies and links with other measures provide a basis for decisions on which applications are to receive grants.

Klimp 2006 has provided grants worth SEK 317 million for 25 climate investment programmes, in total worth SEK 1200 million of investments in climate protection measures and measures intended to assist restructuring of the energy system. They include activities such as expansion of district heating systems, digestion of refuse to produce biogas, conversions to biofuels, improving the efficiency of energy use and the provision of local information on climate related matters. In total, the measures are intended to reduce annual emissions of greenhouse gases by about 203 000 tonnes, as well as to reduce energy use by 215 GWh.

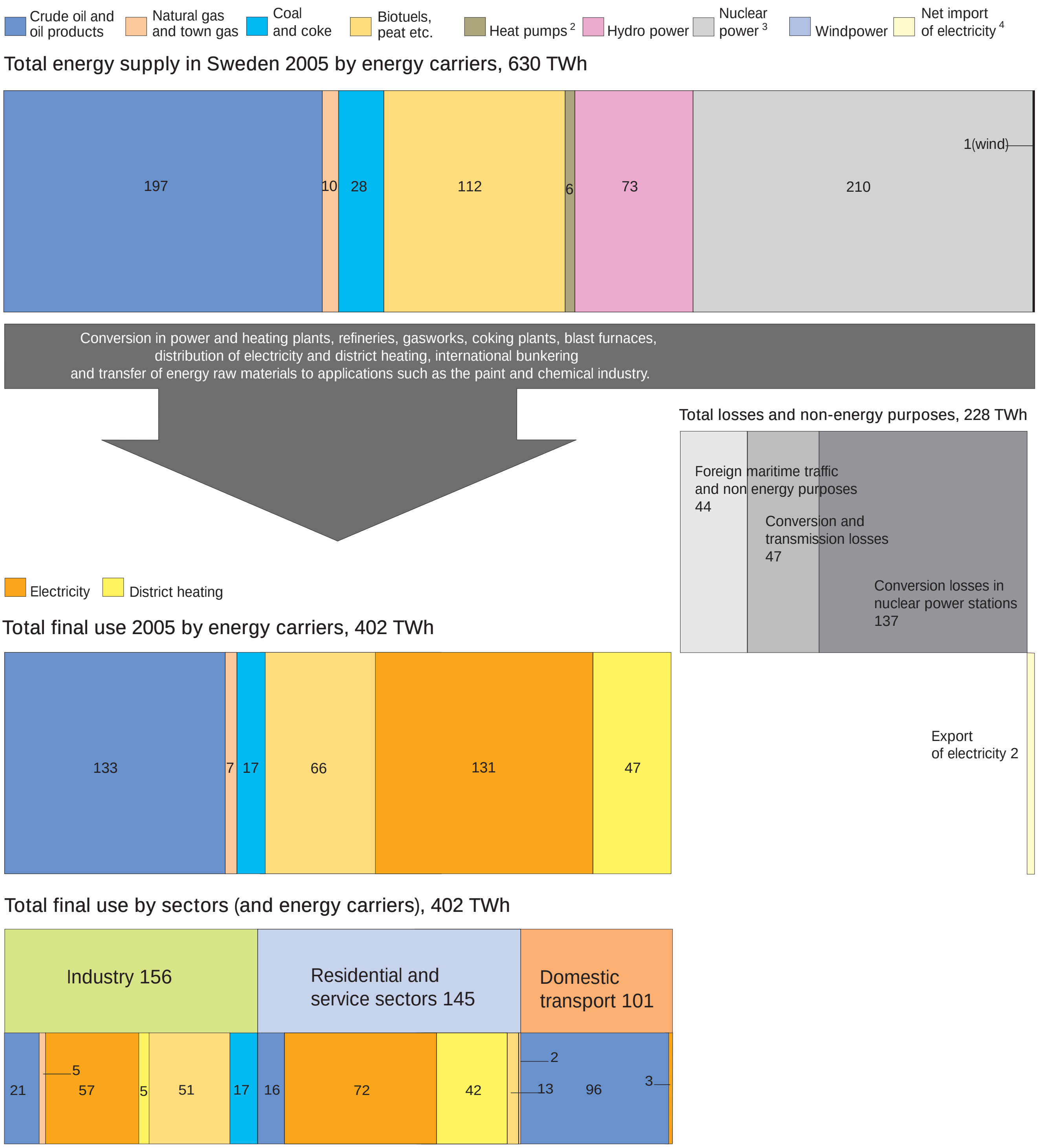
Klimp is operated by the Swedish Environmental Protection Agency which, in turn, seeks advice from other agencies concerning the merits of applications under the programme. Final choice is made by a special board within the Environment Protection Agency, deciding which programmes are to receive grants, and of how much.

Information activities

The fact that knowledge and understanding affect how we act in given situations means that information activities occupy an important and central part among the policy measures available to the State. In its application of state energy policy, the Swedish Energy Agency is a central provider of information, employing many different channels and parties in order to ensure that information reaches its target groups. 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. They are, in turn, backed up by regional energy offices that provide training and coordinate information activities.

The Government has instructed the Swedish Energy Agency, the National Board of Housing, Building and Planning, the National Consumer Agency and the Swedish Environmental Protection Agency to run information activities during 2006-2007, aimed at domestic consumers, detached house and apartment building owners with the aim of increasing their awareness of long-term energy-efficiency improvement and energy conservation measures. The Swedish Energy Agency has been given overall coordination responsibility for the work, which was started by means of a joint advertising activity in September 2006. ■

Figure 7: Energy supply and use in Sweden, 2005, 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, 6.1 TWh. Heat collected from the surroundings amounted to over 4.3 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.

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

Sweden's energy balance

Energy can never be destroyed, but only converted. The 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 .[54]

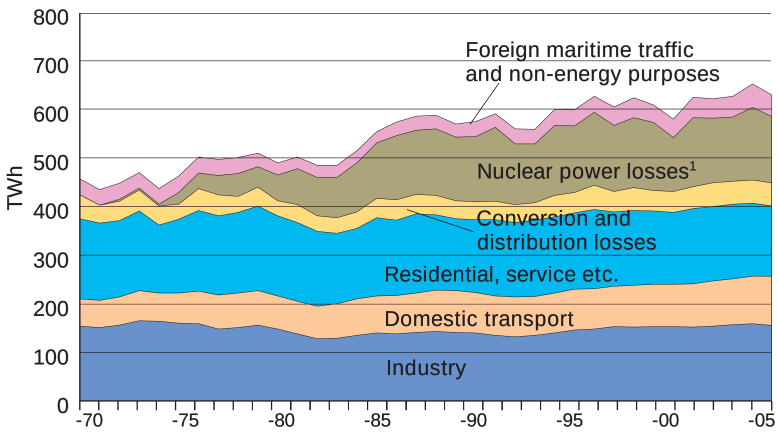
Figure 7 shows (aggregated and simplified) Sweden's energy system in terms of the energy flows from supply to final use. Energy is supplied in order to meet users' demand for energy, which in turn depends on their needs in terms of functions such as transport, lighting, heating, cooling, processes etc. 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. However, 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[55], distribution 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 chemical industry, lubricating oils and oils used for surface treatments in the building and civil engineering sectors (asphalt and binders). Total energy supply in Sweden is made up of the country's net import (the difference between imports and exports) of energy materials and carriers, such as oil, natural gas, coal, biofuels and electricity, plus indigenous supply of biofuels, hydro power, rock heat, lake heat, air heat and ground heat to district heating heat pumps, and fuels for nuclear power production. To this must be added changes that occur in storage.

Total energy use

Total energy use in 2005 amounted to 630 TWh. Of this, total final energy use made up 402 TWh, and conversion and distribution losses made up 184 TWh, of which 137 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 44 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 80 % 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. 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.

[54] Statistics for the period from 1970 to 2003 are final, while those for 2004–2005 are preliminary. There are differences between the statistics for 2003 and 2004 in this edition of Energy in Sweden compared to last year's edition. In the same way, statistics given for 2004 and 2005 in this edition may change in next year's edition.
[55] As used here, energy plants are those that produce electricity and/or district heating, refineries, gasworks, coking plants and blast furnaces.

Figure 8: Total energy use in Sweden, 1970–2005



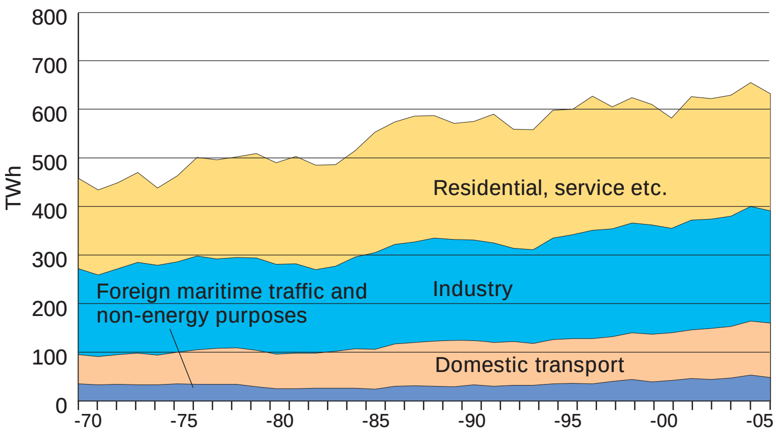
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY
Note: 1Calculated in accordance with the UN/ECE method for energy supply from nuclear power.

System boundaries

The concept of system boundaries provides an aid for analysing the country's energy system. Since 1970 the demand for energy[56] has increased by 7%, from 375 TWh to 402 TWh. However, over the same period, total energy supply has increased by no less than 38 %, from 457 TWh to 630 TWh.[57] The reason for the supply of energy increasing over five times more rapidly than the demand for energy is because 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, e.g. when produced in nuclear power stations. 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. 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 9 shows such an assignment of losses, based on exactly the same statistics as shown 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. Other system boundaries can also be considered.[58]

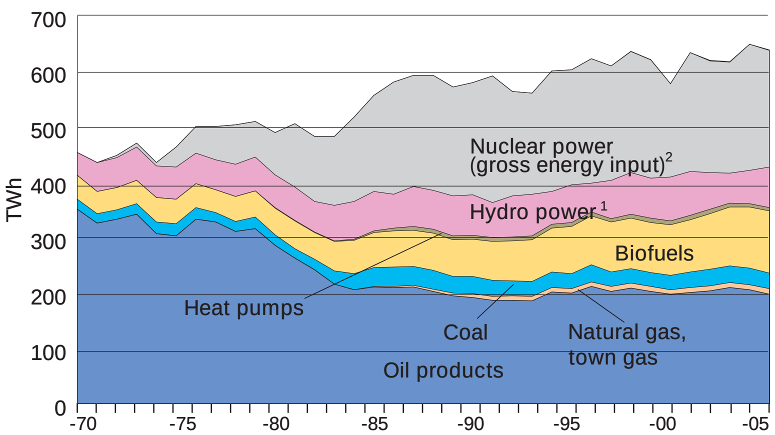
[56] In this context, demand for energy refers to total final energy use.
[57] Calculated in accordance with the UN/ECE method, which means that the energy conversion losses in nuclear power stations are included.
[58] Source: 'All or Nothing - System boundaries for heating of buildings' [in Swedish]. http://www.energimyndigheten.se/.
[59] Estimations by the Swedish Energy Agency based on data for the period 1985-2005

Figure 9: Sweden's total energy use in various user sectors, 1970–2005, with the conversion sector losses apportioned to the end-users



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

Figure 10: Energy supply in Sweden, 1970–2005, excluding net electricity export



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

Note: [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 2005 amounted to 630 TWh, excluding a net export of about 8 TWh of electricity (see Figure 10.) 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 47 %, while the net production of electricity has increased by about 250 % as a result of the construction of nuclear power stations and expansion of hydro power production. The supply of biofuels has increased by over 60 %. During the 1980s, local authority energy utilities installed large heat pumps for supplying district heating. At the same time, natural gas was brought to towns along the west coast, while wind power construction started in the middle of the 1990s. The use of coal and coke as fuels increased during the beginning of the 1980s, but has declined somewhat since then. Nuclear power used 210 TWh of fuel energy input in 2005, to produce 69 TWh of electricity. Hydro power produced 73 TWh of electricity, which was considerably above productions of 54 TWh and 61 TWh during the two respective preceding years. Hydro power production varies widely, depending on the amount of precipitation during the year: average annual production is 67.5 TWh.[59] Fuel based thermal power production produced 12.2 TWh of electricity, while wind power supplied 0.9 TWh. About 55 TWh of fuels were used for district heating production. The proportion of renewable energy sources in the country's total energy supply amounted in 2005 to 29 %, which is a relatively high figure in international terms. Renewable energy sources include biofuels, hydro power and wind power. ■

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 2005, against the background of developments in energy use since 1970.

The residential and service sector

The residential and service sector consists of residential premises, commercial premises and public buildings (excluding industrial premises), holiday homes, land use[60] and other service activities, which include the construction sector[61], street lighting, sewage treatment plants, electricity and waterworks. Energy use in this sector in 2005 amounted to 145 TWh, representing about 36 % of Sweden's total final energy use, and about 5.8 TWh less than during the previous year.

About 87 % 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 6 % of total energy use in the sector; holiday homes account for another 2 %, and other service applications for 5 %.

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.[62] The heating energy requirement in 2005 was about 8 % less than in a statistically average year, with a preliminary corrected usage figure of about 149.3 TWh, which is 4.3 TWh less than in 2005.

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 2005. 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 construction picked up during the 2000s, to the extent that work started on 31 100 dwelling units in 2005, or 14 % more than during the previous year. The rate of construction of commercial premises has been low in recent years.

From oil to electricity and district heating

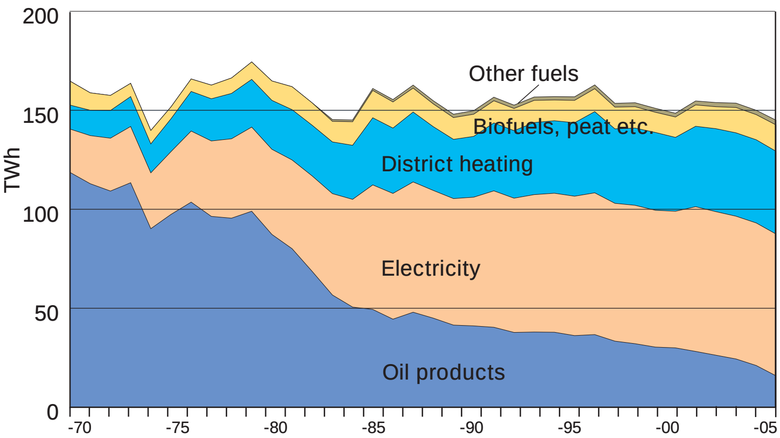
The relative proportions of the different energy carriers have changed: see Figure 11. Oil crises, rising energy prices, changes in energy taxation and investment policies have all affected the shift from oil to other energy carriers. In 2005, total use of fossil fuels in the sector amounted to 18.3 TWh, less than one-sixth of consumption in 1970 (118.6 TWh). Much of this reduction is due to a move away from the use of oil for heating to district heating, electricity or biofuels. Figure 11 clearly shows

[60] Land use includes agriculture, forestry, horticulture and fishing. More detailed information on energy use in these sectors can be found in the publications 'Energy use in agriculture, 2002' and 'Energy use in the fishing sector, 2005', ER2006:35. Information on energy use in greenhouse horticulture can be found in 'Horticulture production, 2005' which can be downloaded from http://www.jordbruksverket.se/. A publication on energy use in forestry in 2006 will be available next year from the Swedish Energy Agency.

[61] Energy use in the construction sector, 2004, ER2006:02.

[62] With effect from 2003, the reference period for normal year correction is 1970-2000. Until 2002, it was 1961/62-1978/79.

Figure 11: Final energy use in the residential and service sector, 1970–2005



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

that the use of oil has declined in this sector in recent years. An important reason for this has been the rise in oil prices.

Although the population has grown, heated floor areas have increased, and the number of electrically-powered appliances has increased, total energy use in the sector remained relatively stable between 1970 and 2001. Since then, statistically-corrected energy use has declined somewhat each year. The main reason for this stability and subsequent decline in recent years is primarily because different energy carriers have different distribution losses and different conversion loss characteristics, depending on whether they are fuels (such as oil) or 'ready-to-use' energy (such as district heating or electricity). This means that if electric heating or district heating replace oil heating, the effect is a reduction of energy losses, and thus also a reduction of the total final energy use by the residential and service sector. However, at the same time, there will be an increase in losses in the conversion sector.

A contributory reason is also the fact that there has been a considerable increase in the number of heat pumps in recent years. Heat pumps deliver 2-3 times as much thermal energy as they use in the form of electrical energy for driving them, which means that their use reduces the actual use of energy for space heating and domestic hot water production in buildings. In other words, the use of heat pumps reduces the actual energy use for space heating and domestic hot water production in buildings. 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. Technical development is steadily improving the efficiency of equipment 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.

Figure 12 clearly shows how total use of electricity in the sector, for electric heating, operational electricity[63] and domestic electricity[64] has increased since 1970. The use of electricity grew steadily from 1970 until the middle of the 1990s, stabilising at somewhat over 70 TWh (corrected value for statistically average conditions) in recent years. After correction, use of electricity for heating increased gradually from 4.7 TWh in 1970 to 29 TWh in 1990, reaching a peak at the beginning of the 1990s, and then falling somewhat. Electric heating amounted to 20.8 TWh in 2005.

Space heating and domestic hot water production

Of the 85.3 TWh that were used for space heating and domestic hot water production in residential and commercial premises in 2005, about 42 % were used in detached houses, 32 % in apartment buildings and 26 % in commercial premises and public buildings. Electricity used for such purposes as floor heating and fan heaters also contributes to the heating of a building, but is partly accounted for in the statistics as domestic electricity

The commonest form of heating in detached houses is electricity[65], used by 22 % of them in 2005. Of these, over a half have only direct electric heating, with the rest having only waterborne electric heating. The use of direct electric heating in combination with some other form of heating is common in detached houses: about 44 % of detached houses had some form of combination heating system in 2005. About 7 % were heated solely by district heating, 4 % were heated solely by oil, 7 % were heated solely by biofuels, and about 11 % had a rock/earth/water heat pump. Other detached houses had other combinations, or were heated with gas.

Dual-fuelled boilers allow households to change between electricity, oil and/or biofuels. In 2005, about 22 % of detached houses had dual-fuel boilers, providing a degree of flexibility 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 of energy carriers. The main reason for the high proportion of electric heating in detached houses 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 (including electricity for heat pumps) in detached houses amounted to 15.3 TWh in 2005.

District heating is the commonest form of heating in apartment buildings, with about 77% of apartments being heated by it in 2005.[66] Oil is used as the sole heat source for 2% of apartments. 3%

[63] Operational electricity is a statistical combination of electricity for building services systems and activity electricity. Electricity for building services systems is used for fixed systems in the building for climate control, and for equipment such as lifts, escalators and lighting in common areas. Activity electricity is used for the activities performed in the building, such as for computers, office equipment and lighting.
[64] Domestic electricity is that which is used for lighting, white goods, domestic appliances and other electrical equipment in a home.
[65] If larger heat pumps that are used in combination with some other form of heating are included, this proportion rises to over 40 %.
[66] In addition to this, district heating is used in combination with other forms of heating in 5 % of heated buildings.

of apartments are heated by electricity alone. Other areas are heated by combinations of various heating systems, or by gas or biofuels. Total use amounted to 23.1 TWh of district heating, 1.3 TWh of oil, 1.7 TWh of electric heating, 0.4 TWh of gas and 0.3 TWh biofuels.

The main source of heat in offices, commercial premises and public buildings is also district heating, with about 59 %[67] of such buildings in 2005 being supplied solely with district heating. About 7 % of this floor area was heated by electricity alone, with about 4 % being heated by oil alone. A further 3 % was heated by a combination of electricity and oil. Other heating systems included combinations of various energy carriers, or gas or biofuels alone. Total use amounted to 15.5 TWh of district heating, 1.9 TWh of oil, 3.6 TWh of electric heating, 0.6 TWh of gas and 0.4 TWh of biofuels.

Domestic electricity and electricity for building services systems

The use of electricity for domestic purposes doubled between 1970 and 2005, from 9.2 TWh to 19.7 TWh, with most of the increase occurring during the 1970s and 1980s. 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. In 2005, average domestic electricity use amounted to about 6200 kWh in detached houses, and in apartment buildings to about 40 kWh[68] per m² and year which, for a 66 m² apartment, means an annual electricity use of 2640 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 has increased substantially, from 8.4 TWh in 1970 to 31.1 TWh in 2005. The reasons for this development include rapid growth in the service sector and greater use of office machines and comfort cooling. 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. Lighting and ventilation which, at the beginning of the 1990s, accounted for about 70 % of the use of electricity in building services systems, have become more efficient as a result of improved light sources, more sophisticated operational control and correct sizing of systems at the time of installation. Nevertheless, there is still regarded as being considerable potential for further improvements in the efficiency of electricity use in offices, commercial premises and public buildings. The Swedish Energy Agency is carrying out a project to obtain data on the use of electric heating in different types of premises (offices, schools, health-care facilities etc.), and on different uses of electricity (lighting, computers, cooling, fans etc.). About 800 premises will be inspected over a six-year period.[69]

Industry

In 2005, industry used 3.2 TWh less energy than during 2004, amounting to 155.6 TWh, or 39 % of the country's final energy use. Industry's use of energy was met by 21 TWh of petroleum products, 16.8 TWh of coal and coke and 56.9 TWh of electricity. Use of natural gas amounted to 4.8 TWh, and that of district heating to 5.3 TWh. The use of biofuels, peat etc. amounted to 50.8 TWh: (see Figure 13). Final energy use in industry therefore consisted of 27 % of fossil energy and 33 % 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 electricity or from black liquors.[70] 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.

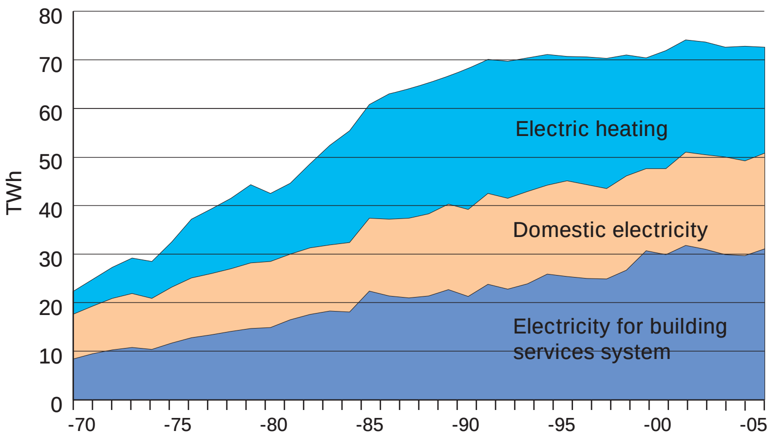
[67] In 2003, this proportion was 60 %. The apparent reduction is due to a redefinition in the statistics from 2004. Electric heating of domestic hot water, with space heating provided by district heating, is classified as district heating and electricity.

[68] This guideline figure was produced from the results of a questionnaire survey of energy use by apartment building residents that was carried out by Statistics Sweden over the period 1997–1999. Prior to 1999, the assumed value had been 50 kWh/m2, year.

[69] Within the framework of the project "Improved energy statistics for buildings" the Swedish Energy Agency has established the portal "eNyckeln" which shows energy statistics for apartment buildings and service buildings. www.enyckeln.se

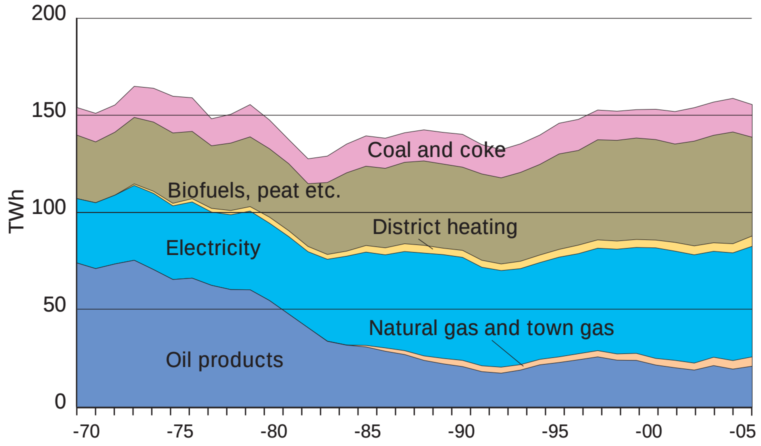
[70] Black liquors are by-products of pulp manufacture. They are used as fuel in special black liquor recovery boilers to recover chemicals for re-use and produce energy.

Figure 12: Electricity use in the residential and service sector, 1970–2005, after correction to statistically average climate conditions



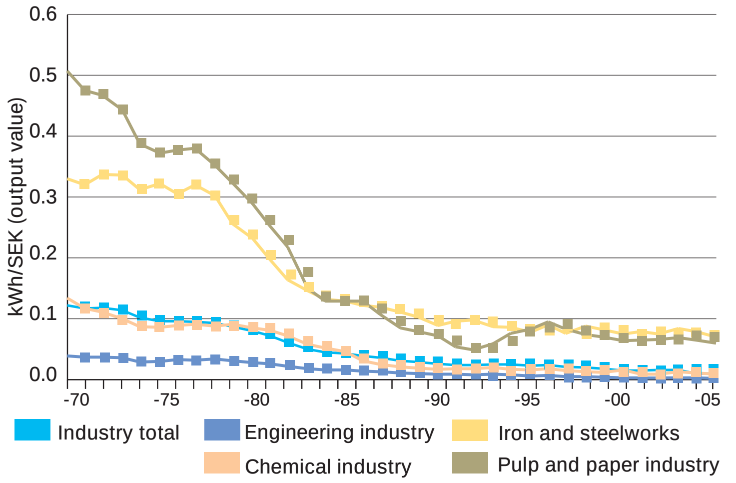
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 13: Final energy use in industry, 1970–2005



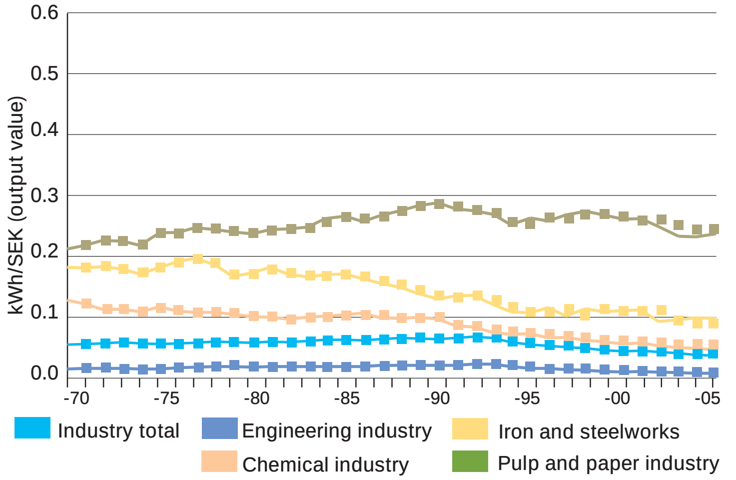
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 14: Specific use of oil in industry, 1970–2005, 1991 price levels



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

Figure 15: Specific use of electricity in industry, 1970–2005, 1991 price levels



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

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 8% of industrial energy use: here, electricity is used mainly for electrolysis processes. Together, these three energy intensive sectors account for over 70% 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 production 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 2002-2005. Over the period 2000-2005, industrial output increased by almost 4% per annum. Energy use increased by almost 2% over the whole period. Electricity use in 2005 rose to the same level as in 2000. In total, industrial output has increased by 100% between 1992 and 2005, for an increase of 12% in total energy use and 15% 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 37%. At the same time, the use of oil has fallen from 48% to 13% 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. Although overall use of oil by industry has fallen by about 72% since 1970, the use of oil products increased by almost 5 TWh, or 24%, between 1992 and 2005. Contributory factors for this have included increased industrial output, changes in energy and carbon dioxide taxes and a greater use of oil as a replacement for disconnectable electric boilers.[76] Biofuels are the main energy provider in the pulp and paper industry and in the wood products industry. Between 1970 and 2005, 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 2005, it fell by 60%, 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 2005, 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 45%, with specific use of oil falling by 46% and that of electricity by 46%. 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.

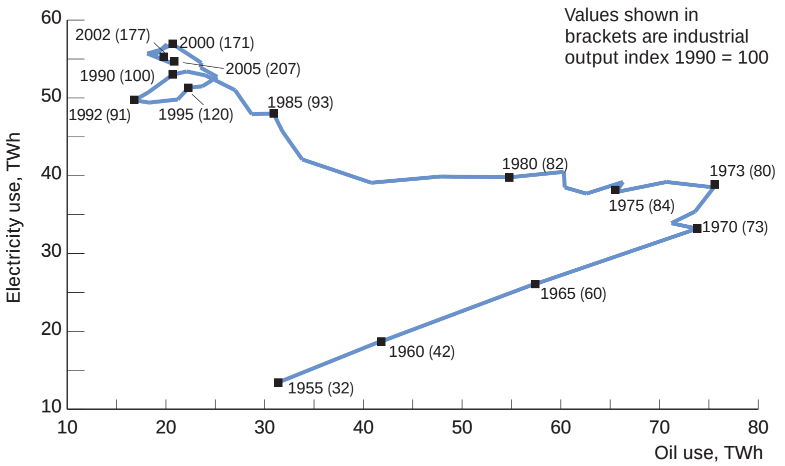
Transport

Total energy use for transport (excluding bunkering for foreign maritime traffic) in 2005 amounted to 101 TWh, equivalent to about 25% of the country's total final domestic energy use. Foreign maritime traffic used about 23 TWh of bunker oils.

Energy use in the transport sector consists mainly of oil products, primarily petrol and diesel fuel. In 2005, 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 - with aviation fuel accounting for a further 10% and electricity for 3%. The remaining energy requirement for transport was met by medium and heavy fuel oils, natural gas and ethanol. The use of petrol declined somewhat between 2004 and 2005, which can be partly explained by increased use of ethanol admixture. Excluding 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 2000–2005, while that of aviation fuel decreased over the period 2000–2003, and then increased in 2004–2005. This increase over the last two years is due partly to improved economic conditions and partly to increased com-

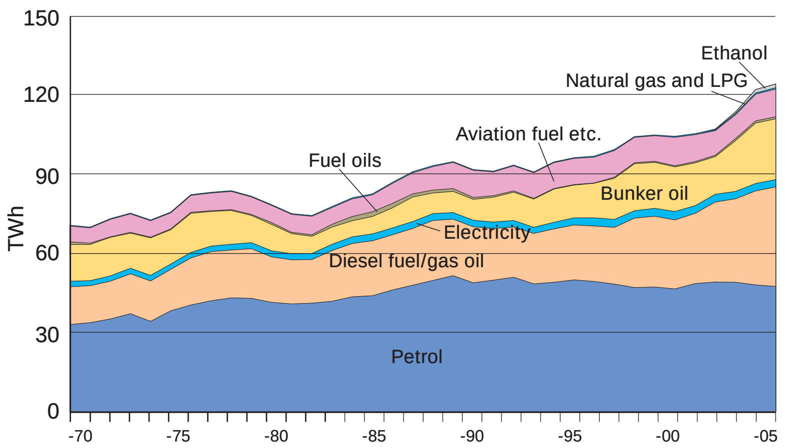
[71] Electric boilers make it possible to switch between electricity and an alternative energy source. This is done, for example, in response to high electricity prices.

Figure 16: Use of oil and electricity in industry, 1955-2005



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

Figure 17: Final energy use in the transport sector, 1970–2005



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

petition giving rise to a large number of cheap flights. Bunkering for international maritime traffic increased in 2005, partly due to the production by the Swedish oil refineries of low-sulphur fuel oils that meet stringent environmental requirements.

About 2% of energy use in transport (excluding foreign maritime traffic) in 2005 was met by renewable motor fuels (ethanol, FAME[72] and biogas). Expressed in proportion to the quantity of petrol and diesel oil used, renewable motor fuels amounted to about 2.3%. 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 in the price of petrol/diesel oil. At about the end of June 2006, a litre of 95-octane unleaded petrol cost about SEK 12.44. The corresponding price of a litre of E85 fuel (consisting of 85 % ethanol and 15% petrol) was about SEK 7.99. 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 a litre of petrol. The cost of using E85 at that point in time was thereby about SEK 2.00 per litre less than the cost of petrol. Gas as a motor fuel was also cheaper than petrol, with a difference of about SEK 3.90/litre (petrol equivalent).[73] The relatively high price of petrol 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. A change in the taxation of newer vehicles was introduced in October 2006, based on their carbon dioxide emissions rather than, as previously, on their weight.[74]

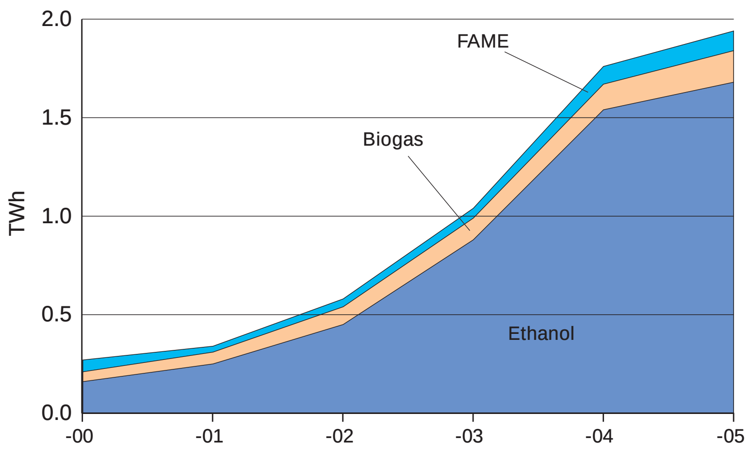
[72] FAME is an umbrella name for Fatty Acid Methyl Esters, of which Rapeseed Methyl Ester (RME) is the most commonly used in Sweden today.
[73] Svensk Biogas, http://www.svenskbiogas.se/, 2006-06-28
[74] Bill no. 2005/06:65
[75] SIKA, Statens institut för kommunikationsanalys (Swedish Institute for Transport and Communication Analysis)
[76] National Rail Administration, Sector report, 2005
[77] SIKA, Statens institut för kommunikationsanalys (Swedish Institute for Transport and Communication Analysis)
[78] Standing Committee on Traffic, Report 2005/06:TU6
[79] Swedish Environmental Protection Agency
[80] Bill no. 2005/06:160, page 322
[81] http://www.miljofordon.se/

Transport work

Since 1990, domestic passenger transport work has increased by 14% so that, excluding pedestrian, cycle and moped travel, it amounted to about 123 x 10^9 (thousand million) person km in 2005. Road traffic dominates this, with about 88% of passenger transport work in 2005, with railways carrying about 9 % of passenger traffic, and aviation almost 3 %.[75] 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.[76]

Domestic goods transport has increased by 27% since 1990, amounting to over 98.7 x 10^9 tonne km in 2005. This is the highest amount to date, representing an increase of over 5000 million tonne kilometres over 2004. About half of this increase represents the road and rail transport of storm-felled trees in the wake of storm Gudrun. Of the total goods transport, 40% were carried by road, 22% by rail and 38% by ship. Since 1990, road transport of goods has grown by 35 %, maritime traffic by 29% and rail traffic by 14%.[77]

Figure 18: Final energy use of renewable motor fuels, 2000-2005



SOURCE: STATISTICS SWEDEN, SWEDISH GAS ASSOCIATION

Development and use of alternative motor fuels

1st April 2006 saw the introduction of what is referred to as the Pumps Act which, in its first stage, means that all petrol stations selling more than 3000 m³ of petrol or diesel fuel per year must supply at least one renewable fuel.[78] In its additional budget for 2006, Parliament has made available SEK 50 million in the form of a grant to increase the use of renewable motor fuels. Its intention is that it should help to meet the cost of supplying renewable fuels other than ethanol at filling stations that have been required to sell renewable motor fuels.[79] In addition, the use of low environmental impact vehicles is being encouraged by reducing their notional benefit taxation rate and exempting them from any congestion charge[80]. In addition, certain local authorities reduce parking charges for such vehicles.[81]

Low admixture (5%) of ethanol in petrol expanded in 2005, although production of a similar admixture, of 2% FAME in diesel fuel, remained constant. However, with effect from 1st August 2006, the permissible admixture proportion in diesel fuel has been raised to 5%[82], which will increase the use of FAME.

A total of about 285 000 m³ of ethanol was used in the transport sector in 2005. Sweden has at present two factories that produce motor fuel ethanol. The factory in Norrköping produces about 55 000 m³ of ethanol per year from grain, while that in Örnsköldsvik produces about 18 000 m³ from by-products from various processes in an adjacent pulp mill. However, with effect from the beginning of 2006, customs duties for the importation of ethanol were changed. For certain types of ethanol importation this can represent an increase of over SEK 1.50 per litre in the price. The purpose of this introduction of customs charge is to assist the Swedish ethanol industry and to increase security of supply from it. The result of the customs charge has been that importation of Brazilian ethanol has essentially ceased, with supplies replaced by ethanol from southern Europe. This in fact probably has a negative environmental effect, as the European ethanol has a lower energy content than the Brazilian ethanol produced from sugar cane.[83] The 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. There are plans to build more ethanol factories in Sweden, including Umeå, Norrköping and Halmstad.

Congestion charge experiment

A new policy measure was introduced on trial in Stockholm on 3rd January 2006, in the form of a congestion charge for vehicles wishing to drive in central Stockholm. Additional public transport was provided, in the form of 14 new bus routes trafficked by 197 new buses. A first review of the effect of the congestion charge was that motor traffic to and from the centre of the city had been reduced by about 20-25%, and that queue times during the morning rush hour had been reduced by about a third. The charge also seems to have resulted in an increase of about 4% of journeys by public transport during the spring of 2006, in comparison with the same period in 2005. A further effect is that emissions of particulates and NO_x from road traffic in the city centre have fallen by about 8-12% .[84]

Infrastructural and technical development

Technical development occurs in the form of both improvements to existing technology and completely new technical solutions. As far as the road traffic sector is concerned, it is thought that it is likely that hybrid vehicles, bi-fuel vehicles and flexible fuel vehicles (FFV) will achieve commercial breakthroughs during the next ten years. 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, for many users, 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.

In January 2006, there were about 7880 NGVs (Natural Gas Vehicles) in Sweden, of which 6948 were private cars, 656 were buses and 276 were refuse collection vehicles or distribution vehicles.[85] There were also over 23 000 FFV vehicles in the country.

Technology continues to advance, too, in rail, air and maritime traffic. Trials of 'energy-conscious' driving of goods trains were carried out during the autumn and winter of 2005-2006 on the line between Halmstad and Hyltebruk. Five diesel locomotives were fitted with flow meters, and about a dozen drivers were trained in appropriate driving techniques. The results indicate an average reduction of about 20% in fuel consumption, with a corresponding reduction in carbon dioxide emissions.[86] ■

82 Bill no. 2005/06:160
83 Swedish Environmental Protection Agency
84 The Congestion Charge Office
85 Swedish Gas Association
86 National Rail Administration, Rallaren no. 3, April 2006

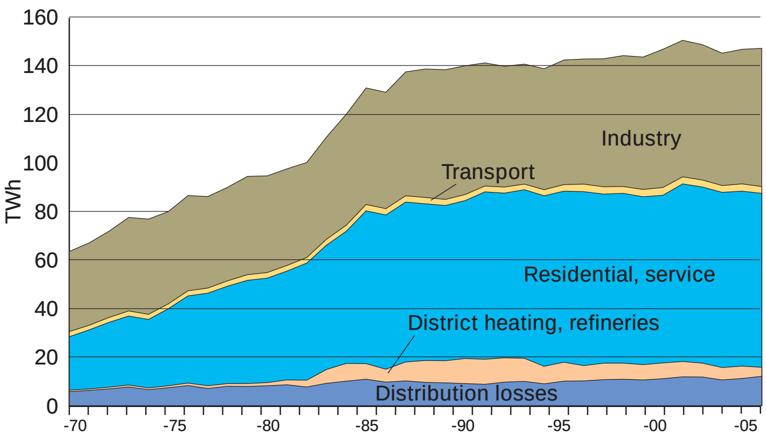
Energy markets

Energy markets are changing in step with world-wide growth in energy demand, developments in technology and with growing 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, biofuels and electricity. With the growing world-wide demand for energy, any 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, with particular emphasis on Sweden.

The electricity market

Major changes have occurred in the electricity markets in the Nordic countries and the EU over the last few years, resulting 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 south of the Baltic Sea (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 19: Sweden's electricity use, by sectors, 1970-2005



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 year. However, this rate of increase has since declined, to less than 0.4 % per year on average. In 2002 and 2003, electricity use in Sweden fell, before turning upwards again slightly over the last two years. Economic and technical development, changes in energy prices, business structure, population changes and the weather all affect electricity use. Total electricity use in Sweden in 2005 amounted to 147 TWh, with the residential and service sector accounting for almost half of this, and industry for almost 40 %. The remainder is accounted for by the transport sector, district heating and distribution losses.

Per-capita electricity use in Sweden amounts to almost 17 000 kWh per year. Only Norway, Finland, Iceland, Canada and Luxembourg have higher per-capita uses. The high electricity use in Sweden is due to a high proportion of electricity-intensive industries, a cold climate, a high proportion of electric heating and historically low electricity prices. Per-capita electricity use in the USA is about 14 % lower than in Sweden, while average use in the EU-15 is about 55 % less than that in Sweden.

Electricity production

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 2005, nuclear power supplied 45% of the country's electricity, hydro power supplied about 47% and the remaining 8% was made up of fossil-fuelled and biofuel-based production and wind power. Total production amounted to 154.6 TWh, which was almost 4 % higher than in 2004.

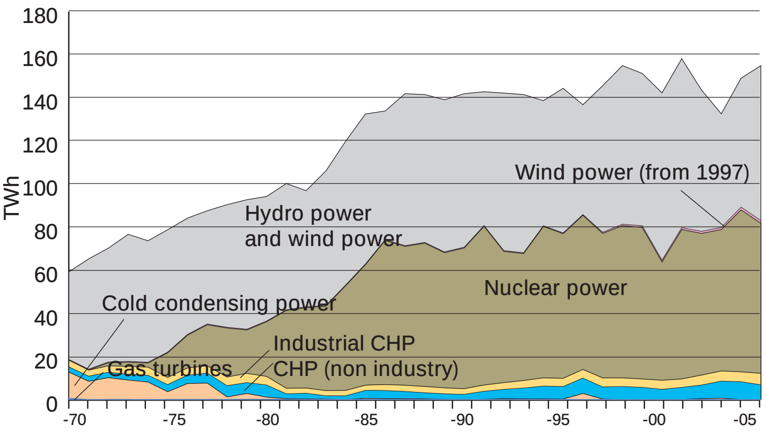
At 72.1 TWh, hydro power production increased considerably in 2005, due to good precipitation during the year. The country's nuclear power stations produced 69.5 TWh in 2005, or 9% less than the previous year's record production. Barsebäck 2 was shut down on 31st May 2005, as the result of a parliamentary decision. Combustion-based electricity production amounted to 12.1 TWh, with almost 60% of the fuel input being in the form of biofuels, 22% consisting of coal, 14% of oil and 5% of gas. In comparison with 2004, the proportions of biofuels and natural gas have increased, while that of oil has decreased. Today, it is combined heat and power (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 8% during 2005, contributing 0.9 TWh.

99% of electricity production in Norway is based on hydro power. In Denmark, most electricity is produced from thermal power, although the country also has a relatively high proportion of wind power (16%). In Finland, over half of the country's electricity is produced by non nuclear thermal power, with a further 26% 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 2004, 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

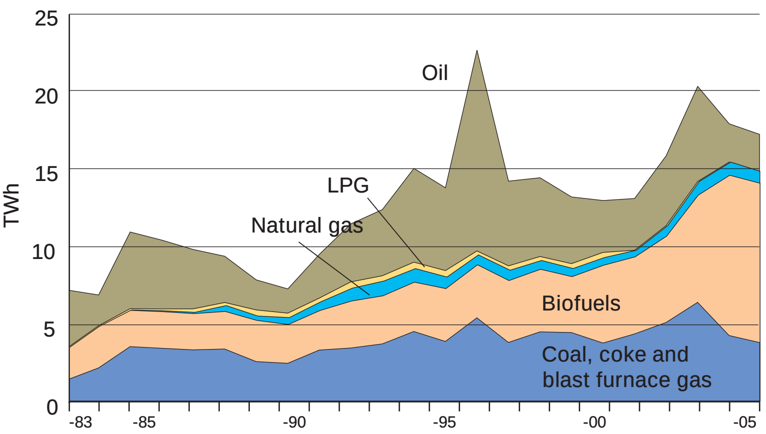
Electricity cannot be stored. When we turn a light on at home, the necessary electricity is produced in a power station at the same instant. In order to en-

Figure 20: Power production in Sweden, by power source, 1970-2005



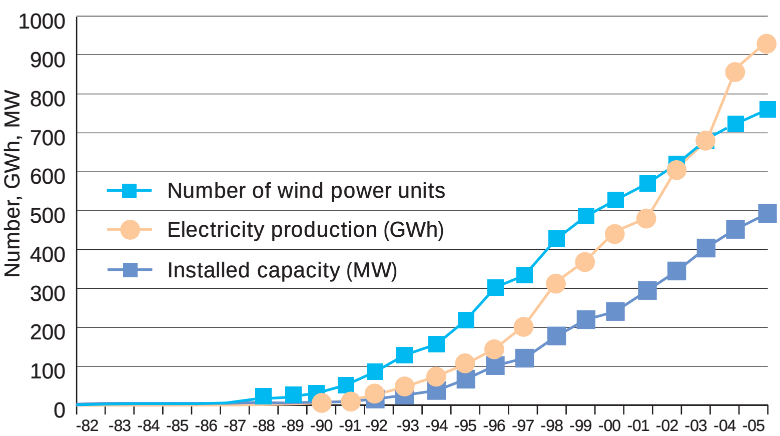
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 21: Fuel input for electricity production (excluding nuclear fuel), 1983-2005



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

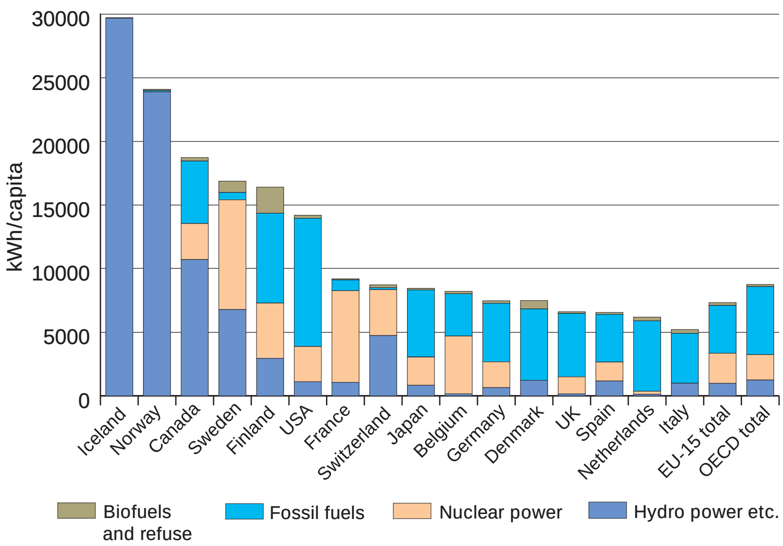
Figure 22: Wind power production in Sweden, 1982-2005



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

Note: Differences in the number of plants as shown in this diagram and in Table 5 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.

Figure 23: Per-capita electricity production from different sources, 2004



SOURCE: IEA, ELECTRICITY INFORMATION 2005

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

sure 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 network in Sweden is divided into three levels: the national grid, regional grids and local distribution networks. The national grid, which consists of 15000 km of cables and overhead lines, is a high voltage transmission system (200 kV and 400 kV), carrying electricity over long distances and to neighbouring countries. The regional grids, which consist of about 36000 km of lines (40 kV–130 kV), are owned mostly by the three larger electricity utilities. They carry electricity from the national grid to the local distribution networks and, in some cases, directly to larger electricity users. The local distribution networks, amounting to about 477000 km of lines (<40 kV), are owned primarily by the large electricity producers and by local authorities. Security of supply over the various grids and networks has become increasingly important in step with the growing dependence on electricity. Storm Gudrun, which struck southern Sweden in January 2005, destroyed over 30000 km of overhead lines, plunging thousands of businesses and over half a million domestic consumers into darkness. Many had to wait for days or even weeks before their supply was restored.

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. A special unit, the Energy Market Inspectorate, was set up within the Agency on 1st January 2005 to take over these duties. It applies the Grid Benefit Model as one means (among several) of assessing the fairness of tariffs.

There are at present links between Sweden and Norway, Finland, Denmark, Germany and Poland. The Nordel organisation has put forward five investment projects 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 is planned to be commissioned before 2010. They are needed for a number of reasons, including elimination of bottlenecks in the system and improving the overall security of supply. At present, the total transmission capacity between Sweden and other countries amounts to about 9000 MW, i.e. about one-third of Sweden's maximum demand.

At the end of 2005, Sweden's total installed capacity was 33 212 MW, made up of 16 150 MW of hydro power (48.5%), 525 MW of wind power (1.5%), 8 961 MW of nuclear power (27%), and 7576 MW of other thermal power (23%). Maximum demand in 2005 occurred on 3rd March, and amounted to 25800 MW[92]. This can be compared with Sweden's hitherto highest demand of 27000 MW, which occurred in January 2001[93]. 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 2000 MW. This has been done by entering into agreements with electricity producers and users to make additional production capacity (or reduction in demand) available. This arrangement applies until the end of February 2008, when a more market-based solution is to take over.

Electricity trading

Power wholesale trading is vital in order to ensure

[87] Nordel
[88] Svenska Kraftnät

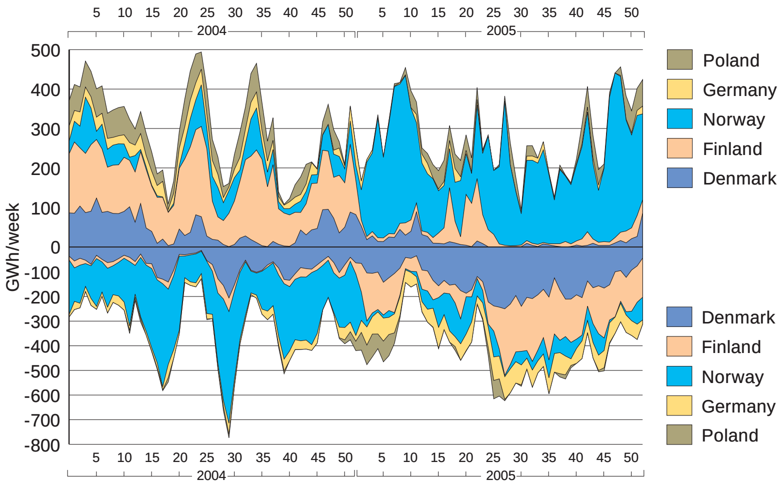
a properly operating electricity market. Since deregulation, this has been provided by a joint Nordic electricity power exchange, Nord Pool. It facilitates the economic use of Nordic power plants, and offers transparency of pricing. It has two main markets: one for trading in electricity as such, and one for trading in financial instruments. In 2005, about 45% 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 internally within electrical utilities or via 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 786 TWh (about twice the underlying physical need), partly as a means of ensuring prices and partly for speculative objectives.

In 2005, Sweden had a net export of over 7 TWh of electricity, as against 2 TWh in 2004. This substantial figure was due largely to the high availability of hydro power. Electricity trade flows 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 price level of electricity in the different countries. In 2005, Sweden was a net importer of electricity, primarily from Norway, and a net exporter to Denmark, Germany and Finland. The Nordic countries as a whole exported about 1 TWh in 2005, which is less than 1% of their electricity requirements.

Electricity price makeup and development

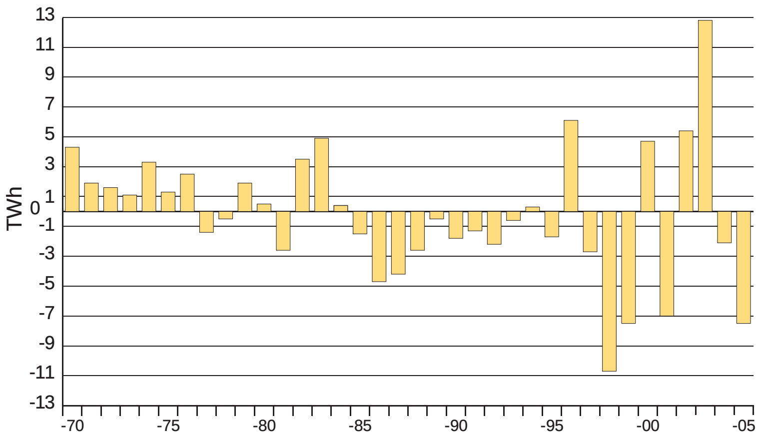
The price of electricity on the electricity exchange is not the same as the final price that a domestic customer sees on his or her bill. The total price to the customer consists of the price for the electricity itself, the price of electricity certificates, the network price, energy tax and value added tax. Of these, it is the price of the electricity itself and that of the electricity certificates that are subject to competition. In January 2006, the total price of electricity to the customer category of detached houses without electric heating was made up of about 33% for the electricity itself, 28% for the network charge, 2% for green certificates, 18% for energy tax and 20% for value added tax. The price of electricity may be fixed for usually 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, almost half

Figure 24: Sweden's electricity import (+) and export (-), January 2004–December 2005, GWh/week.



SOURCE: SWEDENERGY; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 25: Sweden's net import (+) and net export (-) of electricity, 1970–2005



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

Table 7: Total price of electricity (excluding electricity certificates) for different customer categories, including taxes and value added tax, öre/kWh

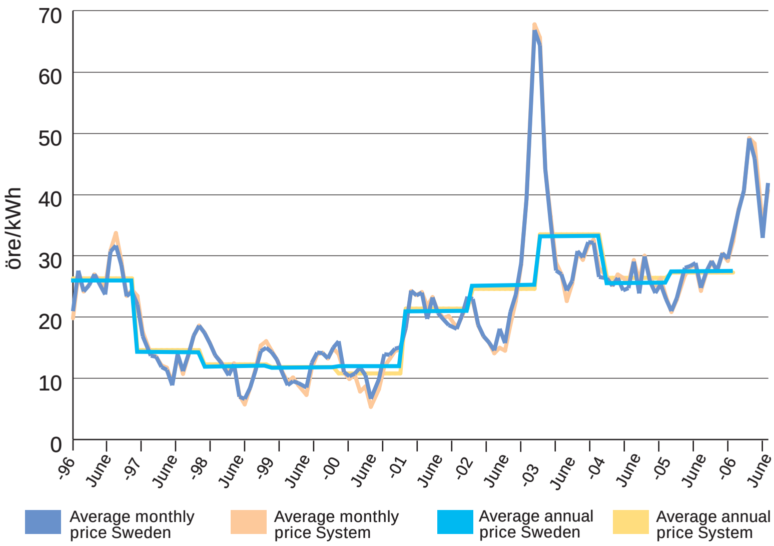
Date	Light industry [1]	Detached house with electric heating [2]	Detached house without electric heating [3]
1st Jan. 2002	43.8	87.9	111.3
1st Jan. 2003	59.9	111.4	135.4
1st Jan. 2004	62.4	117.9	143.6
1st Jan. 2005	55.2	109.9	135.9
1st Jan. 2006	61.3	117.4	143.9

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 in the respective years.

1) Annual consumption 350 MWh, 2) Annual consumption 20 000 kWh, 3) Annual consumption 5000 kWh.

Figure 26: 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

of the customers have what are known as open ended contracts, and have not renegotiated their contracts. 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[89] was 2.7 öre/kWh[90]. For most domestic customers, electricity tax has increased by 6.3 öre/kWh since 2002, an increase of 32%. 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 2005 as a whole, the average spot price was 27.2 öre/kWh, an increase from 26.4 öre/kWh in 2004. The somewhat rising price can be partly explained by the introduction of trading in emission allowances. The sector organisation, Svensk Energi, estimates that trading in emission allowances in 2005 had contributed to the electricity price increase by about 10 öre/kWh. The recent rising world market prices for oil, coal and natural gas have also exerted upward pressure on the price of electricity.

[89] According to data reported to the Swedish Energy Agency
[90] For customers with an annual demand of less than 50 MWh
[91] The Nils Holgersson Survey, 2005. Formed by five large housing organisations, and monitors local authority charges for heating, domestic hot water, water, sewage treatment, electricity and waste disposal.
[92] Boiler plants that supplied a single block or a small number of blocks. Previously common in the 1960s' 'Million New Homes' programme areas.

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, while 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, and are more widely spread over the country, than district cooling systems, which are concentrated in 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, and the main form of heating in the centres of 234 of the country's 290 municipalities[91]. 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[92] 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 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 bio-fuel-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. Figure 27 shows the growth in the use of district heating since 1970.

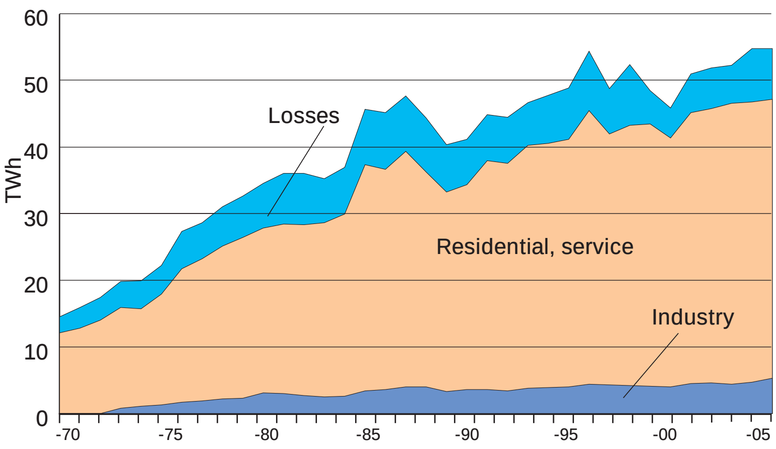
Energy policy has favoured district heating through various forms of state support, e.g. grants for the extension of existing district heating systems and the connection of group heating systems and even individual buildings to existing systems. A conversion grant is available from the beginning of 2006 to the end of 2010 for changing from direct electric heating or oil heating to heating from district heating, heat pumps, biofuel-fired boilers or solar heating.

Replacing a multitude of small individual boilers by district heating has reduced emissions from heating of residential buildings and commercial premises. The urban environment 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 heating market is undergoing changes. As district heating requires an expensive infrastructure, it is a de facto monopoly as far as distribution is concerned. On an unregulated market, this means that a district heating supplier can relatively easily charge what it likes, without having to be too concerned about competitors. However, the heating market can be regarded as a competitive market as far as the potential choices facing a new customer are concerned. Nevertheless, it is the major differences from one area to another that are particularly noticeable. The regular price comparisons by the Public Service Fee Group and the Swedish Energy Agency's annual surveys of the heating markets provide information on price differences between areas. Conditions for the construction of district heating systems vary from place to place, in respect of such aspects as the type of built environment and the type of geological ground conditions. A customer's choice of heating systems is very dependent on where the building is located.

A more in-depth review of district heating in the heating markets has been carried out by the District Heating Commission[93], with the aim of preparing proposals for strengthening the position of customers when dealing with suppliers. 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 finished its work in June 2005, proposes that these measures should be realised

Figure 27: Use of district heating, 1970–2005



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

through a special district heating act. The details are now being worked out in the Government Offices.

The amendments to the Electricity Act that came into force on 1st July 2005 include requirements for separate accounting of district heating activities. The purpose of this is to increase market transparency and to reduce cross-subsidy of services, i.e. enabling a company with activities in several fields to use its profits from district heating to compete in some other more competitive market, e.g. the electricity market.

A new item of legislation on guarantees of origin came into force at the beginning of July 2006. Under it, producers of electricity and district heating from high-efficiency CHP[94] or renewable energy sources can obtain a guarantee of origin from Svenska Kraftnät, the grid operator. The idea is that the guarantee can be used for marketing purposes. At the same time, the requirement for obtaining a concession for constructing district heating mains networks has been removed. This, in combination with changes in the taxation of CHP, is intended to make the market for district heating production more attractive.

Today, district heating supplies about 48% of the total heating requirement of residential and commercial premises. It is the commonest form of heating in apartment buildings, supplying heat to about 78% of the heated floor area, while about 56%[95] of commercial and similar premises are heated by it. In detached houses, on the other hand, the proportion is only about 9%.

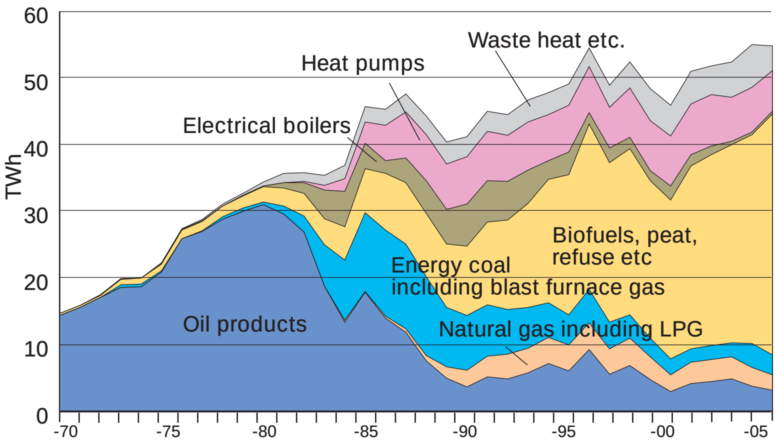
Over 47 TWh of district heating were supplied in 2005, representing a slight increase on 2004. Of the total quantity, about 60% were for residential heating (apartment buildings and detached houses),

[93] SOU 2003:115, 2004:136, 2005:33, 2005:63

[94] High-efficiency CHP uses at least 10 % less fuel than would be used by separate production of the same quantities of heat and electricity.

[95] This is a 4 percentage points reduction from last year, due to a redefinition of the statistics. Premises with district heating for space heating, but electricity for domestic hot water production, have previously been classified as heated by district heating, but from 2004 are classified as heated by district heating and electricity.

Figure 28: Energy input to district heating, 1970–2005



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

about 30% for commercial premises and 10% for industry. 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. Corresponding decreases can be found in industry's use of biofuels.

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 renewables - particularly biofuels - being the main energy source. Total energy supply to the district heating sector in 2005 was almost 55 TWh. Figure 28 shows how the proportion of biofuels has increased steadily since the 1970s, when it was about 2%, reaching over 25% in 1990. Since then, the rate of increase has further accelerated. The introduction of carbon dioxide tax in 1991 has given biofuels a favoured position. See the section 'Biofuels, peat and waste' for a more detailed diagram of the use of biofuels in district heating. Biofuels consist largely of forms of wood fuel. Waste has become a steadily more important fuel for district heating production: the substantial growth in its use over the last three years can be credited partly to low costs for waste and to the policy measures[96] introduced to reduce disposal of waste in landfill.

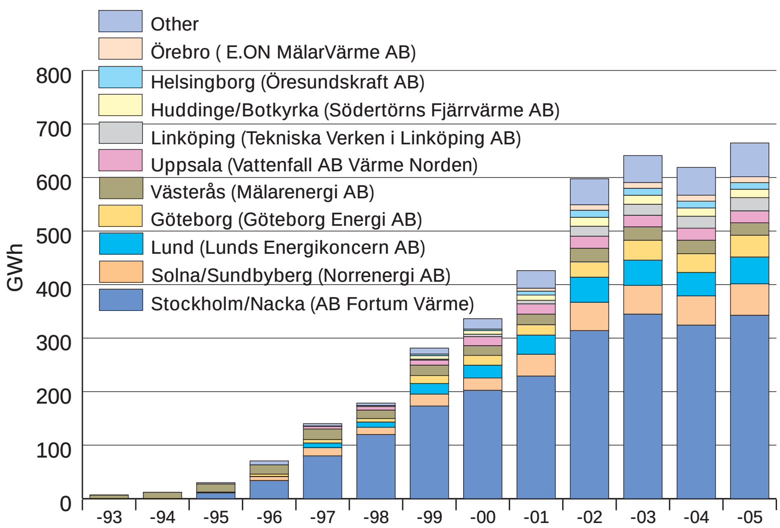
The use of electricity in the sector, with most of it being accounted for by electric boilers, has fallen substantially since market deregulation in 1996. The electrical energy input to heat pumps, however, has remained relatively constant. District heating losses have fallen since the 1980s as a result of improved technology and higher load factors. In 2005, distribution and conversion losses amounted to somewhat less than 14% 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 several have common owners. In 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[97] interests.

[96] Landfill tax was introduced in 2000, by The Act (1999:673) Concerning Tax on Waste. The tax rate was last raised on 1st January 2006, and now amounts to SEK 435 per tonne. Disposal of unsorted waste in landfill was banned in 2002, followed by a ban on disposal of organic combustible waste in landfill in 2005.

[97] Through Vattenfall for the Swedish state, and through Fortum for the Finnish state.

Figure 29: District cooling supplies, 1993-2005, by suppliers



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: cooled 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 plants, 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. Figure 29 shows district cooling supplies in Sweden. In 2005, there were 28 commercial district cooling suppliers, some operating more than one system. 664 GWh of district cooling were supplied.

The energy gases market

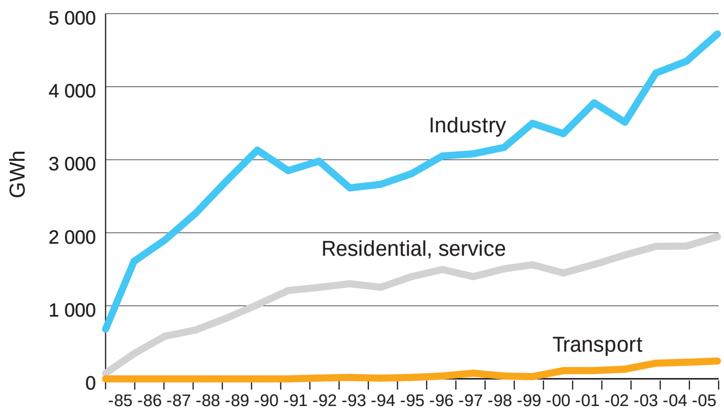
Sweden uses a relatively small quantity of energy gases[98] in comparison with many other European countries. However, the distribution network for natural gas in Sweden is being extended. The rest of Europe is covered by an extensive natural gas distribution network. The use of natural gas in Europe has increased over the last couple of decades, primarily as a replacement for 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.

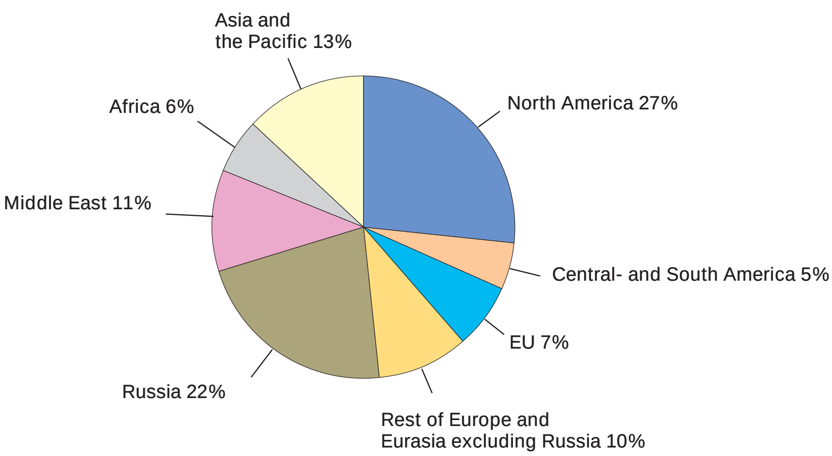
Natural gas was introduced to Sweden in 1985. Its use has started to increase again in recent years, as a result of extension of the natural gas grid. In 2005, imports amounted to 883 million m³, equivalent to 9.8 TWh. Industry accounts for almost 70% of total use, with the residential sector accounting for almost 30%. A small amount of natural gas is also used as motor fuel. Total use of natural gas in 2005 amounted to 6.9 TWh in these user sectors, with about a further 2.9 TWh being used by CHP and district heating plants. Natural gas is distributed at present to about 30 municipalities, where it meets about 20% of energy demand. On the natio-

Figure 30: Use of natural gas in Sweden, 1985-2005, by sectors.



SOURCE: STATISTICS SWEDEN

Figure 31: World natural gas production, 2005. Total 2763 x 10^9 m^3 (*thousand million*)



SOURCE: THE STATISTICAL REVIEW OF WORLD ENERGY 2006, WWW.BP.COM

[98] Energy gases are natural gas, LPG, biogas, town gas and hydrogen.

nal level, it supplies almost 2% of total energy demand.

With effect from 1st July 2005, the state utility Svenska Kraftnät has the system responsibility for the national market for 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 network extends from Trelleborg in the south to Gothenburg (on the west coast), 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 November 2004 to the Danish Dong Naturgas A/S. E.ON Gas Sverige AB is responsible for the branch mains in southern Sweden. Three separate concession applications have been submitted for extension of the existing main from Gislaved/Gnosjö to Oxelösund (on the east coast) 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.

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 2005, commercially viable reserves amounted to almost 180 000 x 10^9 m³ (thousand million), which would last for almost 65 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 Republics (32%) and in the Middle East (40%). Only a little over 1% 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 the Netherlands. The proportion of total global energy supply met by natural gas has increased rapidly during the last decade, by over 30% between 1992 and 2005. 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.

Transport of natural gas

Pipeline transportation of natural gas is the main way of transporting natural gas between producers and consumers. The physical transport system can be approximately divided up into transmission and distribution. Transmission pipes carry the gas over long distances under high pressure: the quantities of energy represented by the gas can be very significant. At the reception points, the pressure is reduced in metering and pressure regulation stations, before the gas is supplied to local distribution networks for delivery to the end users. Several Asiatic countries, particularly Japan and South Korea, are far from their sources of supply. Gas is delivered to them by ship in liquid form, having been liquefied by extreme cooling. Liquefied natural gas (LNG) has historically been unable to compete to any greater extent with pipe borne natural gas, due to 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 not allowed, as otherwise revenues from the transport monopoly 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 EC Natural Gas Directive was issued in February 1998, with the aim of increasing competition on the European natural gas markets. It was implemented 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 the two activities of 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. Since 1st July 2005, all non-domestic customers have been 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.

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 2005, 4.7 TWh of LPG were used in industry, 0.5 TWh in the residential sector and almost 0.2 TWh for electricity and district heating production.

Biogas consists mainly of methane, formed by the breakdown of organic materials such as sewage sludge, domestic waste 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. After cleaning, and having its methane concentration increased, biogas can then be used for electricity and heat production, or for transport. In 2004, 49 GWh were used for electricity production, and 364 GWh for heat production. Biogas was also used 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. Stockholm, too, is planning to change from naphtha-based gas to natural gas-based town gas[99]. 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 2005.

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.

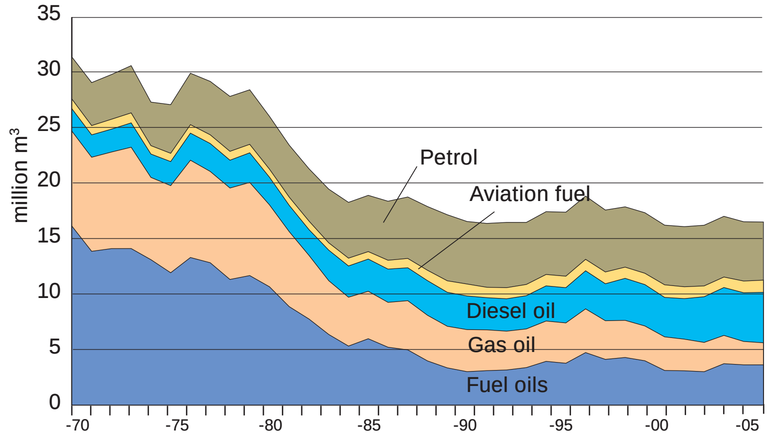
The oil market

Oil in Sweden

In 2005, oil provided almost 31% 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 47% 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

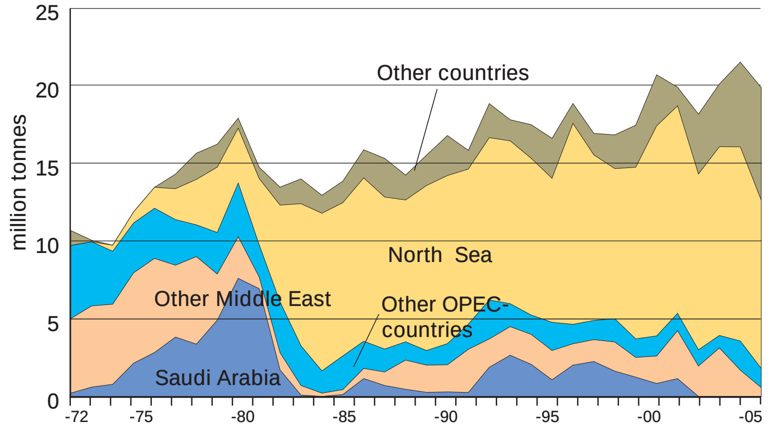
[99] City Planning Department

Figure 32: Use of oil products in Sweden, including foreign maritime traffic, 1970-2005



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

Figure 33: Net Swedish imports of crude oil and oil products, by country of origin, 1972–2005



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

considerable quantity of oil for heating supplies, see Figure 11. 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 2005, Sweden imported a little less than 19.9 million tonnes of crude oil, and net-exported 3.6 million tonnes of refinery products. About 50% of Sweden's total crude oil imports come from the North Sea. In recent years, there has been a substantial increase in the proportion of Sweden's oil that comes from Russia. Overall, 36% comes from Russia, 25% comes from Denmark, 25% from Norway, 6% from Venezuela, 4% from the UK and 3% from Iran, as shown in Figures 33 and 34. This substantial importation of oil is due to the fact that much of the oil is processed in Sweden before re-export[100]. 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. In the autumn of 2005, the IEA asked its member countries to release some of their stocks to the market, to help to meet shortages that had arisen as a result of hurricane Katrina in the Gulf of Mexico. In response to the IEA request, Sweden permitted the release of a maximum of 2261 m³ per day, corresponding to a total of 67830 m³, in accordance with the IEP agreement[101].

Preem Petroleum's GasOil investment project[102] at its Lysekil refinery was completed at the beginning of 2006. Costing SEK 3200 million, and involving the construction of a hydro-cracker and a plant for the production of hydrogen, with important ancillary process equipment, it increases the proportion of sulphur-free motor fuels from 50% to 70% of the company's production. The net effect on global CO_2 emissions is a reduction of about 270000 tonnes of CO_2 per year. Planning started in the autumn of 2006 for a new investment project to enable the Lysekil and Gothenburg refineries to process heavy oil and to produce industrial coke. The project is expected to be completed in the autumn of 2011.

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 burned, 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

[100] For additional data and statistics from the oil industry, see (for example) 'The Oil Year, 2005' [in Swedish - Oljeåret 2005], http://www.spi.se/
[101] http://www.iea.org/Textbase/about/IEP.PDF
[102] Previously Scanraff AB
[103] Coal with a standardised calorific value of 6000 kcal/kg.
[104] IEA, Coal Information 2005

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[103] and USD 46 per tonne. The price started to rise steeply in April 2003, reaching USD 78 per tonne in July 2004, which is a record. In November 2005, the price had fallen to USD 52 per tonne, but had risen again to USD 63 per tonne by July 2006. 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 and consumption continue at the present rate, proven and economically recoverable world reserves would last for about 165 years[104].

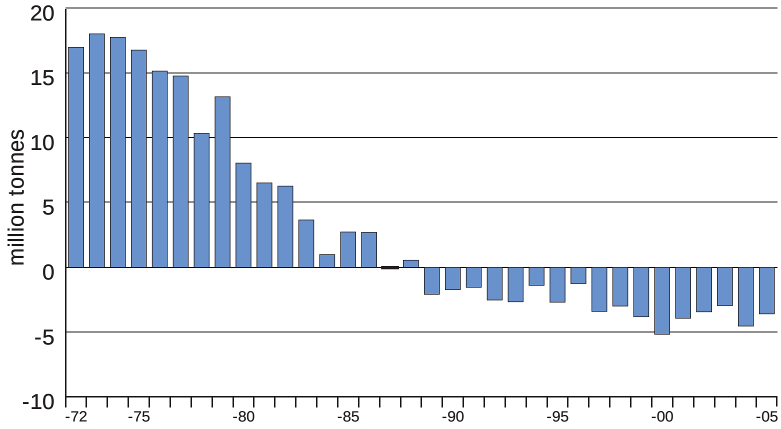
Sweden's coal use

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 3.4 million tonnes of hard coal was used in Sweden in 2005. 2.0 million tonnes of this were coking coal, leaving 1.4 million tonnes for energy purposes. To this must be added a net import of 0.3 million tonnes of coke.

The use of coal in industry

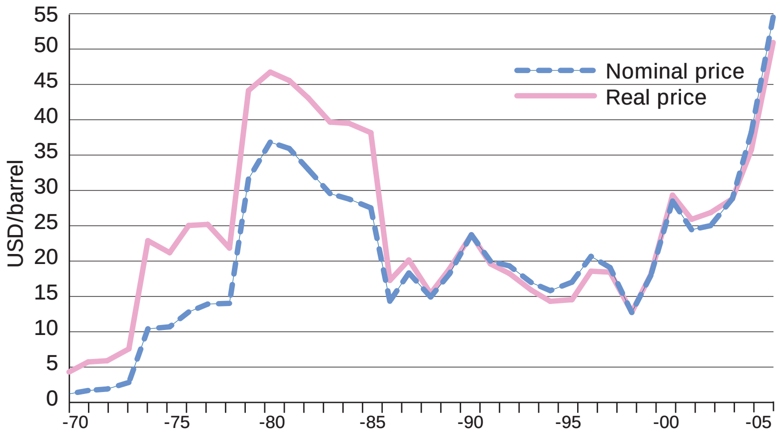
Industry uses energy coal, metallurgical coal, coke and smaller quantities of other coal products such as graphite and pitch. Coke is essentially pure carbon, produced in coking plants from metallurgical coal. The country's two coking plants, at steelworks in Luleå and Oxelösund, also produce coke oven 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 conver-

Figure 34: Net imports (+) and net exports (-) of refinery products, 1970–2005



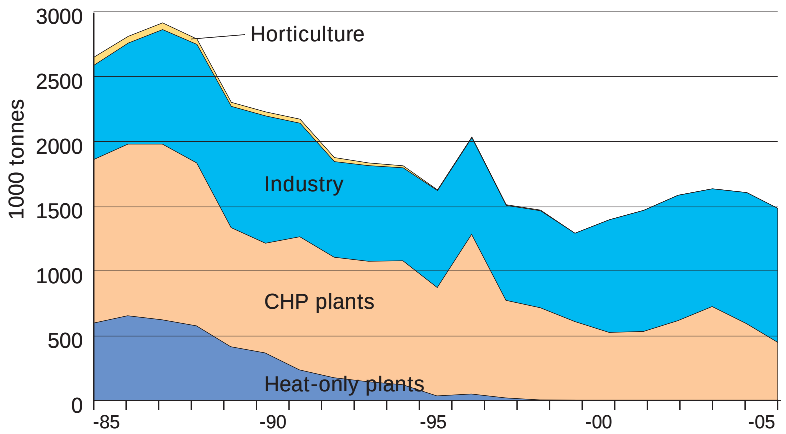
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 35: Nominal and real prices of light crude oil, 1970 – 2005, US dollar per barrel



SOURCE: WWW.BPAMOCO.COM AND THE WORLD BANK

Figure 36: Use of energy coal in Sweden, 1985-2005



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

ted 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 2005, together with 1.0 million tonnes of energy coal and the country's entire net import of 0.3 million tonnes of coke. The quantity of energy coal provided an energy input of 7.5 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. CHP plants still use a certain amount of coal, as taxation on a combined production regime is less than on heat alone. The heat production fraction in a CHP plant is exempted from energy tax, carbon dioxide tax is reduced by three-quarters, and the electricity production is entirely tax-free. This tax structure is intended to promote the competitiveness of CHP plants against that of plants producing only heat or electricity. SSAB's steel mill in Luleå supplies coke and 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's district heating system. In 2005, the district heating sector used 0.4 million tonnes of energy coal (3.2 TWh) and 2.5 TWh of coke oven and blast furnace gas for electricity and heat production.

Electricity production

0.15 million tonnes of coal (1.1 TWh), together with 2.5 TWh of coke oven and blast furnace gas, were used for electricity production in 2005, giving a total of about 2.2 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 18% in 2005. Most of the increase has been by industry and district heating plants.

The total use of biofuels, peat and waste in 2005 amounted to 112 TWh, of which about 51 TWh were used in industry, 13 TWh in the residential and service sector, and about 1.7 TWh in the transport sector, with about 36 TWh being used for district heating production. District heating cogeneration plants used 5.7 TWh for electricity production, while industrial back-pressure plants used 4.4 TWh of such fuels.

Most of the biofuels, peat and waste used in the Swedish energy system are indigenous, consisting mainly of:

- wood fuels (logs, bark, chips and energy forests and 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, 5% as admixture in 95 octane petrol, and the main ingredient in E85 and E92 motor fuels).

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. 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 are converted to pellets, briquettes or powder in order to improve their energy density, simplify handling and reduce the cost of transport. In 2005, the Swedish energy system used a total of about 1.5 million tonnes of pellets, equivalent to about 7.2 TWh, making up over 1% of the country's total energy supply. Deliveries of pellets to the Swedish market have more than doubled between 2000 and 2005

Each year, there is a relatively extensive commercial importation of biofuels. This import consists largely of pellets and ethanol: it is estimated that about 80% of the ethanol used in or as motor fuels is imported. As far as pellets are concerned, it is estimated that a good 10% are imported (about 330 000 tonnes), and about 145 000 tonnes are exported. Unfortunately, no reliable import or export statistics are at present collected, and so it is difficult to estimate quantities. However, imports are included in the country's energy balance as indigenously produced, calculated from the statistics of use. 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 contribution. Most of the imported material is used for the supply of district heating.

The forest products industry

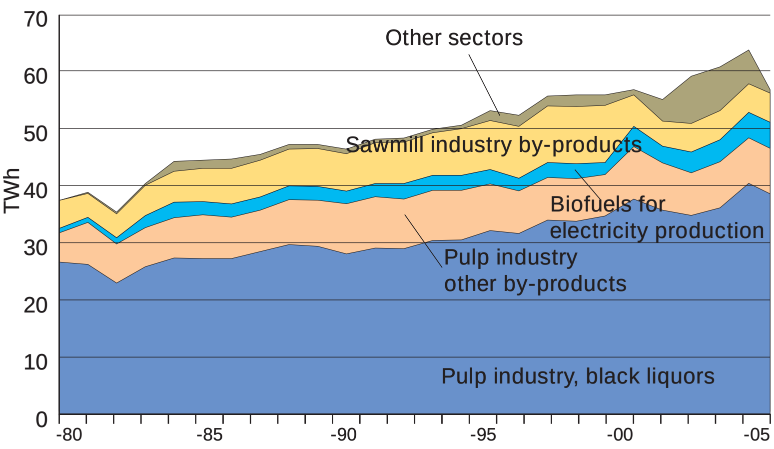
The forest products industry uses the by-products and waste from various manufacturing processes, together with raw materials that do not meet quality standards, for the production of heat and electricity. As part of the overall process of producing chemical wood pulp for paper making, pulp mills recover 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.

Energy from burning black liquors is used internally in the pulp industry: in 2005, it provided almost 38 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 2005, the pulp industry used a total of over 7 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 over 55 TWh of various types of biofuels for heat and electricity production in 2005.

District heating plants

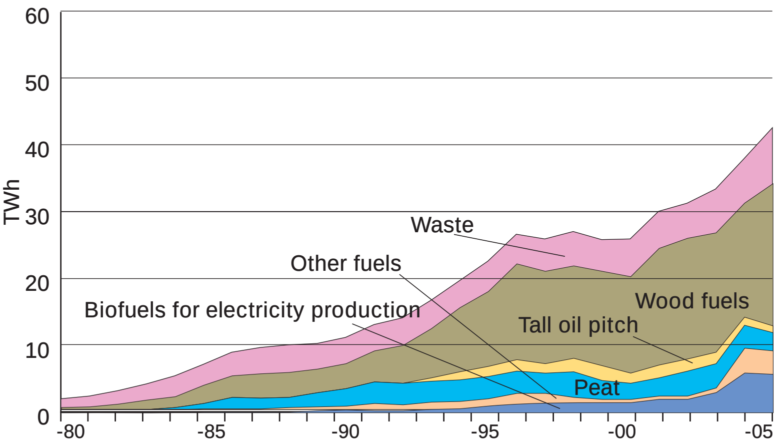
Over 36 TWh of biofuels, peat etc. were used for heat production (i.e. excluding electricity production) in district heating plants in 2005. Of this, wood fuels accounted for over 12 TWh, waste for over 8 TWh, black liquors and tall oil pitch for over 1 TWh, peat for almost 3 TWh and other fuels for about 3 TWh. The use of wood fuels by the district heating sector has increased by more than fivefold since 1990, as shown in Figure 38. The main form of these fuels is felling residues and by-products from the forest products industry, although processed fuels such as briquettes and pellets are also being increasingly used.

Figure 37: Use of biofuels, peat etc. in industry, 1980–2005



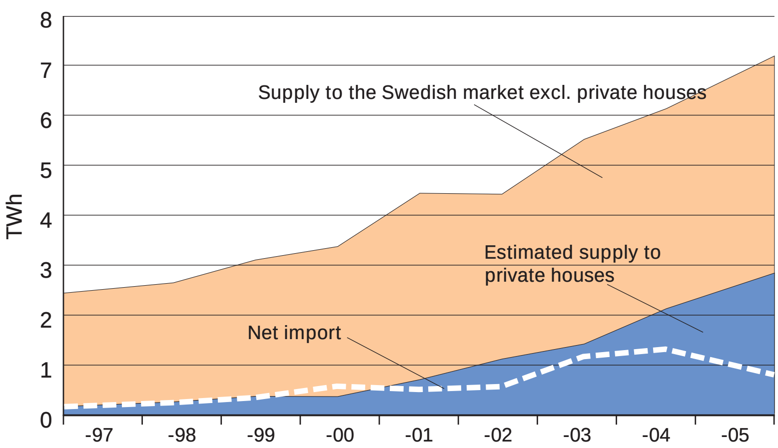
SOURCE: STATISTICS SWEDEN; ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Figure 38: Use of biofuels, peat etc. for district heating, 1980–2005



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

Figure 39: Supply of pellets to the Swedish market, 1997–2005



SOURCE: PELLETSINDUSTRINS RIKSFÖRBUND (PIR), WWW.PELLETSINDUSTRIN.ORG

Waste

Waste has been used for district heating production since the 1970s. The quantity increased from almost 4 TWh in 1990 to over 8 TWh in 2005, 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. The use of domestic waste as fuel is taxed on the basis that part of it that consists of organic fossil carbon, representing an extension of energy and carbon dioxide taxation. Per tonne of fossil carbon in the waste, the tax rates for the two elements are SEK 150/tonne as energy tax and SEK 3374/tonne as carbon dioxide tax. This taxation was introduced on 1st July 2006. Landfill disposal of waste has been taxed since the beginning of 2000: from 1st January 2006, the rate has been SEK 435 per tonne.

Some quantities of waste, demolition timber and similar fuels are imported, 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 can 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. Since 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 in accordance with the two bans on its 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 3.5 TWh in 2005. The harvest in 2005 amounted to about 1.8 million m³, i.e. somewhat below the average for the past few years. Imports in 2005 were somewhat lower than in 2004, amounting to about 1.1 million m^3. [105]

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 extracts peat 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.

Since 1st April 2004, the use of peat in approved CHP plants entitles electricity producers to Green Electricity Certificates. Electricity production from peat amounted to about 0.4 TWh in 2005. The European 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.

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 effects of this and other actions on the peat industry have been investigated for the government in the spring of 2006[106].

The detached house sector

11.2 TWh of biofuels, peat etc., were used in detached houses for heating in 2005. 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 most common among property owners with good access to forests, e.g. in agricultural or rural areas. Industry figures show that the use of pellets in the detached house sector increased by more than seven times over the period 2000–2005, so that in 2005 over 80 000 houses were heated by pellets-fired boilers. According to the industry, the use of pellets in the detached house sector increased by about a third between 2004 and 2005. A total of 11.9 TWh of biofuels, peat etc. were used for heating residential and commercial premises in 2005.

An international comparison

About 18 % 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 population. The following factors have a considerable effect on their use in energy systems: good availability of forests and raw

[105] Further information on peat can be found in Statistics Sweden's notice no. MI 25 SM 0601.

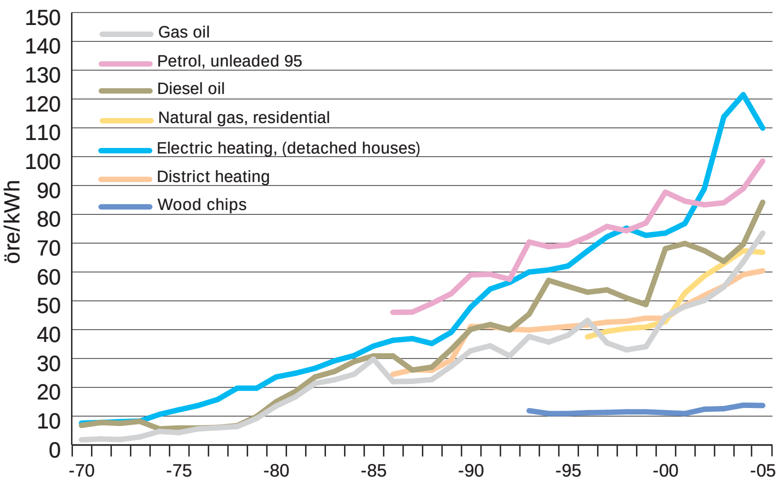
[106] Report to the Government, published 1st June 2006, entitled 'Uppdrag avseende de ekonomiska förutsättningarna i vissa regioner mot bakgrund av situationen för torvbruket' ['Report on the economic conditions in certain regions against the background of the situation for the peat industry'], National Board for Industrial and Technical Development (NUTEK), Swedish Energy Agency, Swedish Environmental Protection Agency and Swedish Institute for Growth Policy Studies (ITPS).

materials, a developed forest products industry, wide use 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 includes the network charge and, if the consumer has a quota obligation, the price of the necessary electricity certificates. Trading in emission allowances was introduced on 1st January 2005, but is not considered in the energy price presentations. Figure 40 shows the commercial energy prices. Table 8 shows the prices of fuels net of taxes, electricity certificates and value-added tax for industrial customers. 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 40 in Energy in Sweden 2006 – Facts and figures. ■

Figure 40: Commercial current energy prices in Sweden, 1970–2005 (including tax)



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

Table 8: Fuel prices for industry and the price of electricity for industry in Sweden, excluding taxes and VAT, current prices, öre/kWh

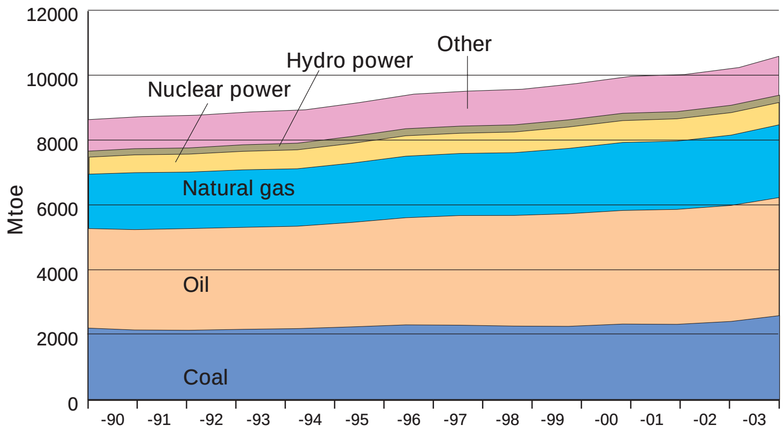
Energy carrier	1994	1995	1996	1997	1998	1999	2000	2001	2002	2003	2004	2005
Gas oil 1 [1]	20.3	22.3	26.3	17.8	14.7	16.0	26.4	25.7	25.0	25.7	30.1	39.9
Heavy fuel oil [1]	15.5	14.1	14.1	9.4	7.9	9.2	17.1	20.5	17.0	16.8	17.3	23.7
Coal [2]	4.2	4.4	4.5	4.9	4.9	4.3	4.7	5.9	5.3	4.9	5.6	6.9
Wood chips [3]	10.9	10.9	11.2	11.3	11.5	11.5	11.2	10.9	12.4	12.6	13.8	13.7
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	47.6
Natural gas, used in industry [4]	-	-	12.8	15.0	14.4	11.0	15.7	29.7	19.2	24.1	20.5	23.2
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	41.2	34.6

SOURCE: 1) SWEDISH PETROLEUM INSTITUTE, SWEDISH ENERGY AGENCY'S PROCESSING. FUEL OILS WITHOUT QUANTITY DISCOUNTS.
2) STATISTICS SWEDEN, SWEDISH ENERGY AGENCY'S PROCESSING.
3) NATIONAL PRICE AND COMPETITION BOARD, NUTEK (1992-1997) AND THE SWEDISH ENERGY AGENCY (1998-). MOISTURE CONTENT, 45 %.
4) EUROSTAT, SWEDISH ENERGY AGENCY'S PROCESSING. THE PRICE FOR INDUSTRY IS FOR AN INDUSTRY WITH AN ANNUAL CONSUMPTION OF 11.63 GWH, 200 DAYS, 1600 HOURS.
5) VATTENFALL (1994–1995) AND EUROSTAT (1996-), SWEDISH ENERGY AGENCY'S PROCESSING. THE PRICE IS FOR A MAJOR INDUSTRY WITH AN ANNUAL CONSUMPTION OF 50 GWH AND 10 MW.

An international perspective[107]

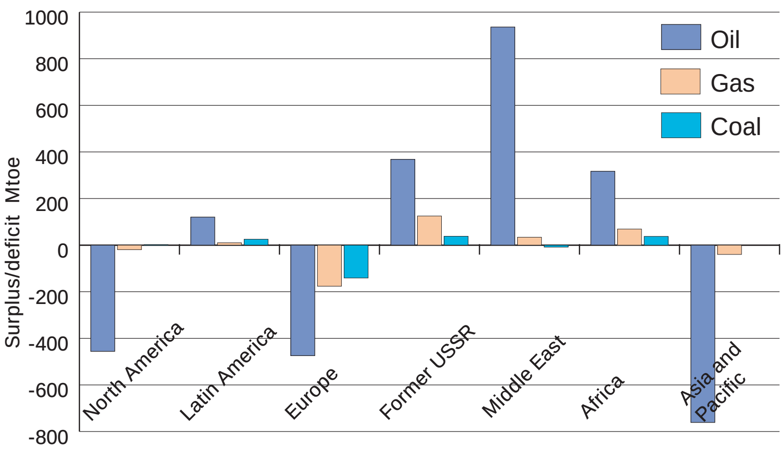
World energy supply is dominated by fossil fuels (80 %), with oil being the most important of them (35 %). The proportion of renewable energy (including hydro power) has remained at about 13 % over the last ten years, with nuclear power, at almost 7 %, supplying the rest. However, there are major differences in the use of energy between regions, both in terms of per-capita use and of the forms of energy supply. These differences are due to countries' different conditions in terms of availability of energy, economic development, infrastructure and climate. Any imbalance between supply and demand of some form of energy supply in a region quickly spreads via the price system to neighbouring energy markets and regions, and affects the whole world market.

Figure 41: Global supplies of primary energy



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

Figure 42: The regional balance for fossil fuels, 2004



SOURCE: BP STATISTICAL REVIEW OF WORLD ENERGY, JUNE 2005

A general overview

Global energy use, excluding biomass[108], increased by 2.4% in 2005, returning to the average rate of increase over the last ten years. China alone was responsible for more than 50% of the increase in the demand for energy. The rest of Asia accounted for 20% of the increase, with the countries of Eastern Europe, the Middle East and Latin America each increasing their use by about 8%. On the other hand, both the USA and EU-25 showed a slight reduction in energy use. Development in 2005 was characterised primarily by steeply rising oil prices, resulting in growing international interest in bio-based motor fuels.

Interest in geopolitics has again increased in recent years. Rapid economic growth in Asia has meant that this region as a whole is now experiencing a rapidly growing shortage of energy, while at the same time deficits in Europe and North America are also increasing. 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.

Energy supply

Oil

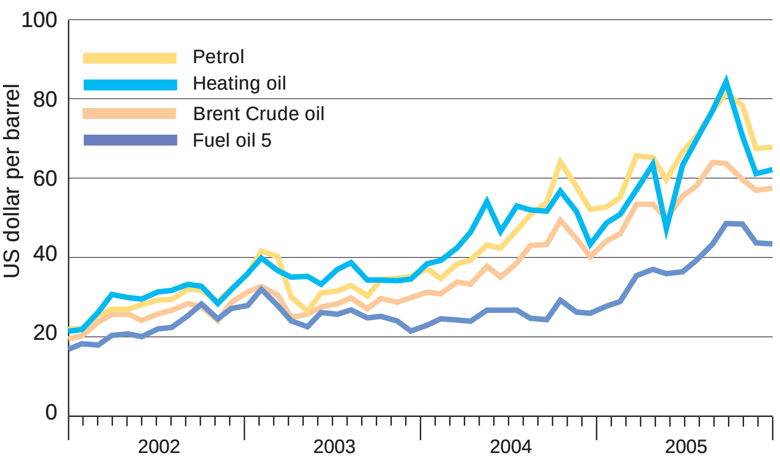
The proportion of oil used in the global energy balance continues to decline slowly, so that it was down to less than 35% in 2005.[109] On the other hand, total use of oil increased by about 1% over the year, as compared with an increase of over 4% in 2003. A number of OECD states, such as the USA, Canada, Germany, France and Italy reduced their consumption in 2005, as did some non-OECD states such as India, Turkey and Malaysia. Most of the increase occurred in the Middle East and Africa (4.4%), followed by South America with almost 3%.

The historical trend, of the increase in demand for motor fuels being greater than that for fuel oils, was partly broken during the year. 2005 saw a breakthrough for alternative motor fuels: ethanol became commercially competitive with petrol. Petrol consumption fell in both Europe and the USA, although the reduced consumption in Europe was offset by an increase in the consumption of diesel fuel. Consumption of heavy fuel oils, known as residual oils, increased by over 2%, with the increase being greatest in the USA. China reduced its consumption of oil after its record increase in 2004.

Prices continued to rise substantially in 2005, from an average of USD 40/barrel in January for Brent crude to over USD 57/barrel in December, with an average of USD 54.47/barrel for the year as a whole. Hurricanes Katrina and Rita pushed up the prices of oil to extreme levels during the third quarter of the year.

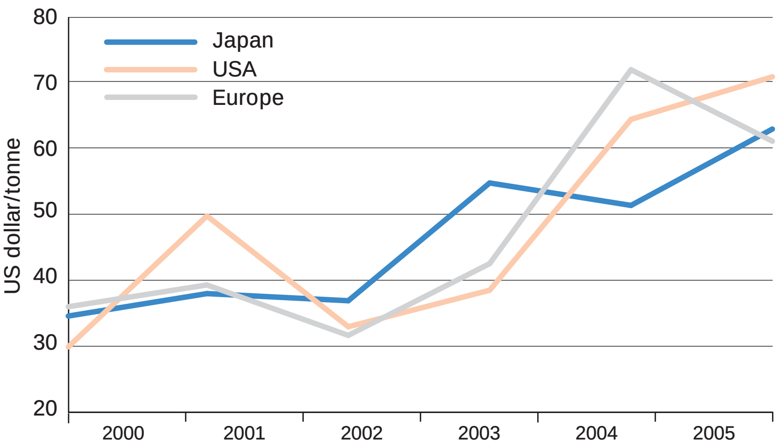
Political instability in important oil-producing countries has continued during the year. Proven reserves have increased by an amount equivalent to extraction. Investments in new oil production increased substantially during the year.

Figure 43: Oil prices in Europe, 2002-2005



SOURCE: IEA OIL MARKET REPORT

Figure 44: Coal prices in Europe, USA and Japan, 2000-2005



SOURCE: IEA COAL AND NATURAL GAS IMPORT COSTS AND EXPORT PRICES, JUNE 2006

Coal

The use of coal increased by over 4% in 2005. Almost all of this increase (90%) occurred in Asia, which in practice means that the use of coal in other parts of the world remained almost unchanged.

Over the last five years, the use of coal has grown more rapidly than that of natural gas, so that coal maintains its place as the second largest world energy source, with over 24%.

Coal prices stabilised during 2005. In Europe, this means that the price fell from an average of over USD 70 per tonne to somewhat over USD 61 per tonne.

China increased its coal production by over 10% in 2005, so that it now produces almost 40% of the world's coal, followed by the USA with 20% and Australia with 7 %.

The rundown of unprofitable coal production in the EU continues. During 2005, output fell by over 3%, and the use of coal by 2%.

Natural gas

The use of gas increased by 2.3% in 2005, which means that it is still the world's third largest energy source, with a market share of about 21%. Asia accounts for only 15% of global use, but it was there that use increased the most (8%). In North America, on the other hand, which uses almost 30% of world output, use actually decreased by over 1%. The EU-25 countries increased their use by 2%, although EU-15 reduced its use by over 1%.

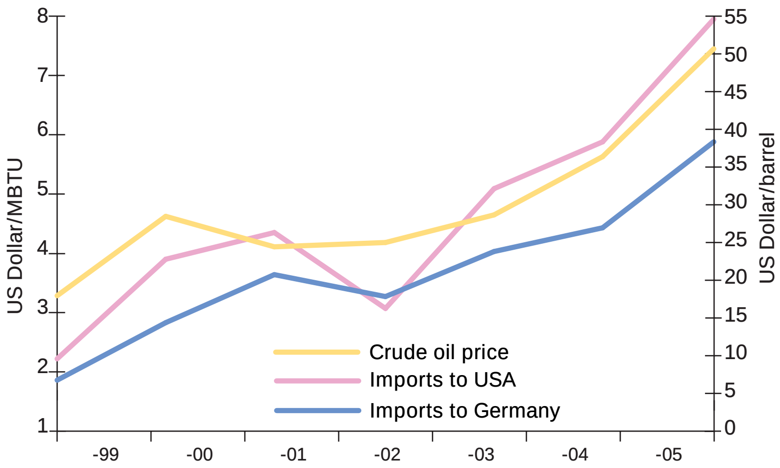
The price of natural gas is linked to the price of oil, either directly through contract provisions or by gas and oil often being alternatives for each other on the end user market. In Europe, the price has almost doubled over the last four years, while the price spread between the three major import regions of Europe, the USA and Japan has narrowed.

[107] Statistics for this section have been taken from various sources, primarily the IEA's data bases of Energy Balances of non-OECD Countries. These statistics cover the whole world, but with several years' delays. In principle, statistics are not available for periods later than 2003. In addition, IEA published internal member statistics in its Energy Balances of OECD Countries, which are available up to and including 2004. Price statistics and certain other special statistics are available with a delay of about three months. All the analyses and descriptions have used the latest available statistics, which means that comparison years can differ in different tables and diagrams.

[108] Due to delays, there is no complete data for the use of biofuels after 2003.

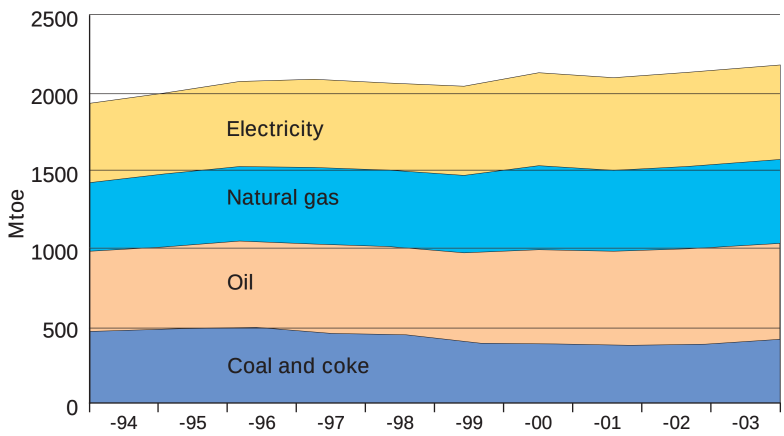
[109] BP Energy review, June 2006

Figure 45: Import price of natural gas and crude oil price 1999-2005



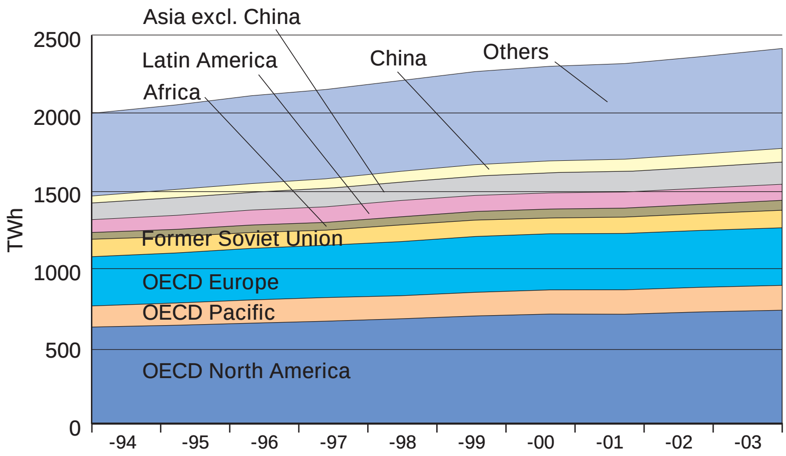
SOURCE: IEA, NATURAL GAS IMPORT COSTS, JUNE 2006

Figure 46: World use of energy by industry 1994-2003



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

Figure 47: World energy use in the transport sector 1994-2003



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

The market for liquefied natural gas (LNG) has grown substantially in recent years. According to preliminary calculations by Cedigaz[110], about 530 x 10^9 m^3 (530000 million m^3) of natural gas were traded internationally via pipelines, and almost 200 x 10^9 m^3 in the form of LNG. However, the proportion of gas carried between countries in international trading makes up only a small part of the total production of 2.4 x 10^{12} m^3 (2.4 million million m^3): almost 75% of all gas is consumed locally.

Other energy

Other forms of energy sources and carriers include hydro power, nuclear power, biofuels, wind power, geothermal power, solar cells etc., i.e. which, with the exception of nuclear power, are mainly various forms of renewable energy. Statistics for nuclear power and hydro power are available for 2005, but those for other forms of energy are not yet available beyond 2003. 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 13%.

Over a ten-year period, the total proportion of renewable energy has remained relatively stable, at about 13.5%. In Africa, almost half of total energy use is in the form of renewables; in Asia, the proportion is almost one third, while in Latin America it is about one fifth. In the former Soviet Union, however, less than 2 % of energy is from renewable sources, and in the Middle East it is less than 0.5%. The proportions of renewable energy are declining slowly but steadily in Africa, Asia and Latin America, although this fall is offset by a corresponding increase in the OECD countries and in non-OECD European countries.

Although the use of renewable energy has possibly increased more rapidly than has the use of fossil alternatives in 2003 and 2004, it is unlikely that this growth has been sufficient to increase the actual proportion of energy supply provided from renewable energy. However, the high prices of fossil fuels, particularly during the last two years, have increased the competitiveness of biofuels, and especially that of biobased motor fuels.

Energy use

Industry

Energy use in industry increased by 2% in 2003. Seen over the past ten-year period, the annual rate of increase has been a little over 1%. Industry's share of total energy use is in slight decline, being just under 30% in 2003.

For the first time, electricity use in industry in 2003 equalled the use of oil by industry. However, coal was the energy source that increased the most, by 8%, although this might be a once-off effect of the severe shortage of electricity in China in 2003.

Transport

Energy use in the transport sector in 2003 increased 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 statistically negligible. The sector is increasing its proportion of the total energy balance, with a third of all consumed energy being used by it in 2003.

The rate of increase of consumption is greatest in China, Africa and the rest of Asia. China's energy demand for transport increased by 12% in 2003, followed by Africa's at 6% and Russia's at 4%.

Residential and service sector[111]

Over the last decade, energy use in the residential sector has increased at about 1,5% per annum. However, in 2003, the increase was about 3%. The use of natural gas rose by almost 5%, and that of electricity by 3%. The use of coal again increased, not only in absolute terms but also in its share of the energy balance for the domestic sector. At about one third, the proportion of energy used by the residential sector has remained more or less constant over the last ten years: the change between 2002 and 2003 was only marginal.

The residential sector is traditionally the largest user of renewable energy, although its proportion of renewable energy has declined from almost 80 % in 1994 to 77.5% in 2003.

Of total energy use in the residential and service sector in 2003, 25% was electricity and 23% was natural gas. Oil has retained its share at 15% between 1990 and 2003.

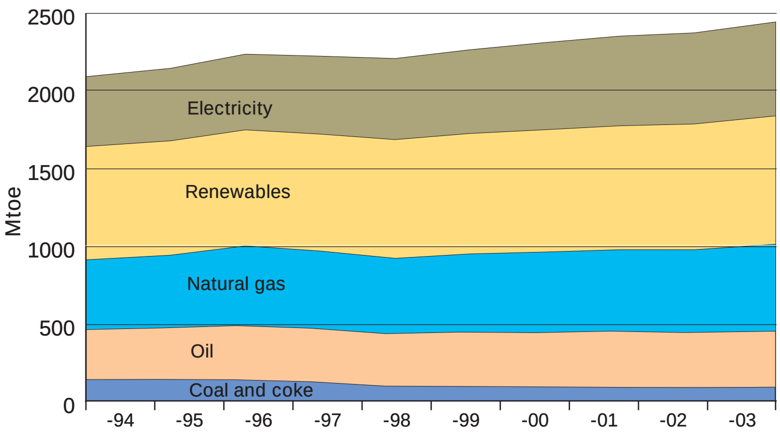
Electricity production and use

World electricity production increased by about 4% between 2002 and 2003, amounting to almost 17.000 TWh. The average rate of increase in electricity use has remained at almost 3% per annum since 1994.

Coal is still the predominant source of energy input for electricity production, providing 40% of all electricity in 2003. At a little less than 7%, oil is steadily losing its share of electricity production to natural gas, at 19%. Renewable electricity production (excluding hydro power) has increased its proportion from 1.3 % to 1.9 % since 1994.

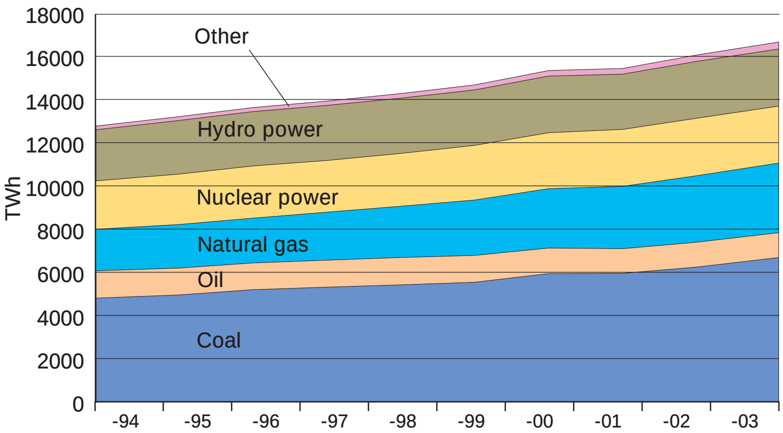
Although the OECD states dominate world electricity use, with a proportion of over 60 %, demand is increasing most rapidly in non-OECD countries. Within OECD, it was only in Europe that there was any increase in 2003, amounting to 2 %. China increased its use of electricity by 11 % in 2002, and then by a further 16 % in 2003, which meant that China alone was responsible for 45 % of the world increase in 2003.

Figure 48: World energy use in the residential and commercial sector 1994-2003



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

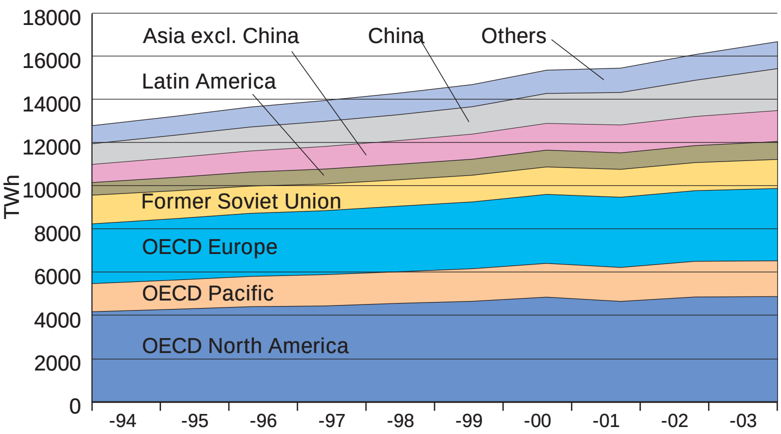
Figure 49: World electricity production by energy sources 1994-2003



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

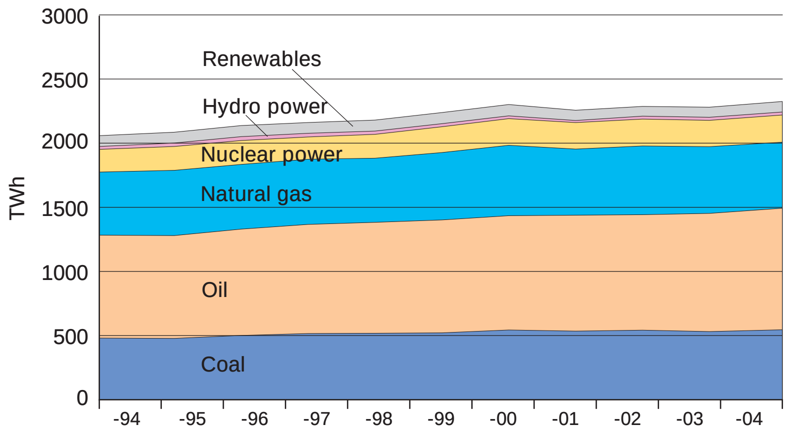
[110] Cedigaz is the international sector organisation for natural gas.
[111] Here, we have used the classification of 'Domestic and service sector'. IEA uses a different classification, treating 'Commercial sector' and 'Households' separately. Nevertheless, unless there is special reason to the contrary, we have in this report combined these two sectors in order to facilitate comparison with Swedish statistics.

Figure 50: Regional world electricity production 1994-2003



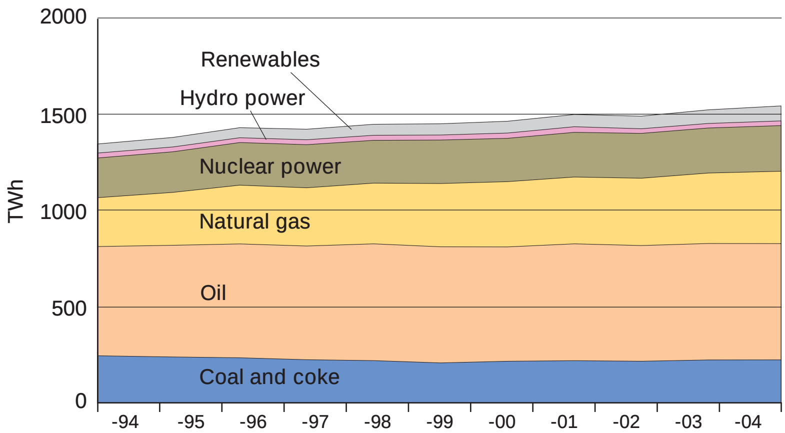
SOURCE: ENERGY BALANCES OF NON-OECD COUNTRIES (2005 EDITION), IEA

Figure 51: Energy supply in the USA 1994-2004



SOURCE: ENERGY BALANCES OF OECD COUNTRIES (2006 EDITION), IEA

Figure 52: Energy supply to EU-15 1994-2004



SOURCE: ENERGY BALANCES OF OECD COUNTRIES (2006 EDITION), IEA

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 2003, industry was using over 42% of electricity, as against less than 29% used by households and 23% used by the commercial sector. The household and commercial sectors are, in other words, 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 less than 2% of world electricity, although this proportion has increased in recent years.

Some regional outlooks

USA

The USA is alone responsible for almost a quarter or world energy use: 25% of all oil and gas consumption, 20% of coal consumption and almost 30% of total electricity production occur in the USA.

Energy supply in 2004 increased by 2%, after a reduction of 0.3% in 2003. Total energy supply to North America amounted to 2.325 Mtoe. The supply of natural gas declined, due mainly to the fact that production in the USA is falling, and cannot be replaced in the short term by imports. Volumes of other energy carriers increased. According to preliminary statistics, the reduction in the use of natural gas continued in 2005, and was accompanied by a slight fall in the use of oil.

Total energy use in 2004 increased by 3% in the industry sector, after a fall in 2002 and 2003. The sector accounts for over 20% of energy use, as compared with one third for the world in general. The greatest increase, of 25%, occurred in the agricultural sector. However, this sector accounts for only a little over 1% of total energy use. The transport sector increased its use of energy by 1.5% which means that it nowadays accounts for about 45% of total energy use. The world average is 33%. The residential and service sector decreased its total energy use by almost 0.5%.

EU-15

Energy supply in Europe increased by 1.3% in 2004, in line with the trend for the last ten years. The change in the energy balance is modest, but the rising trend of both natural gas (at 24%) and renewable energy (at 6%, including hydro) increasing their shares, while oil (at almost 40%) is in decline, continues. The fall in the use of coal was halted in 1999, with coal now back to its 1997 level of over 223 Mtoe (15%).

Industry is steadily reducing its share of the energy balance, and now accounts for 27%. The transport sector, on the other hand, has increased its share to one third, with the residential and service sector accounting for 40%.

Electricity use increased by almost 2%, from about 2360 TWh to 2400 TWh. Almost all of this increase was in the residential and service sector, which means that this sector now accounts for 56% of all electricity consumption in EU-15, with the industry sector accounting for 41% and the transport sector for 2%.

EU-25

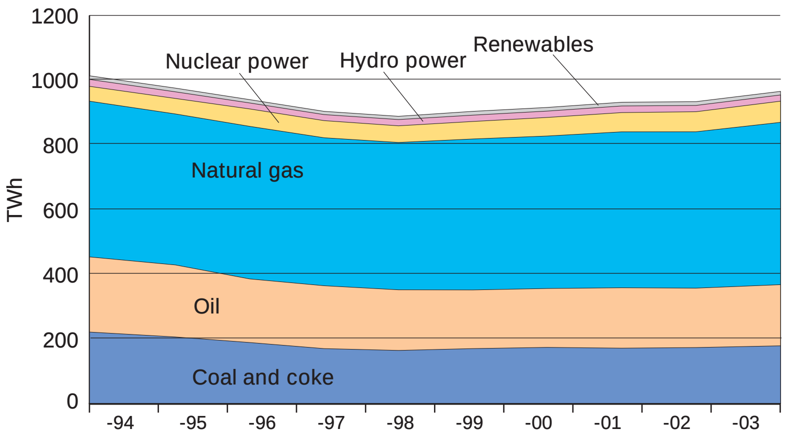
With the accession of ten new member states in May 2004, the EU now consists of 25 countries varying widely in their size, physical geography and economic conditions. The new states account for about 11% of the total EU-25 energy use. The most marked difference between them and the original EU-15 is the dominant position of coal in their energy systems. In 2003, coal still accounted for over 40% of total energy supply to the ten new member states. Oil, on the other hand, supplied only 22% of their energy, as compared with almost 40% in EU-15. These proportions are much the same for electricity use: the ten new states use less than 10% of the total EU-25 amount. In EU-10, the industry sector uses over 50 % of final energy use, while the transport sector uses 15%, i.e. the EU-10 industry use is twice as high as that in EU-15, while its transport sector use is only half of that in EU-15.

Russia

The decline in Russian energy supply began to stabilise in the middle of the 1990s, starting to rise again in 1998. It is worth noting how important natural gas is in the energy system, providing 52 % of energy supply, which can be compared with the world average of somewhat over 20 %. Of equal note are the low proportions of energy supplied by oil at less than 20 %, and by renewables, at a little over 2 % (which includes hydro power). Russia has substantial indigenous resources of oil, and a major biomass potential.

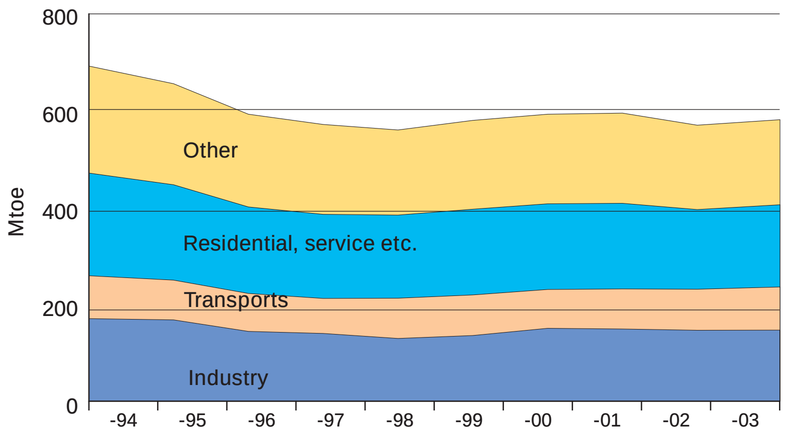
It can be worth noting that domestic gas consumption amounts to over 75 % of the total gas production: no other major gas exporting region uses such a high proportion of its own production.

Figure 53: Energy supply in Russia and CIS 1994-2003



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

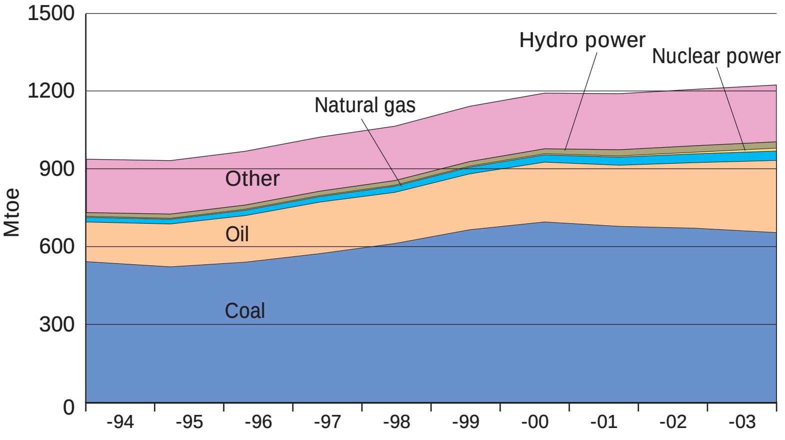
Figure 54: Energy use in Russia and CIS 1994-2003



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

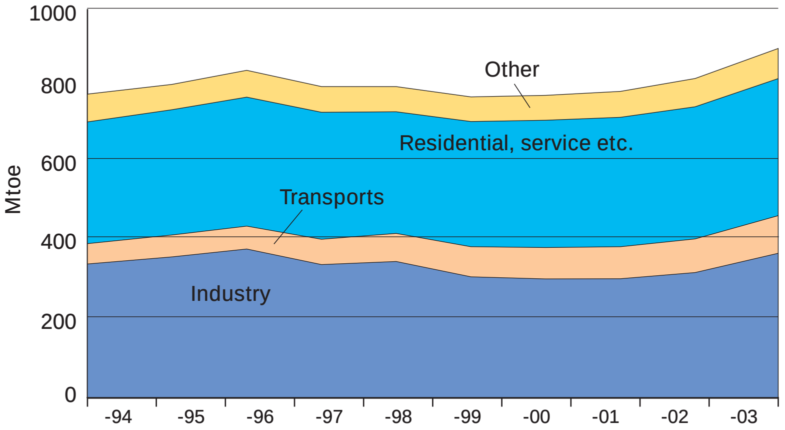
After the decline in connection with the breakup of the Soviet Union, energy use in Russia has stabilised at a little below 600 Mtoe per annum. Much of the energy or energy carriers (oil, gas etc.) produced in the country is exported, amounting to almost 500 Mtoe in 2003. It should be noted that, at 29% of total energy use, the residential and service sector accounts for a very high proportion. The reasons for this are partly because household energy consumption is still strongly subsidised, and also because there are substantial heat losses from poorly insulated buildings and district heating systems. Prices are gradually being brought into line with world prices, parti-

Figure 55: Energy supply in China 1994-2003



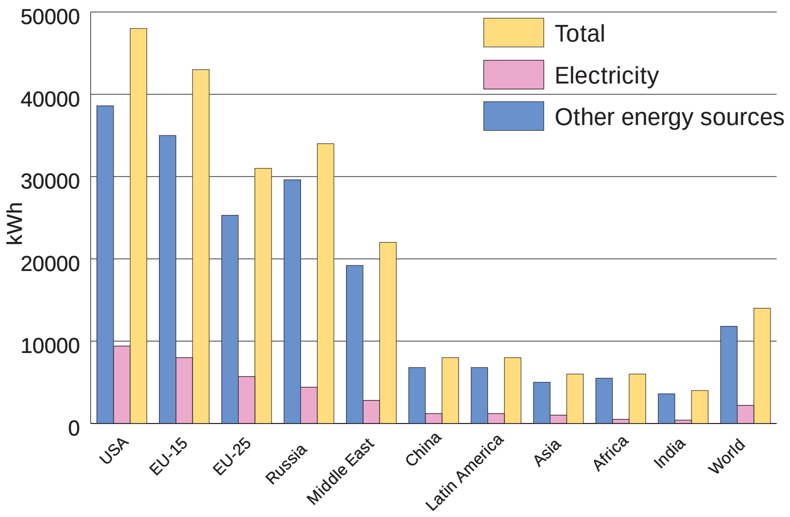
SOURCE: ENERGY BALANCES OF NON-OECD COUNTRIES (2005 EDITION), IEA

Figure 56: Energy use in China 1994-2003



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

Figure 57: Per-capita regional energy use in the world



SOURCE: ENERGY BALANCES OF NON-OECD COUNTRIES (2005 EDITION), IEA; ENERGY BALANCES OF OECD COUNTRIES (2006 EDITION), IEA

cularly in the industrial sector, but attempting to change prices to domestic users is politically highly sensitive.

China

China's total energy use in 2003 increased by 14% over the previous year. On average, the annual rate of increase over the last ten years has been about 4.5 %, but it can be seen from the table that the rate of growth has been uneven. Energy supply in China is dominated by coal, which provided over 60% of the country's energy in 2003, an increase of 20% compared to the previous year. For some years now, the traditionally next largest energy source, biomass and waste heat, has been surpassed by oil. In 2003, 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 15%.

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 8%. Preliminary figures indicate a continued high rate of growth in 2004, but an expected decline in 2005. At over 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 less than 11% of energy use, but it is in this sector that demand is growing most rapidly. ■

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. Although less environmentally harmful energy sources can have positive effects on some environmental problems, they may have an adverse environmental impact, such as in the form of their effects on nature and the landscape. Much has been done to reduce the impact of energy systems on the environment, but 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, but also by how far it spreads. At the national level, Sweden has been setting environmental objectives since 1999 as a way of structuring work intended to improve the environment. Environmental targets provide an indicator of conditions in the Swedish environment, and define the national perspective in international contexts.

Swedish environmental objectives

Parliament has set targets for environmental quality in sixteen areas: to the original fifteen targets from April 1999 that of ’A rich plant and animal life’ has been added in November 2005. They describe the quality and conditions for the country’s environmental, nature and cultural resources that are regarded as ecologically sustainable in the long term.

The aim is that we should have resolved the major environmental problems by the time that the next generation takes over. This means that all important actions in Sweden must have been completed by 2020 (or 2050 for climate objectives). However, nature needs time to recover and, in some cases, we will not be able to achieve the desired environmental quality within the time limit, even if major actions are taken. Each of the sixteen environmental targets has a number of sub-targets, expressed as concrete and quantifiable targets, which are annually reviewed in the Swedish Environmental Objectives Council’s publication ’de Facto’.

Sweden’s 16 environmental objectives

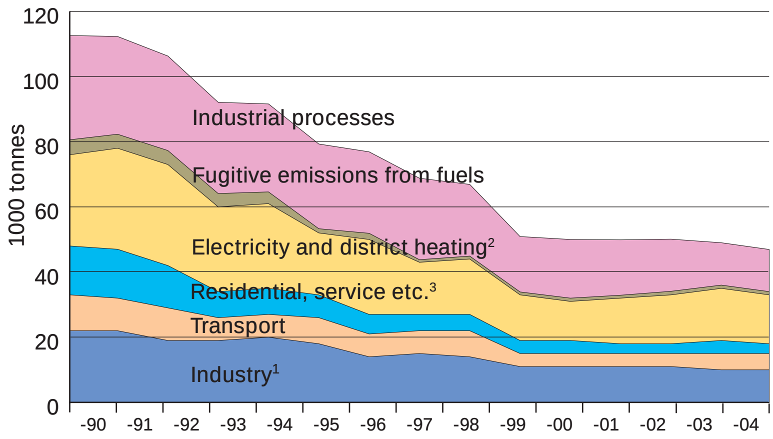
1. Reduced climate impact
2. Clean air
3. Natural acidification only
4. A non-toxic environment
5. A protective ozone layer
6. Safe radiation environment
7. Zero eutrophication
8. Flourishing lakes and streams
9. Good quality groundwater
10. A balanced marine environment, flourishing coastal areas and archipelagos
11. Thriving wetlands
12. Sustainable forests
13. A varied agricultural landscape
14. A magnificent mountain landscape
15. Good built environment
16. Rich plant and animal life

Read more about the environmental objectives at www.miljomal.nu

The purposes of the targets are to:

- support human health
- safeguard biological diversity and the natural environment
- care for the cultural environment and culture-historical values

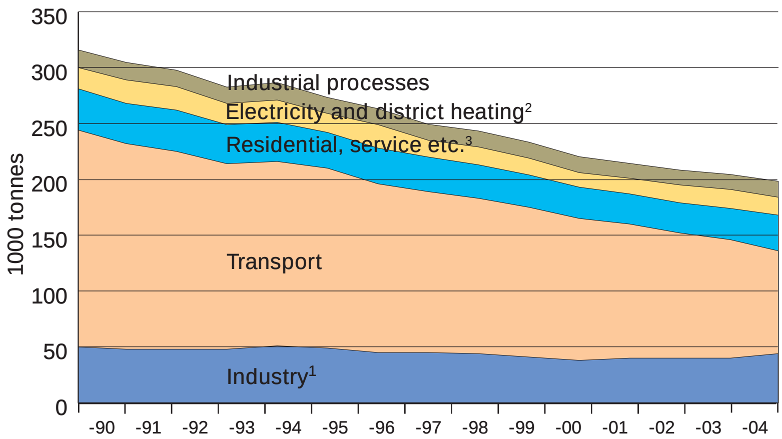
Figure 58: Sulphur dioxide emissions in Sweden, 1990-2004



SOURCE: SWEDEN'S PROGRESS REPORT TO THE UN CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION (CLRTAP), SWEDISH ENVIRONMENTAL PROTECTION AGENCY, 2005, WITH ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY.

Note: [1] Including electricity production from industry and waste incineration
[2] Including coke and refineries
[3] Including agriculture, forestry and fishery

Figure 59: NO_x emissions in Sweden, 1990-2004



SOURCE: SWEDEN'S PROGRESS REPORT TO THE UN CONVENTION ON LONG-RANGE TRANSBOUNDARY AIR POLLUTION (CLRTAP), SWEDISH ENVIRONMENTAL PROTECTION AGENCY, 2005, WITH ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY.

Note: [1] Including electricity production from industry and waste incineration
[2] Including coke and refineries
[3] Including agriculture, forestry and fishery

- maintain the long-term productivity of ecosystems
- ensure good conservation and management of natural resources.

The energy sector affects all environmental objectives in one way or another. However, four objectives have been pointed out as the most important, as it is reasonable to assume that the energy-related impact on them is particularly important in deciding whether the objectives can be achieved. They are:

- Reduced climate impact
- Clean air
- Natural acidification only
- Good built environment

Reduced climate impact

In accordance with the UN Framework Convention for Climate Change, the concentration of greenhouse gases in the atmosphere shall be stabilised at a level that ensures that anthropogenic effects on the climate system do not become dangerous. This objective shall be achieved in such a way, and at such a rate, that biological diversity is maintained, food production is assured and other objectives for sustainable development are not put at risk. Sweden, together with other countries, has a responsibility for achieving the global objective.

Sweden is responsible for only about 0.2% of global emissions, so that its achievement of the objective of 'reduced climate impact' is dependent on international efforts. The Swedish Energy Agency's and the Swedish Environmental Protection Agency's most recent forecast for Sweden expects carbon dioxide-equivalent emissions in 2010 to be about 2% below their 1990 levels. Sweden is one of the few countries with economic growth that can show lower emissions during the 2000s than in 1990.

The greatest reduction in greenhouse gas emissions has occurred in the residential and service sector. Reduced use of oil has resulted in a reduction in emissions of almost 5 million tonnes since 1990. At the same time, there has been an increase in the use of district heating. However, as this increase has resulted primarily from an increase in the use of biofuels, it has also had the effect of reducing emissions from district heating production.

Clean air

The air shall be so clean that no adverse effects are caused to human health, and so that no harm or damage is caused to animals, plants or cultural values.

Elevated concentrations of oxides of nitrogen, particles and volatile organic compounds (VOCs) in the air in urban areas are caused by emissions from traffic, industry and residential heating systems. Burning logs and other biofuels releases VOCs and particles, to such an extent that they can cause severe air problems in areas where a high proportion of heating is provided by them. However, much air pollution is caused by long-distance transportation of air pollutants.

There are many air pollutants that have an adverse effect on human health. Particularly in urban areas, high concentrations of pollutants can result in bronchial problems and allergies and, in the longer term, also in cancer. Among those that cause such effects can be named oxides of nitrogen, sulphur dioxide and ground-level ozone. A number of volatile organic compounds and sub-10 µm particles (PM10) can also cause these effects. Acidifying pollutants also affect buildings through acceleration of breakdown processes in the material. In addition, compounds such as oxides of nitrogen and sulphur contribute to eutrophication and acidification.

Natural acidification only

The acidifying effects of precipitation and ground use shall be less than the limit of what the ground and water can withstand, and nor may precipitation of acidifying substances increase the rate of corrosion of technical materials or cultural objects or buildings.

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. Sulphur dioxide emissions arise from the presence of sulphur in fuels, while oxides of nitrogen are formed mainly by the effects of combustion on the nitrogen in the combustion air.

The main source of sulphur dioxide is combustion of fossil fuels, although emissions have been reduced as a result of flue gas cleaning and sulphur removal from fuels before use. 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 much greater than the contribution from indigenous sources. On the other hand, Sweden 'exports' about 60 % of its own sulphur emissions to other countries: only about 11 000 tonnes fell back to Swedish soil and water in 2000.

A good built environment

Towns, urban areas and other built environments shall provide a good, healthy living environment and play their part in contributing to a good regional and global environment. Cultural and natural values shall be cared for and developed. Buildings and structures shall be sited and designed in a manner appropriate to their environment and in such a way as to assist long-term conservation and management of the ground, water and other resources.

The target of providing a good built environment is complex, with many different aspects. Those that primarily concern the energy sector are those aimed at reducing the environmental impact of energy use in residential buildings and commercial and public premises. This is to be achieved through improvements in the efficiency of energy use reducing the need for energy input, and by increasing the proportion of energy provided by renewable sources.

Will we achieve our environmental objectives?

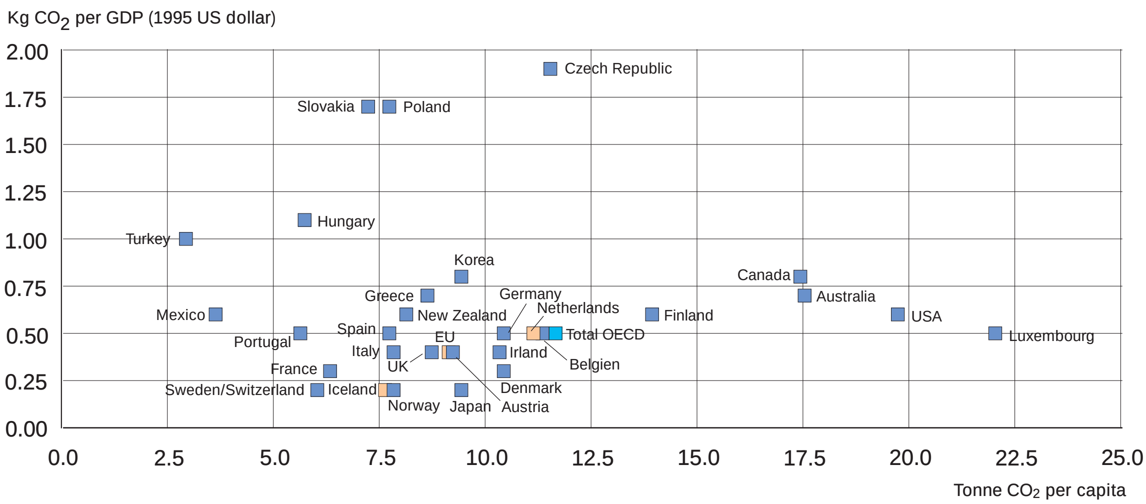
Of the four environmental objectives that were identified above as being key for the energy sector, it is only the good built environment that is regarded as achievable, and then only with major efforts. However, these problems are caused by sectors of society other than energy use.

The Clean Air and Natural Acidification Only target is not regarded as feasible to reach with the 2020 time frame, although most of its sub-targets are expected to be reached. However, reaching the sub-targets is not the same as meeting the national target. The two main difficulties in the way of reaching the targets are that nature takes a long time to heal - i.e. that time is needed for good environmental conditions to return after the sources of damage have ceased or been reduced to levels that are safe for health and the environment - and the effect of long-distance transport of pollution from sources outside Sweden, not least in respect of the reduced climate impact target. As far as clean air is concerned, the energy sector continues to face a challenge in the form of reduction of particles and associated substances, such as benzo(a)pyrenes which originate in poor combustion in log stoves.

The environment – an international concern

Many environmental problems are of such a type that they affect wide areas; sometimes the whole

Figure 60: Per-capita and per-GNP carbon dioxide emissions from combustion in the EU and OECD states



SOURCE: OECD IN FIGURES - 2005 EDITION, HTTP://WWW.OECD.ORG/

world, as in depletion of the ozone layer and climate effects, and sometimes larger regions such as acid rain and long-distance air pollution. It is particularly within the EU and the UN that Sweden performs its international environmental work.

The European Union

In the environment field, the European Union works through binding decisions (directives), information, research and development, and international negotiations.

The EU often negotiates as a single body, e.g. in climate negotiations and other areas that affect both the energy sector and the environment. In such cases, Sweden's role as a member country is to work to ensure that matters that are important for it are properly considered and included, while also acting independently in many contexts.

A range of activities in the climate field was started in 2000 under the umbrella name of the European Climate Change Program (ECCP), the purpose of which is to assist the EU in achieving its commitments under the Kyoto Protocol. A second commitment period, ECCP II, was agreed at the end of 2005.

Achieving the Clean Air and Natural Acidification Only targets will require continued work throughout the EU. One of the cornerstones of this work is the strategic Clean Air for Europe (CAFE) programme, ranging over all types of air pollutants. During the spring of 2006, the Commission has backed a strategic plan which, among other aspects, identifies ground-level ozone and particles as the most worrying contaminants from a health point of view. The strategic plan contains stage objectives for air pollution levels in the EU, with proposals for how these levels can be reached. Recommendations include an overhaul of present legislation, and that more must be done to integrate environmental considerations in other policies and programmes.

The UN

UN climate-related work is carried out primarily within the framework of the two UN programmes; United Nations Environment Programme (UNEP) and the Commission on Sustainable Development. UNEP does not first and foremost operate its own projects, but coordinates the work of other UN bodies in the field of the environment and sustainable development. It also administers the UN IPCC climate panel, which brings together information in the fields of scientific, technical and socio-economics from scientists and researchers in the field of climate change from all over the world. IPCC's conclusions are based on scientific findings, and are intended to provide material for decisions on responses and actions. IPCC also publishes guidelines for reports to be submitted under the terms of the Framework Convention on Climate Change and the Kyoto Protocol, which are used to monitor fulfilment of commitments by the Parties to the Convention and the Protocol.

For more information see Chapter 1, Climate Policy. ■

Energy facts

This chapter explains some energy terms that are used in Energy in Sweden. Units and conversion factors are described. Relationships between various energy units are also given, in order to make it possible to compare statistics with other international statistics.

Energy units and conversion factors

Conversion factors are revised when changes in fuel energy contents have occurred. During the latest such major revision in 2001, the specific energy content of petroleum coke, petrol, diesel fuel, gas oil, all grades of heavier fuel oils and natural gas were changed. The calorific value of natural gas as used in this edition of Energy in Sweden has also been 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, in Sweden the watt-hour (Wh) is 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 10: Conversion factors between energy units

	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 11: Prefixes used with energy units

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

Table 9: Calorific values in MWh and GJ per physical quantity

Fuel	Physical quantity	MWh	GJ
Wood chips	1 tonne	2.00–4.00	7.20–14.4
Peat	1 tonne	2.50–3.00	9.00–11.0
Pellets, briquettes	1 tonne	4.50-5.00	16.0–18.0
Coal	1 tonne	7.56	27.2
Coke	1 tonne	7.79	28.1
Nuclear fuel	1 toe	11.6	41.9
Crude oil	1 m^3	10.1	36.3
Topped crude oil	1 m^3	11.1	40.1
Petroleum coke	1 tonne	9.67	34.8
Asphalt, road dressing oils	1 tonne	11.6	41.9
Lubricating oils	1 tonne	11.5	41.4
Road fuel petrol	1 m^3	9.04	32.6
Virgin naphta	1 m^3	9.08	32.7
Light virgin naphta	1 tonne	8.74	31.5
Petroleum naphta	1 m^3	9.34	33.6
Aviation paraffin and intermediate oils	1 tonne	9.58	34.5
Other paraffin	1 m^3	9.54	34.3
Diesel fuel and gas oil	1 m^3	9.96	35.9
Heavy fuel oils and bunker oil	1 m^3	10.6	38.1
Propane and butane	1 tonne	12.8	46.1
Gasworks gas, coking gas	1 000 m^3	4.65	16.7
Natural gas[1]	1 000 m^3	11.0	39.7
Blast furnace gas	1 000 m^3	0.930	3.35

Note: Conversion factors are given in the table to three significant figures.

1 The value given for natural gas is the net (lower) calorific value, which has been adjusted since the previous issue of Energy in Sweden.

A little energy reference book

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/m³. 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 (lignite), with a calorific value of 10–28 MJ/kg
– Hard coal (bituminous 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, gas coal or coking 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 of a boiler can never exceed 100 %, but the coefficient of performance can exceed 100 % if, for example, flue gas condensation is used (see 'Calorific value'). 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 70-90 %. 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.

Energy
Is measured in the SI unit joules, which equal 1 newton-meter or watt-second. One kilowatt-hour (kWh) therefore equals 3600 kilojoules (kJ), 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. Water reservoirs store energy in potential form, i.e. capable of delivering energy if the water is discharged to a lower level through a water turbine. Hot water as used in district heating is an energy carrier that delivers heat to users. Cold water in district cooling systems is an energy carrier that removes heat from buildings etc. Hydrogen is an energy carrier that must be produced by some suitable chemical process.

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 mainly methane) and LPG (mainly propane or butane) are fossil gases found in the crust of the earth. The others are produced from energy-rich raw materials by various technical processes. Biogas (methane) is formed by the organic decomposition of organic materials by bacteria, and can be produced by digestion of sewage sludge or other biological waste.

Energy intensity and improving the efficiency of energy use
Energy intensity can be defined as the quantity of input energy divided by the useful output quantity/value, or as E = I x Q, where Q is the useful output quantity/value, I is the energy intensity and E is the input energy quantity. Improving the efficiency of energy use means that we reduce the energy intensity (I) by various means.

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 electricity by means of a thermal process, usually driving a steam turbine with steam from a boiler fired with solid, liquid or gaseous fuels, or from a nuclear reactor. A thermal power station can also be one in which the generator is driven by a combustion engine. Steam turbine power stations can be of cold condensing type, which produce only electricity, or combined heat and power (CHP) type, which produce electricity and heat in the form of hot water or steam. In a cold condensing power station only electricity is produced, the remaining heat in the steam 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 fossil-fuelled or nuclear-fuelled. All nuclear-fuelled power stations in Sweden are of cold condensing type. Combined heat and power 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 remaining heat in the steam after the turbine is used, for example, to heat water for a district heating network. In industry, this form of power generation is generally referred to as back-pressure power generation. The only difference is that, instead of the exhaust steam being used to supply heat to a district heating system, it is used instead as process steam in the industry. Combined cycle power stations have two turbines: a gas turbine, which drives an electrical generator, with the hot gases leaving the turbine being used to raise steam to drive a steam turbine, which in turn drives a second electrical generator. The exhaust steam from the steam turbine can be used to supply district heating, or it may be condensed in the same way as in a cold condensing steam power station. Electricity yield is higher than in a cold condensing power station, but the initial plant cost is considerably higher. Heating plants are simply boiler plants that supply only heat, usually for district heating networks.

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 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, and 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 converts a substance to gaseous form without changing it chemically. It 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. all electricity production based on the use of water as the working medium in a thermal process. 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 hydrofluorocarbons, 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. 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 contain many other elements, including 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, which also 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. Other products are pyrolysis oil, 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.

Green Paper
An official European Commission document presenting the first drafts or suggestions for possible actions at EU level.

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 in 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.

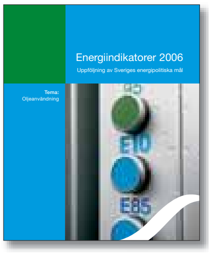
Peat
An organic type of soil, formed under damp and oxygen-deficient conditions by the bacterial and chemical decomposition of dead plant and animal matter. Peat is renewed relatively slowly, and is therefore somewhere between renewable fuels and non-renewable fossil fuels.

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 on the comparison.

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: if it is at too low a temperature, it can be used as a heat source for heat pumps operated by the district heating supplier. Refineries, cement factories, steel mills, pulp mills and sewage effluent treatment plants are major sources of waste heat.

White Paper
An official document from the European Commission, containing structured proposals for EC regulations. A Swedish Parliamentary bill is similar to a White Paper. ■



Energy Indicators 2006
The purpose of this report, which is published annually, is to present indicators for monitoring the progress of achievement of energy policy targets. The 2006 edition, which is introduced with a brief presentation of Sweden's energy policy targets, contains five new indicators for the use of oil and 20 updated base indicators. (This report is produced only in Swedish).

The Energy Markets Inspectorate - Annual Report 2005
The Energy Markets Inspectorate's annual report presents data and statistics for the piped and wired energy markets in Sweden: that is, electricity, natural gas and district heating. In addition to discussing the most important aspects and events of 2005, it also describes the work of the Inspectorate during the year and presents the results of analyses and reviews of the markets' developments and operations.

www.enyckeln.se
This web site is a data base for collecting official energy statistics on, and for comparisons of, energy use in apartment buildings and non-residential premises.

www.swedishenergyagency.se
This, the web site of the Swedish Energy Agency, provides information on energy statistics. Links are also given to other energy-related sites in Sweden and in other countries, covering official statistics and other sources.

www.energimarknadsinspektionen.se
The Energy Markets Inspectorate's web site includes collated statistics from the reports that electricity network companies and electricity suppliers are required to submit to the Inspectorate. Examples of statistics include network price developments, supply failure statistics and local network companies' revenues for electricity distribution. The site also includes links to other sources of statistics of this type.

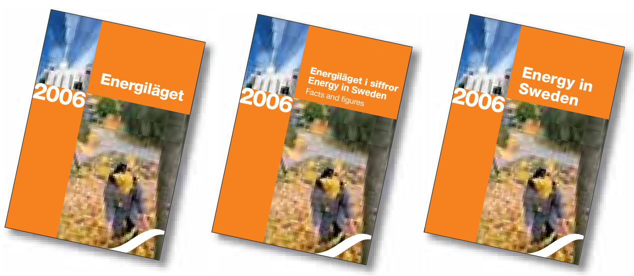
An efficient, low-environmental-impact energy system

The Swedish Energy Agency is Sweden's central public authority for matters concerned with energy. The overall objective of our work is to achieve a low-environmental-impact, reliable and efficient energy system in Sweden and, ultimately, in the rest of the world. We encourage more efficient energy markets, based on a greater element of renewable energy. We exercise surveillance of the country's network utilities, and are responsible for Sweden's contingency planning for maintaining essential energy supplies in crisis situations. Working in conjunction with universities, research institutes and industry, we provide funding for a large number of research and development programmes in the energy sector.

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.

The following publications provide more in-depth information. They can be ordered directly from our publications department, or be downloaded from our web site www.energimyndigheten.se.

Energiläget 2006 – printed
Energiläget 2006 – PDF
Energy in Sweden – Facts and figures 2006 – printed
Energy in Sweden – Facts and figures 2006 – PDF
Energy in Sweden – Facts and figures 2006 – Excel
Energy in Sweden 2006 – printed
Energy in Sweden 2006 – PDF
OH pictures, Swedish – PDF
OH pictures, English – PDF



Energy in Sweden - Facts and figures contains tables with detailed figures for most of the diagrams in Energy in Sweden. All material is given in both English and Swedish.

OH pictures contain all the diagrams in Energy in Sweden in PDF format.

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