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Preface

Around the world, the challenges presented by energy policy are more or less the same. Energy supplies need to be reliable, have minimum negative environmental effect and be available at reasonable prices. These three fundamental objectives can complement each other or be mutually opposed, which highlights 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. Activities in these fields are increasing, linked by the EU as an important driving force. International cooperation is vitally important, not only for development of the energy system but also for tackling cross-border and worldwide environmental problems. 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 and restructuring of energy systems is that of international cooperation in the climate sector, where the Swedish Energy Agency's work includes management of Sweden's membership of the emissions trading system, international climate projects and climate research related to energy policy. The Agency is Sweden's central public authority for matters relating to energy. It works in conjunction with other public authorities, business and industry, energy utilities, local authorities and the research/academic world. Its work also includes regulatory surveillance of the Swedish energy markets, contingency planning for crises, and research, development and demonstration activities.

The acquisition and publication of information on the energy system and its development are 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 2006, complemented where possible by input reflecting current events and decisions up to the middle of 2007.

Eskilstuna, November 2007

Thomas Korsfeldt, Director-General

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Current energy and climate policy areas

Political and legal considerations determine the framework conditions of energy markets. Political decisions are intended to influence development of energy use and energy production in order to create a sustainable energy system. The Swedish energy markets are affected primarily by national and EC 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 energy policy agreement[1] , together with a strategy for continued restructuring of the country's energy system.

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.

In January 2007, responsibility for energy matters was transferred from the previous Ministry of Sustainable Development to the Ministry of Enterprise, Energy and Communications. However, climate policy and environmental aspects of the energy sector fall within the remit of the Ministry of Enviroment. The Government has taken three steps[2] for broader and more in-depth cooperation in respect of climate work between industry, research and politics: establishment of a Sustainable Development Commission, with the Prime Minister as Chairman, a Science Council for Climate Matters and a Parliamentary Commission for Climate Matters. The work of these three bodies will include drafting of the Climate Policy Bill that the Government intends to submit to Parliament in 2008. They are also intended to make it possible for Sweden to play a leading part in the international negotiations for a new international climate regime that will have to be prepared before and during Sweden's coming presidency of the EU in the autumn of 2009. The next Swedish Environmental Policy Bill will be submitted to Parliament in 2009, and will include description of the progress of the work on the country's 16 environmental quality objectives, and on what further work is needed.

Measures in the short and medium-long terms

The electricity certificate system was introduced in 2003, and has the objective of increasing the use of electricity from renewable sources by 17 TWh between 2002 and 2016. The Programme for Energy Efficiency Improvement in Energy-Intensive Industries (PFE) was started at the beginning of 2005. On behalf of the Government, the Agency is carrying out a review of the system and is due to present a final report in March 2008. 2005 also saw introduction of the EU emission trading scheme. This is described in more detail in the sections Emissions Trading , Green Electricity Certificates and The Efficiency Improvement Energy Programme.

The planning objective for wind power production includes a requirement that local authorities must have agreed plans for 10 TWh of wind power production by 2015[3]. The Agency has been instructed by the Government[4] to produce a new planning objective for 2020. The Government's Wind Power Bill[5] includes proposals for measures to assist achievement of the planning objective, including support for local autho-

[1] Bill no. 1996/97:84. Current energy policy represents an agreement between the Social Democrats, the Left Party and the Centre Party.
[2] Bill No. 2006/07:100. The spring Budget Bill.
[3] Read more on distribution of the national planning target and other aspects in the Swedish Energy Agency's report no. ER 16:2003.
[4] Government Decision N2007/1205/E (for publication not later than 1st December 2007).
[5] Bill no. 2005/06:143 Green electricity from wind power - Ensuring a healthy wind power sector.

FACTS: The Budget Bill

The Budget Bill sets out the Government's economic policy proposals for the coming year. It includes proposed expenditure for various areas, one of which is Expenditure Area 21, Energy.

- The Government emphasises the importance of climate-related work, and how intimately associated it is with energy-related work.
- In 2008, the Government intends to put forward a bill on climate policy. It wants to achieve a broad spectrum of agreement between all political parties on future climate policy.
- The Government also emphasises the importance of international co-operation on climate and energy matters, and particularly the importance of the negotiations for a new climate regime after 2012. EU cooperation is a cornerstone of Sweden's international work.
- SEK 1 000 million will be invested over the period 2008-2010 on climate-related work in the following areas: improvements in the efficiency of energy use, support for second-generation biobased motor fuels, climate research and international research work, the sustainable towns program, a national network for wind power generation, climate investments in other countries and sustainable production of biomass materials.
- From 1st January 2008, the Energy Markets Inspectorate will become an independent public authority, no longer part of the Swedish Energy Agency. Its duties will include supervision of the country's network operators and monitoring of developments on the electricity market.
- A review of energy taxation will be started, in order to improve coordination between energy taxation and other environmental and energy policy measures. The Government also wants to reach broad agreement on future energy policy, and the review will be closely linked to that on future climate policy. The aim is to achieve a coordinated energy and climate policy that is also in accord with the country's business and trading policies.
- Carbon dioxide tax will be increased by 6 öre/kg of carbon dioxide. There will be no change in the percentage reduction in the tax on fuels used in certain applications.
- Carbon dioxide tax on fuels used in industry, for district heating and CHP plants in the EU emissions trading scheme will be reduced in two stages. In the first stage, from 1st January 2008, the percentage reduction in the tax paid by these plants will be increased, while the second stage will reduce the tax rate for these plants to the minimum tax rates set by the EU.
- The energy tax on diesel oil will be increased. The environmental bonus available for new diesel cars will be halved, and the particulates discount for diesel vehicles with low particulate emissions will be removed. Vehicle tax on diesel cars will be reduced, while that on light goods vehicles and buses will be increased.
- The energy tax on electricity in northern Sweden will be reduced by 3 öre/kWh.
- The limits for repayment of energy and carbon dioxide tax to agriculture, forestry and aquaculture will be reduced.
- The tax on nuclear power will be increased by 24 %.
- Commissions will be appointed to investigate the taxes on refuse incineration and aviation fuel. The Government will put forward proposals in due course.
- Legislation on general tax relief for carbon dioxide-neutral motor fuels will be introduced in 2009, to run to no later than the end of 2013.

The Budget Bill (Bill no. 2007/08:1)

rity land use planning for 2007 and 2008. The planning process was simplified in the autumn of 2006, so now the local authority only need to b notified about plans for wind farms with aggregated capacities not exceeding 25 MW. 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.

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. In March 2007, the Government instructed the Swedish Agency for Administrative Development to put forward a proposal for a new public authority for surveillance of the energy markets. The new authority will be established on 1st January 2008, with Yvonne Fredriksson as its Director-General.

In the spring of 2006, the Inspectorate carried out an initial review of the 2005 tariffs of the country's all 168 network companies. Based on the results of this review, the Inspectorate continued with more in-depth inquiries into the tariffs of 23 network companies. In November 2006, the Ordinance Concerning Presentation of District Heating Activities was published, providing guidance for the detailed breakdown of operational statistics by district heating utilities, and forming an important first step for analysis of the district heating market. New rules in the Electricity Act will make it easier and quicker for consumers to change suppliers of their electricity. 2007 saw a final deregulation of the Swedish natural gas market.

A special conversion grant, available from 2006 until 2010, was introduced at the beginning of 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. However, grants for conversion away from oil were withdrawn from the beginning of 2007, because all funding had been used up. Until the end of 2008, owners of public premises can apply for grants for conversion and energy efficiency improvement measures. Grants for installation of solar cells for use by public premises have also been available from 2005, and will remain available until 2008. The previous tax reduction concession for the installation of biofuel-fired heating systems and higher-performance windows in new detached houses has been replaced by a corresponding grant. Until the end of 2010, there is also a grant for solar heating in commercial premises. From 1st April 2007, private persons buying a new low-environmental-impact car can obtain a grant of SEK 10 000. With effect from 1st April 2006, larger petrol stations have been required to sell renewable motor fuels, which has mainly had the effect of encouraging the 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[6] 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 the 1973 oil crisis. This means that Sweden has now had a coordinated public policy of research and development in the energy sector for over 30 years.

The 2005 Budget Bill[7] 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 transition to a sustainable energy system. The programme provides funding to a value of about SEK 800 million per year. Continued support is provided for pilot projects in the field of wind power. The Energy Research Bill[8], which was presented to Parliament in 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. Work on a new ordinance to support research, development and demonstration activities in the energy sector is in progress. It will replace three existing ordinances[9], and is intended to open the way to the opportunities presented by the new EU public support framework.

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 basic 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: 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.

On the political level, current policy is still that nuclear power production shall be phased out, but no specific date has been set. The negotiations with the nuclear power companies that were started between the Government and the nuclear power industry in 2003 were broken off in October 2004 without any agreement having been reached. However, Barsebäck 2 was closed in May 2005, in accordance with the strategy presented by the Social Democrats, the Left Party and the Centre Party. The present Government has said that it will not make any political decisions on reactor closures during its mandate period (2006-2010). The ban on construction of new reactors still applies, and the Government will consider applications for increases in output in accordance with current legislation and procedures.

Current investigations

In June 2005, the Government appointed a commission of inquiry to investigate the effects of climate change and how to reduce society's vulnerability to them. An area of particular interest is that of the effects of climate change on infrastructure, e.g. on roads, railways, telecommunications, building stock, energy production, electricity supply, land use, water supply and effluent treatment. The possible effects of climate change on human health and biological diversity will also be considered. An interim report[10] was published on 1st November 2006. It identifies land around Lakes Mälaren and Vänern as being at high risk of flooding, and suggests substantial increases in the rates of flow out of the lakes at Slussen in Stockholm, in Södertälje and from Lake Vänern. A final report was presented in October 2007, and is now being circulated for comments.

A commission of inquiry 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. To achieve this, the public sector is expected play a leading role. In addition, companies in the energy sector 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, while another is to find a way of measuring and monitoring improvements in the efficiency of energy use. It will be permissible to include certain previously effected improvements in the calculations. The Commission is due to submit proposals on 31st October 2007 for a national plan for further necessary improvements in the efficiency of energy use, and the final report is due for submission by not later than 31st October 2008.

6 Bill no. 2005/06:145 National programme for improving the efficiency of energy use in buildings and smart energy construction.
7 Bill no. 2004/05:1.
8 Bill no. 2005/06:127. Research and new technology for future energy systems.
9 Ordinance concerning public support for energy research, SFS 1998:222; Ordinance concerning sulic support for energy technology, SFS 1998:653; Ordinance concerning energy technology grants, SFS 1998:654.
10 SOU 2006:94 Threat of flooding – risks and actions for Lakes Mälaren, Hjälmaren and Vänern.

An inquiry 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 if they were 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.

The commission investigating connection of electricity from renewable sources to the public electricity network will consider whether the present regulatory regime is hindering large-scale development and expansion of renewable electricity production. The commission's report is due for publication by not later than 1st January 2008. A Standing Committee on Climate matters will carry out an overall review of Swedish climate policy, assessing the possibilities of achieving the national climate objective and putting forward proposals for further work that may be necessary. Its report is due for publication by not later than 15th January 2008.

Investigations concluded during the second half of 2006 and the first half of 2007

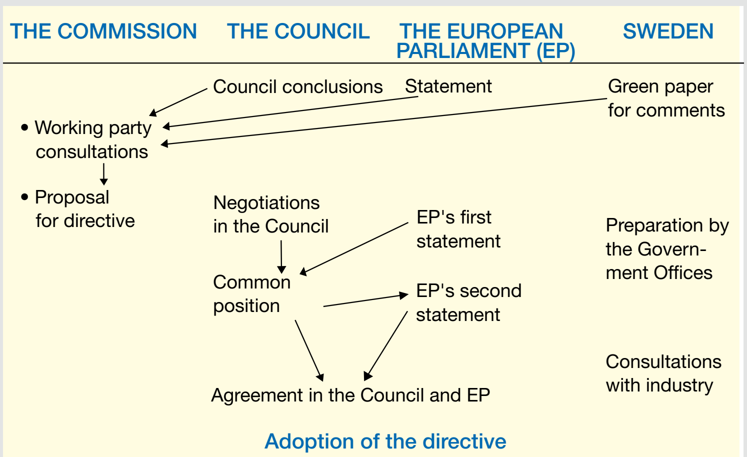
In May 2004, the Government appointed a commission of inquiry to evaluate and review the country's forestry policy as it had been applied over the last ten years. Among the aspects to be considered were the increasing and competing demands for raw materials. The work was delayed for a number of reasons, including the effects of an additional directive, and the commission's report was finally submitted[11] on 3rd October 2006. Among its suggestions are that forests and their borders should be more clearly defined, that greater importance should be attached to the part played by the forests in maintaining public health and that it should be obligatory for forest owners to prepare a forest usage plan. The report also points out the need to improve the general consideration given to the cultural and environmental aspects of forestry. The boundaries of upland forests and slow-replacement forests need to be reviewed and Sweden should to coordinate its forestry-related activities in an international context.

In July 2005, the Government appointed a special commission to investigate the conditions for Swedish agriculture to produce bioenergy. The report was published[12] in May 2007. Its overall assessment is that the existing system for encouraging agriculture to produce bioenergy is working well on the whole. Publicly funded, limited-time projects should be concentrated primarily on salix (willow) and manure-based biogas production. The necessary public input for second-generation motor fuels is regarded as consisting mainly of support for research, development and demonstration activities. There is also a potential for improving the efficiency of first-generation production systems, by such means as development of energy combinates producing various combinations of electricity, heat, cooling, steam, pellets, motor fuels, chemicals, animal feeds or biogas.

[11] SOU 2006:81 Added value from the forests.
[12] SOU 2007:36 Bioenergy from agriculture – a growing resource.

FACTS: The progress of a directive

A schematic diagram of the preparation, drafting, agreement and publication of directives. After promulgation, directives must be enacted in the respective member states' legislation. In Sweden, this means that, in the normal case, a commission (SOU) is set up to submit a report, on the basis of which the Government prepares a bill, which is submitted to a draft legislation advisory committee, after which it is reviewed by a standing committee before being submitted to Parliament for a decision. The directive is then finally enacted in Swedish legislation.



SOURCE: MINISTRY OF ENTERPRISE, ENERGY AND TRANSPORTATION

Energy in the EU

Climate change, growing dependence on imports and higher prices of energy are problems facing all EU states. At the same time, in exactly the same way as in many other areas, member states' mutual dependence in respect of energy supplies is increasing. Any interruption to power supplies in one country has immediate effects in other countries.

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.

Current work by the European Commission

At the Spring Summit in 2006, the European Commission was instructed to present a strategic energy review for submission to the 2007 Spring Summit, based on the previously presented energy Green Paper.

The Commission presented this review, under the title of 'An energy policy for Europe'[13] on 10th January 2007. It consists of an umbrella document that summarises ten individual Notices[14] into the single 'energy package'. The review results in proposals for a number of concrete actions – an action plan for energy – for which the support of the Council and European Parliament is asked. The Notices are as follows:

- Limiting climate change to 2 °C - Policy options for the EU and the world for 2020 and beyond.[15]
- Prospects for the single electricity and gas market.[16]
- Sustainable power production from fossil fuels: Aiming at almost zero emissions from coal after 2020.[17]
- An outline programme for nuclear energy.[18]
- A status report on bio-based motor fuels.[19]
- Priority interconnection plan.[20]
- Towards a strategic EU plan for energy technology.[21]
- A longer term target for renewable energy – Renewable energy sources during the 2000s: Towards a more sustainable future.[22]
- Follow-up actions of the Green Paper – report on progress in renewable energy.[23]
- Investigation of the European gas and electricity sectors.[24]

A central element of the energy review and its reports is successfully to tackle climate change. The Commission proposes that the EU will reduce its greenhouse gas emissions by at least 20 % by 2020, in comparison with 1990 emission levels. This target will be increased to 30 % in those cases where there is an international agreement, under the terms of which other industrialised countries undertake to make comparable emission reductions, with the more economically advanced developing countries making reasonable contributions to reductions in accordance with their abilities and liabilities. Several different actions within the energy sector are proposed in order to help to meet these targets. In the case of renewable energy, the target is to increase the proportion of renewable energy to 20 % by 2020, while the transport sector is set a target of 10 % renewable bio-based fuels by 2020. The proposals for concrete measures for which the Commission seeks support are concerned with:

The single market for electricity and gas
To improve the operation of the single market by means of actions such as more distinct separation, and more formalised cooperation between regulatory authorities and between system operators.

Debundling
The Commission states that further actions are required in order to ensure separation between network companies and companies that produce and trade electricity and gas, in order to strengthen competition on the electricity and gas markets.

More effective regulation
Better cooperation between surveillance authorities, with harmonisation of their powers.

Harmonisation of technical standards
With the aim of achieving effective cross-border trade, and to support the single market.

New EU mechanism for network operators
This mechanism should be responsible for coordinated network planning, and should also propose minimum standards of safety.

Transparency
Today, transmission system operators (TSOs) in different countries provide different levels of information, with the result that some markets are less easily accessible. Requirements also differ in respect of the information to be provided by electricity producers. The Commission therefore proposes that minimum standards should be established.

New energy user rules – energy as a basic commodity
To take further steps to assure the supply of energy to weak groups, particularly when energy prices rise, by developing a common charter for energy users.

New infrastructure
The Commission wishes to put forward a plan for priority infrastructure development, with the aim of accelerating the construction of important pipe and wire/cable connections.

Solidarity and crisis mechanisms
The Commission intends to propose solidarity between member states in the event of crises or interruptions in the supply of energy, by means of more effective mechanisms and by such means as the introduction of strategic stocks.

Global actions against climate change
The EU should further strengthen its work for global participation against climate change.

Improvements in the efficiency of energy use
In accordance with the recently presented action plan for improvement in the efficiency of energy use, the Commission proposes a target of a 20 % reduction in EU energy use by 2020.

Renewable energy
This proposal is a binding overall target to increase the proportion of energy supplied from renewable sources by 20 % by 2020, which includes a binding target that at least 10 % of motor fuels in the transport sector must be supplied from bio-based sources.

[13] An Energy Policy for Europe {SEK(2007) 12}, COM (2007) 1.
[14] Notices are documents in which the Commission formally presents its views on actions that it considers can or should be taken in order to implement EU policy.
[15] COM (2007) 2.
[16] COM (2006) 841.
[17] COM (2006) 843.
[18] COM (2006) 844.
[19] COM (2006) 845.
[20] COM (2006) 846.
[21] COM (2006) 847.
[22] COM (2006) 848.
[23] COM (2006) 849.
[24] COM (2006) 851.

Strategic energy technology plan
More effective inputs for research, development and demonstration activities, as well as for the introduction of new technology.
Carbon Capture and Storage (CCS)
The Commission intends to encourage coal-fired and gas-fired power stations to install the technology for carbon dioxide separation and storage facilities.
Nuclear power safety
The Commission proposes the establishment of a high-level group for nuclear safety, with a mandate to develop a common view and understanding of the problems.
International energy matters – external relations
The EU must strengthen its international role, by such means as speaking with one voice in international contexts, developing an Africa-Europe partnership in energy, and working towards the establishment of an international agreement concerning improvements in the efficiency of energy use.
Overview and reporting
The Commission proposes that a strategic overview of the energy situation should be presented every second year, and that an 'energy observatory' should be established in the Commission, with the aim of coordinating and improving transparency on the EU energy markets.

It is expected that this package of energy measures will be followed up by more concrete legislative proposals during the second half of 2007. Proposals concerning the single market directives and the Framework Directive For Renewable Energy are expected in the autumn. However the majority of directive proposals are not expected before 2008-2009.

New framework programme

A new framework programme for competitiveness and innovation (European Competitiveness and Innovation Programme), CIP 2007-2013, started on 1st January 2007. This means that the Intelligent Energy for Europe Framework Programme (IEE) is integrated in the larger programme. The second IEE programme period started on 1st January 2007.

The EU's international energy policy priorities

The EU cannot single-handedly achieve its energy and climate objectives. It needs to work not only with industrialised countries and developing countries, but also with users and producers of energy. It wants to work actively with developing a common external energy policy that will make it possible for the EU to speak with one voice on energy to other countries.

The Commission proposes a series of concrete measures to strengthen international agreements, including the Energy Charter Treaty, a post-Kyoto climate agreement and expansion of emission allowance trading to global parties. Energy must become an integral part of all the EU's external links, and in particular in its relations with its neighbours. Two important initiatives are the Commission's proposal for establishing a broad partnership between Africa and Europe, and an international agreement on improving the efficiency of energy use.

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 to jointly tackle the global threat of climate change, with the parties to the conference signing the United Nations Framework Convention on Climate Change (UNFCCC), also known as the Climate Convention.

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 their 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[25], it was noted that the incentives to take action were not sufficient, and a process was started to produce a legally binding document.

The Kyoto Protocol

At the third Conference of the Parties in Kyoto in 1997 (COP 3), agreement was reached on a document - the Kyoto Protocol - regulating emissions of carbon dioxide and five other greenhouse gases. The Protocol sets out quantitative reductions for all Annex 1 countries, i.e. the OECD states and other countries in Central and 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 quickly fulfilled many years ago, but as Russia and the USA together were responsible for more than 50 % of the total emissions from industrialised countries, it was necessary for at least one of them to ratify the Protocol before it could come into force. Russia ratified the Protocol in

[25] COP, Conference Of the Parties, consists of representatives of all the states that are party to the Climate Convention, and is the highest body of the Climate Convention, by which final decisions are made. The Conference Of the Parties to the UNFCCC serving as the Meeting Of the Parties to the Kyoto Protocol, COP/MOP, consists of representatives of all parties to the Kyoto Protocol, and is its highest decision-making body. Conferences Of the Parties are held each year.

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 September 2007, 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[26], 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. Sweden has a commitment not to increase its emissions by more than 4 % within the EU burden-sharing agreement. The new member states (except Cyprus and Malta) have their own commitments to reduce emissions, of between 6 % and 8 %, under the Protocol.

The Marrakech Accords

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, known as the Marrakech Accords, was reached between the Parties to the Protocol on detailed rules and guidelines for continued application of the Protocol at the Marrakech meeting in 2001 (COP 7), thus making it possible for the countries to assess the consequences of ratification. The points on which agreement had been 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

What are known as 'Flexible Mechanisms' are included in the Marrakech Accords 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

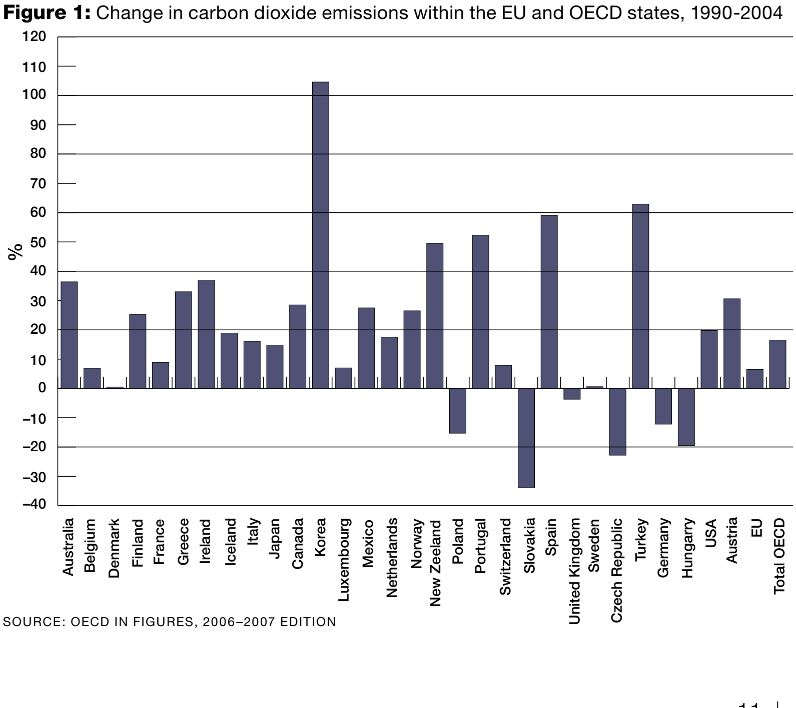
International trading in emission allowances under the Kyoto Protocol starts in 2008. However, in accordance with a directive adopted in 2003[27], the EU started an EU-wide emissions trading scheme in 2005, as a preparation for global trading under the terms of the Protocol. With effect from 1st January 2007, when Romania and Bulgaria acceded to the EU, the trading system covers 27 states. The purpose of the trading system is to reduce carbon dioxide emissions in a nationally cost-effective manner. Emission allowance trading is a central climate policy instrument of the European Climate Change Programme (ECCP). Its target is to assist the EU to achieve its Kyoto Protocol commitments in respect of reduced carbon dioxide emissions.

The first trading period in the EU system runs from 2005 to 2007, and serves as an introductory phase prior to the start of international emissions trading in 2008. Initially, the Trading Directive covers only a limited number of sectors, in energy-intensive industries and electricity and heat producers, with the result that it covers about 40 % of EU greenhouse gas emissions. In Sweden, about 35 % of greenhouse gas emissions are covered by the trading system[28]. At present, trading covers only carbon dioxide emissions, but additional greenhouse gases, as well as emissions from new sectors, may be included in the next trading period. Discussions have been held in 2007 concerning inclusion of air transport in the trading system with effect from 2011. In addition to the companies covered by the Trading Directive, other companies, individuals and organisations may trade emission allowances.

The trading system is based on each member state, prior to each trading period, setting a ceiling for its permitted national emissions. At the European level, the Commission assesses and approves each member

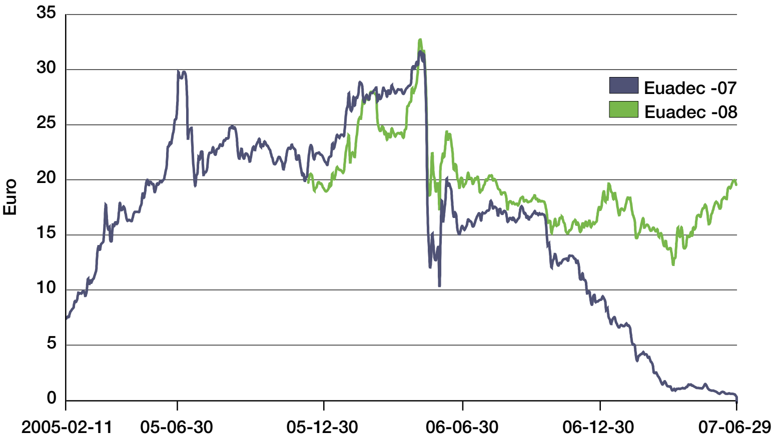
26 EU is the fifteen member states of the EU prior to the enlargement on 1st May 2004.
27 Directive 2003/87/EC, establishing a scheme for greenhouse gas emission allowance trading and amending Council Directive 96/61/EC. Also known as the Trading Directive.
28 In accordance with Sweden's national allocation plan for emission allowances for the period 2008-2012. The figure is for Swedish emissions in 2004.

Figure 1: Change in carbon dioxide emissions within the EU and OECD states, 1990-2004



SOURCE: OECD IN FIGURES, 2006–2007 EDITION

Figure 2: Prices of EU emission allowance units, 2005-2007



SOURCE: NORD POOL'S FTP SERVER. PRICES FOR EUADEC-07 AND EUADEC-08

state's national allocation plans, which give details of the total number of emission allowances that the state intends to allocate. Each emission allowance unit (EAU) corresponds to one tonne of carbon dioxide. The total of the member states' individual emissions ceilings gives a joint emissions ceiling for the entire EU, which is intended to meet the EU's commitments under the Kyoto Protocol. The trading system establishes a market price for carbon dioxide emission allowances, with the price being determined by supply and demand. The quantity of allowances available for trading consists of the total allocation of allowances plus the quantities of credits from project-based mechanisms, while the demand depends on factors such as the demand for electricity and heat production, the prices of fuels and general economic conditions.

Each EU member state is required to set up and administer a national register for recording EAU transactions in the trading system. The Swedish register (SUS) was established by the Swedish Energy Agency in March 2005. Its purpose is to ensure reliable recording and accounting of the issue, holding, transactions and cancellation of EAUs. The information provided to the register is auditable. The Swedish state has issued[29] emission allowances corresponding to about 67.3 million tonnes of CO_2 for the entire 2005–2007 trading period. In addition, there is a reserve of about 2.1 million tonnes of CO_2 for new members of the trading system and for capacity increases of existing plants.

In November 2006, the Commission granted Sweden an allocation of 22.8 million EAUs per year for the 2008-2012 commitment period. In October 2007, the Swedish government approved allocation of 22.5 million allowances. Existing district heating and electricity plants will not be allocated any allowances during the trading period.

What is known as the Link Directive[30] links the Kyoto Protocol's project-based mechanisms with the European Trading System (ETS). This means that industries, power producers etc. covered by the EU emissions trading system can credit themselves with emission reductions that result from projects carried out by them in other countries. Overall environmental benefit is guaranteed by the fact that additional emission allowances within the EU are compensated by measured emission reductions outside the EU. Since 2005, emission reductions from CDM projects have been included in the European trading system, while emission reductions from JI projects will be included in it with effect from 2008. This later inclusion is a result of the fact that credits from JI projects results from converted Kyoto AAU units, which means that each country must first be allocated emission allowances in accordance with the Kyoto Protocol[31].

The right for companies to use CDM and JI credits in order to achieve their target obligations during the 2008-2012 commitment period have been limited by the European Commission, depending on how close each member state is to fulfilling its Kyoto commitments, and on whether there is any state purchase of project credits. Swedish companies are permitted to use project credits up to 10 % of the total allocation.

Market prices of emission allowance units

When figures for verified emissions during the first year (2005) of the trading system were published in April/June 2006, they were found to be less than the allocated quantities, which meant that the market had a substantial surplus of EAU's. Over just two days at the end of April, the price of an EAU fell from about EUR 30 to below EUR 14. The price subsequently stabilised at around EUR 16 during the summer, but started to fall again during the autumn, reaching a price below EUR 1 per tonne in February 2007 (see Figure 2). The emissions statistics, together with the subsequent price crash, showed that there had been an over-allocation of emission allowances to European companies for the 2005-2007 period. By the middle of April 2007, the emissions of 2006 reported up to that time amounted to 1 954 million tonnes of carbon dioxide, which was a somewhat lower surplus than for 2005, but represented a continued surplus for the trading period.

Trading in emission allowances is conducted largely in the form of forward contracts which, if they are not sold on, call for delivery of the allowances in December of the year to which the contract relates. There are therefore contracts for delivery of EAU's in December 2005-2007, as well as for delivery in December of one of the five years in the 2008-2012 trading period. In September 2006, when the price of EAU's for that trading period again started to fall, the price of EAU's for the 2008-2012 period did not fall in parallel. Instead, the price for these units stabilised

[29] Issued emission allowances are the quantity of emission allowances that Sweden allocates to the companies covered by the trading system.
[30] Directive 2004/101/EC of the European Parliament and of the Council 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.
[31] Under the terms of the Kyoto Protocol, each country is assigned a quantity of emission allowances (Assigned Amount Units [AAU]), corresponding to the country's permitted emissions for the 2008–2012 commitment period.

at a higher level, varying between EUR 13-19 during the autumn of 2006 and spring of 2007. The reason for the sharp fall in the price of the 2005-2007 emission allowances can be that, during the autumn, the electricity and heat producers (in particular) had purchased sufficient quantities of EAUs to assure their production (emissions) for 2006 and for 2007, with the result that the unsold surplus took over the market. The more stable price level of EAUs for 2008-2012 was largely due to price signals sent out by the EU Commission's decision to cut down the total allocations in national allocation plans for the coming trading period. When 20 of the 27 national allocation plans were examined in May 2007, it could be seen that the Commission had reduced the total of the proposed plans by about 10 %.

Project-based mechanisms

JI and CDM differ from trading with emission allowance units 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 in which the costs of so doing are lower than in 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 also 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 required also to contribute to sustainable development as indicated by the host country.

The Clean Development Mechanism (CDM) is the mechanism that has been operative for the longest, as the CDM agreement in the Marrakech Accord included a 'prompt start' element. Under this, an international Executive Board (EB) was appointed to approve, register and monitor CDM projects. As a result of the Board's activities, a number of detailed 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. Track 1 JI 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 JI projects or CDM projects. An international Supervisory Committee (SC) for Track 2 JI projects was established at the first Conference of the Parties in December 2005. Read more about in the section Swedish Climate Strategy.

Continued negotiations on climate cooperation

Negotiations on climate cooperation for the period after 2012 were started at the first combined Conference of the Parties and Meeting of the Parties meeting (COP/MOP 1) in Montreal in December 2005. At this meeting, the Protocol was given its final form in terms of rules for compliance. A process for negotiations on international cooperation and the future climate regime after 2012 was also started. The parties also met in November 2006 at COP/MOP 2 in Nairobi in Kenya. The next planned meeting will be in Bali in December 2007. 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, and which can follow on from the Kyoto Protocol when the latter's first commitment period expires in 2012.

Swedish climate strategy

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

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

It is only by all the world's countries working together that the climate problem can be solved. A natural part of the Swedish strategy is therefore 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 tackling climate change. The Government is therefore of the opinion that it is im-

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

portant 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 this strategy, Parliament has set a Swedish objective for greenhouse gas emission 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. Sweden has gone further and, as its target, has elected that its greenhouse gas emissions shall not exceed 96 % of 1990 emissions (i.e. 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'.

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 20-30 % by 2020.

Sweden's long-term climate objective is to aim for stabilising greenhouse gas concentrations in the atmosphere at a level less than 550 ppm[33] carbon dioxide-equivalents. Globally, this is calculated as equivalent to 4,5 tonnes carbon dioxide-equivalents per year and person by 2050. In 2005, Sweden's per-capita emissions were about 7.44 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, and so international cooperation is 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, 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.

Sweden's climate measures 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. The Swedish Energy Agency and the Environment Protection Agency have been instructed by the Government to provide material for the reports. For the 2008 Report, the emphasis is on expected developments up to 2020. The work includes analysis of an objective for Sweden of a 25 % reduction in comparison with emissions in 1990. The two agencies are of the opinion that this target can be achieved by a three-element strategy: a reduction in the allocation of emission allowances within the framework of the EU trading system, further development of EU policy measures and incentives, as well as of national policy measures in sectors outside the EU trading system, and through the purchase of emission reduction units through investments in other countries. The two agencies are of the opinion that such an objective can be achieved with relatively little effect on the public economy as a whole.

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 January 2007, the European Commission published a combined climate and energy strategy, which is discussed in more detail in the section Energy in the EU.

In addition to its EU cooperation and its national work on reducing greenhouse emissions, Sweden is also engaged in international climate cooperation. It is involved in the work with the Kyoto Protocol's project-based mechanisms in order to obtain experience of them and to contribute to further development of the mechanisms into reliable instruments of climate policy. The Swedish Energy Agency has been instructed by the Government to develop and carry out CDM and JI projects, and has been responsible since 2002 for the Swedish International Climate Investment Programme (SICLIP). Sweden has so far approved funding of SEK 200 million for projects within the SICLIP framework.

Sweden's objective for it's CDM projects is to assemble a geographically balanced portfolio, concentrating on small-scale projects in the category of renewable en-

33 The unit 'ppm' (parts per million) describes the concentration of a substance.

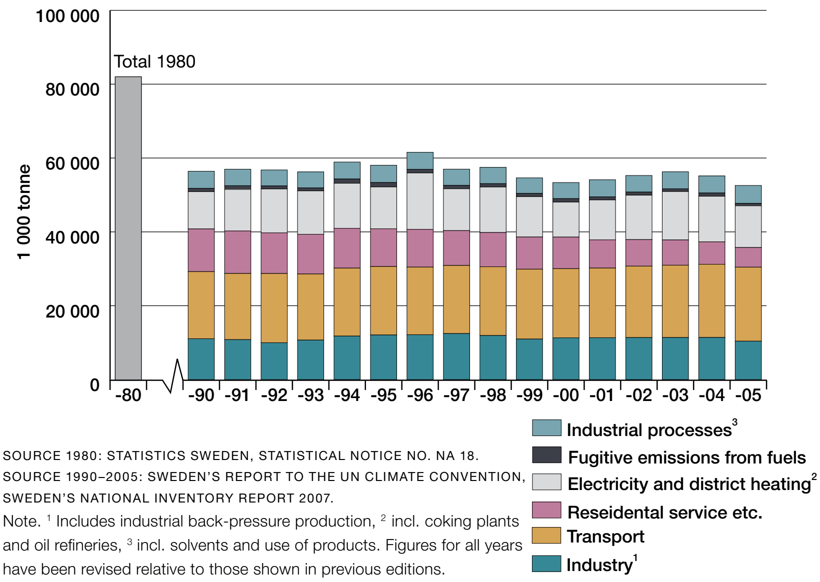
ergy sources. The Swedish Energy Agency has now entered into agreements concerning the purchase of certified emissions reductions from six projects; three in Brazil, one in India and two in China, which have also been registered as CDM projects with the CDM Executive Board (CDM-EB). Most of the expected emission reductions from the Brazilian projects have been achieved, and the certified units have been credited to the Agency's account with the CDM EB. A CDM project is currentlying negotiated with Botswana. 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. To date, the Agency has entered into purchasing agreements for two JI projects; one in Rumania and one in Estonia. Two projects are in process of negotiation with Ukraine and Russia.

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, and is based on a 2003 decision by the region's energy ministers to make the Baltic Sea region into a trials area for climate investments. Sweden's contribution to the fund amounts to almost EUR 3,5 million of the fund's total of EUR 35 million. In addition to the Baltic Sea region states, a number of commercial companies are also members of the fund.

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 developing countries and in transition economies.

During 2007, Sweden joined the Asiatic Development Bank's CDM fund, with a deposit of about SEK 105 million. The fund concentrates on CDM projects in Asia, and provides good opportunities for climate projects in the least developed countries. Sweden is also a member of 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 in those transition economies (e.g. Russia and Ukraine) where the Bank operates. 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

Figure 3: Carbon dioxide emissions in Sweden, 1980, 1990-2005



SOURCE 1980: STATISTICS SWEDEN, STATISTICAL NOTICE NO. NA 18.
SOURCE 1990–2005: SWEDEN'S REPORT TO THE UN CLIMATE CONVENTION, SWEDEN'S NATIONAL INVENTORY REPORT 2007.
Note. [1] Includes industrial back-pressure production, [2] incl. coking plants and oil refineries, [3] incl. solvents and use of products. Figures for all years have been revised relative to those shown in previous editions.

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 in this way 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, these projects can be seen to be very cost-efficient.

The Agency is also the official Swedish Designated National Authority and Designated Focal Point[34] with responsibility for authorising Swedish companies and organisations wishing to participate in project-based mechanisms, and to decide whether proposed projects meet the requirements for purchasing emission reduction credits, in accordance with the rules set out in Article 6 of the Kyoto Protocol. This means that the details of a proposed project are examined in order to decide whether it will reduce greenhouse gas emissions. It also means that the Agency is the official contact point with the Climate Convention's Secretariat. Since starting this duty in 2005, the Agency has approved 76 CDM projects and 6 JI projects. Only a few Swedish parties are direct, active participants in these projects. In June 2007, Sweden hosted a ministerial-level climate meeting. This was the third such high-level dialogue meeting on climate that had been held in recent years, in order to provide an introduction for the international climate negotiations. On behalf of the Ministry of Environment, the Agency prepared the discussion material for the meeting. ■

[34] In order to be able to register projects for treatment as project-based mechanisms, each party shall appoint a nationally responsible public authority, the Designated National Authority (DNA), for approval of projects for participation in CDM projects, and a Designated Focal Point (DFP) for approval of participation in JI projects. In Sweden, the National Energy Agency has been appointed as DNA and DFP, under the common designation of the Project Authority.

Policy measures and incentives

Several policy measures and incentives have been introduced in order to achieve the targets set out in the country's energy and climate policy. The most wide-reaching means of achieving energy policy 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 and incentives for the built environment and transport, technology procurement, the climate investment programme and information campaigns. Emissions trading is described in the previous chapter, "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 that 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 costs and benefits 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 incentives and policy measures

Administrative policy measures	Economin policy measures	Information	Research
Regulations	Taxes	Information	Research
Limit values for emissions	Support, grants, subsidies	Advisory service	Development
Requirements for types of fuels and energy effieincy	Lodgins of securities	Education	Demonstration
Long-term agreements	Emission allowance trading	Opinion-forming	Commerciali-sation
Environmental classification	Certificates trading		Procurement

Energy taxes

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

Table 2: Revenue from energy taxes after the 2006 Energy and Tax Act, SEK million millions

Energy carrier	Energy tax	CO_2 tax	Sulphur tax	Total
Petrol	14 588	10 879		25 467
Oil products	4 689	13 702		18 391
Unrefined tall oil	16			16
Other fuels	75	976		1 051
All fuels			83	83
Electricity	19 015			19 015
Electricity from nuclear power plants*	3 089			3 089
Totalt	**41 472**	**25 557**	**83**	**67 112**
Proportion of national tax revenue				9.0%
Proportion of GDP				2.5%

SOURCE: NATIONAL TAX BOARD, THE SWEDISH NATIONAL FINANCIAL MANAGEMENT AUTHORITY, STATISTICS SWEDEN

*This tax is a tax on power output at production level, and is not to be confused with the energy tax that is paid by users.

process of harmonisation of taxation of fuels and electricity throughout the EU. The system has been further aligned with the Energy Taxation Directive with effect from 1st January 2007, covering such matters as the taxation liability of fuels, qualification of energy-intensive companies for reduction of the carbon dioxide tax in accordance with the 0.8 % rule, and the extent of tax exemption of fuels in certain industrial processes.

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 also 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 2006, revenues from energy taxes raised over SEK 67 100 million, making up about 9 % of State revenue or 2.5 % of GDP. (See Table 2.) There is also taxation expenditure (taxation relief) on the income side of the national budget. The definition of taxation expenditure is that the tax received is less than a certain specified standard[35]. 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 over SEK 38 000 million in 2006, according to the 2007 Budget Bill[36].

Types of taxes and tax rates

’Energy tax’ is an umbrella name for spot taxes on fuels and electricity. They can be roughly divided up into fiscal[37] taxes and taxes 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 emitted quantities of carbon dioxide from all fuels except biofuels and peat. In 2007, the general rate of carbon dioxide tax is 93 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/m^3 for each tenth of a percent of sulphur by weight in oil. Oils containing less than 0.05 % of sulphur by weight are exempted from the tax. The environmental levy on the emission of NO_X was introduced in 1992, and is applied at a rate of SEK 40/kg of NO_X on emissions from boilers, gas turbines and stationary combustion plant supplying at least 25 GWh per annum. However, it is intended to be fiscally neutral, and is repaid to plant operators in proportion to their energy production and in inverse proportion to their NO_X emissions, so that only those with the highest emissions are net payers.

35 If a taxation expenditure is removed, it results in increased taxation revenues and thus to an improvement of the budget for the public sector in the same way as if an expenditure from the national budget had been removed.
36 Bill no. 2007/8:01, Expenditure Areas 21, 22, 23 and 24.
37 A fiscal tax is intended mainly to generate revenue for the national exchequer.

Table 3: General energy and environmental taxes as at 1st January 2007, excluding VAT

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax öre/kWh
FUELS					
Gas oil, SEK/m3 (<0,05 % sulphur)	750	2 663	-	3 413	34.3
Bunker oil, SEK/m3 (0,4 % sulphur)	750	2 663	108	3 521	33.3
Coal, SEK/tonne (0,5 % sulphur)	319	2 317	150	2 786	36.9
LPG, SEK/tonne	147	2 801	-	2 948	23.0
Natural gas, SEK/1000 m^3	243	1 994	-	2 237	20.2
Unrefined tall oil, SEK/m^3	3 413	-	-	3 413	34.8
Peat, SEK/ton, 45 % moisture (0,3 % sulphur)	-	-	50	50	1.8
Domestic waste, SEK/tonne of fossil carbon*	152	3 426	-	3 578	15.0
MOTOR FUELS					
Petrol, unleaded, env. class 1, SEK/l	2.9	2.2	-	5.1	55.9
Diesel fuel, env. class 1, SEK/l	1.1	2.7	-	3.7	37.3
Natural gas/methane, SEK/m^3	-	1.1	-	1.1	10.3
LPG, SEK/kg	-	1.4	-	1.4	10.8
ELECTRICITY USE					
Electricity, northern Sweden, öre/kWh	20.4	-	-	20.4	20.4
Electricity, rest of Sweden, öre/kWh	26.5	-	-	26.5	26.5
INDUSTRY					
Electricity, industrial processes, öre/kWh	0.5	-	-	0.5	0.5

SOURCE: SWEDISH NATIONAL TAX BOARD AND THE SWEDISH ENERGY AGENCY

*The proportion of fossil carbon in domestic refuse is assumed to be 12.6 % of the weight of the refuse

Taxation to assist achievement of environmental objectives

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, partly within the framework of the general shift in the tax regime towards environmentally targeted taxes.

Electricity and heat production

Electricity production in Sweden is exempted from energy and carbon dioxide tax, although it is subject to the NO_X levy and sulphur tax in certain cases. However, the use of electricity is taxed, at rates that vary depending on in which part of the country the electricity is used, and on what it is used for. Nuclear power plants were previously taxed on the basis of their electricity production, but since 1st July 2000 the tax has been based on the maximum permissible thermal power rating of their reactors. This tax was increased 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[38] and a further levy that amounts to about 1 öre/kWh for financing future storage facilities for spent nuclear fuel[39].

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

With effect from 1st July 2006, combustion of cer-

[38] The Act (1988:1597) Concerning Financing of the Handling of Certain Radioactive Waste etc.
[39] The Act (1992:1537).

tain domestic refuse was also made liable to energy tax. The energy tax element amounts to SEK 152 per tonne of fossil carbon, while the carbon dioxide tax element is levied at the rate of SEK 3 426 per tonne of fossil carbon. 12.6 % by weight of the refuse is assumed to be 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

Taxation of use of energy

Manufacturing industry, horticulture, farming, forestry and aquaculture[40] pay no energy tax on fossil fuels, and only 21 % of the carbon dioxide tax[41]. 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. To qualify for this reduction, companies must (from 1st January 2007) meet the 0.5 % rule definition of an energy-intensive company[42]. From the same date, too, the further reduction given by the 1.2 % rule has been abolished. There are various tax levels for transport, depending on the environmental class of the fuel, which have resulted in reduced emissions of some pollutants. Tax rates on petrol and diesel fuel were left unchanged for 2007. No energy tax is payable on the use of diesel fuel or fuel oils used in commercial maritime traffic or railborne traffic, or on aviation petrol or aviation paraffin. No energy tax or carbon dioxide tax is charged on ethanol, rapeseed oil methyl ester (RME) or biogas, while natural gas used in the transport sector pays no energy tax. Domestic users pay different rates of electricity tax, depending on whether they live in the north of the country or the rest of the country, see Table 3. Electricity tax was raised by 0.3 öre/kWh in 2007. 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 2006, 57 % of the cost of fuel used by owners of detached houses for heating was made up of tax if that fuel was oil, while only 18 % of the cost was tax (value-added tax only) if the fuel was pellets. For drivers, 62 % of the cost of petrol was tax (including value-added tax). See Figure 4.

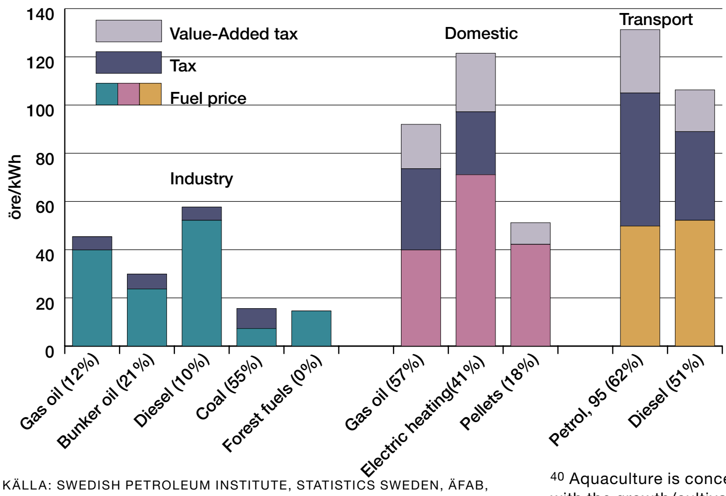
Table 4: Energy and environmental taxes on industry, agriculture, forestry, fisheries and heat production in CHP plants from 1st January 2007

	Energy-tax	CO_2 tax	Sulphur-tax	Total tax	Tax, öre/kWh
Gas oil 1, SEK/m³	-	559	-	559	5.6
Bunker oil 5, SEK/m³	-	559	108	667	6.3
Coal, SEK/tonne	-	487	150	637	8.4
LPG, SEK/tonne	-	588	-	588	4.6
Natural gas, SEK/1000 m³	-	419	-	419	3.8
Unrefined tall oil, SEK/m³	559	-	-	559	5.7
Peat, SEK/tonne, 45 % moisture, 0,3% Sulphur	-	-	50	50	1.8
Domestic waste, SEK/tonne fossill carbonne*	-	719	-	719	3.0

SOURCE: SWEDISH NATIONAL TAX BOARDAND THE SWEDISH ENERGY AGENCY.

*Maximum CO2 tax relief (79 %) is received for an electrical efficiency of 15 %. Full relief from energy tax is received for an electrical efficiency of 5 %.

Figure 4: Total energy prices for various user categories , 2006



KÄLLA: SWEDISH PETROLEUM INSTITUTE, STATISTICS SWEDEN, ÄFAB, NATIONAL TAX BOARD

Note. Prices shown for industry do not include any large-user discounts. The share of taxes are givin within brakets.

Green electricity certificates

1st May 2003 saw the introduction of a new support system for renewable electricity production, based on trading in certificates for renewable electricity. The certificate trading system is being complemented by transition rules for wind power production in the form of an energy tax reduction (known as the environmental bonus) which, in 2006, amounted to 6.5 öre/kWh for onshore production and 15 öre/kWh for offshore production[43]. This bonus has been, and is being, progressively reduced over the period from 2004 so that, 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

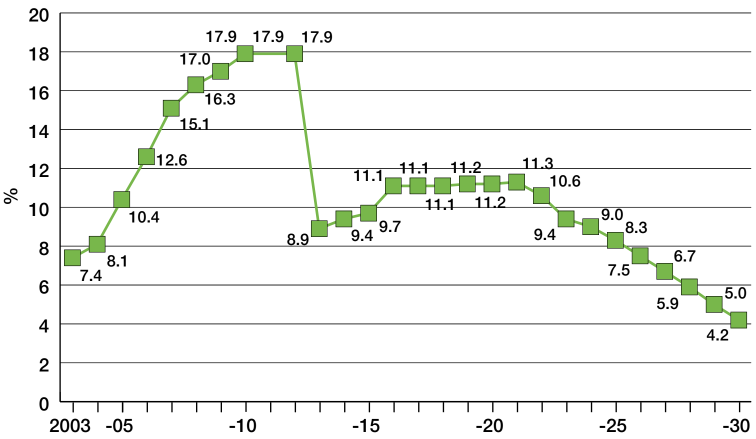
40 Aquaculture is concerned with the growth/cultivation of all kinds of aquatic creatures and plants in water.

41 Energy tax is levied, however, on raw tall oil and electricity.

42 Under the 0.5 % rule, a company is regarded as energy-intensive if the tax remaining (excluding sulphur tax) after the general tax reduction on fuels used for heating or operation of stationary equipment in the manufacturing industry and horticulture amounts to at least 0.5 % of the added production value.

43 Budget Bill no. 2003/04:1 included a proposal for progressive reduction of the energy tax relief for electricity produced from wind power, known as the environmental bonus.

Figure 5: Required quota proportions for the electricity certificate system, 2003-2030



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

Table 5: Number of plants, installed capacity and renewable electricity production in the electricity certificate system

	No of approved plants[1]	Installed capacity (MW)	Renewable electricity production, 2003[2] (MWh)	Renewable electricity production 2004 (MWh)	Renewable electricity production 2005 (MWh)	Renewable electricity production 2006 (MWh)
Hydro	1 075	540	963 637	1 968 325	1 799 446	2 018 577
Wind	706	583	455 642	864 546	939 125	988 340
Biofuels[3]	130	3 643	4 218 276	8 215 561	8 559 802	9 149 918
Solar	3	0.036	4	6	5	20
Total	**1 909**	**4 765**	**5 637 559**	**11 048 438**	**11 298 378**	**12 156 855**

SOURCE: SVENSKA KRAFTNÄT AND THE SWEDISH ENERGY AGENCY

Note. [1] Number of approved plants on 2007-01-01. [2] For the period May - December 2003. [3] Electricity production includes peat which in 2004 provided about 545 GWh, in 2005 about 631 GWh, and in 2006 about 556 GWh.

Table 6: Market statistics for the green electricity certificate system, 2003-2006

	2003[1]	2004	2005	2006
Volume-weighted average prices of electricity certificates (SEK)	201	231	216	191
Quote obligation (no. of certificates)	4 534 335	7 892 330	10 129 963	12 398 543
Cancelled certificates	3 489 984	7 832 352	10 119 869	12 391 446
Quota obligation fulfilment (%)	77.0	99.2	99.9	99.9
Total quota obligation fee (SEK million)	183	14	3	2

SOURCE: SVENSKA KRAFTNÄT AND THE SWEDISH ENERGY AGENCY
[1] For the period May - December 2003

[44] Peat is not regarded as a renewable fuel in Directive 2001/77/EC Concerning the Production of Electricity from Renewable Energy Sources.

from wind power, solar energy, geothermal energy, certain biofuels, wave energy and small-scale 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 2006, users had to buy certificates corresponding to 12.6 % 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 of production. During 2006, the average price of electricity certificates was SEK 191, as shown in Table 6. The system covers only electricity produced in Sweden.

The purpose of the certificate trading system is to produce a greater proportion of the country's electricity from renewable sources, increasing it by 17 TWh between 2002 and 2016. In June 2006, Parliament decided on changes to the electricity certificate system, in the form of various changes intended to extend the long-term strategic 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. Quotas, including adjustment of those for 2007-2010, have been set for this period. 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 progressively phased out of the scheme, starting from the end of 2012 or 2014. A new definition of electrically-intensive companies, based on the amount of electricity used and the company's total sales value, instead of being based simply on the industry sector in which the company operates, has applied from the beginning of 2007. In 2006, 262 companies were registered as electrically-intensive under the old rules, thus relieving them of quota liabilities of 40,5 TWh for the year. For 2007, 439 companies are registered as electrically-intensive under the new rules.

Production of renewable electricity under the certificate system amounted to 11.6 TWh in 2006, after subtraction of production from peat[44]. 6.5 TWh of this production existed in 2002, which means that there has been a net increase of 5.1 TWh between 2002 and 2006.

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

The overall objective of the programme for energy efficiency improvement in energy-intensive industry (PFE) has been to encourage efficient use of energy. The background to the programme is the energy tax on electricity used in manufacturing industry that was introduced on 1st July 2004, at a rate equivalent to the minimum required tax rate as set out in the Energy Taxation Directive[45]. With effect from that date, manufacturing industry, which had hitherto enjoyed a zero tax rate on electricity used by it for its processes, has paid 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[46]. 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 value, or

b) The total energy, sulphur and carbon dioxide tax for the company must amount to at least 0.5 % of its conversion value.

Through the energy management systems and energy audits that form part of the programme, companies will improve their awareness of their potentials for cost-efficient energy efficiency improvements. In addition, the companies benefit from the introduction of a process for continuous, structured improvement in their efficiency of energy use. In January 2007, there were 117 companies in the programme, operating about 250 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 (46), the wood products industry (22) or the chemical industry (16). Other participants include companies in the food industry (10), the iron, steel and mining industry (15), the engineering industry and a few other sectors. The scheme is open to admission of more companies up to and including 2009.

98 of the participating companies submitted their first reports to the Agency during the autumn of 2006, describing the results of their work on energy auditing and the introduction of energy management systems. The reports also include details of implemented and planned efficiency improvement measures. They show that the companies have undertaken to improve their efficiency of electricity use by a total of 1 TWh/year, for a total investment cost of somewhat over SEK 1 000 million. Approximately half of the efficiency improvements have been found in the production processes themselves, with the remainder in ancillary systems, such as pumps, fans and other motor drives. Many of the improvements are concerned with demand control response (e.g. speed control), process adjustments or optimisation, although replacement of equipment by more energy-efficient equipment is also common. Many of the improvement measures pay for themselves in a very short time. In some cases, the electrical efficiency improvement measures have also resulted in a reduction in other forms of energy use. Measures involving direct conversion from electricity to some other form of energy carrier do not quality for the PFE tax reductions.

In addition to the measures described above, companies in the PFE scheme must also consider the life cycle costs of electricity-using equipment when purchasing new equipment and/or when planning, modifying or renovating plant or equipment. This will result in further improvements in efficiency during the remaining three years of the programme, with the results being included in the final five-year report of the results. All these factors therefore indicate that the total improvements in electrical efficiency brought about by the PFE scheme will be very much more than have so far been reported.

Buildings

Building regulations

A whole range of policy measures are used in order to influence energy conservation and management in buildings[47]. The National Board of Housing, Building and Planning's Building Regulations[48] 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.

[45] Directive 2003/96/EC restructuring the community framework for the taxation of energy products and electricity.
[46] The Act (2004:1196) Concerning the Programme for Improving the Efficiency of Energy Use etc.
[47] Most of the measures described here are administered by the National Board of Housing, Building and Planning and/or by the County Councils. See www.boverket.se/ for more information.
[48] Most recent change: BFS 2006:22.

Energy declarations

Another administrative policy measure is that of the Act Concerning Energy Declarations for Buildings[49], which is based on an EU Directive[50]. Owners of detached houses, apartment buildings and commercial premises are required to provide information on the buildings' energy use, together with certain parameters of the indoor environment, in an energy declaration. The purpose is to encourage efficient energy use and good indoor environmental conditions in buildings. The launch of the energy declarations is at present in an introductory stage, and is expected to come fully into operation at the end of 2008.

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 for installation of solar heating systems for space heating and/or domestic hot water production, and has been available for projects started since 1st June 2000.

Assistance for conversion of heating systems

The purpose of these conversion grants[51] 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 properties having direct electric heating can receive a grant for the cost of conversion of such heating systems by district heating or by rock, earth or lake water heat pumps, or by biofuelled boilers. The grant has been available for the period from the beginning of 2006, and will continue until the end of 2010. Until the end of March 2007, it was also available to those replacing oil-fired heating systems by one of these alternative heating systems: a benefit that was taken up by about 50 000 owners of detached houses[52].

Grants for high-performance windows or biofuel boilers etc. in detached houses

Builders of new detached houses can apply for a grant for the installation of a biofuel-fired facility, such as a pellets-fired boiler, as the primary heating source. Owners of single-family or two-family houses can obtain a grant for the installation of new windows having a maximum U-value[53] 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[54]. This grant is available until the end of 2008.

Grants for energy efficiency improvement and conversion in public premises

The purpose of the grants for conversion and energy efficiency improvements in public buildings[55] is that the public sector should lead the way in energy improvements and set an example. Owners of premises used for public activities can apply for grants for conversion of heating systems from electricity or fossil fuels to biofuels, district heating or earth, rock or lake water heat pumps. Grants are also available for investments intended to improve the efficiency of energy use, and for the installation of solar cells in public buildings. These grants were introduced in 2005, and will be available until the end of 2008.

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 the Consumer Price Index. 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 and carbon dioxide tax. 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 production of such fuels.

The law requiring larger petrol stations to sell at least one renewable motor fuel since 1st April 2006 is also intended to affect the growth of biofuel-based motor fuels. It has encouraged particularly the sale of ethanol fuel. A special measure during 2006 and 2007 provides support for other alternative motor fuels in the form of a grant for petrol stations selling renewable motor fuels other than ethanol.

Motor vehicle tax is primarily a fiscal tax, although it also includes an environmental objective element. Since October 2006, it provides an incentive to buy more energy-efficient (fuel-efficient) vehicles or vehicles running on alternative motor fuels. The tax is now based on the vehicle's carbon dioxide emissions instead of, as was previously the case, on the vehicle's weight. 2006 also saw the introduction of a total reduction of SEK 6000 in the tax of diesel cars having particle filters. This reduction is available only until the end of 2007, by which time it is expected that most new diesel passenger cars will be fitted with particle filters.

With effect from 1st April 2007, private purchasers of

49 The Act (2006:985) Concerning Energy Declarations for Buildings. Introduced on 1st October 2006.
50 Directive 2002/91/EC concerning the energy performance of buildings.
51 Ordinances (2005:1255) and (2005:1256).
52 Source: The National Board of Housing, Building and Planning.
53 The coefficient of thermal conductivity, a performance indicator for windows. The lower the value, the better the performance of the window.
54 Ordinance no. (2006:1587).
55 Ordinance no. (2005:205).
56 The National Road Administration, Årsredovisning 2006.
57 The National Road Administration. *Payment of vehicle scrapping premium*, 2007-06-11.

low-pollution vehicles can obtain a grant of SEK 10 000 for the purchase. Its purpose is to encourage the purchase of fuel-efficient vehicles and vehicles running on alternative motor fuels[56].

New rules for disposals of vehicles at the end of their lives came into force on 1st June 2007. The previous system, involving an initial end-of-life payment, and subsequent fees for disposal, has been replaced by transfer of liability to the vehicle manufacturers. Under the new rules, vehicle owners are entitled to return a vehicle for scrapping to the manufacturer, without charge, with the manufacturer being responsible for approved scrapping of the vehicle. Vehicles that were in use on 31st August 2006, and which were older than 1989 models, qualified their owners for a scrapping payment of SEK 4 000, subject to availability of liquidity in the vehicle scrapping fund. However, as a result of the unexpectedly large numbers of vehicles that were scrapped after introduction of the law, the fund was exhausted and only vehicles notified for scrapping before 4th July 2007 could be sure of qualifying for payment from the fund[57].

A congestion charge was introduced in Stockholm on 1st August 2007, with the aim of improving traffic flow in the city and reducing pollution, while also helping to finance investments in the road network in the Stockholm region.

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 and tolls for certain heavy traffic[58].

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[59] 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

The Government's 'Research and New Technology for Future Energy Systems' [60] Bill has been approved by Parliament for a new long-term programme of research, development and demonstration activities for the development of technologies and processes aimed at the establishment of a sustainable energy system. Expenditure on energy research over the period 2006-2008 was set at about SEK 815 million/year in the 2006 budget. See Figure 6 Responsibility for the public energy research programme has been vested in the Swedish Energy Agency.

As expressed in the Bill, the objective of energy research is to "... establish such scientific and technical knowledge and skills among universities, institutes of technology, research institutes, public authorities and industry as are needed to support a changeover to a long-term sustainable energy system in Sweden through application of new technologies and new services, and to develop technologies and services that can be commercialised by Swedish industry, and thus contribute to the restructuring and development of the energy system in Sweden and on other markets"[61]. Research into energy covers the entire chain from fundamental research and technical development through to demonstration activities and business development.

Activities are structured in six theme areas: Energy System Studies, Energy Use in the Built Environment, Transport, Energy-intensive industry, the Power System and Fuel-based Energy Systems. Each theme area is supported by development platforms made up of experts from public authorities, industry and other relevant parties.

Research in the field of **energy system studies** is aimed at improving knowledge of, and competence in, the energy system and its dynamics, and interna-

58 A complete review of economic incentives in the transport sector can be found in the Swedish Energy Agency's report no. ER 2006:34, Economic Incentives.
59 The list can be downloaded from the Agency's web site: www.energimyndigheten.se.
60 Bill no. 2005/06:127.
61 See the report, Energy Research in Sweden 2006 for a more detailed presentation of Sweden's energy research programme.

tional climate policy. The research is largely multidisciplinary, and the results constitute important resources for the provision of support material for decision-making 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 gender perspectives.

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 buildings and their 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 production 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.

Research in the **transport sector** is divided into two parts: alternative motor fuels and energy-efficient vehicles. This includes research and development of biofuel-based motor fuels, combustion engines and electrical drive systems. Looking ahead, biofuel-based motor fuels have the potential to make a significant 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.

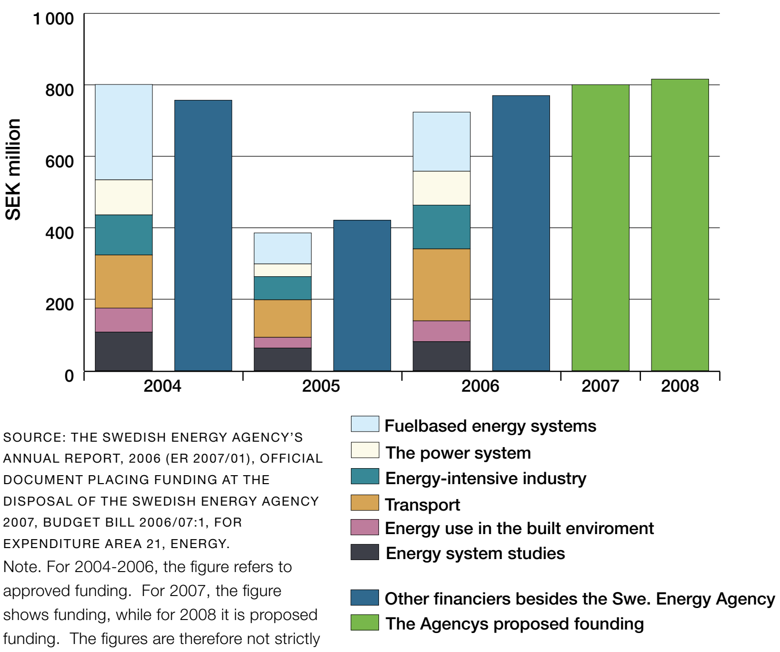
The **energy-intensive industry** area gives priority to improvements in the efficiency of energy use, particularly for energy-intensive processes in the pulp and paper industry and in the steel industry. Gasification of black liquor can provide the forest products industry with a fuel for additional 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 accumulation 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 their 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 supply and energy production, based mainly on biomass-fuelled systems. Research in the area is intended to help increase the quantities of fuels available, to improve the cost efficiency and resource efficiency of the chain from raw material to finished product, to improve the electrical yield from processes, and to help commercialise the technology. Sweden is one of the world's leading countries in terms of the production and use of solid processed 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.

The Agency attaches particular importance to the development of three larger bioenergy-related pilot plants, covering the entire chain from research to de-

Figure 6: Funding for research, development and demonstration activities



SOURCE: THE SWEDISH ENERGY AGENCY'S ANNUAL REPORT, 2006 (ER 2007/01), OFFICIAL DOCUMENT PLACING FUNDING AT THE DISPOSAL OF THE SWEDISH ENERGY AGENCY 2007, BUDGET BILL 2006/07:1, FOR EXPENDITURE AREA 21, ENERGY.
Note. For 2004-2006, the figure refers to approved funding. For 2007, the figure shows funding, while for 2008 it is proposed funding. The figures are therefore not strictly comparable between years.

monstration: a development plant for black liquor gasification in Piteå, a plant for gasification of biomass in Värnamo, and an ethanol pilot plant in operation in Örnsköldsvik. They are regarded as strategically important when seen against the background of Sweden's favourable conditions for the production of bio-sourced motor fuels from forest raw materials.

The climate investment programme

The Climate Investment Programme (KLIMP) 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. It has been running 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 receive grants.

Under the scheme, a total of SEK 409 million has been allocated in 2007 to 23 climate investment programmes and to ten particularly efficient improvement measures. These programmes represent investments to a total value of SEK 1 800 million in measures to reduce effects on climate and to assist the transition to a sustainable 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 expected to reduce annual emissions of greenhouse gases by about 300 000 tonnes, as well as to reduce energy use by 300 GWh.

The Swedish Environmental Protection Agency is the main operator of KLIMP, but seeks advice from other agencies concerning the merits of proposed measures. The final decision as to which programmes are to receive grants, and of how much, is made by a special board within the Environment Protection Agency.

Information activities

The fact that knowledge and understanding affect how we act in given situations when decisions are required 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 working with a large number of different 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 Swedish Consumer Agency and the Swedish Environmental Protection Agency to run information campaigns 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, during 2007, has included an information tour around the country and creation of a web site with tips and advice. ■

3 SWEDEN'S ENERGY BALANCE

Figure 7: Energy supply and use in Sweden, 2006, TWh[1]

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

[1] Preliminary statistics. Due to rounding of figures, there may be differences in the totals.

[2] These are large heat pumps in the energy sector. Energy delivered to the energy system as heat produced, 5.6 TWh. Heat collected from the surroundings was about 4 TWh and input drive energy from electricity 1.6 TWh

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

[4] Net import of electricity is treated as supply.

Sweden's energy balance

Energy can never be destroyed or consumed, but only converted (in everyday language called 'used'). The total quantity of energy used must therefore always be balanced by a corresponding quantity of energy supplied. This chapter gives details of the balance between Sweden's total energy supply and its total energy use[62].

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, miscellaneous 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 sector, 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, and nor does it show losses in hydro power production. Most of the losses shown in the diagram are made up of the thermal energy that is removed by cooling when producing electricity in nuclear power stations. Other losses include conversion losses in energy plants[63] and distribution losses in connection with the supply of electricity, district heating, natural gas and town gas, coke oven and blast furnace gas. 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 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 and 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.

Total energy use

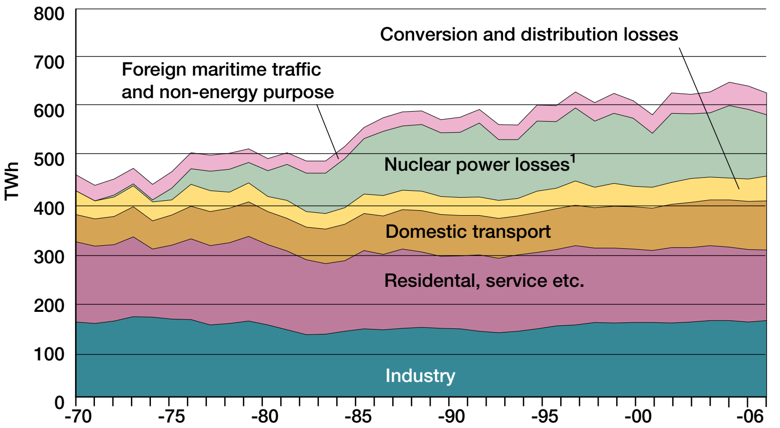
Total energy use in 2006 amounted to 624 TWh. Of this, total final energy use made up 403 TWh, and conversion and distribution losses made up 177 TWh, of which 126 TWh were in nuclear power production. Bunker oils for foreign maritime transport, together with the use of energy products for non-energy purposes, accounted for a further 45 TWh. Although industry, and the residential and service sector, both use more or less the same amount of energy now as in 1970, much has changed: the total heated floor area of commercial premises, for example, is greater, population numbers have risen by 12.8 %, and industrial production is considerably higher than it was in 1970. The move away from oil to electricity and district heating has 'transferred' some of the losses to the supply side of the energy system: see 'System Boundaries' below. Total energy use by the transport sector (excluding foreign maritime traffic) has increased by 80 % since 1970. For the industrial sector, the 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.

System boundaries

The concept of system boundaries provides an aid for analysing the country's energy system. Since 1970 the demand for energy[64] has increased by 7.5 %, from 375 TWh to 403 TWh. However, over the same period, total energy supply has increased by 36.5 %, from 457 TWh to 624 TWh. The reason for the supply of energy increasing almost 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 during the period. Although electricity is a very efficient energy carrier as far as users are concerned, it is associated with major losses on the production side, e.g. when produced in nuclear power stations. As a result, much of the conversion losses have been transferred from the end users to the supply side of the energy system. These

[62] Statistics for the period 1970 to 2004 are definitive. Those for 2005–2006 are preliminary.
[63] In this context, energy plants are electricity and district heating production plants, refineries, gasworks, coking plants and blast furnaces.
[64] As used here, 'demand' refers to the total final energy use.
[65] All or nothing – system boundaries for heating of buildings: www.energimyndigheten.se.
[66] The Swedish Energy Agency's calculations, based on the period 1985–2005.

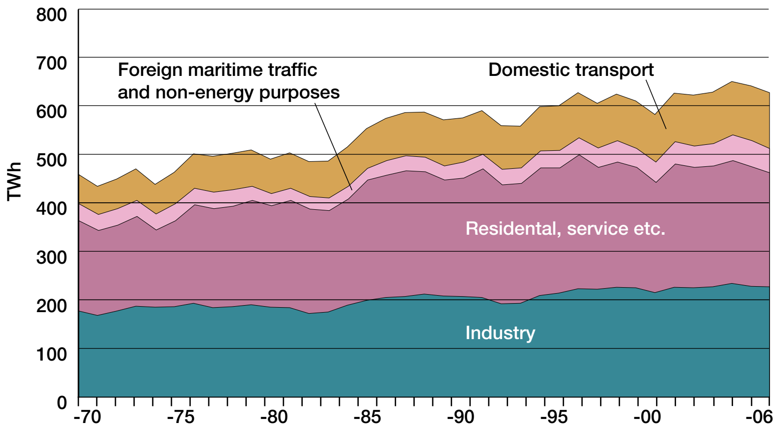
Figure 8: Sweden's total energy use, 1970–2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

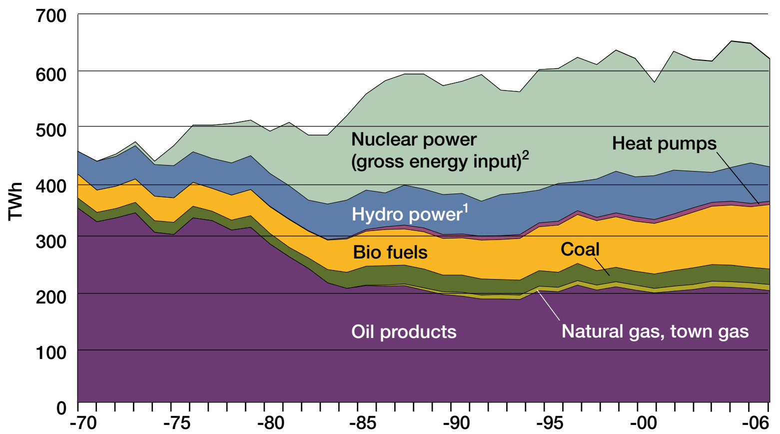
Note. [1] Calculated in accordance with the UN/ECE method for energy supply from nuclear power.

Figur 9: Total energy use in Sweden, 1970-2006. Conversion losses in the production sector are allocated to end users.



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 10: Total energy use in Sweden, 1970-2006, excluding net electricity exports.



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

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

losses are not shown as part of the end-users' demand, but as an item of their own. Losses occur, for example, in electricity production, in the production of district heat and in refineries. By assigning all the losses proportionally to the use of electricity, district heating and oil products in the user sectors, we obtain an alternative picture of the development of energy use in the various end-user sectors. Figure 9 shows such an assignment of losses, based on exactly the same statistics as shown in Figure 8, but with the difference that the losses are not shown on their own. The difference between the way in which the information is shown in the two figures is due to where we set the system boundary. If the boundary is set at the factory gate, or at a residential building wall, we obtain the result as shown in Figure 8. If, on the other hand, the boundary is set where the electricity, district heating or oil products are produced, we obtain Figure 9. Other system boundaries can also be considered[65].

Total energy supply

Sweden's total energy supply in 2006 was 624 TWh, including a net import of about 6 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 about 43 %, while the net production of electricity has increased by about 137 % as a result of the construction of nuclear power stations and expansion of hydro power production. The supply of biofuels has increased by over 170 %. 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, and wind power construction started in the middle of the 1990s. The use of coal and coke as fuels increased during the 1980s, but has since declined somewhat. Nuclear power used 194 TWh of fuel energy input in 2006, to produce about 65 TWh of electricity. Hydro power produced 61 TWh of electricity, which is low in historic terms. Hydro power production varies widely, depending on the amount of precipitation during the year: average annual production is 67.5 TWh[66]. Fuel-based thermal power production produced 12.6 TWh of electricity, while wind power supplied about 1 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 2006 to 29 %, which is a relatively high figure in international terms. Renewable energy sources include biofuels, hydro power, wind power and other sources. ■

Energy use

Modern society is 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, industry and transport. This chapter describes energy use in 2006[67], against the background of developments in energy use since 1970.

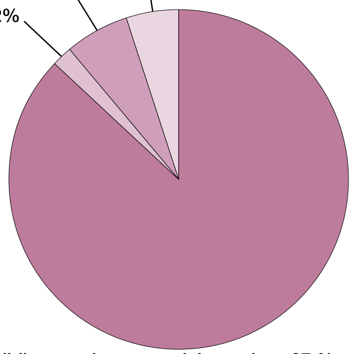
The residential and service sector

The residential and service sector accounts for 36 % of Sweden's total final energy use, amounting in 2006 to 145.3 TWh. The sector consists of residential premises (including permanently occupied holiday homes) and commercial premises (excluding industrial premises), land use[68] and service activities, which include the construction sector[69], street lighting, sewage treatment plants, electricity and waterworks. Of the total energy use in the sector, most (about 90 %) is used in residential buildings and commercial premises; see Figure 11.

Almost 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 [70]. The number of degree-days in 2006 was 90.85, which means that the heating energy requirement was about 9 % less than in a statistically average year, with a preliminary corrected usage figure of about 150.5 TWh, which is 3 TWh less than in 2005.

The number of dwelling units (single-family houses and apartments in apartment buildings) in the country steadily increases. In 2006, there were about 4.4 million dwelling unit, representing an increase of about 40 % since the 1970s. The rate of construction was relatively low during the latter half of the 1990s, but picked up during the 2000s, to the extent that 29 800 new dwelling units were completed in 2006, or 29 % more than during the previous year. Despite the increased in the number of dwelling units, total energy use in the sector has remained relatively constant.

Figur 11: Energy use in the residential and service sector, 2005



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Electricity use

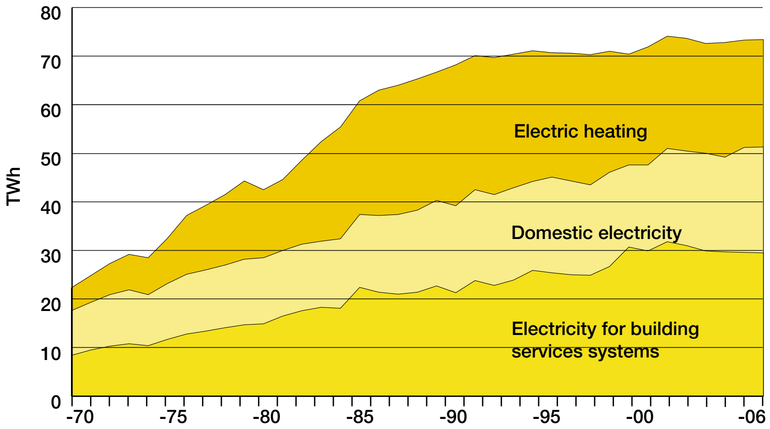
Figure 12 shows how total use of electricity in the sector has increased since 1970. The steady rise tapered off in the middle of the 1990s, since when electricity use has remained constant at somewhat over 70 TWh (statistically corrected).

Much of the electricity used in this sector is for building operations[71] in commercial premises. The amount of electricity used for this purpose has increased substantially, from 8.4 TWh in 1970 to 29.5 TWh in 2006. This increase has been driven by a rapid growth in the service sector, with a resulting increase in physical floor areas, coupled with a greater variety and use of office equipment. This in turn has resulted in knock-on effects such as more lighting and greater need of comfort cooling.

In order to obtain more detailed data of energy use in commercial premises, the Swedish Energy Agency

67 Statistics for 2006 are preliminary and may be adjusted later.
68 'Land use' includes agriculture, forestry, horticulture and fishing. See the publications "Energy use in agriculture 2002" (Statistics Sweden), "Energy use in the fishing sector 2005", ER 2006:35, and "Energy use in forestry 2005", ER 2007:15 for more detailed information on energy use in these sectors. Information on energy use in horticulture can be found in the report "Horticultural production, 2005", which can be downloaded from: www.jordbruksverket.se. [Note that these reports are in Swedish.]
69 "Energy use in the building sector, 2004" ER2006:02. (In Swedish).
70 Since 2003, the reference period for meteorological data for statistical correction to an average year has been 1970-2000. Until 2002, it had been the period 1961/62–1978/79.
71 Electricity for building operations is given by a statistical summing of electricity used for building services systems and that used by the business carried on in the building. Electricity for building services systems is that used for fixed installations and for climate control in the building, such as elevators, escalators and general lighting.

Figure 12: Electricity use in the residential and service sector, 1970–2006, statistically corrected for weather conditions.



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

is part-way through a seven-year investigation (that started in 2005) of energy use in a sample of about 1000 commercial and similar premises. The investigation, under the name of STIL2, is intended to provide data on the use of energy and electricity in various sorts of premises (offices, schools, health care facilities etc.) and for various applications. The results from the first year's collection of data for office premises show that there are considerable variations in energy use in different buildings. In general, over half of the electricity used is for the particular activity being carried out, with lighting and computers accounting for the largest proportions (21 % and 14 % respectively). Electricity for building services systems is used mainly for powering fans, which account for over 15 % of a building's electricity use. There is regarded as being considerable scope for further improvements in the efficiency of electricity use in office and commercial premises, as well as in public premises[72].

The use of electricity for domestic purpose[73] increased from 9.2 TWh in 1970 to 22.1 TWh in 2006, 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 2006, the average annual domestic electricity use amounted to about 6200 kWh per house in detached houses, and in apartment buildings to about 40 kWh[74] per m^2 and year.

Over the period 2005-2008, the Agency is carrying out a study to provide up-to-date data on the breakdown of uses of domestic electricity. The preliminary results indicate a wide spread in measured electricity use between households, varying from 2000 kWh/year to 7000 kWh/year for a detached house, and from between 1000 kWh/year and 5000 kWh/year for an apartment. Over the whole year, lighting is the largest user of domestic electricity, followed by electricity use for refrigerators and freezers in second position, and entertainment electronics (TV, computers etc.) in third position.

After correction, the use of electricity for heating in the sector 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. In 2006, electric heating amounted to 21.8 TWh. Electricity used for floor heating and fan heaters also contributes to the heating of a building, but is partly accounted for in the statistics as domestic electricity.

Space heating and domestic hot water

A total of 89 TWh was used for space heating and domestic hot water production in 2006, equivalent to 94 TWh after correction for a statistically average climate year. Of this, about 42 % (37 TWh) was used in detached houses, 32 % (28 TWh) in apartment buildings and 26 % (23 TWh) in commercial premises and public buildings.

The most common form of heating in detached houses is electric heating, used by about a third of them in 2005. Of these, over half have direct electric heating, with the rest having waterborne electric heating. 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.

The use of direct electric heating in combination with some other form of heating is common in detached houses: about 40 % of detached houses had some form of combination heating system in 2005. About 7 % had rock, earth or lake water heat pumps, and 22 % had dual-fuelled boilers, which allow households to change between electricity, oil and/or biofuels. They are relatively flexible, with their use being largely determined by the relative price levels of the different energy carriers. Other households, not having this ability to quickly change their energy carriers, are more vulnerable to changes in the relative prices of energy carriers.

About 8 % of detached houses were heated solely by district heating, 11 % were heated solely by biofuels, and 6 % were heated solely by oil. Other detached houses had other combinations or were heated by gas.

72 As part of the work of the "Statistics in the Built Environment" project, the Agency has set up a web portal www.enyckeln.se that provides energy statistics for apartment buildings and commercial premises

73 Domestic electricity is that which is used for lighting, white goods, domestic appliances and other electrical equipment in a home.

74 This guide value figure was developed from a questionnaire investigation of energy use by apartment residents, carried out by Statistics Sweden over the period 1997–1999. Prior to 1999, the figure had been 50 kWh/m2, year.

A total of 11.2 TWh of biofuels, 5.4 TWh of oil, 3.7 TWh of district heating and 0.4 TWh of gas was used for space heating and domestic hot water production in detached houses.

District heating is the most common form of heating in apartment buildings, with about 77 % of apartments being heated by it in 2005[75]. Oil is used as the sole heat source for 2 % of apartments, while 3 % 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, 1.7 TWh of electric heating, 1.3 TWh of oil, 0.4 TWh of gas and 0.3 TWh biofuels.

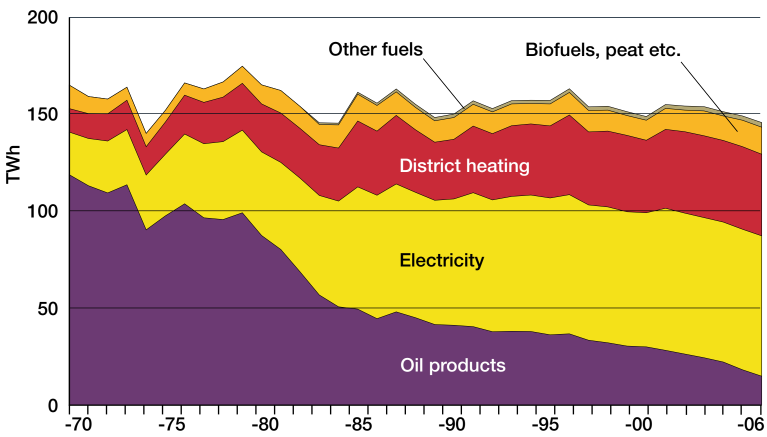
The main source of heat in offices, commercial premises and public buildings is also district heating, with about 59 % of such buildings in 2005 being supplied solely with district heating. About 7 % of this floor area was heated by electricity alone, and about 4 % by oil alone. A further 3 % was heated 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, 3.6 TWh of electric heating, 1.9 TWh of oil, 0.6 TWh of gas and 0.4 TWh of biofuels.

Changes in the residential and service sector

The relative proportions of the different energy carriers have changed since the 1970s, which can be seen in Figure 13. Oil crises, rising energy prices, changes in energy taxation and investment policies have all affected the shift from oil to other energy carriers. In 2006, total use of oil fuels in the sector amounted to 14.9 TWh, about one-seventh of consumption in 1970 (118.6 TWh). Much of this reduction is due to a growing move away from the use of oil for heating to district heating, electricity or biofuels. Figure 13 shows how the use of oil has declined in this sector in recent years. An important reason for this has been the rise in oil prices. The use of biofuels for heating is becoming increasingly common in the sector, particularly in detached houses. The most common of such fuels is logs, although pellets and wood chips are also used.

The total statistically corrected energy use in this sector remained relatively stable between 1970 and 2000, after which it has started to show a decline, particularly in respect of energy supplies for space heating and domestic hot water production. The most important reason for this decline in recent years is that different energy carriers have different distribution and conversion losses at the point of use, depending on whether it is a fuel (e.g. oil) or a ‘ready-to-use’ (district heating or electricity) energy carrier that is being used. A reduction in total final energy use in the residential and service sector, due to the replacement of oil by electric heating or district heating, results in increased losses in the conversion sector[76] which can skew the picture of improvements in the efficiency of energy use in the sector.

Figure 13: Final energy use in the residential and service sector, 1970–2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Another contributory reason for the reduction in energy use in the sector is the increase in the number of heat pumps. Heat pumps deliver three times as much thermal energy as they use in the form of electrical energy for driving them[77], which means that their use reduces the actual use of energy 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.

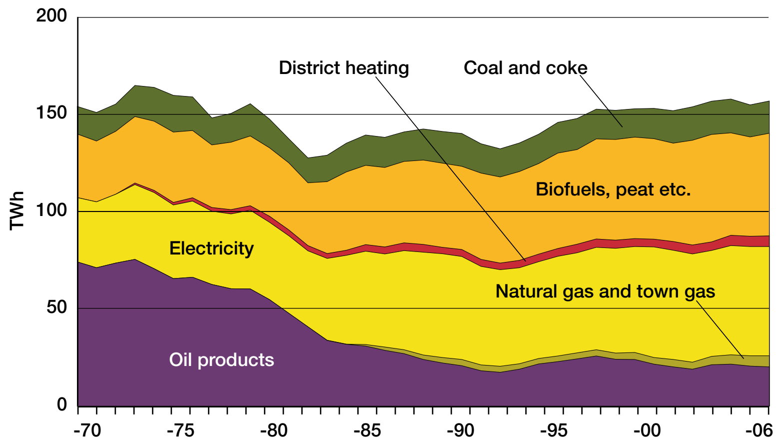
Other factors that reduce energy use for space heating and domestic hot water production in residential buildings and commercial premises include various energy conservation measures, such as retrofitting additional thermal insulation or upgrading windows in older buildings. Technical development is steadily improving the efficiency of equipment that replaces older products having higher energy consumptions. Manufacturers constantly update their product ranges, the energy efficiency of which is steadily improving, although this is countered by the general parallel increase in the number of electrically powered items used.

Industry

In 2006, industry used 3.4 TWh more energy than during 2005, amounting to 157.0 TWh or about 39 % of the country’s final energy use. Industry’s use of energy was met by 20.2 TWh of petroleum products,

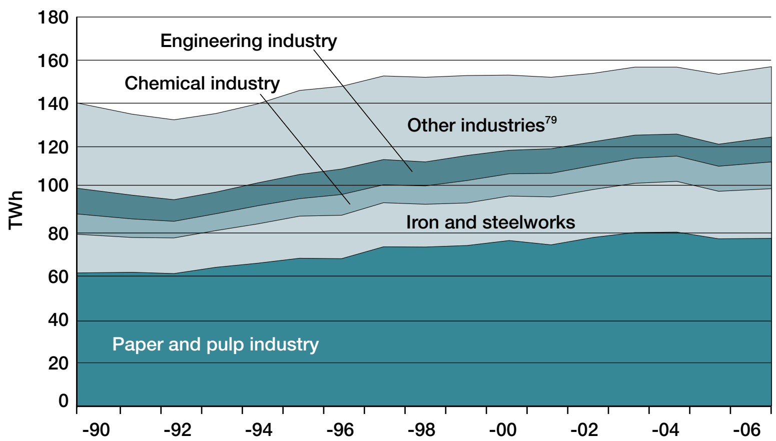
[75] In addition to this, district heating was used in combination with other forms of heating for 5 % of floor areas.
[76] See also Chapter Sweden’s Energy Balance, under ’System boundaries’.
[77] Heat pumps in energy statistics – Suggestions, www.energimyndigheten.se

Figure 14: Final energy use in industry, 1970-2006



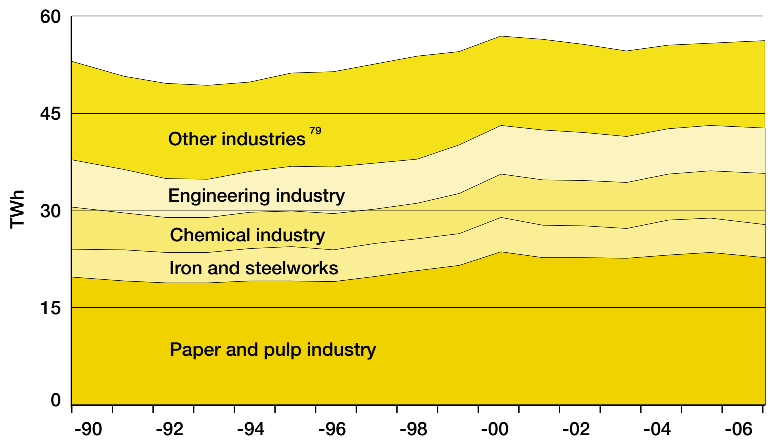
SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 15: Energy use in industry, by sectors, 1990-2006.



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 16: Electricity use in industry, by sectors, 1990-2006.



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

16.6 TWh of coal and coke and 56.2 TWh of electricity. Use of natural gas amounted to 5.7 TWh, and that of district heating to 5.5 TWh. The use of biofuels, peat etc. amounted to 52.8 TWh, see Figure 14. Final energy use in industry therefore consisted of 27 % of fossil energy and 34 % 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, see Figure 15. The pulp and paper industry uses about 49 %, primarily electricity and black liquors[78]. The electricity is used mainly for grinders producing mechanical pulp, while the black liquors provide fuel for soda recovery boilers in sulphate mills. The iron and steel industry uses about 15 % of industry's energy, primarily in the form of coal, coke and electricity. Coal and coke are used as reducing agents in blast furnaces, while the electricity is used chiefly for arc furnaces for melting steel scrap. The chemical industry takes 8 % of industrial energy use, mainly electricity used for electrolysis processes. Together, these three energy-intensive sectors account for almost three-quarters of total energy use in industry. The engineering industry, although not regarded as energy-intensive, never-the-less 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 2002-2006. Over the period 2000-2006, industrial output increased by almost 3 % per annum. Energy use increased by almost 3 % over the whole period, but electricity use fell by about 1 %. In total, industrial output has increased by 102 % between 1992 and 2006, for an increase of 17 % in total energy use and 13 % in electricity use.

Changes in use of the most important energy carriers

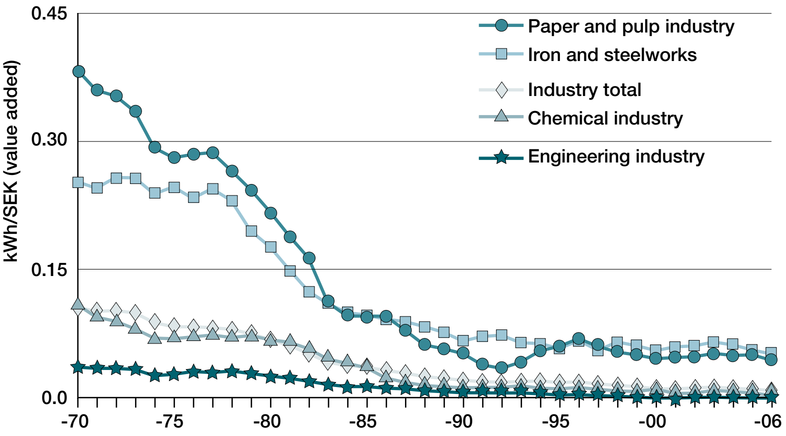
Despite rising industrial output, the use of oil has fallen substantially since 1970, due to greater use of electricity and improvements in the efficiency of energy use. This trend started in connection with the oil crises of the 1970s, which resulted in both State and business starting intensive work aimed at reducing the use of oil. In 1970, the use of oil constituted 48 % of industry's total energy use, which can be compared with the present proportion of 13 %. At the same time, the use of electricity has increased from 21 % to 48 % of industry's energy use. Other forms of energy carrier, such as electricity, have 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 almost 73 % since 1970, the use of oil products increased by almost 3 TWh, or 16 %, between 1992 and 2006. 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[80]. Biofuels are the main energy provider in the pulp and paper industry and in the wood products industry. Between 1970 and 2006, the proportion of biofuels, peat etc. has increased from 21 % to 34 % 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 2006, it fell by 58 %, reflecting a clear trend towards less energy-intensive products and production processes, together with structural changes in the sector. During this period, industrial output value has more than doubled.

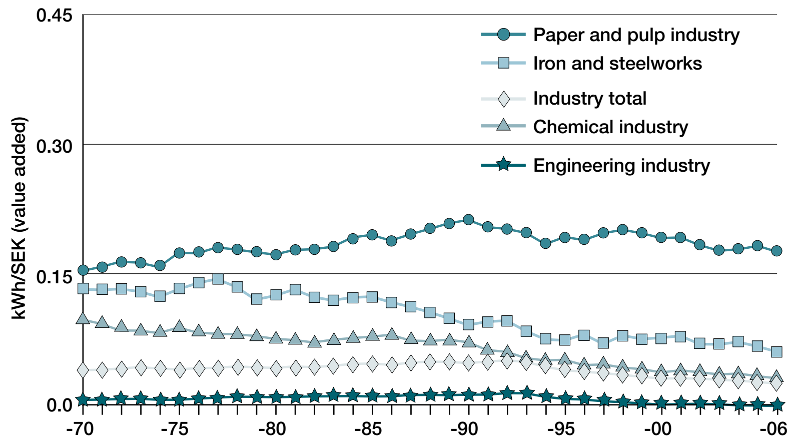
The change from oil to other energy carriers, particularly electricity, is reflected in the specific use of oil and electricity per unit of output value. Specific use of oil fell by 81 % between 1970 and 1992, while specific use of electricity increased by 23 %. Ups and downs in the economy between 1992 and 2006, coupled with changes in the energy taxation of industry, are reflected in changes in specific energy use, which continues to fall. Over this period, it fell by 42 %, with specific use of oil falling by 44 % and that of electricity also by 44 %. More generally, the reduction in specific energy use is due to the fact that production value has increased considerably more than has energy use. For several reasons, we can expect a continued fall in specific energy use. Over a longer period of time, technical development and structural changes have reduced specific energy use.

Figure 17: Specific use of oil in industry, 1970-2006, (2000 price level)



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 18: Specific use of electricity in industry, 1970-2006, (2000 price level)



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Transport

Total energy use for transport in 2006 amounted to about 126 TWh, see Figure 19. Of this, domestic transport used about 93 TWh, and foreign transport (including bunkering for foreign maritime traffic and air transport) used about 33 TWh.

Energy use in the transport sector consists mainly of oil products, primarily petrol and diesel fuel. In 2006, the use of these two fuels met 89 % of the country's energy requirement for domestic transport, with electricity accounting for a further 3 % and aviation fuel for 3 %. The remaining energy requirement for transport was met by medium and heavy fuel oils, natural gas and ethanol. The use of petrol has declined

78 Black liquors are a by-product of pulp manufacture in sulphate pulp mills. They can be burnt to recycle chemicals and release energy.

79 'Other industries' include the mining industry, metal industry, wood products industries, quarrying and the food industry.

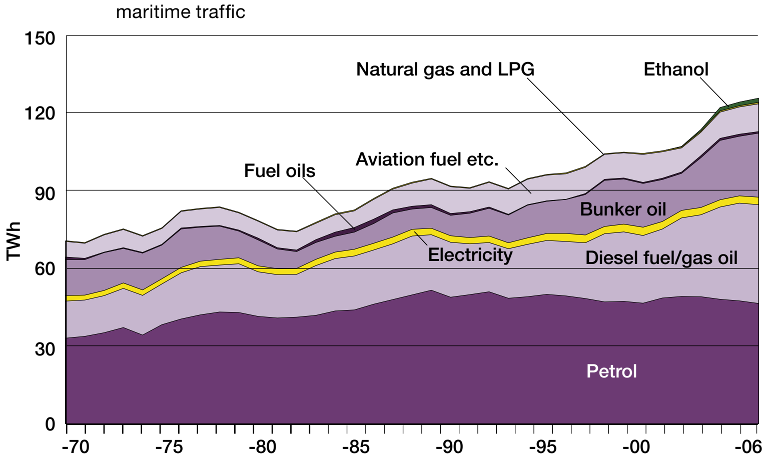
80 Electric boilers provide a means of switching between electricity and an alternative fuel, e.g. in response to high electricity prices.

somewhat since 2002, which can be partly explained by increased use of ethanol admixture, and also by a falling proportion of petrol engines in passenger cars and light commercial vehicles. The use of diesel fuel has increased steadily over the period 2000-2006, which is largely due to a steadily increasing proportion of diesel-powered vehicles among new vehicle sales. In 2006, the proportion of new vehicles that were diesel-powered was 19.7 %, against 9.7 % in the previous year[81]. The use of aviation fuel decreased over the period 2000-2003 and then increased in 2004-2006. This increase over the last three years is due partly to improved economic conditions and partly to increased competition giving rise to a large number of cheap flights. Bunkering for international maritime traffic increased in 2006, partly due to the fact that maritime traffic is experiencing a period of strong growth.

In 2006, renewable motor fuels (ethanol, FAME[82] and biogas) supplied about 3.1 % of the energy use for road traffic. At present, the costs of producing alternative motor fuels exceed the corresponding costs for petrol and diesel oil. However, this difference in cost, and the difference in cost of using such fuels instead of petrol or diesel fuel 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 present, biobased motor fuels are untaxed, which means that their cost at the pump can be less than that of conventional fuels despite a higher production cost. At the beginning of June 2007, a litre of 95-octane unleaded petrol cost about SEK 12.09. The corresponding price of a litre of E85 fuel (consisting of 85 % ethanol and 15 % petrol) was about SEK 7.89. 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. Allowing for this, the cost of using E85 at that time was about SEK 2.00 per petrol-equivalent litre less than the cost of petrol. LPG as a motor fuel was also cheaper than petrol, with a difference of on that date of about SEK 3.50/litre (petrol-equivalent)[83].

[81] BIL Sweden
[82] FAME is an umbrella name for fatty acid methyl esters, of which ROME (rapeseed methyl ester) is the most common in Sweden today.
[83] Svensk Biogas, www. svenskbiogas.se, 2007-06-01
[84] The National Rail Administration, *Sector report 2006.*

Figure 19: Final energy use in the transport sector, 1970–2006, including foreign maritime traffic



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Transport work

The total domestic passenger transport work in 2006 amounted to about 134 thousand million person-km. Road traffic dominates this, with about 87 % of passenger transport work in 2006, with railways carrying about 9 % of passenger traffic, aviation almost 3 %, and domestic water traffic about 1 %. About 70 % of long-distance passenger travel (i.e. trips over 100 km) was provided by car traffic. For short-distance travel, car and motor cycle use accounted for about 77 % of journeys.

Domestic goods transport in 2006 amounted to 98.8 thousand million tonne-km. This is the highest amount to date, representing a slight increase over 2005. A significant contributory factor to this was due to the road and rail transport of storm-felled trees in the wake of storm Gudrun. Transport work resulting from the storm, which occurred at the beginning of 2005, amounted to 2.7 thousand million tonne-km in 2005, and to 0.6 thousand million tonne-km in 2006. If the total transport work is reduced by these temporary flows, the increase in goods transport in 2006 over 2005 would have amounted to 2.5 thousand million tonne-km, which is a significant increase. Of the total goods transport, 40 % were carried by road, 22 % by rail and 38 % by ship[84].

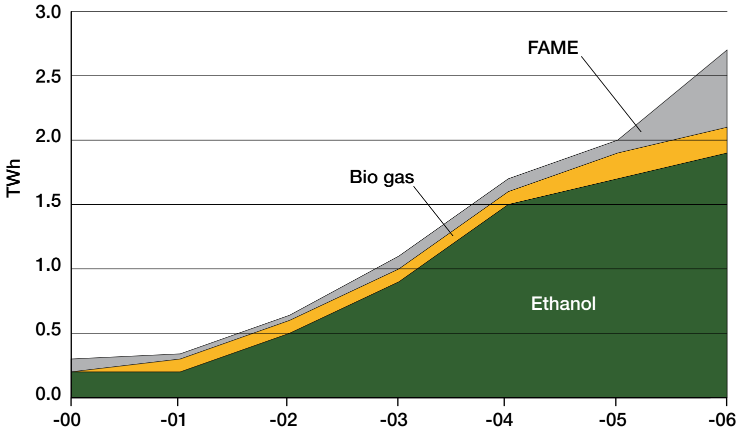
Development of alternative motor fuels

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 m^3 of petrol or diesel fuel per year must also supply at least one renewable fuel. The effect has been that the petrol stations have installed almost exclusively E85 pumps. A government grant has been introduced to help petrol stations meet the cost of supplying renewable fuels other than ethanol. Up to March 2007, grants had been approved for 57 installations of biogas pumps around the country.

With effect from 1st August 2006, the permissible admixture proportion of FAME in diesel fuel has been raised to 5 %, which increased its sales during the second half of 2006. In December 2006 over 60 % of all diesel fuel contained 5 % admixture of FAME. However, due to problems with engines in some heavier vehicles, this was reduced to only 2 % during the winter of 2007. Similar problems have occurred in some parts of the country with E85 fuel, with starting problems arising at relatively modest winter temperatures. In addition, exhaust emissions are high when engines are started. One solution to this problem is to use fuels with a higher petrol content during the winter and a Swedish standard for winter-grade E85 has been developed.

At the beginning of January 2007 there were about 11 500 LPG-powered vehicles in Sweden of which 10 400 were private cars, 760 were buses and 340 were refuse collection vehicles or distribution vehicles[85]. There were also over 47 000 flexible-fuel vehicles in the country.

Figure 20: Final energy use of renewable motor fuels, 2000–2006



SOURCE: STATISTICS SWEDEN, THE SWEDISH ENERGY AGENCY AND THE SWEDISH GAS ASSOCIATION

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 expected that hybrid vehicles will achieve commercial breakthroughs during the next ten years. A hybrid vehicle has two alternative drive systems, such as an electric motor and a combustion engine. Development is also in progress of what are known as plug-in hybrid vehicles, which are electric hybrid vehicles that can also be recharged off the mains. It would 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.

Technical development does not stand still, either, in the fields of rail, air or maritime traffic. In the aviation field, the LFV Group (previously the Swedish Civil Aviation Administration), together with SAS, has tested what are known as 'green approaches'. Under this, information in the aircraft's flight management system and in the ground control systems are jointly processed in a manner that has not been done previously. This exchange of information allows the controllers to plan the approach more exactly than is at present possible, so that the aircraft can glide for much of the approach, thus reducing noise and emissions[86].

2007 will see the launch of a number of new fuels for road traffic. One of these is what is known as Diesel Eco 20, consisting of 20 % biofuels and 80 % fossil fuel, reducing carbon dioxide emissions by about 12 % in comparison with emissions from regular diesel fuel.

Projects are in progress in a number of Swedish cities with the aim of creating local public transport systems operating on renewable fuels. Examples of current projects include trolleybuses in Landskrona powered by renewable electricity from wind and hydro power, buses in Sundsvall running on paradiesel (a mixture of biodiesel and Fischer-Tropsch-diesel), hydrogen admixture in natural gas for buses in Malmö and the world's first biogas-powered train in Linköping.

Stockholms Lokaltrafik has decided to, during 2008, carry out a large-scale trial of electric hybrid buses. The buses will be powered by an electric motor, combined with a diesel engine running on ethanol. Electricity will be stored, not in batteries as in traditional hybrid vehicles, but in lighter and more efficient super-capacitors. It is hoped that this concept will significantly reduce both noise and fuel consumption. ■

[85] The Swedish Gas Association

[86] LFV Group (previously, the Swedish Civil Aviation Administration), www.lfv.se, 2007-05-30

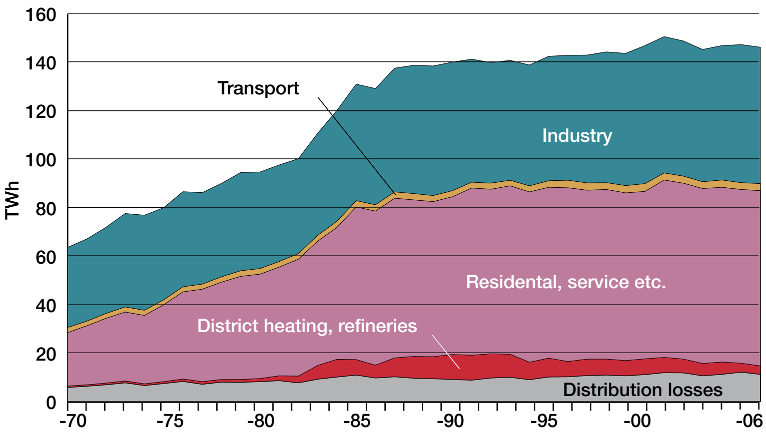
Energy markets

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 around the world, and is affecting the markets for fossil fuels, biofuels and electricity. With the growing world-wide demand for energy, any unexpected event can have repercussions on many different 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 in recent 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, 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 increases in taxation have also increased the price of electricity to consumers.

Figure 21: Electricity use in Sweden, by sectors, 1970–2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Use of electricity

Between 1970 and 1987, electricity use in Sweden increased at an average rate of almost 5 % per year. This rate of increase has since declined to less than about 0.3 % per year on average. Electricity use over the last three years has remained relatively constant. 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 2006 amounted to 146.1 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 Iceland, Norway and Canada have higher per-capita levels. 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 13 % 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 2006, nuclear power supplied 46 % of the country's electricity, hydro power supplied about 44% and the remaining 10 % was made up of fossil-fuelled and biofuel-based production and wind power. Total production amounted to 140.1 TWh, which was almost 9 % less than in 2005.

At 61.2 TWh hydro power production was 15 % less than in 2005, due to low precipitation during the spring. The country's nuclear power stations produced 65.0 TWh in 2006, or 13 % less than the record production of 2004. This was due partly to production problems at Forsmark 1 as well as problems at other nuclear power stations during the summer and autumn. Combustion-based electricity production amounted to 13.0 TWh, with 61 % of the fuel input being in the form of biofuels, 20 % consisting of coal, 14 % of oil and 5 % of natural gas. In comparison with 2005, the proportions of biofuels, natural gas and oil have increased, while that of coal has decreased. Today, it is combined heat and power production (CHP) and industrial back-pressure production that dominate combustion-based electricity production, while oil-fired cold condensing power plants and gas turbines serve primarily to provide reserve capacity. Wind power production during the year amounted to almost 1 TWh.

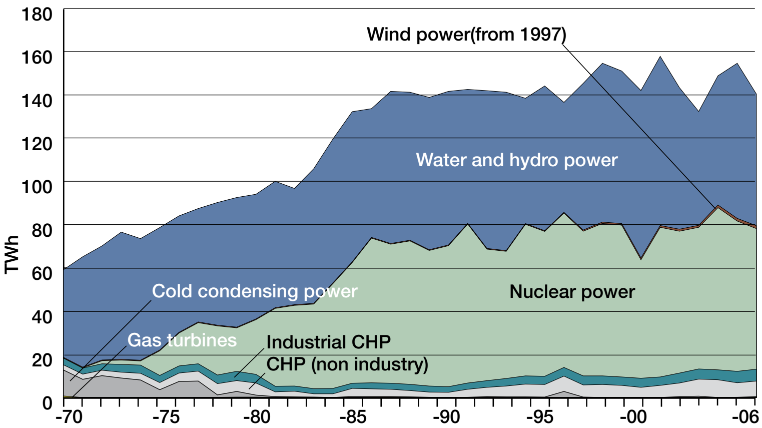
99 % of electricity production in Norway is based on hydro power. In Denmark, most electricity is produced from thermal power, although the country also has a relatively high proportion of wind power (18 %). In Finland, over half of the country's electricity is produced by non-nuclear thermal power, with a further 33 % being produced by nuclear power and 20 % 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 2005, 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 and so, at all times, there must be a balance between demand and production. To ensure this, there must be a party responsible for overall operation of the system.

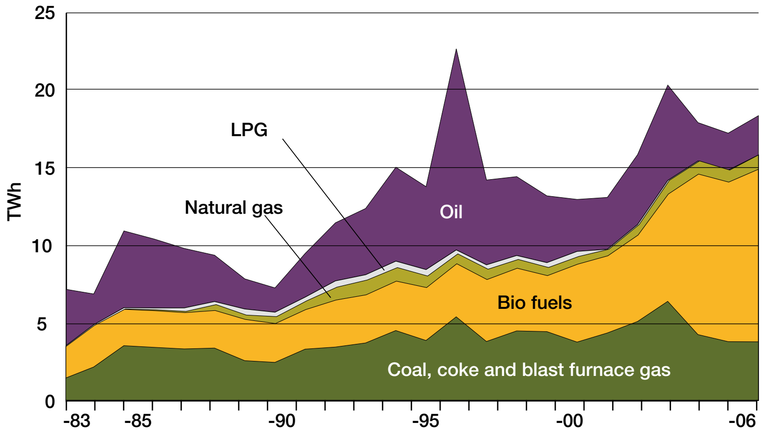
In Sweden Svenska Kraftnät is responsible for maintaining this balance. It is also responsible for operation and maintenance of the country's bulk power transmission grid.

Figure 22: Sweden's electricity production, by types of energy source, 1970–2006



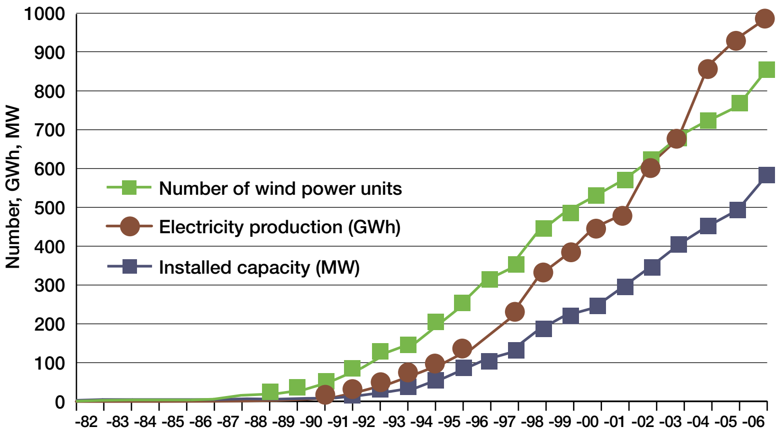
SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 23: Fuel input for electricity production (excluding nuclear fuel), 1983-2006



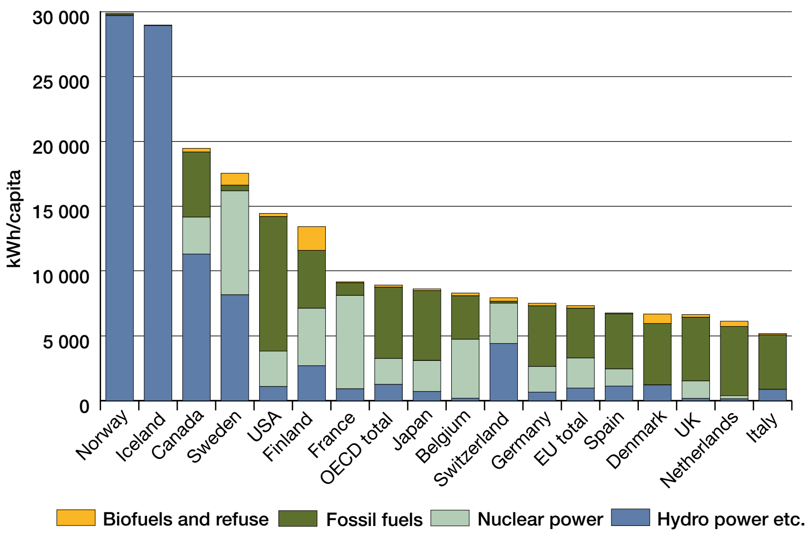
SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 24: Wind power production, 1982–2006



SOURCE: SWEDISH ASSOCIATION OF ELECTRICAL UTILITIES AND THE SWEDISH ENERGY AGENCY'S ANNUAL REPORT ON THE ELECTRICITY CERTIFICATE SYSTEM

Figure 25: Per-capita electricity production, by types of production, 2005



SOURCE: ELECTRICITY INFORMATION 2006 IEA/OECD

Note. 'Hydro power etc.' includes wind power, solar electricity and geothermal electricity.

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 15 000 km of cables and overhead lines, is a high-voltage transmission system carrying electricity over long distances and to neighbouring countries. The regional grids, which consist of about 36 000 km of lower-voltage lines, 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 477 000 km of lines, are owned primarily by the large power companies 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 30 000 km of overhead lines, resulting in a power failure that affected thousands of businesses and well over half a million domestic consumers. As a result, work on reinforcing local distribution networks has been further stepped up, with a change to buried cables as the main alternative. At present, almost 58 % (276 000 km) of local networks are in the form of buried cables.

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, whose duties include responsibility for surveillance of the tariffs of the grid owners, ensuring that they comply with regulations concerning metering and that they provide good security of supply. A special unit, the Energy Market Inspectorate, was set up within the Agency on 1st January 2005 to take over these duties. On 1st January 2008, the Inspectorate will become an autonomous public authority. 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[87] 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 are 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 2006, Sweden's total installed capacity was 33 819 MW, made up of 16 180 MW of hydro power (47.8 %), 580 MW of wind power (1.7 %), 8 965 MW of nuclear power (26.5 %), and 8094 MW (23.9 %) of other thermal power. Maximum system load in 2006 occurred on 19th January between 17.00 and 18.00, and amounted to about 26 300 MW[88]. This can be compared with Sweden's hitherto highest system load of 27 000 MW, which occurred in January 2001[89].

As a result of deregulation of the electricity market, electricity producers took a considerable amount of peak load capacity out of operation, as plants that were seldom used did not justify their costs. In 2003, legislation was therefore brought in to require a certain amount of reserve capacity. Svenska Kraftnät has been given temporary responsibility for negotiating a maximum reserve capacity of 2 000 MW. This has been done by Svenska Kraftnät 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. Discussions are under way at present to decide how reserve capacity is to be assured when the present Act (2003:436) Concerning Reserve Capacity expires. The 2007 Autumn Budget Bill has proposed that the Act should be extended until March 2011[90].

87 Nordel is a pan-Nordic organisation for the national network operators in the Nordic and Scandinavian countries. In addition to Sweden's Svenska Kraftnät, it includes the Norwegian Statnett, the Finnish Fingrid, the Danish Energinet and Iceland's Landsnet.
88 Svensk Energi.
89 Svenska Kraftnät.
90 Prop. 2007/08:1.
91 According to reported data to the Swedish Energy Agency.
92 For customers with an annual use <50 MWh.

Electricity trading

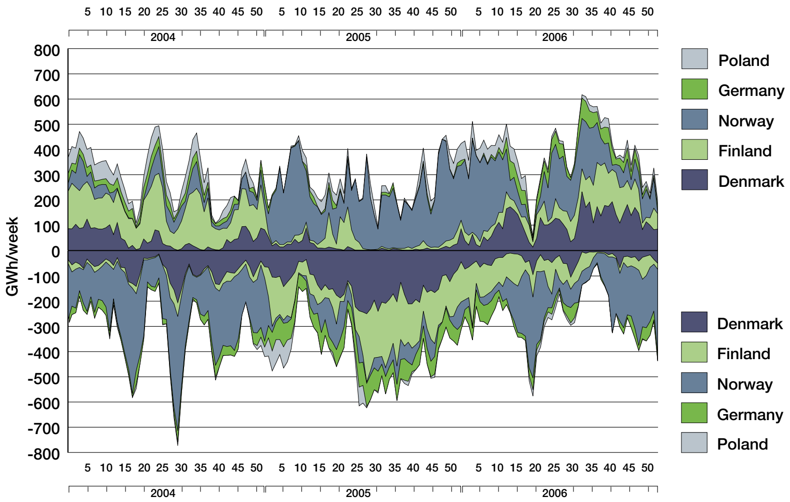
Trading of electricity production is vital in order to ensure a properly operating electricity market. Since deregulation, this has been provided by a joint Nordic electricity power exchange, Nord Pool, which facilitates the economic use of Nordic power plants and offers transparency of pricing. It has two main markets: one for trading in physical electricity, and one for trading in financial instruments. In 2006, over 63 % of the electricity used in the Nordic countries (apart from Iceland) was traded on Nord Pool's physical electricity spot market, an increase from 45 % in 2005. The remaining electricity was traded internally between 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 766 TWh, about 20 TWh less than in 2005, partly as a means of ensuring prices and partly for speculative purposes. Bilateral financial standard contracts can also be cleared via Nord Pool: in 2006, a volume of 1454 TWh was traded in this way. Members of Nord Pool consist of power producers, power suppliers, larger end-users, portfolio managers, fund managers and brokers. The majority of all electricity consumers purchase their power from suppliers on the end-user market. Nowadays, Swedish electricity certificates and EU emission allowances are also traded Nord Pool via power brokers and bilaterally.

In 2006, Sweden had a net import of 6.0 TWh of electricity, as against a net export of 7.4 TWh in 2005. This was largely due to the relatively low run-off of melt water during the spring, with low reservoir levels as a result, and to operational problems leading to shutdowns in the nuclear power stations. Electricity trade flows between Sweden and its neighbours vary during the year and from year to year, depending on price differences between Nord Pool areas. These price difference can arise due to differences in (for example) precipitation and reservoir fill percentages. In 2006, Sweden was a net importer of electricity, primarily from Denmark. The Nordic countries as a whole were net importers of 11.5 TWh in 2006, which can be compared with a net export of about 1 TWh in 2005.

Electricity price development and makeup

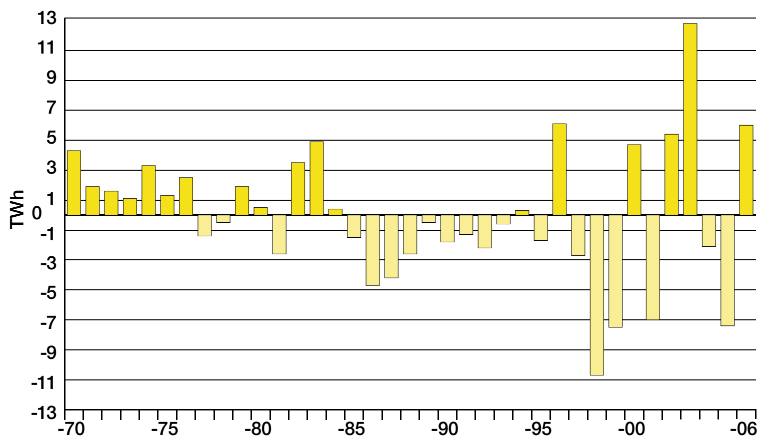
The total electricity price to the customer consists of the price of the electricity itself, the price of green electricity certificates, the network price, energy tax and value-added tax and the network company's profit. Of these, it is the price of the electricity itself and that of the electricity certificates that are subject to

Figure 26: Sweden's electricity imports (+) and exports (-), January 2004 -December 2006



SOURCE: SWEDENERGY AND THE SWEDISH ENERGY AGENCY

Figure 27: Sweden's net import (+) and export (-) of electricity, 1970-2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

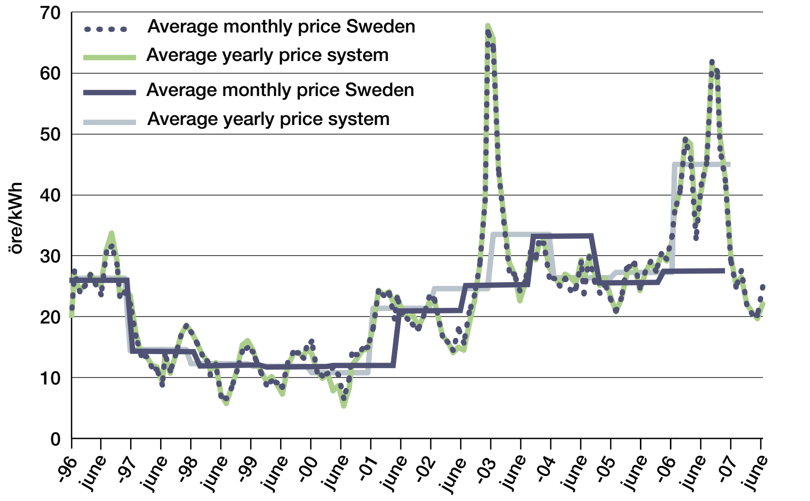
Table 7: Total price of electricity (excluding electricity certificates) for different customer categories, including network charges, tax and value-added tax, öre/kWh

Datum	Light industry[1]	Det. house w. electric heating[2]	Det. house without electric heating[3]
1 January 2002	43.8	87.9	111.3
1 January 2003	59.9	111.4	135.4
1 January 2004	62.4	117.9	143.6
1 January 2005	55.2	109.9	135.9
1 January 2006	61.3	117.4	143.9
1 January 2007[4]	82.1	144.4	171.3

SOURCE: SWEDENERGY AND THE SWEDISH ENERGY AGENCY

Note. These are average prices from the network companies, available to each customer group on 1st January of the respective years. [1] Annual use 350 MWh, max. power 100 kW or 160A. [2] Annual use 20 000 kWh, 20 A main supply fuse. [3] Annual use 5 000 kWh, 16 A main supply fuse. [4] Including the green electricity certificate price.

Figure 28: Spot prices on Nord Pool. Monthly and annual average prices for the system and for Sweden, January 1996-June 2007



SOURCE: NORD POOL, FTP SERVER

competition. In January 2007, the total price of electricity for domestic consumers in detached houses without electric heating was made up of about 41 % for the electricity itself, 24 % for the network charge, 15 % for energy tax and 20 % for value-added tax. The price of electricity may be fixed for e.g. one, two or three years, or it may be variable, with or without a fixed term and depending on such factors as the average monthly price on the power exchange. However, almost half 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[91] charged to customers by the electricity companies was 2,7 öre/kWh[92]. For most domestic customers, electricity tax has increased by 6 öre/kWh since 2002, an increase of 3 %. 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 2006 as a whole, the average spot price was 45.0 öre/kWh, an increase from 27.2 öre/kWh in 2005. Despite a relatively normal inflow to the reservoirs for the year as a whole, the price of electricity in 2006 was at a record high. During the first four months of the year, the rise in the price was due primarily to rising prices of emission allowances, so when the price of these allowances fell drastically at the end of April, the price of electricity fell with them. The highest daily mean price of the year was reached at the end of August, driven by extensive production problems in the nuclear power stations during the end of the summer and the autumn, low reservoir levels and the need to import electricity.

The situation turned in October, with inflow to the reservoirs increasing and the Nuclear Power Inspectorate permitting Forsmark 1 and 2 to be restarted. At the same time, mild weather resulted in low demand, which also affected the price of electricity. The hydrological balance became positive in November, and continued to be so during the beginning of 2007. This, in combination with falling prices for emission allowances, has resulted in average electricity prices during the first half of 2007 being lower than they have been for a long time.

Development of the internal electricity market

The electricity market in many parts of the world is at present undergoing extensive changes in terms of changing market conditions, new technology and more stringent environmental requirements. Within the EU, policy is concerned largely with deregulation and harmonisation in order to achieve a competitive market, measures to ensure the security of energy supply and the establishment of sustainable development and environmental conditions. Directive 2003/54/EC[93] sets out common rules for production, transmission, distribution and supply of electricity. Under its time plan all non-domestic customers have been able to choose freely from among competitive suppliers since July 2004, which must also apply to domestic consumers by not later than July 2007. However, the degrees of openness and deregulation vary between EU states.

The reform of the electricity markets means that electricity can be traded, transported and supplied across national borders. The power utilities are developing into larger and more integrated energy utilities, operating in several countries. In a trans-national market, electricity is produced where it is technically and economically most favourable to do so. The ordinance from 2003 concerning conditions for access to cross-border connections for trade in electricity is intended to ensure fair conditions for such trade, and thus to improve competition on the single market for electricity[94].

93 Directive 2003/54/EC of the European Parliament and of the Council of 26th June 2003 concerning common rules for the internal market in electricity and repealing Directive 96/92/EC.

94 Regulation (EC) no. 1228/2003 of the European Parliament and of the Council of 26th June 2003 on conditions for access to the network for cross-border exchanges in electricity.

Electricity from renewable energy sources is at a disadvantage on competitive markets due to its high production costs. Directive 2001/77/EC[95] is intended to encourage the production of electricity from renewable sources. Each member state is free to choose whatever method it prefers to encourage the production of renewable electricity. Sweden has chosen a certificate trading scheme, which has been in operation since May 2003.

The district heating and district cooling markets

District heating has been used in Sweden since the 1950s, but district cooling did not appear until the 1990s. District heating supplies residential buildings, commercial premises and industries with heat for space heating and domestic hot water production, while district cooling, on the other hand, finds a market mainly in the commercial sector for air conditioning of shops and offices, but also 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 most common form of heating in apartment buildings and commercial premises, and the main form of heating in the centres of 247 of the country's 290 municipalities[96]. 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 combined heat and power production (CHP). A CHP power station produces both electricity and heat for hot water. 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 existing building stock. Group heating systems[97] 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. District heating became a net user of electricity, in disconnectable boilers and large heat pumps, rather than a net producer of electricity, which is more common in most other countries with substantial district heating systems. However, in recent years, interest in CHP (now mainly biofuel-fired) has again revived in Sweden, due to such factors as carbon dioxide taxation, changes in the taxation regime for CHP and the electricity trading certificate scheme. Figure 29 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.

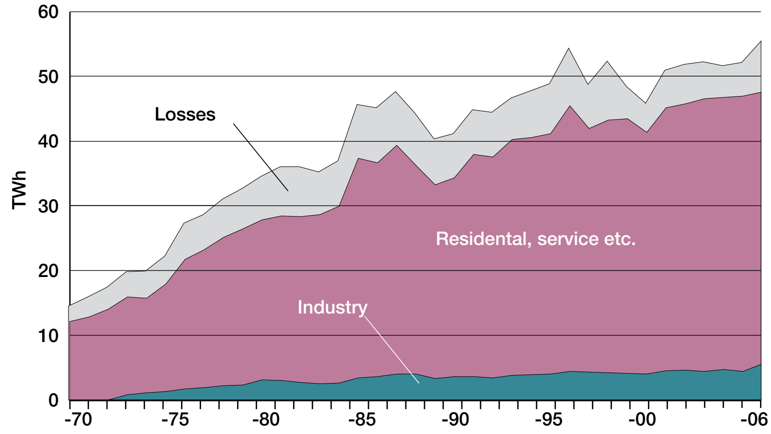
Until 1st March 2007, a conversion grant was available for changing from oil heating to heating from district heating, rock, lake water or earth heat pumps, or biofuel-fired boilers. Grants are still available for conversion from direct electric heating to one of the above alternative systems. 21 % of the conversions from oil heating have been to district heating, while 69 % of those converting from electric heating have converted to district 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 improved as a result of the expansion of district heating and improved flue gas treatment, which have greatly reduced emissions of SO_2, particulates, soot and NOx. District heating is not price-controlled, although the heating market is undergoing changes. The Government intends to present its bill, "A new District Heating Act etc." to Parliament during the autumn of 2007. As district heating requires an expensive infrastructure, it is a de facto monopoly as far as distribution is concerned. This, in combination with the high cost of replacing heating systems in a building wich effectively locks in customers to district heating suppliers, means that customers can be dependent on their district heating suppliers. However, the heating market can be regarded as a competitive market as far as the potential choices facing a new customer are concerned.

The District Heating Commission[98] carried out an in-depth review of the district heating market, submitting its report in June 2005. The purpose of the investigation was to produce proposals for strengthening customers' positions in relation to suppliers. Among the conclusions of the report are suggestions for separate accounting of district heating activities, legal and functional separation between district heating and electricity market activities, the publishing of key performance indicators and the establishment of a district heating panel for negotiations and resolution of conflicts.

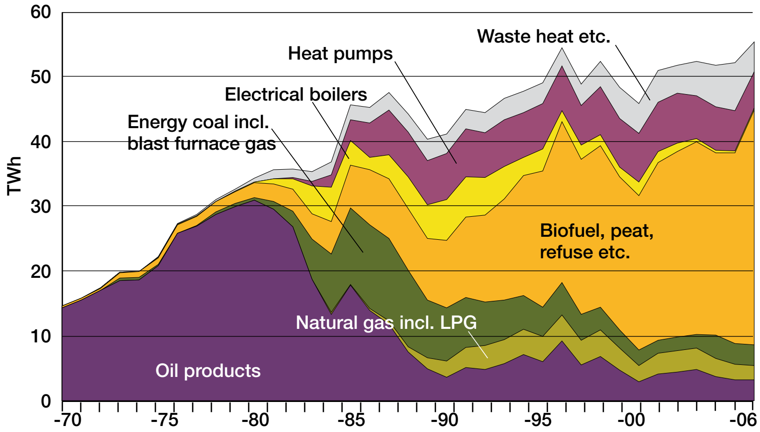
95 Directive 2001/77/EC of the European Parliament and of the Council of 27th September 2001 on the promotion of electricity produced from renewable energy sources in the internal electricity market.
96 The Nils Holgersson Survey, 2007. Formed by five large housing organisations, and monitors local authority charges for heating, domestic hot water, water, sewage treatment, electricity and waste disposal.
97 Boiler plants that supply a single block or a small number of blocks. Previously common in the 1960s' 'Million New Homes' programme areas.
98 SOU 2003:115, 2004:136, 2005:33, 2005:63.

Figure 29: District heating use, 1970–2006



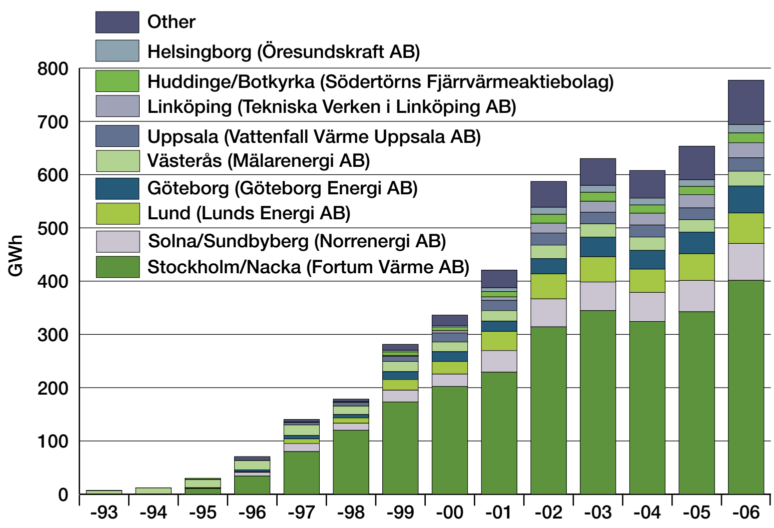
SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 30: Energy supplied by district heating, 1970–2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 31: District cooling supplied, 1993–2006



SOURCE: SWEDISH DISTRICT HEATING ASSOCIATION

The regular price comparisons by the Public Service Fee Group and the Energy Market Inspectorate's annual surveys of the heating markets provide information on significant 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 possible choices of heating systems is very dependent on where the building is located.

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. preventing a company with activities in several fields from using its profits from district heating to compete in a more competitive market, e.g. the electricity market.

New legislation concerning guarantees of origin came into force on 1st July 2006. Under it, producers of electricity and district heating doing so in high-efficiency CHP plants[99] or from renewable energy sources can obtain a Guarantee of Origin from Svenska Kraftnät. The idea is that this guarantee can be used in marketing. At the same time, the requirement for a concession for constructing district heating distribution mains is removed. This, in combination with changed taxation of CHP production, will help to open up the market for district heating production.

Today, district heating supplies about half of the total heating requirement of residential and commercial premises in Sweden. It is the most common form of heating in apartment buildings, supplying heat to about 77 % of the heated floor area, while about 59 % of commercial and similar premises are heated by it. In detached houses, on the other hand, the proportion is only about 8 %.

Over 47 TWh of district heating were supplied in 2006, representing a slight increase compared to 2005. Of the total quantity about 60 % were for residential heating (apartment buildings and detached houses), 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 as 'packaged heat'. This then appears in the statistics as district heating, despite the fact that it is actually district heating without distribution pipes. This 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, 90 % of the fuel input for district heating 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 2006 was over 55 TWh. Figure 30 shows how the proportion of biofuels has increased steadily since the 1970s, when it was about 2 %, reaching 65 % in 2006. 1990 the proportion of biofuels was 25 % and 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 description 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[100] introduced to reduce disposal of waste in landfill.

The use of electricity in the district heating sector, and particularly for supplies to electric boilers, has declined since deregulation of the electricity market. Its use for powering large heat pumps, on the other hand, has remained relatively constant. Since the 1980s, losses from district heating distribution systems have fallen as a result of improved technology and higher load factors. In 2006, distribution and conversion losses amounted to 14 % of the total district heating input, as against a value of almost 20 % in 1980. However, some of this reduction can be explained by an increasing proportion of 'packaged heat' which is not distributed via true district heating distribution systems.

Until the beginning of the 1980s, most district heating plants were operated as local authority services. Since then, the majority have been converted to local authority-owned companies. Today, there are about 220 heat-producing companies in Sweden, although several have the same main owners. Since deregulation of the electricity market, there has been a concentration of ownership in the sector as the larger energy companies have bought up local authority energy companies, including their district heating activities. Nowadays, local authority-owned companies supply about 60 % of the country's district heating. Several of the systems in larger cities, such as Stockholm, Malmö, Uppsala, Norrköping or Örebro, are owned by private or state owners[101].

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 most common 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 sometimes used for district heating. Another common method of production is simply to use cold bottom water from the sea or a lake, i.e. free cooling. A further alternative is to install absorption refrigerant plant, powered by district heating, in or near a customer's premises, which increases the load factor of the district heating system in the summer.

One of Europe's largest district cooling operations has been built up in central Stockholm since 1995. The market for district cooling has expanded strongly since the first system was started up in Västerås in 1992, powered by such factors as higher internal heat loads in offices and shops, greater awareness of the importance of good working conditions and the phase-out of ozone-destroying refrigerants. The progressive prohibitions on the use of such refrigerants have meant that property-owners have been forced to convert existing equipment or invest in replacement systems. Figure 31 shows district cooling supplies in Sweden. In 2006, there were 26 commercial district cooling suppliers, some operating more than one system. 780 GWh of district cooling were supplied, which is an increase of 17 % compared to 2005.

The energy gases market

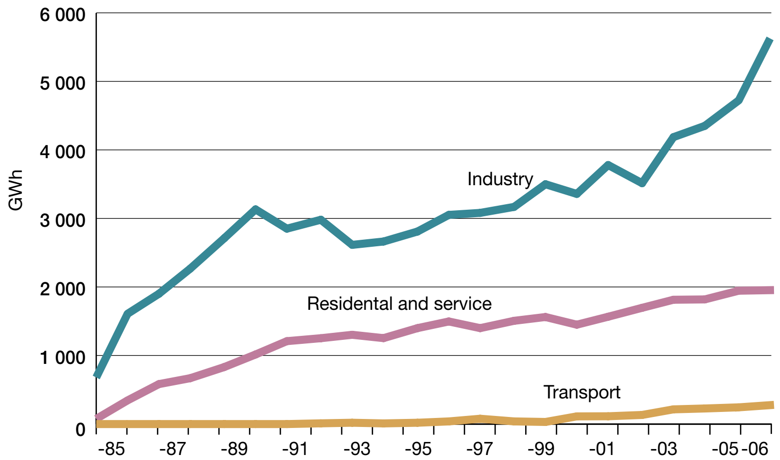
Sweden uses a relatively small quantity of energy gases[102] in comparison with many other European countries. However, the distribution network for natural gas in Sweden is being extended. The rest of Europe is covered by an extensive natural gas distribution network. The use of natural gas in Europe 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 %

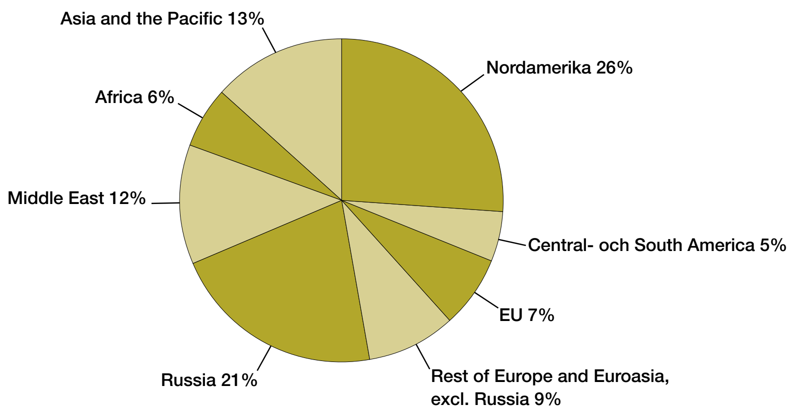
99 High-efficiency CHP uses at least 10 % less fuel than would be used by separate production of the same quantities of heat and electricity.
100 Disposal of sorted combustible waste in landfill was banned in 2002, followed by a ban on disposal of organic waste in landfill in 2005.
101 The Swedish state through Vattenfall, and the Finnish state through Fortum.
102 Energy gases are natural gas, LPG, biogas, town gas and hydrogens.

Figure 32: End use of natural gas in Sweden, 1985–2006, by sectors, GWh



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 33: World natural gas production, 2006. Total: 2865 thousand million m³



SOURCE: STATISTICAL REVIEW OF WORLD ENERGY 2007

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 the extension of the natural gas grid. In 2006, imports amounted to 924 million m³, equivalent to 10,2 TWh. Industry accounts for over 70 % of total use and the residential sector for about 25 %. A small amount of natural gas is also used as motor fuel. Total use of natural gas in 2006 amounted to 7.8 TWh in these user sectors, with about a further 3.0 TWh being used by CHP and district heating plants. Natural gas is at present distributed to about 30 municipalities, where it meets about 20 % of energy demand. On the national 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. However, responsibility for the system does not include its operation. Responsibility for operation, maintenance and expansion of the mains rests with the owners of the respective sections.

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. Swedegas AB (previously Nova Natural gas AB) owns much of the trunk grid. Its trading activities were sold in November 2004 to the Danish Dong Energy A/S. E.ON Gas Sweden 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. The concession for the section from Gislaved/Gnosjö to Jönköping has been supported by the Energy Markets Inspectorate, and the details are now being prepared for a decision by the Cabinet Office. In conjunction with Verbundnetz Gas, Sjællandske Kraftværker and Norsk Hydro, E.ON Gas Sweden AB 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 2006, commercially viable reserves amounted to almost 181 000 thousand million m³, which would last for about 63 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 and at the present rate of use, this would last for only 13 years. Over the last decade, natural gas supplies to the EU states have been increasingly based on production from the North Sea and imports from Russia and Algeria. In order to increase the security of supply, there is European interest in increasing the number of links between the Russian and the Norwegian natural gas fields and the continent. Today, the world's major producing countries are Russia, the USA and Canada. Within the EU, the major producers are the UK and Holland. The proportion of total global energy supply met by natural gas has increased rapidly during the last decade, by about 40 % between 1992 and 2006. Consumption of natural gas is highest in the USA, Russia and Iran. 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 Asian 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, and thus keep down gas prices. 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 to correctly assign the costs for each and to prevent cross-subsidisation. (Cross-subsidisation is the practice of using the revenue from one activity to support another.) This is unacceptable, 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 gas supplier.

The EU Natural Gas Directive was adopted 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 adopted 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.

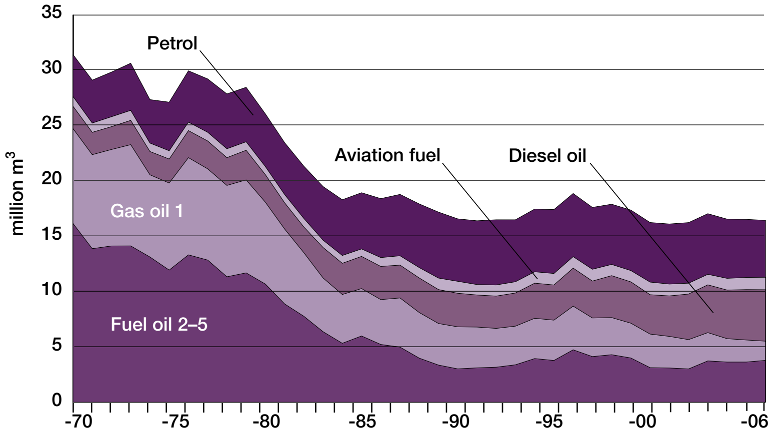
The new Natural Gas Directive necessitated significant changes to Swedish legislation, reflected by the new Natural Gas Act that came into force 1st July 2005. One of the effects of the act is that the two activities of transport and sales of gas in Sweden must be carried out by separate legal parties (unbundling). The new act also specified 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 2006 4.7 TWh of LPG were used in industry, 0.8 TWh in the residential and service sector and almost 0.2 TWh for electricity and district heating production.

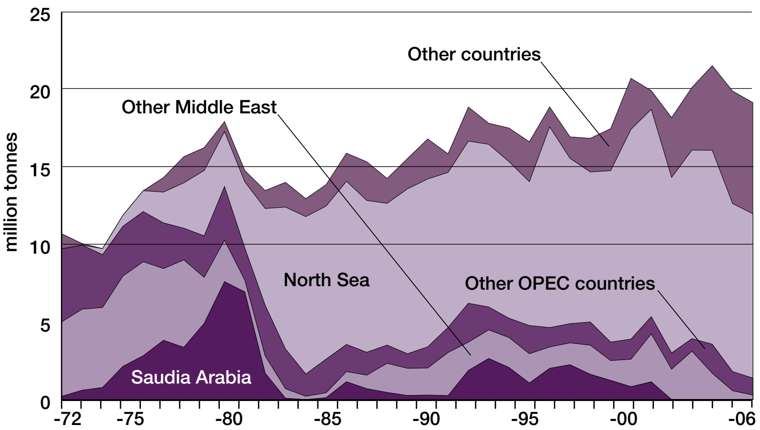
Biogas consists mainly of methane, formed by the breakdown of organic materials such as sewage sludge, domestic waste or industrial waste under anaero-

Figure 34: Use of oil products in Sweden, including foreign maritime traffic, 1970-2006



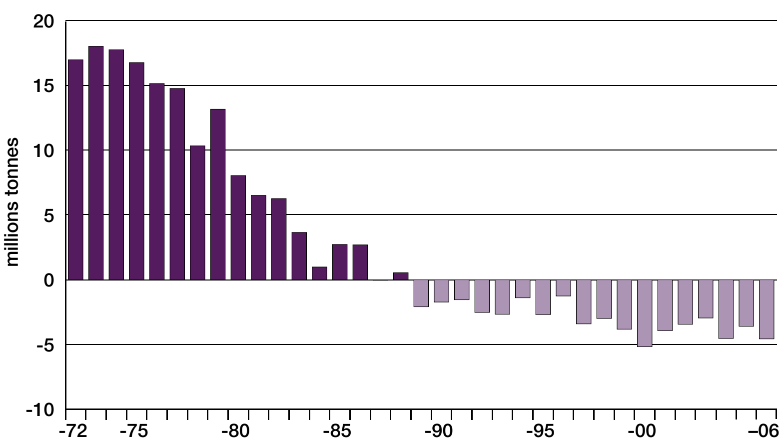
SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 35: Swedish net imports of crude oil by country of origin, 1972–2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Figure 36: Net imports (+) and exports (-) of refinery products, 1972–2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

bic (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 2005, 40 GWh were used for electricity production and 330 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. It is used for heating detached houses, larger properties and industries, as well as for cooking in homes and restaurants. 0.4 TWh of town gas were used in 2006.

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 2006, oil provided almost 32 % of Sweden's energy supply. On the user side, it is the transport sector (including bunkering supplies for international maritime transport) that is most dependent on oil, using over twice as much oil as do the industry and residential/service sectors together. The use of oil has been substantially reduced since 1970, falling by almost 48 % since 1970. It is particularly the use of fuel oils that has been reduced (and especially in the detached house sector), as can be seen in Figure 34. 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 2006, Sweden imported slightly less than 19.1 million tonnes of crude oil and net-exported almost 4.6 million tonnes of refinery products, see Figure 36. Over 54 % of Sweden's total crude oil imports come from the North Sea - primarily from Denmark and Norway. In recent years, there has been a substantial increase in the proportion of Sweden's oil imported from Russia. Overall, 36 % comes from Russia, 27 % comes from Denmark, 25 % from Norway, 6 % from Venezuela, 3 % from the UK, 1.5 % from Iran, and 0.5 % from Holland, as shown in Figure 35. This substantial importation of oil is due to the fact that much of the oil is processed in Sweden before re-export[103].

Strategic stocks of oil products are held in order to reduce the country's vulnerability to the effects of conflicts affecting the oil market. Problems in the supply of oil are tackled primarily through the agreements that have been signed with the International Energy Agency (IEA) and the EU. The size of the strategic oil stocks required for peacetime crises is set annually by the Government. 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 Government decided, in response to a request from the IEA in accordance with the IEP Agreement[104], to permit the release of 67 830 m3 of petrol from the strategic stocks in order to ameliorate the effects of hurricane Katrina on the oil market. This quantity was restored to stocks during the first half of 2006.

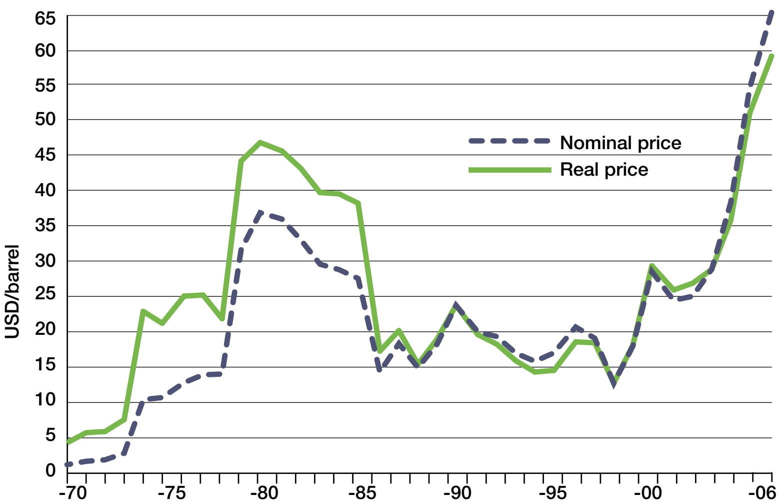
Preem Petroleum's GasOil investment project at its Lysekil[105] refinery was completed at the beginning of 2006. Costing SEK 3 200 million, and involving the construction of a hydro-cracker and a plant for the production of hydrogen, with important ancillary process equipment, it increases the proportion of sulphur-free motor fuels from 50 % to 70 % of the company's production. A new investment project is being planned, to enable the company to deal with the heavier fractions in the crude oil from the Lysekil refinery and in Preem's sister refinery in Gothenburg. These fractions will be converted into diesel fuel, petrol and LPG, with industrial coke as a by-product. 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 lower energy content and a higher moisture content. Sweden uses almost exclusively only hard coal, which is divided traditionally into two different categories: metallurgical coal (coking coal or injection coal), which is used in the iron and steel industry, and steam coal, which is sometimes referred to as energy coal and is used for energy purposes.

Coal supplies a quarter of the world's primary energy, and is the next largest energy source after oil. It is also the next largest source of carbon dioxide emissions after oil. World production and use of coal have increased considerably in recent years. The largest producers of hard coal are China and the USA, which together account for 64 % of world production. The major exporting countries are Australia, Indonesia and Russia. Coal production in Europe is falling, while imports remain unchanged. Between 1991 and 2002, the spot price of coal in north-western Europe varied between USD 26 per tonne[106] 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 has followed a rising trend

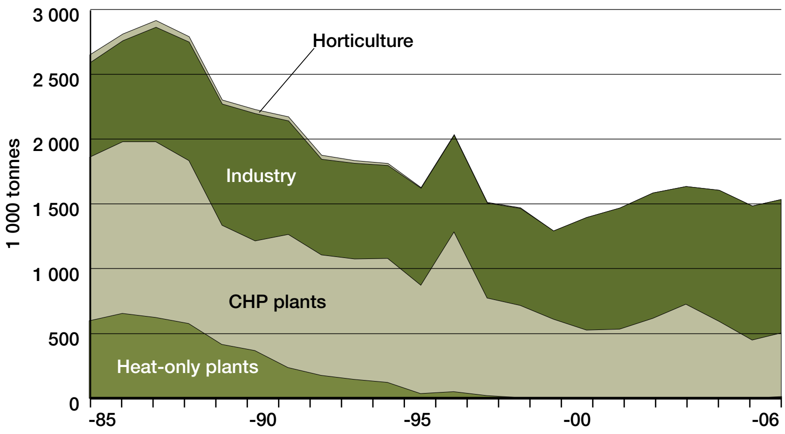
Figure 37: Nominal and real prices of light crude oil, 1970–2006, USD/barrel



SOURCE: WWW.BP.COM AND THE WORLD BANK

[103] For additional data and statistics from the oil industry, see e.g. 'The Oil Year, 2005' (in Swedish - Oljeåret 2005), www.spi.se.
[104] www.iea.org/Textbase/about/IEP.PDF.
[105] Previously Scanraff AB.
[106] Coal with a standardised calorific value of 6000 kcal/kg, delivered CIF.

Figure 38: Use of energy coal in Sweden, 1985–2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

since then. The price during the first half of 2007 was about USD 70-77 per tonne. If production and consumption continue at the present rate, proven and economically recoverable world reserves would last for about 170 years[107].

Sweden's use of coal

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 2006 - about the same as in the previous year. 2.0 million tonnes of this were coking coal, leaving 1.5 million tonnes for energy purposes (including use as injection coal in blast furnaces). To this must be added a net import of 0.2 million tonnes of coke.

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 in the blast furnaces and also provides an energy input to the process. Some of the energy content of the coke is converted to blast furnace gas, which is used in the same way as the coke oven gas. In addition to metallurgical coal and coke, ordinary energy coal is also used in industry. 2.0 million tonnes of metallurgical coal were used in industry in 2006, together with 1.0 million tonnes of energy coal and the country's entire net import of 0.2 million tonnes of coke. The quantity of energy coal provided an energy input of 7.5 TWh.

[107] IEA, Coal information 2006.

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 79 %, while 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 mills in Luleå supply coke oven gas and blast furnace gas to the town's district heating CHP 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 2006, the district heating sector used 0.5 million tonnes of energy coal (3.7 TWh) and 2.5 TWh of coke oven and blast furnace gas for electricity and heat production.

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 19 % in 2006. Most of the biofuels, peat and waste used in the Swedish energy system are indigenous, consisting mainly of:

- wood fuels, unprocessed (felling residues, bark, chips, return timber and energy forests and plantations), and processed (briquettes and pellets),
- black liquors and tall oil (intermediate and by-products in chemical pulp mills),
- peat,
- combustible waste (from industries, domestic waste etc.),
- ethanol (100 % for use in industry, as admixture in 95-octane petrol and the main ingredient in E85 and E92 motor fuels).

Biofuels are used mainly in the forest products industry, in district heating plants, for electricity production and for heating of residential buildings. See Section ”Transport” for details of the use of biofuels in the transport sector. Most of the increase in the use of bioenergy has occurred in industry and for district heating, although use has also increased in the residential sector. In 2006, the total use of biofuels, peat and waste amounted to 124 TWh[108]. Industry used almost 53 TWh, the residential and service sector used over 14 TWh, and the transport sector used 2 TWh. About 36 TWh were used for district heating production, and almost 11 TWh for electricity production.

The forest products industry

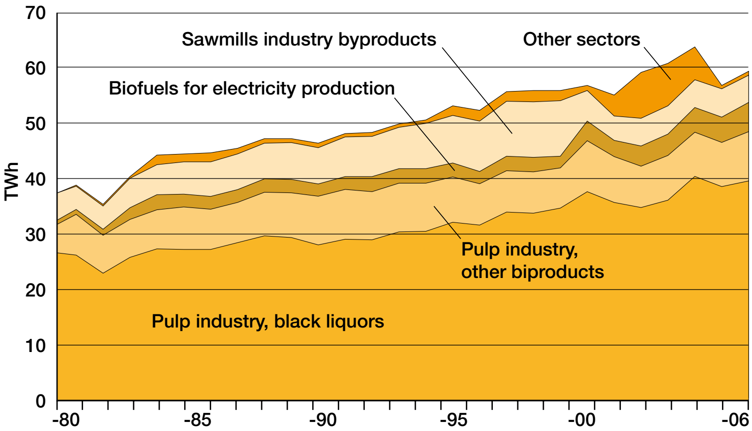
A large quantity of by-products and waste products is created in the forest industry. Most of the quantity of wood fuels used in the energy sector come from forestry in the form of branches and tops, other felling residues and firewood, as well as material from the woodworking industry and the pulp and paper industry in the form of solid by-products (bark and sawdust).

Biofuels are converted to pellets and briquettes in order to improve their energy density, simplify handling and reduce the cost of transport. In 2006, the Swedish energy system used a total of almost 1.7 million tonnes of pellets, equivalent to about 8 TWh, making up over 1 % of the country's total energy supply. Deliveries of pellets to the Swedish market have increased by almost 14 % between 2005 and 2006.

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 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. Raw 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 the use of black liquors as fuel is used internally within the pulp industry. In 2006, it amounted to almost 39 TWh, excluding electricity production. Both the pulp industry and sawmills use wood fuels in the form of solid by-products such as sawdust and bark.

In 2006, the pulp industry used a total of over 8 TWh of wood fuels for energy production, while sawmills and other woodworking industries used

Figure 39: Use of biofuels, peat etc. in industry, 1980-2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY
Note. The preliminary statistics for other sectors have been under-estimated for the last few years. See the text for more details.

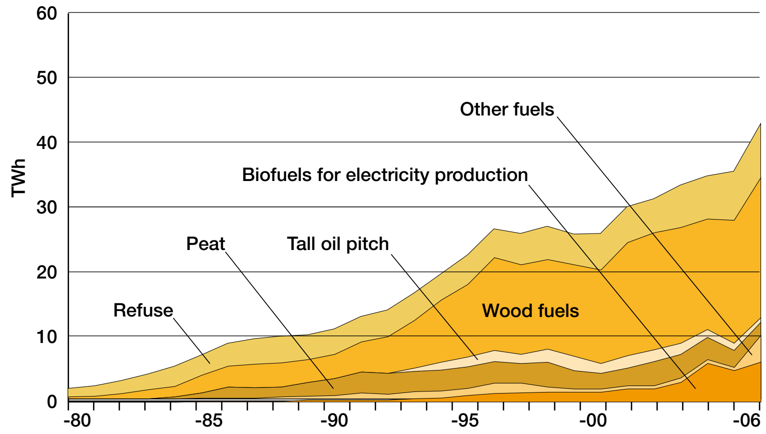
about 5 TWh of wood fuels. Other industry sectors[110] used almost 1 TWh of biofuels. In total, the forest products industry used nearly 58 TWh of various types of biofuels, peat etc. for heat and electricity production in 2006, see Figure 39. However, the Swedish Energy Agency has discovered a statistical error between preliminary and definitive statistics, which has had the effect of systematically underestimating the use of biofuels in other sectors in comparison with the definitive statistics. What this systematic difference is due to is not clear at present, but one reason may be that the preliminary and the definitive statistics use different sources. This means that the figure of almost 1 TWh that is given above is probably too low. One way of correcting this is to carry out a statistical revaluation, using the average percentage systematic error for the last six years. This gives the result that the use of biofuels in other sectors should be about 3.5 TWh, which means that the total use of biofuels in the industry should be about 60 TWh for 2006[111].

District heating plants

35.9 TWh of biofuels, peat etc. were used for heat production (i.e. excluding electricity production) in district heating plants in 2006. Of this, according to preliminary figures, wood fuels accounted for over 21.4 TWh, waste for over 8 TWh, black liquors and tall oil pitch for about 1 TWh and peat for almost 2 TWh. The use of wood fuels by the district heating sector has increased by more than fivefold since 1990, as shown in Figure 40. The main form of these fuels is felling residues and solid by-products from the forest products industry, although processed fuels such

108 As the statistics for 2006 are preliminary, this figure may be adjusted later.
109 As the statistics for 2006 are preliminary, this figure may be adjusted later.
110 'Other industry sectors' include the food industry, chemical industry, engineering industry and others.
111 As this statistical error affects only the preliminary statistics, it is only the figures for 2006 that are affected by this increase.

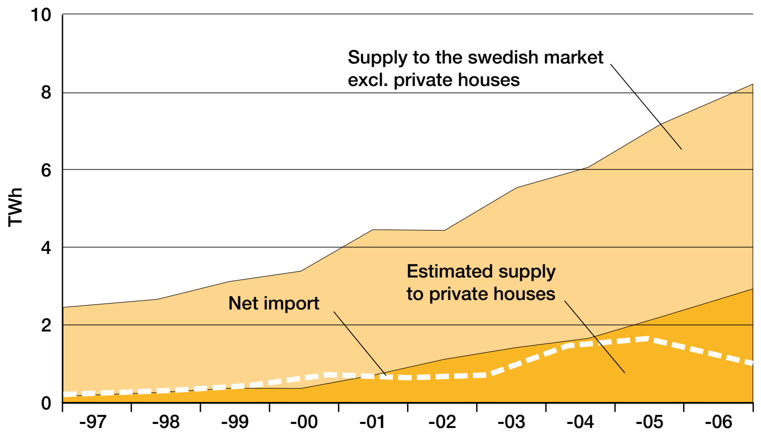
Figure 40: Use of biofuels, peat etc. in district heating plants, 1980-2006



SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Note. The preliminary statistics for the use of wood fuels have been systematically over-estimated for several years. See the text for more details.

Figure 41: Deliveries of pellets to the Swedish market, 1997-2006



SOURCE: NATIONAL ASSOCIATION OF PELLETS INDUSTRIES (PIR)

as briquettes and pellets are also being increasingly used. The statistical error described in Section "Forest Products Industry", also affects the use of wood fuels used in district heating plants, which have been systematically overestimated in the preliminary statistics. Reducing these figures in the same way as described above indicates that the total use of wood fuels for district heating should be about 19.9 TWh. From this, the total use of biofuels, peat etc. for heat production in district heating plants should be about 34.4 TWh.

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 2006, 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 peat in district heating systems amounted to 2 TWh in 2006, which is the lowest level since 1988. One reason for the reduction is the fact that, in the emissions trading system, peat is regarded as a fossil fuel, which reduces its competitiveness. The use of peat as a fuel in Sweden was previously subject only to the sulphur tax, but now requires emission allowances. The effects of this, and other changes, on the peat industry were investigated during the spring of 2006 on behalf of the Government[112].

About 3 million m^3 of energy peat were harvested in 2006, which is a considerably larger quantity than during the two previous years. Imports declined somewhat for the second consecutive year, amounting to about 1.0 million m^3 in 2006[113]. 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 in 2006 amounted to about 0.7 TWh. The European Commission approved peat as an effective fuel for cogeneration production due to its environmental properties and to the fact that there was a risk of it losing out to coal for this purpose on competitive grounds.

Biofuels for electricity production

Almost 11 TWh of biofuels were used for electricity production during the year. Over 6 TWh of this were used in CHP plants, and almost 5 TWh in industrial back-pressure plants.

Heating of residential buildings

Biofuels are used as the heating energy source for about 10 % of detached houses in Sweden. 11.2 TWh of biofuels, peat etc., were used in detached houses for this purpose in 2005. Most of this was in the form of firewood, 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. According to the industry, the use of pellets in the detached house sector increased by almost half in 2006.

112 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).

113 Additional information on peat can be found in Statistics Sweden's Notice no. MI 25 SM 0601.

A total of 12.0 TWh of biofuels, peat etc. were used for heating residential and commercial premises in 2005.

Conversion grants have been available since 2006 for replacement of direct electric heating systems to district heating, rock, lake water or earth heat pumps, or biofuel-fired boilers. These grants will be available until the end of 2010. A similar grant has been available for replacement from oil heating systems, but its availability has been shortened from 2010 until 1st March 2007. Of the conversions from oil heating, 36 % have changed to biofuels, while 7 % of those changing from electric heating have so far changed to biofuels.

International trade

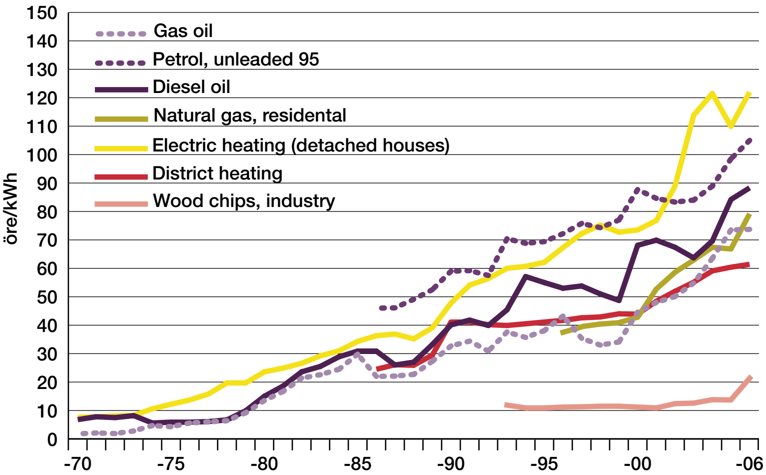
Each year, there is a relatively extensive importation of biofuels. This import consists largely of pellets, ethanol and peat. It is estimated that about 80 % of the ethanol used in or as motor fuels is imported. As far as pellets are concerned, it is estimated that a good 10 % were imported (about 350 000 tonnes), and about 129 000 tonnes were 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.

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. However, 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.

An international comparison

About 19 % 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 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.

Figure 42: Nominal commercial energy prices in Sweden, including tax, 1970-2006



SOURCE: SWEDISH PETROLEUM INSTITUTE, STATISTICS SWEDEN, EUROSTAT AND THE SWEDISH ENERGY AGENCY

Energy prices

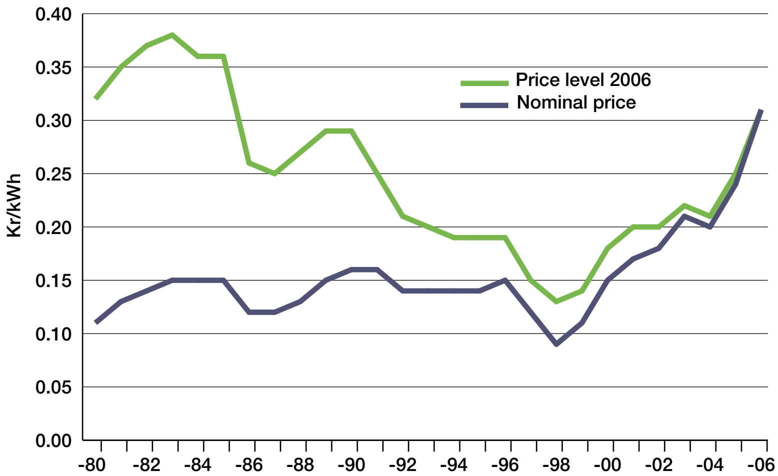
Commercial energy prices consist of the price of the fuel, taxes and value-added tax. The taxes and other charges vary depending on how and where the fuel is used. This section describes the real price development of certain energy prices for various users. By using real prices, allowance is made for inflation. The real prices are expressed in the 2006 price level. The trends of commercial energy prices are shown in Figure 42 and in the table to Figure 42 in Energy in Sweden 2006, Facts and Figures.

The real price development

In real terms, the cost of energy per kWh supplied was at its highest in 1982, at about 37 öre/kWh and then fell gradually to about 13 öre/kWh in 1998. Since then the cost has increased to about 30 öre/kWh today, as can be seen in Figure 43.

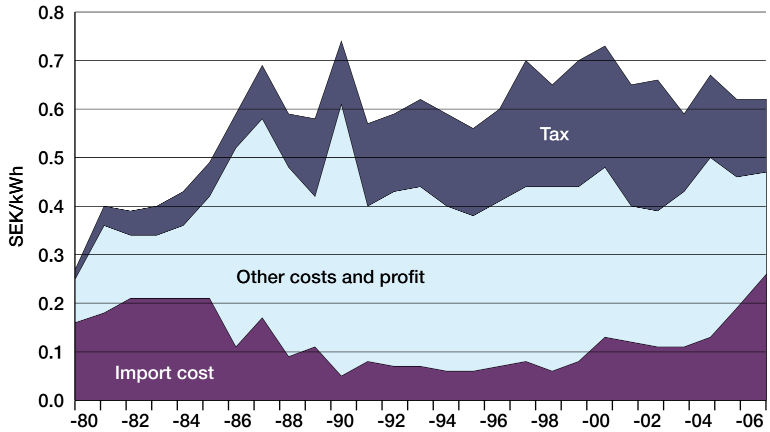
The diagram shows the cost only of 'raw' energy, i.e. the price of the oil, natural gas and coal that has been imported, together with the biofuels and electri-

Figure 43: Cost of 'raw' energy supplied, 1980-2006, 2006 price level



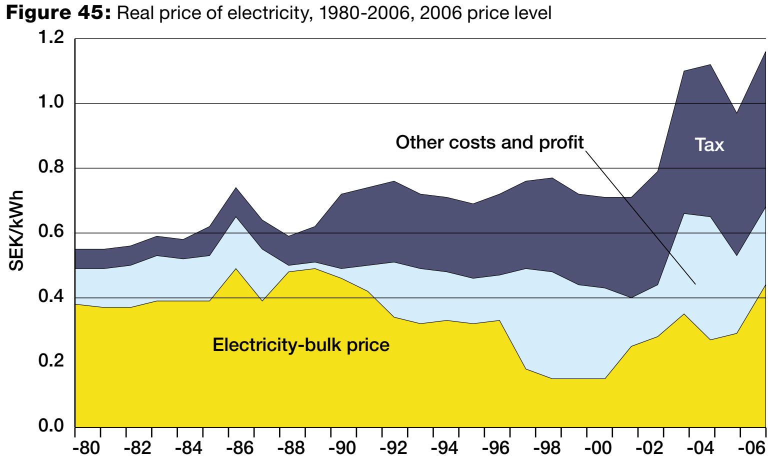
SOURCE: STATISTICS SWEDEN, THE SWEDISH ENERGY AGENCY AND THE BANK OF SWEDEN

Figure 44: Real cost development of imported fuels, 1980-2006, 2006 price level



SOURCE: STATISTICS SWEDEN, THE SWEDISH ENERGY AGENCY, THE BANK OF SWEDEN AND IEA: PRICES AND TAXES

Figure 45: Real price of electricity, 1980-2006, 2006 price level



SOURCE: STATISTICS SWEDEN, THE SWEDISH ENERGY AGENCY AND THE BANK OF SWEDEN.
Note. Until 1996, the network costs were included in the price of electricity, but after 1996 were included in the companies' other costs.

city produced in Sweden. The final price of energy also includes operating and maintenance costs, conversion costs, distribution costs and capital costs together with the energy utilities' required returns, here referred to as the industry's mark-up. To all this taxes must be added. The picture changes when all these factors have been considered, and it becomes particularly clear that the supply conditions and applications of different forms of energy or energy carriers differ very considerably. The prices and costs of the different forms of energy have been weighted in the calculations on the basis of their annual proportions of total supply or use.

Forms of energy

Imported fuels have generally been more heavily taxed than indigenous fuels. However, at the same time, conditions for them have been more competitive and so their mark-ups have been kept down. There has been only a limited need for investments in Swedish facilities for storage, conversion and distribution, as the market as a whole has contracted.

The import cost of **fossil fuels** fell substantially after 1984, dropping to less than half and remaining at a low level until 2000. During this period, the oil industry increased its margins, while at the same time taxes also increased. In real terms, this therefore means that the price of oil rose continously until the end of the century. During this period, real oil prices for consumers doubled. The rapid international rise in the price of oil since 1999 has forced the oil industry again to reduce its mark-up, while at the same time taxation pressures have eased. This has resulted in a fall in the price of oil in real terms since 2004, so that the total price level is now back where it was in 1988. However, the reduction in tax has benefited only industry. The drop in real price has not been reflected in the price of oil to the transport sector or to domestic consumers. The actual effects of this total price fall are therefore split.

There has been a parallel development for indigenous fuels. The real price of electricity has also doubled, although the cost of district heating has not increased to the same extent.

Before 1996, there was no distinction between the trading price of **electricity** and network costs. The 'raw' price of electricity until 1996 therefore also includes all the associated network costs. With effect from 1996, the Nord Pool prices have been used for calculating the price of the raw electricity, with the network cost included in the utilities' mark-up. This means that there has been a clear underestimate of the electricity industry's mark-up over the period 1982-1995. It is therefore hardly reasonable to claim that the electricity industry's mark-up has increased since deregulation of the electricity market. Instead it is now more exposed to fluctuations than previously. However, at the same time, it should be borne in mind that the rate of investment in the electricity industry has been low over the last 20 years, which should reasonably mean that the costs of capital have been considerably reduced. This does not seem to have had any effect on pricing.

The cost development of **district heating** seems to have been more favourable, although the price has increased in real terms. However, in practice, district heating has received preferential taxation treatment, with the tax take declining over time, instead of increasing. It should also be pointed out that the investments in expansion of district heating systems culminated during the 1980s, which means that 60-70 % of investments have now been written down, and that there has been only a relatively modest need of new investment and re-investment. Seen against this background, it is surprising that the industry's mark-up has increased as substantially as shown in Figure 46. In 2006, the pre-tax mark-up was more than 300 %.

The user sectors

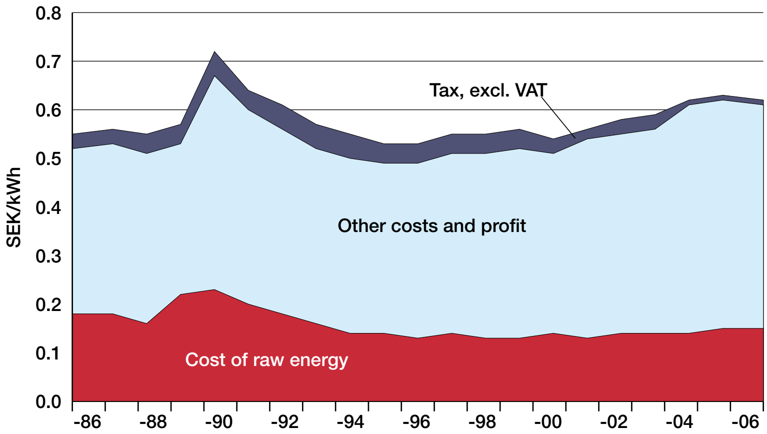
Different user sectors have developed in different ways. Domestic energy costs have tripled, prices in the transport sector have remained more or less constant, and industry has experienced falling real prices over the period under consideration.

In 1980, the average real price per used kWh in the **domestic** sector was 56 öre in 2006 price terms. By 2006, this cost had increased to SEK 1.58 in reality. Over this period, the cost of raw energy fell substantially, so that in 2006 it had still not returned to its 1980 level. The industry's mark-up has increased substantially: in 1980, it made up somewhat less than 40 % of the pre-tax sale price, while in 2006 it had risen to almost 70 %.

In addition to the specific energy taxes, the introduction of value-added tax in 1990 has been a factor in increasing the cost of energy to domestic users.

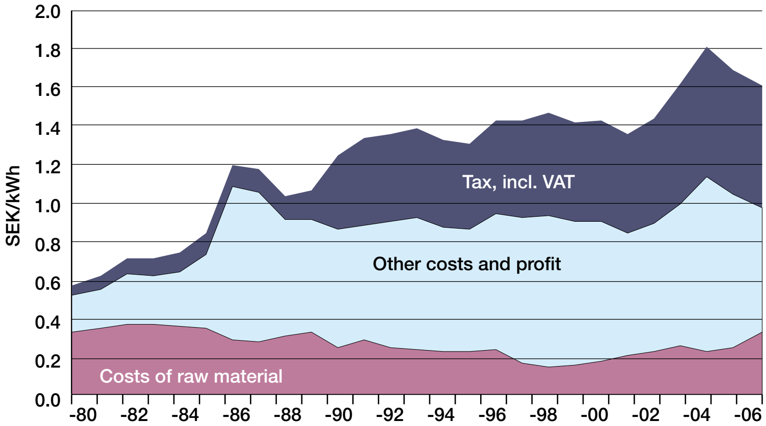
In principle, the real costs of energy in the **transport sector** have remained constant over the period from 1980 to 2006. The real price rise shown in Figure 48 is partly notional. In 1994, the previous kilometre tax for diesel vehicles was replaced by a corresponding rise in the energy tax on the fuel. If the pre-1994 prices are adjusted to take account of this change, the real price rise becomes considerably lower than as shown in the diagram. In practice, subject only to modest upward and downward fluctuations, the real price of petrol has remained unchanged since 1990. The price of diesel oil, too, has remained relati-

Figure 46: Real cost development of district heating, 1986-2006, 2006 price level



SOURCE: STATISTICS SWEDEN, THE SWEDISH ENERGY AGENCY AND THE BANK OF SWEDEN

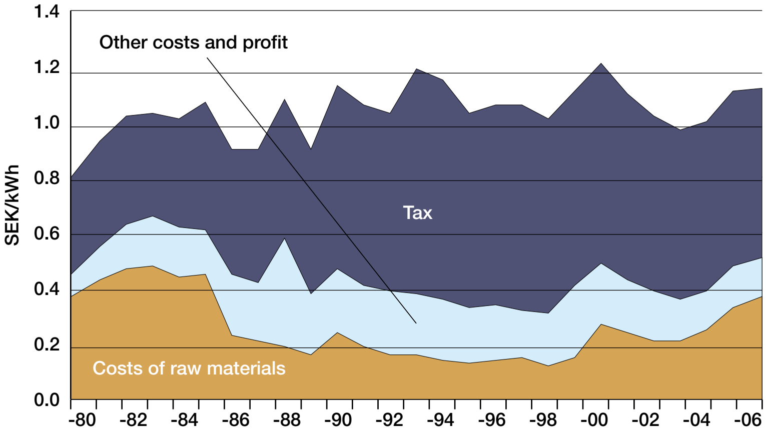
Figure 47: Domestic energy costs, 1980-2006, 2006 price level



SOURCE: STATISTICS SWEDEN, THE SWEDISH ENERGY AGENCY AND THE BANK OF SWEDEN

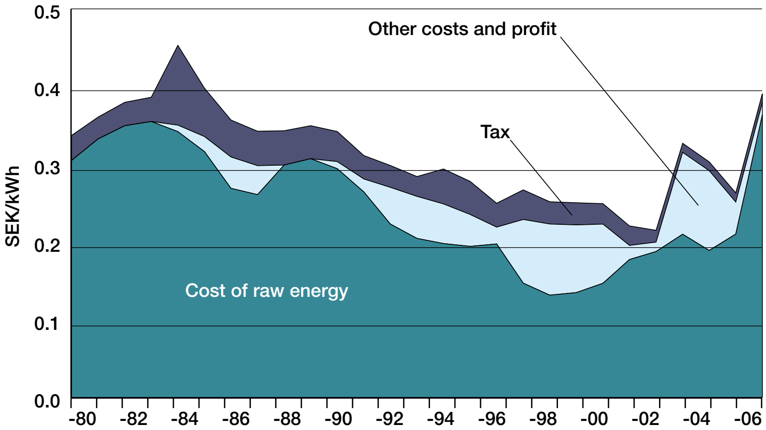
Note. Until 1996, the network costs were included in the price of electricity, but after 1996 were included in the companies' other costs.

Figure 48: Real price development of motor fuels, 1980-2006, 2006 price level



SOURCE: STATISTICS SWEDEN, THE SWEDISH ENERGY AGENCY, THE BANK OF SWEDEN AND IEA: PRICES AND TAXES.

Figure 49: Energy prices in industry, 1980-2006, 2006 price level



SOURCE: STATISTICS SWEDEN, THE SWEDISH ENERGY AGENCY AND THE BANK OF SWEDEN

Note. Until 1996, the network costs were included in the price of electricity, but after 1996 were included in the companies' mark-ups.

vely constant since 1990, although with somewhat greater price fluctuations.

What is noticeable is the low mark-up applied by the oil industry to the raw material cost. Further, it can be seen that the mark-up varies with the underlying price Rising prices result in lower mark-ups and vice versa. The most important explanation for this is probably the very severe competition on the motor fuels market.

The real price of energy for **industry** fell steadily from 1984 until 2002, after which a rising trend occurred, bringing the price to 38 öre/kWh in 2006, which is equivalent to 85 % of the price in 1984. The lowest price of energy to industry occurred in 2001, when the real price was about half of the price in 1984.

Taxation of energy use in industry has progressively declined, so that in 2006 it accounted for less than 3 % of the total price. The supply mark-ups are extremely small, but there are two factors that partly account for this. Until 1996, the network costs were included as part of the raw energy costs, which means that mark-ups prior to 1996 have been underestimated. Secondly, many industrial companies directly import the oil that they use, which means that the handling costs that would normally be included in the purchasing price are treated instead as part of the total cost of production, rather than as a separate cost for the use of energy. However, it is nevertheless clear that, as a purchaser of energy, industry is in a stronger position than particularly domestic users, and that the energy suppliers are forced to compete more severely for business with industry. ■

An international perspectvie[114]

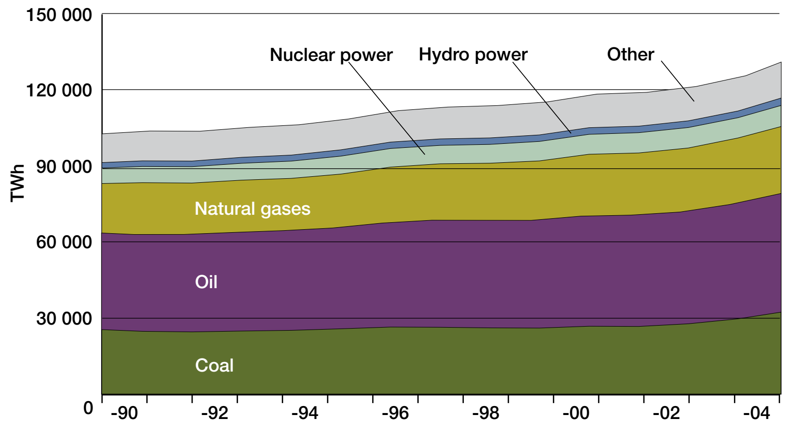
World energy supply is dominated by fossil fuels (80 %), with oil being the most important of them (35 %). The proportion of renewable energy (including hydro power) has remained at about 13 % over the last ten years, with nuclear power, at almost 7 %, supplying the rest. However, there are major differences 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.

A general overview

Global energy use, excluding biomass[115], increased by 2.4 % in 2006, this corresponds with 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 and the non-EU states in Europe (including the previous Soviet republics) each accounted for somewhat over 16 % of the increase. The countries of the Middle East and Latin America each increased their use by about 8 %, while energy use in Africa increased by 3 %. Finally, the EU states increased their energy use by about 1 %. On the other hand, the USA slightly reduced its energy consumption, for the second year running. Development in 2006 was characterised primarily by continued steeply rising oil prices, resulting in strong growing international interest in biobased motor fuels. The EU, USA and Brazil are the leaders in manufacture of biobased motor fuels. Over the last five years, the use of coal has risen twice as fast as that of total energy use: even in the EU, it increased by over 2 % in 2006.

In recent years, interest in geopolitics has again increased. Rapid economic growth in Asia has meant that this region as a whole is now experiencing a rapidly growing deficit 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, too, will decline.

Figure 50: Global supply of primary energy, 1990-2004

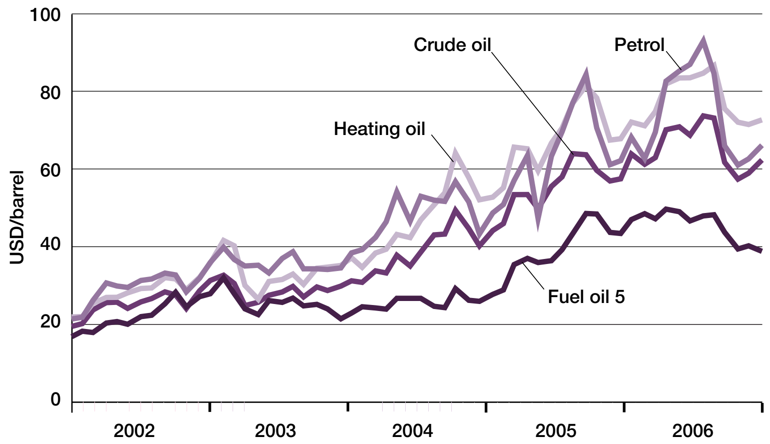


SOURCE: IEA ENERGY BALANCES OF NON OECD COUNTRIES, 2006

114 Statistics for this section have been taken from various sources, mainly from 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 2004. In addition, IEA publishes internal member statistics in its Energy Balances of OECD Countries, which are available up to and including 2005. 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. Figures for the supply of commercially traded energy are available for 2005 and 2006 in i BP Statistical Review of World Energy. Figures given here for these years are from this source.

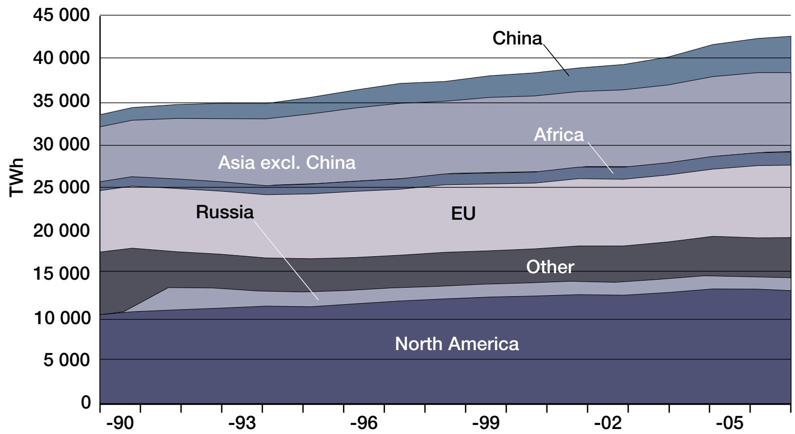
115 Due to delays, there is no complete data for the use of biofuels after 2004.

Figure 51: Oil prices in Europe, 2002-2006



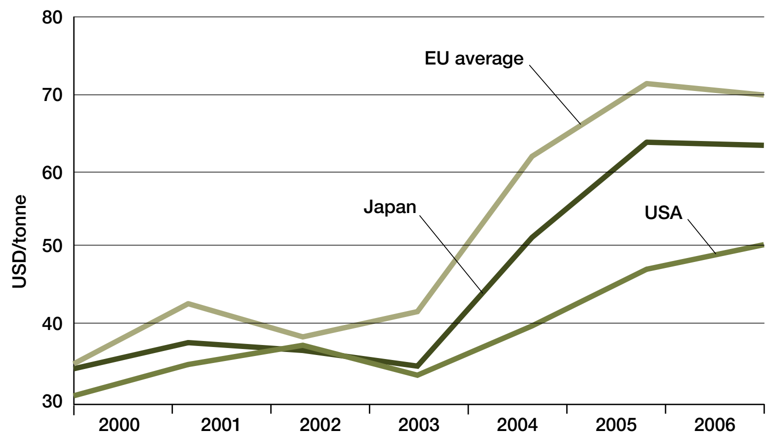
SOURCE: IEA OIL MARKET REPORT

Figure 52: World use of oil, 1990-2006



SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES, 2006. IEA ENERGY BALANCES OF OECD COUNTRIES, 2007. BP STATISTICAL REVIEW OF WORLD ENERGY, 2007

Figure 53: Coal prices in Europe, USA and Japan, 2002-2006



SOURCE: IEA ENERGY PRICES & TAXES, QUARTERLY STATISTICS, SECOND QUARTER 2007

Energy supply

Oil

The proportion of oil used in the global energy balance continues to decline slowly, so that it was down to about 34 % in 2006[116]. On the other hand, total use of oil increased by about 0.7 % over the year, as compared with increases of 1.2 % in 2005 and 3.7 % in 2004. A number of OECD states, such as the USA, Canada, France, Italy and Sweden reduced their consumption for two years in succession. Use of oil also declined in some non-OECD countries, such as Indonesia and Turkey. Most of the increase in use occurred in China and the Middle East, with substantial percentage increases in Poland and Portugal.

As in previous years, the use of fuel oils continues to decline, after temporary increases in 2004 and 2005. In Europe, the use of petrol continues to decline, and even for the OECD as a whole there was a slight decline in 2006. As with previous trends, the demand for intermediate distillate - i.e. diesel oil and aviation paraffin - is increasing the most rapidly.

Prices continued to rise substantially in 2006, and reached a peak in July with an average price of USD 74 per barrel for Brent Crude. The price then fell to a low point of USD 58 in November. The average price for the year as a whole was USD 66 per barrel, almost USD 10 higher than in 2005.

Political instability in important oil-producing countries has continued during the year. Growth in reserves did not quite offset production. Investments in new oil production increased substantially during the year. The high trading prices for fossil energy in particular have resulted in a growing trend of nationalisation of resources. Over 90 % of oil production are nowadays controlled by nationally owned oil companies.

Coal

The use of coal increased by about 4.5 % in 2005. Almost all of this increase (70 %) occurred in China, accompanied by increases in all other regions except the USA. 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 about 25 %.

Coal prices stabilised during 2005, after the very steep price rise in 2004. The cost of transport makes up a significant part of the price of coal, which means that prices vary from one part of the world to another. In Europe prices continued to fall during the first half of 2006, but rose during the second half. Between 2005 and 2006, the average import price to the EU fell, according to EU Coal Statistics, from EUR 62/tsce to EUR 61/tsce[117].

China increased its production of coal by over 10 % in 2005, and now produces almost 40 % of global coal, followed by the USA with 20 % and Australia with 7 %.

Closure of financially unviable pits in the EU continues. Production fell by 3 %, but total use rose by 2 %.

Natural gas

The use of gas increased by 2.5 % in 2006, which means that it is still the world's third largest energy source, with a market share of about 22 %. China increased its use by almost 20 %, although its total use of gas is still less than 3 % of world consumption. Use of gas in the EU fell for the first time since 1997 (by -1.5 %). The EU-15 countries, on the other hand, increased their use by 2 %.

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 more than quadrupled since 1999, from USD 1.8 to USD 8.77 /MBTU[118]. Gas prices in the USA and Canada fell somewhat in 2006 in comparison with 2005, reflecting the fact that the acute shortage of gas that resulted from hurricanes Katrina and Rita was reduced during the year.

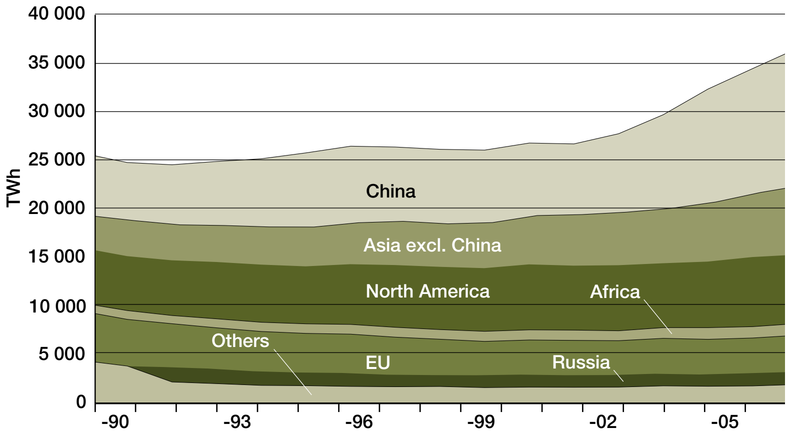
The market for liquefied natural gas (LNG) has grown substantially in recent years. According to preliminary calculations by Cedigaz[119], about 537 000 million m^3 of natural gas were carried internationally via pipelines (an increase of 1.5 %), and about 210 000 million m^3 in the form of LNG (an increase of 5 %). However, the proportion of gas carried between countries in international trading makes up only a small part of the total production of almost 2.9 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 2006, but those for other forms of energy are at present available only up to 2004. In 2004, 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 %.

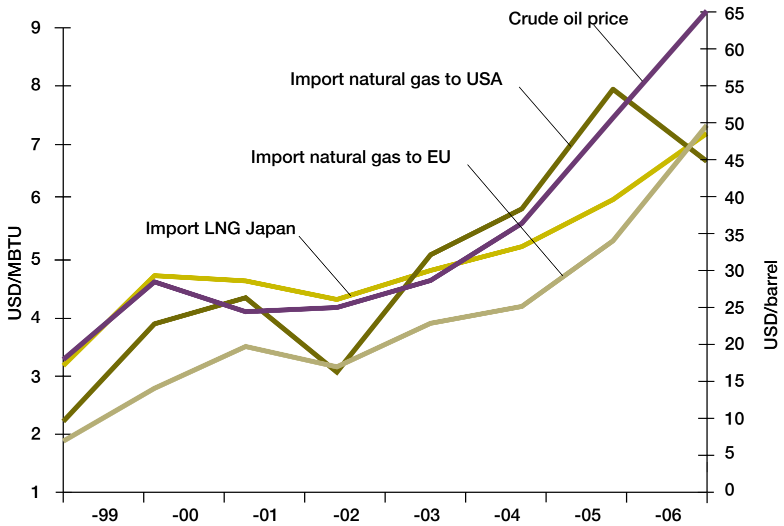
Over a ten-year period, the total proportion of renewable energy has remained relatively stable. In Africa, almost half of total energy use is in the form of renewables; in Asia, the proportion is almost one-third, while in Latin America it is about one-fifth. In

Figure 54: World use of coal, 1990-2006



SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES, 2006. IEA ENERGY BALANCES OF OECD COUNTRIES, 2007. BP STATISTICAL REVIEW OF WORLD ENERGY, 2007

Figure 55: Import price of natural gas and crude oil, 1999-2006



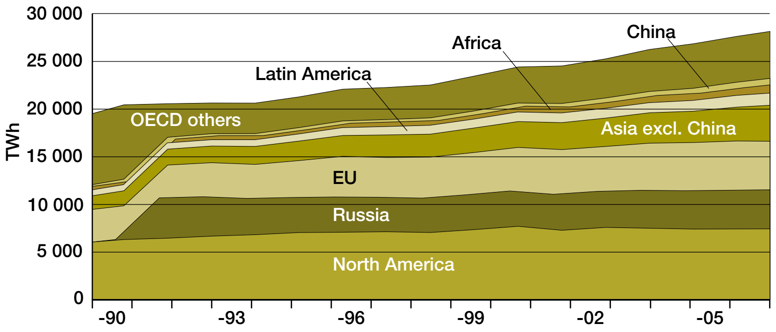
SOURCE: IEA ENERGY PRICES & TAXES, QUARTERLY STATISTICS, SECOND QUARTER 2007

the former Soviet Union, however, less than 2 % of energy is from renewable sources, and the in Middle East trails even further behind with less than 0.5 %. The proportions of renewable energy are declining slowly in Africa, Asia and Latin America. 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 increased more rapidly than has the use of fossil alternatives in 2005 and 2006, this growth has not been sufficient to increase the actual proportion of energy supply provided by renewable energy. However, the high prices of fossil fuels, particularly during the last three years,

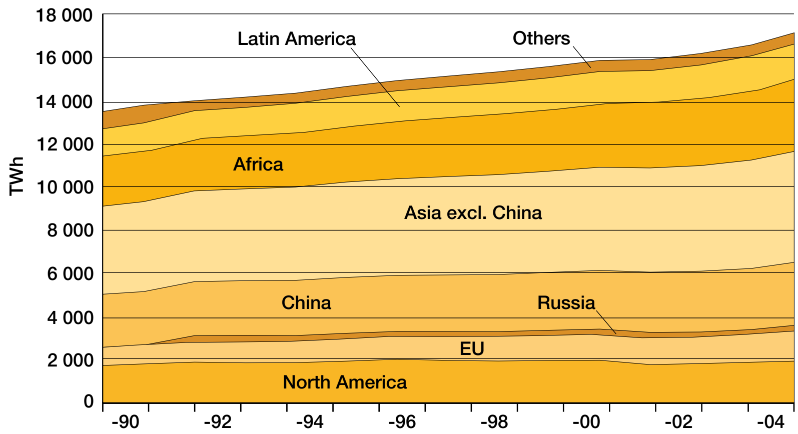
116 BP Statistical Review of World Energy, June 2007.
117 tsce equals 7 780 kWh.
118 BP Statistical Review of World Energy 2007.
119 Cedigaz is the international sector organisation for natural gas.

Figure 56: World use of gas, 1990-2006



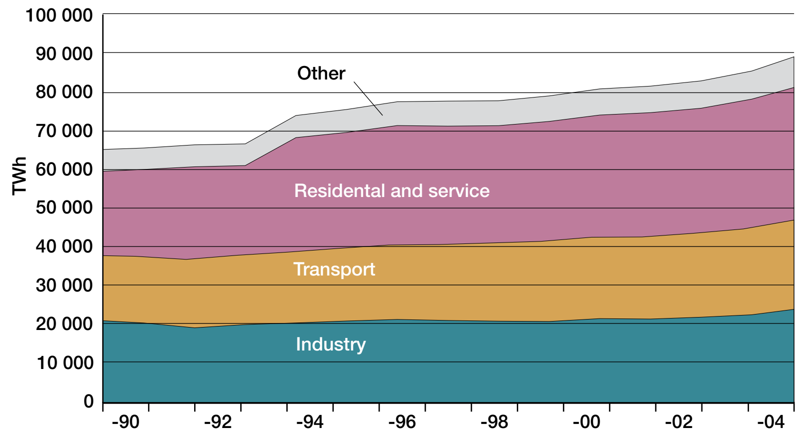
SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES (2006 EDITION). IEA ENERGY BALANCES OF OECD COUNTRIES (2007 EDITION). BP STATISTICAL REVIEW OF WORLD ENERGY.

Figure 57: Use of renewable energy, 1990-2006



SOURCE: IEA ENERGY BALANCES OF NON OECD COUNTRIES (2006 EDITION) IEA ENERGY BALANCES OF OECD COUNTRIES (2007 EDITION)

Figure 58: World use of energy, by sectors, 1990-2004



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

have increased the competitiveness of biofuels, and particularly that of biobased motor fuels.

There is considerable interest in the production of biobased motor fuels, bio-diesel oil and ethanol from palm oil, sugar cane and various grain crops, particularly maize and wheat. This has resulted in exploitation of virgin forests in order to increase land areas for agricultural cultivation, and has also reduced the previous grain surpluses to levels that have driven up world market prices for grain. Many foresee a potential growing future conflict from the fact that the western world is willing to, and can, pay a higher price for biobased motor fuels than most developing countries can afford to pay for food.

Energy use

Industry

Energy use in industry increased at a record rate of 6 % in 2004[120]. Seen over the past ten-year period, the annual rate of increase has been about 2 %. Industry's share of total energy use is steadily declining, being a little less than 30 % in 2004.

Transport

Energy use in the transport sector in 2004 increased by 4 %, which is almost double the average rate of increase over the last ten years. 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. Seen over a longer period of time, the transport sector's proportion of total energy use has remained relatively stable at about 30 %.

The residential and service sector[121]

Over the last decade, energy use in the residential sector has increased at about 4 % per annum. However, in 2004, the increase was about 2 %. Almost all of the increase during the last ten years has occurred in the domestic sub-sector. The use of electricity in particular has increased.

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.

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

Electricity production and use

World electricity production increased by about 4 %, to 14 400 TWh in 2004. The average rate of increase in electricity use has been slightly less than 3 % per annum since 1994.

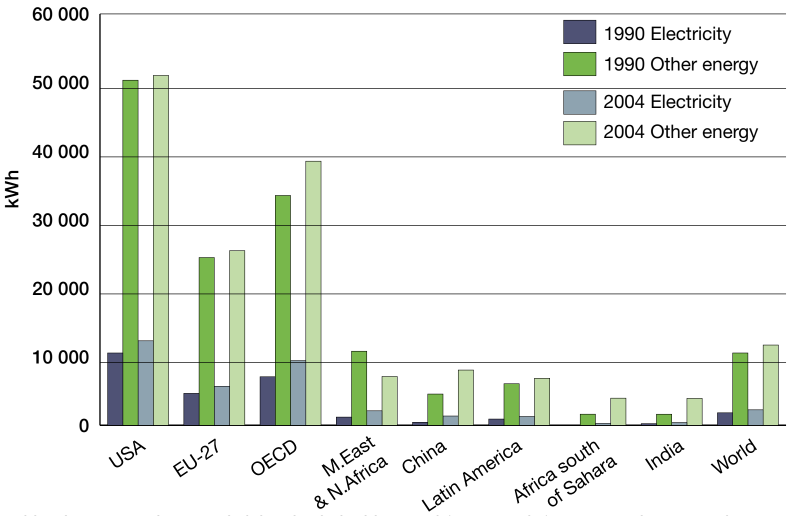
Coal is still the predominant source of energy input for electricity production, although its proportion fell marginally between 2003 and 2004, to just below 40 % of all electricity. Natural gas continues to increase its proportion, fuelling almost 20 % of electricity production in 2004. Renewable electricity production, in the form of geothermal power, solar energy and wind power, together with electricity produced from biofuels and waste, has increased its proportion from 1.7 % to 2.1 % since 2000.

Although the OECD states dominate world electricity use, with a proportion of over 60 % in 2004, 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 and 2004, which meant that it alone was responsible for almost 40 % of the world increase in 2004. Latin America and the rest of Asia both exhibited substantial 5 % increases in their use of electricity in 2004.

The residential and service sector used 57 % of all electricity, but there are considerable differences. Within the OECD, the proportion was over 60 %, but in China was only 33 %. The proportions used by the industrial and transport sectors have remained relatively stable at about 41 % and 2 % respectively, but there are substantial regional differences here too. In 2004, 66 % of all China's electricity was used by industry, whereas this proportion for the OECD was 36 %. ■

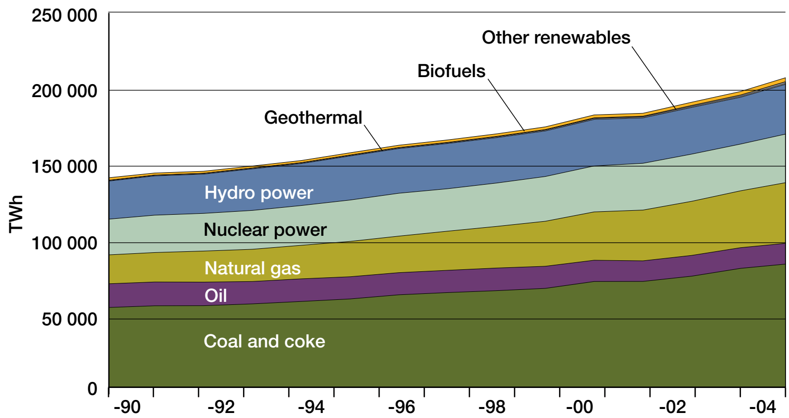
[120] 2004 is the latest year for wich complete statistics are available for energy use by application areas.
[121] Here, we have used the classification of 'Domestic and service sector'. IEA uses a different classification, treating 'Commercial sector' and 'Households' separately. Nevertheless, unless 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 59: Regional per-capita energy use, 1990 and 2004



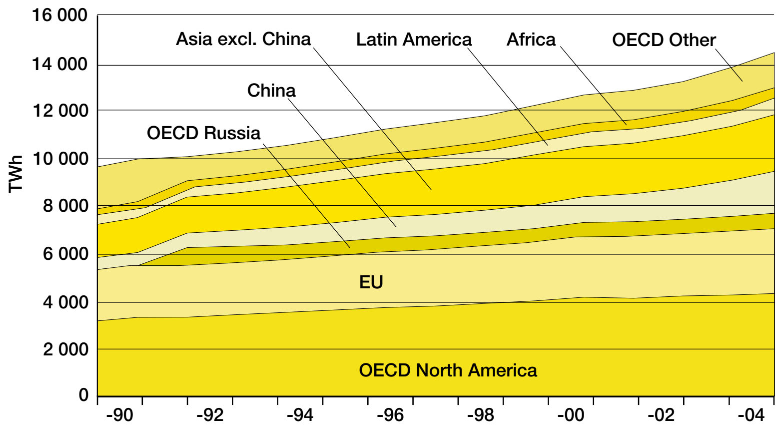
SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES (2006 EDITION), AND THE WORLD BANK'S POPULATION STATISTICS

Figure 60: World electricity production, by type, 1990-2004



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

Figur 61: Regional world use of electricity, 1990-2004



SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES (2006 EDITION), IEA ENERGY BALANCES OF OECD COUNTRIES (2007 EDITION)

The environmental situation

All recovery, conversion and use of energy give rise to some kind of environmental impact. The most significant direct 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 and production processes, such as hydro or wind power generation, can have positive effects on some environmental problems, they may have some other adverse environmental impact, such as in the form of their effects on nature and the landscape. Environmental impact occurs on many levels: local, regional and global. The boundaries between these levels are fluid, determined not only by the type of impact (e.g. emissions), but also by how far it spreads. 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 the national benchmark for ecologically sustainable development. This means that, as well as providing an indicator of conditions in the Swedish environment, they must also be appropriate for defining the national perspective in international contexts.

Swedish environmental targets

Parliament has set targets for environmental quality in sixteen areas. To the original fifteen targets from April 1999 'A rich plant and animal life' was added that of in November 2005. They describe the quality and conditions for the country's environmental, natural 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 subtargets, expressed as concrete and quantifiable targets, which are annually reviewed in the Swedish Environmental Objectives Council's publication 'de Facto'. The purposes of the targets are to:

- support human health
- safeguard biological diversity and the natural environment

Sweden's 16 environmental targets

1. Limited effect on climate
2. Clean air
3. Natural acidification only
4. A non-toxic environment
5. A protective ozone layer
6. A safe radiation environment
7. No eutrophication
8. Living lakes and waterways
9. Good quality of groundwater
10. A balanced marine environment, living coastal areas and archipelagos
11. Thriving wetlands
12. Living forests
13. A varied agricultural landscape
14. A magnificent mountain landscape
15. A good built environment
16. A rich diversity of plant and animal life

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• care for the cultural environment and culture-historical values
• maintain the long-term productivity of ecosystems
• ensure good conservation and management of natural resources.

The energy sector affects all environmental targets 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 targets can be achieved. They are:
• Limited effect on climate
• Clean air
• Natural acidification only
• A good built environment quality.

Limited effect on climate

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's emissions are low in per-capita and per-GNP terms in comparison with those of most other industrialised countries, but are considerably higher than corresponding emissions in the developing countries. Emissions of greenhouse gases have lain below the values for 1990 for every year since 1999. Emissions in 2005 were 7.3 % lower than in 1990. In parallel with this reduction, the economy has grown. 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 4 % below their 1990 levels.

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 over 5.5 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, emissions from district heating production have not increased.

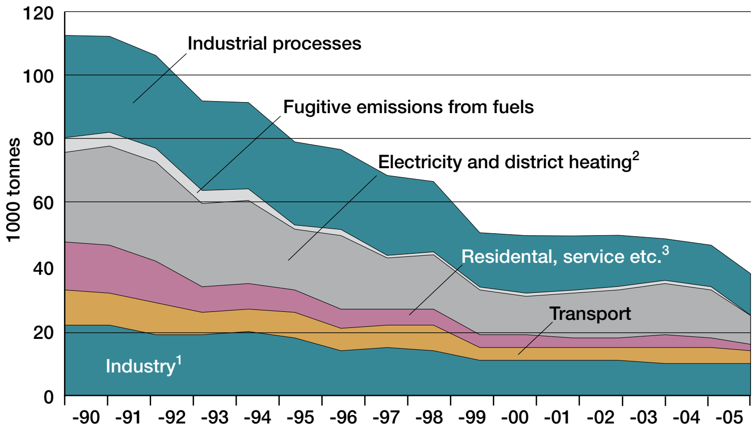
Clean air

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 are detrimental to 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-le-

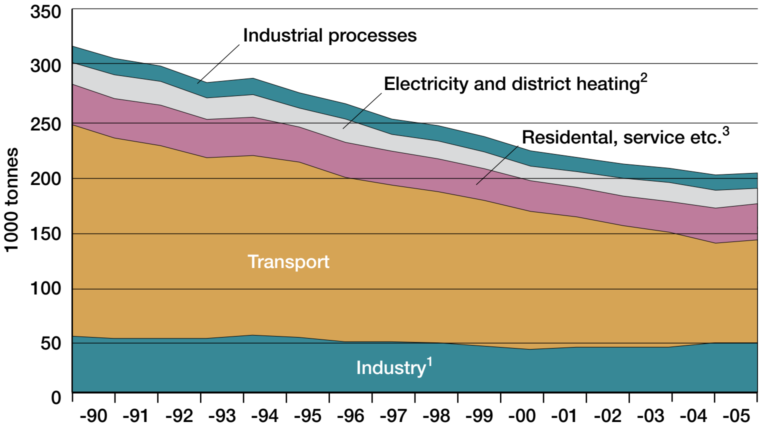
Figure 62: Sulphur dioxide emissions in Sweden, 1990–2005



SOURCE: SWEDEN'S REPORT TO THE UN AIR POLLUTION CONVENTION, SWEDISH ENVIRONMENTAL PROTECTION AGENCY, 2006. ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

Note. The method of calculation for emissions to air has been reviewed by the Swedish Environmental Protection Agency and by Statistics Sweden. Figures for all years have been revised in comparison with those shown in previous issues of Energy in Sweden. [1] Includes industrial back-pressure production and waste incineration, [2] Includes coking plants and oil refineries, [3] Includes agriculture, forestry and fishing.

Figure 63: NOx emissions in Sweden, 1990–2005



SOURCE: SWEDEN'S REPORT TO THE UN AIR POLLUTION CONVENTION, SWEDISH ENVIRONMENTAL PROTECTION AGENCY, 2006. ADDITIONAL PROCESSING BY THE SWEDISH ENERGY AGENCY

[1] Includes industrial back-pressure production and waste incineration. [2] Includes coking plants and oil refineries. [3] Includes agriculture, forestry and fishing.

vel ozone. A number of volatile organic compounds and sub-10 mm particles (PM10) can also cause these effects. Acidifying pollutants also affect buildings and other structures and objects through acceleration of breakdown processes in the material. In addition, compounds such as oxides of nitrogen and sulphur contribute to eutrophication of water bodies 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 harms 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 (NOx) 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 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 the ground and water in other countries.

A good built environment quality

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 from renewable sources.

Will we achieve our environmental objectives?

Of the four environmental objectives 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 **Only Natural Acidification** targets are not regarded as achievable within the 2020 time frame, although most of their sub-targets are expected to be achieved. 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 limited climate effect 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.

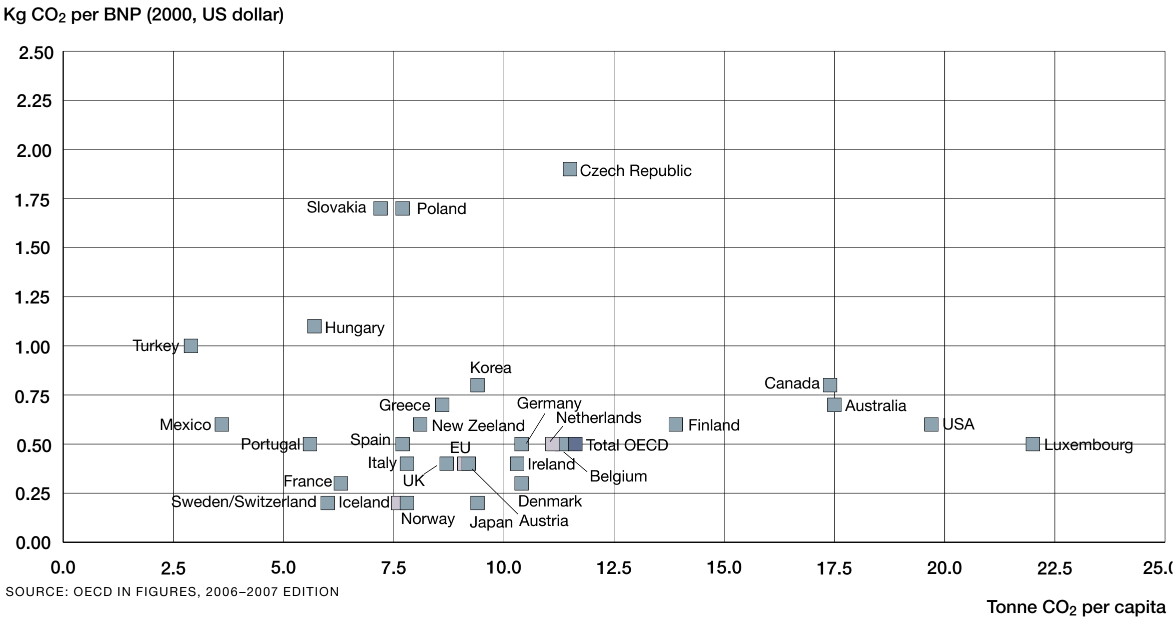
The environment – an international concern

Many environmental problems are of such a type that they affect wide areas; sometimes the whole world, as in depletion of the ozone layer and climate effects, and sometimes larger regions such as acid rain and long-distance air pollution. This means that, to be successful, environmental restoration work must be carried out in an international arena. It is particularly within the EU and the UN that Sweden performs its international environmental work.

EU

In the environment field, the European Union works through binding decisions (directives), information,

Figure 64: Emissions of carbon dioxide from combustion, per capita and GDP, 2003 in EU and OECD states



SOURCE: OECD IN FIGURES, 2006–2007 EDITION

research and development, and international negotiations. It also plays an important part as a source of funding and as the initiative-taker in research and development, not least in the environmental sector.

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 Programme (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. The main activity continues, but on a broader front, in order to increase the likelihood of the EU achieving its commitments under the Kyoto Protocol. One of the most important activities is that of emission allowances trading in a single EU market.

Achieving the Clean Air and Only Natural Acidification 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 climate panel, IPCC, 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 adaption and mitigation measures. 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 Protocol.

The Commission on Sustainable Development was established by the General Assembly after the 1992 Rio Summit. Its first task was to follow up the work after the Rio conference (nowadays after the Johannesburg Summit) by monitoring and reporting if countries achieve their targets. It was also at the Rio Summit that the Climate Convention that has subsequently formed the basis of international climate work was set up. Read more about international climate policy in Chapter 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. The most recent such larger review of calorific values was carried out in 2001. There will be an updating review in the autumn of 2007, which means that any resulting changes will be announced in the near future. 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 most countries, including 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 8: Calorific values as 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	9.0–11.0
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
Other light oils	1 m^3	8.74	31.5
Aviation paraffin and other intermediate oils	1 m^3	9.58	34.5
Other paraffins	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
Town gas and coke oven gas	1 000 m^3	4.65	16.7
Natural gas[1]	1 000 m^3	11.0	39.8
Blast furnace gas	1 000 m^3	0.93	3.35

Note.Conversion factors in this table are given to three significant figures. More significant figures are used in the calculations.[1] The value for natural gas is the net (lower) calorific value.

Table 9: 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 10: 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}	milion million
P	Peta	10^{15}	thousand million million

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

Coal

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

- Brown coal (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 and refrigeration factor

Efficiency can be defined as useful energy output (i.e. that actually obtained), 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. Strictly, the efficiency of a boiler can never exceed 100 %, but its 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 %. The coefficient of performance of most types of heat pumps (including refrigerating machinery) should exceed 1. 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

Energy and power are not the same: energy is the amount of work done or heat delivered. It is measured in the SI unit joule, which equals 1 watt-second. One kilowatt-hour (kWh) therefore equals 3600 watt-seconds.

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 a 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 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, such as a gas turbine or a diesel 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, the steam from the turbine is discharged to a condenser, where it is condensed back into water by giving up its heat to the surrounding air or to some source of cold water, such as a river or the sea . 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 steam leaves the turbine at a higher temperature than is the case for the steam leaving a cold condensing turbine, and 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 (and heat) 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 meet some other heat load, 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 a thermal process. It is usually water that is the process medium. 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.

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

Fuels
Substances or materials with chemically-bound (or fissile) energy. Fuels are usually regarded as being organic compounds or organic materials which release heat when burnt. Nuclear fuels, however, are those that release heat as a result of nuclear fission. 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, in the form of, for example, 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 being 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 (dry distillation) or by partial combustion. In addition, organic non-fossil materials can be gasified by biological processes, to produce biogas. Pyrolysis 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 and ash or sinter. 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 commercial 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.

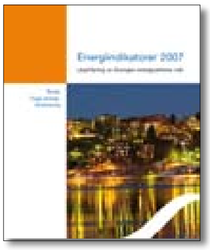
Peat
An organic type of soil, formed under damp and oxygen-deficient conditions by the bacterial and chemical decomposition of dead plant and animal matter. Peat is renewed relatively slowly, and is therefore somewhere between renewable fuels and non-renewable fossil fuels.

Power
Power and energy 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 - that is, large heat pumps operated by the district heating supplier. Refineries, cement factories, steel mills and pulp mills are major sources of waste heat. Sewage effluent treatment plants also produce waste heat, but at a relatively low temperature, and which is therefore used as the heat source for heat pumps.

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 2007

The purpose of this report, which is published annually, is to present indicators for monitoring the progress of achievement of energy policy targets. The 2007 edition, which is introduced with a brief presentation of Sweden's energy policy targets, contains five new indicators for the security supply and 20 updated base indicators. (This report is produced only in Swedish.)

The Energy Markets Inspectorate - Annual Report 2006

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 2006, 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.

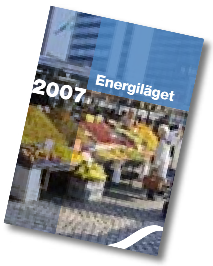
An efficient, low-environmental-impact energy system

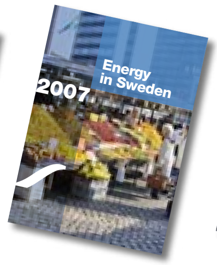
The Swedish Energy Agency is Sweden's central public authority for matters concerned with energy. The overall objective of our work is to achieve a low-environmental-impact, reliable and efficient energy system in Sweden and, ultimately, in the rest of the world. We encourage more efficient energy markets, 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 – Publications.

Energiläget 2007 – printed
Energiläget 2007 – PDF
Energy in Sweden – Facts and figures 2007 – printed
Energy in Sweden – Facts and figures 2007 – PDF
Energy in Sweden – Facts and figures 2007 – Excel
Energy in Sweden 2007 – printed
Energy in Sweden 2007 – 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.

Energy in Sweden is the english translation of Energiläget.

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

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