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Preface

The Swedish Energy Agency is Sweden's central public authority for matters concerned with energy. Its work includes responsibility for Sweden's part in the emission trading system, the Green Electricity certificate system, climate research in connection with energy policy, and international climate projects. Energy related work carried out at regional, county and local authority levels has a key part to play in the strategic programme of converting Sweden's energy system to a more sustainable basis. The Agency operates, finance and participates in many activities in the sector. Activities are carried out in conjunction with other public authorities, with industry, energy utilities, local authorities and the scientific community. The Agency is also responsible for energy-related matters such as strategic planning for crisis or emergency situations, research, development, demonstration and commercialisation activities. The provision of information on the energy system and its development also forms a central part of the work of the Agency.

The annual *Energy in Sweden* report, and its sister publication, *Energy in Sweden – Facts and Figures,* 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 2008, complemented where possible by input reflecting current events and decisions up to the middle of 2009.

Eskilstuna, December 2009

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Contents

Contributors

Sweden's energy policy
Maria Alm
Energy in the EU
Jennie Cato/Lisa Lundmark
Climate policy
Johanna Myrman/Ulrika Raab/Marie Karlberg
Energy taxes and policy measures for buildings
Therese Karlsson
Green electricity certificates
Maria Jöhnemark
Emissions trading
Sophie Bohnstedt
PFE
Karolina Petersson
Policy measures for transport
Karin Sahlin
Technology procurement
Tomas Berggren
Energy research
Markus Bäck/ Mikaela Sahlin
Information activities
Elisabeth Linder
Energy balance, district heating and -cooling, oil
Markus Bäck
Residential and service, industry and transport
Niklas Wagman
Electricity market, energy gases
Mikaela Sahlin
Coal
Carola Lindberg
Biofuels
Matti Parikka
Energy prices, world energy situation
Urban Kärrmark
Secure energy supply
Ester Veibäck
Environmental situation
Emma Östensson

Current energy and climate policy activities

Political and legal considerations determine the framework conditions for energy markets. The 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 EU decisions, although global agreements are becoming increasingly important. The need for global cooperation is essential 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

The European Commission presented a package of proposed climate and energy policy and legislation in January 2008, with agreement of the proposed measures being reached by the EU member states in December of the same year. On 5th February 2009, the party leaders of *Alliance for Sweden*[1] reached an agreement concerning long term and suastainable energy and climate policy. In its *A co-ordinated energy and climate policy – Climate and A coordinated energy and climate policy – Energy* bills[2], the Government states that the agreement is based on material from the Scientific Council, the Standing Committee on Climate, and on dialogues between the Government, industry and society concerning energy and climate matters. The Swedish agreement is based on the EU policy that was decided in connection with the EU climate and energy package.

The Government emphasises the particular importance of a long term plan for the parties involved in the energy market, in order to link its ambitions in the climate sector with current negotiations for a new international climate agreement under the Swedish presidency of the EU. In addition, the Government believes that the agreement will win wide support among the public, in business and in the labour market.

The Government states that Swedish energy policy (which is also seen as constituting the basis for the country's climate policy) should be built on the same foundations as the wider energy cooperation in the EU, i.e. ecological sustainability, competitiveness and security of supply.

Actions in the short and medium long terms

In response to a Government proposal, Parliament has decided that, by 2020, at least 50 % of the country's total energy use should be met by energy from renewable sources. At the same time, at least 10 % of the energy used in the transport sector should also be from renewable sources. This target for 2020 should be seen as a step along the way of the Government's long term aim that, by 2030, Sweden's vehicles should be independent of fossil fuels. Parliament also decided that a target for a 20 % improvement in the efficiency of all forms of energy use should be set for 2020. This target is expressed as an across the board target for a 20 % reduction in energy intensity between 2008 and 2020.

The Energy Bill presents an implementation plan for improving the efficiency of energy use, and for complying with the Energy Services Directive. The Government proposes that a five year programme of energy efficiency improvement measures should be carried out over the period 2010–2014, financed by funding of SEK 300 million per year over the period. The Swedish Energy Agency will

1 This includes the Moderaterna (Moderates), Centre Party, Liberals and Christian Democrats.

2 Bill nos. 2008/09:162 and 2008/09:163

have overall responsibility for carrying out the energy efficiency improvement programme, and for the measures necessary in order to monitor application of the Energy Services Directive. The purpose of the programme is to strengthen regional and local energy and climate activities, and also to strengthen the provision of information and advisory services. The public sector must be seen as setting an example in improving the efficiency of energy use. A special ordinance[3] sets out energy efficiency improvement measures to be applied by public authorities, and appoints the Swedish Energy Agency as the surveillance authority.

The Government intends to introduce a support system with energy monitoring checks for companies using substantial quantities of energy over the period 2010–2014. In addition, it is proposed that energy advisory services for companies should be improved across the board, with particular attention being paid to the needs of small and medium sized companies. The Agency should be instructed to administer and monitor these two measures. Local authorities and county councils will be invited to enter into voluntary energy efficiency improvement agreements with the Agency.

If the efficiency of energy use in society in general is to be improved, one of the requirements is that there should be a wider range of energy efficient products available for consumers. The Government therefore proposes greater emphasis on technology procurement and market introduction of energy efficient technology, in order to make such products available to consumers. The Government also intends to introduce requirements for individual metering of electricity and hot water in new building and conversion projects, except where such metering would be disproportionately difficult.

The Programme for Improving Energy Efficiency in Energy-Intensive Industries (PFE) should continue, with the same emphasis, and with the same target group of energy intensive companies, as today. Requirements relating to energy conservation measures in companies should be better coordinated, and the Agency should be given the role of surveillance and guidance authority in this area. In this respect, the emphasis of continued surveillance in accordance with the Environmental Framework Code should be to encourage continuous work of improving the efficiency of energy use to suit the needs of particular companies, in accordance with the model applied in the PFE programme.

As far as achieving the target of at least 50 % of renewable energy by 2020 is concerned, one of the Government proposals is that the Green Electricity certificate system for renewable electricity production should be further expanded. The earlier target for new renewable electricity (i.e. to achieve an increase of 17 TWh between 2002 and 2016) has been revised, so that the target now is to achieve an

3 Ordinance (2009:893) Concerning Energy Efficiency Measures for Public Authorities

increase of 25 TWh by 2020. The Agency has been given an extensive range of tasks in connection with implementing the Renewables Directive, involving the preparation of an overall plan, a review of the electricity certificate system in the light of a target of 25 TWh, formulating a strategy for the production and use of biogas, and preparing a national framework of regulations concerning sustainability criteria for liquid biofuels. A political agreement has also been reached during 2009 between Sweden and Norway concerning a common electricity certificate system.

At the request of the Government[4], Parliament has set a national planning framework target for wind power to deliver 30 TWh by 2020, of which 20 TWh would be onshore and 10 TWh offshore. In its earlier Wind Power Bill[5] the Government presented measures intended to facilitate the introduction of the planning framework. The planning process was simplified in the autumn of 2006, with the effect that wind farms with aggregated capacities not exceeding 25 MW now need only to be notified to the local authority.

As part of the 2007–2013 Rural Development Programme, SEK 200 million per year have been set aside for the period 2009–2013 for investments in agricultural biogas production from the digestion of manure. A more detailed plan to achieve renewable energy targets will be presented by not later than June 2010. The Government's Budget Bill for 2009 proposes funding of SEK 50 million per year for solar cells and biogas for the period 2009–2011. This funding can also cover demonstration plants for second generation biobased motor fuels.

An objective in the longer term is that, by 2030, road vehicles in Sweden should be independent of fossil fuels. In addition to appropriate taxation, the Government's plans also include concentration on the development of renewable motor fuels and of alternative technologies.

One of the measures intended to encourage the use of low-pollution cars is that new vehicles of this type, bought since 1st July 2009, should be exempted from vehicle tax over a period of five years. The definition of qualifying vehicles for this scheme will be progressively tightened up. Several changes in vehicle taxation have been introduced, with the intention of encouraging the use of cars and commercial vehicles having lower carbon dioxide emissions. As far as non vehicular emissions are concerned, the Government is encouraging wider international application of emission trading, while at home it has raised the energy and carbon dioxide tax rates.

Production of biobased motor fuels and other liquid biobased fuels must meet certain sustainability criteria. Biobased motor fuels that, in comparison with oil based fuels, do not have emissions that are at least 35 % lower than those from the

4 Bill no. 2008/09:163: A Coordinated Energy and Climate Policy – Energy.

5 Bill no. 2005/06:143: Green Electricity from Wind Power – Ensuring a Healthy Wind Power Sector.

oil based fuels, do not qualify towards achieving the target. In order to increase the use of biobased motor fuels, the Government is concerned that the EU's new Motor Fuels Quality Directive should be quickly implemented. Under the Directive, it is permitted to mix up to 10 % ethanol in petrol and up to 7 % FAME[6] in diesel fuel.

As far as electricity production is concerned, the Government states that nuclear power will be an important source of Swedish electricity production for the foreseeable future. One condition for future use of nuclear power is that permission for new reactors will be granted only if they replace existing reactors and are built on the same sites. In the near future, the Government intends to put forward a bill to annul the Nuclear Phase out Act *(see under 'Current Investigations' in this chapter).* The purpose of this is to remove the ban on the construction of new plants that is contained in the Act (1984:3) Concerning Nuclear Technology Activities. However, no public funding support for nuclear power, in the form of direct or indirect subsidies, can be expected.

The Government intends to establish a special Energy Efficiency Improvement Council, as part of the Swedish Energy Agency, in order to coordinate the work of improving the efficiency of energy use. Members of the Council will include representatives from other public authorities concerned. The Agency will be given overall authority for operation of the Energy Efficiency Improvement Programme, and for those measures necessary in order to monitor implementation of the Energy Services Directive.

Long-term measures

During 2008, the Swedish Energy Agency has distributed a total of SEK 875 million for energy research. With effect from 2009, the Agency's resources for this purpose have been increased by a further SEK 110 million per year. In addition, the Science Council has received funding of SEK 40 million per year for energy research.

As stated in the Government's 2008 Research and Innovation Bill, 24 strategic research areas at the country's higher education centres will see an increase in their funding. In the energy sector, the annual grants for universities and institutes of technology will be increased by SEK 50 million in 2010, with a further SEK 50 million in 2011 and SEK 60 million in 2012. Funds for universities and institutes of technology were announced during the spring of 2009, with the applications being evaluated by the Agency in conjunction with the Science Council, with proposals for allocation of the funds given in the 2010 Budget Bill.

It is suggested that the financing should be concentrated on the following areas:

6 Fatty acid methylester

large scale renewable electricity production and its integration in the electricity system; electrical drive systems and hybrid vehicles; energy combinates; biobased motor fuels and renewable materials; and fundamental energy research, including the area of new nuclear technology and carbon dioxide separation and storage.

In addition to the concentration on energy research that was included in the Research and Innovation Bill, Parliament's decision represents an increase of SEK 145 million in the 2009 grant for energy research (in comparison with 2008), of SEK 380 million in the 2010 grant, and SEK 350 million in 2011. This additional funding is intended to facilitate demonstration and commercialisation of new technology for renewable energy. The work will be concentrated on second generation biobased motor fuels, followed by demonstration and commercialisation of other energy technologies of major national importance and having an extensive export potential.

Current investigations

The work of the *New Electricity and Gas Market Commission*[7] includes monitoring the current work within the EU of drafting common rules for the single market for electricity and natural gas, as well as preparing proposals for legislation and regulations in general with the aim of implementing the revised EU Electricity and Gas Market Directive. The Commission is due to report by not later than 1st March 2010.

The *Coordinated Regulation of the Nuclear Power Technology and Radiation Protection Sector Commission*[8] will investigate the conditions for coordinated regulation of activities in the fields of nuclear power technology and protection against ionising radiation. The Commission has been instructed to pay particular attention to the feasibility of merging the requirements of the Act Concerning Nuclear Activities and the Ionising Radiation Protection Act into a single act. The aim of this is to simplify and improve the efficacy of the structure of the regulations, without in any way sacrificing public requirements in respect of nuclear safety and radiation protection. This work is due for reporting by not later than 22nd December 2009.

The *Environmental Objectives System Review Commission*[9] will propose changes to the structure and organisation of the environmental objective system. The aim is to simplify and improve the structure and organisation of the system, including greater sensitivity to the public economic aspects of the systems. The work includes putting forward proposals that recognise and include the international character of environmental problems, and also to make better use of environmental advances by industry etc. in the national environmental targets system.

7 N 2009:04 (NELGA)

8 M 2008:05

9 M 2008:02

The report was due for publication by not later than 30th September 2009.

A new body, under the name of the Swedish Environmental Technology Council (Swentec) has been established with the aim of developing an effective state structure for supporting Swedish environmental technology companies[10]. The Council will submit half yearly interim reports of its activities, with a final report on 31st December 2010.

Against the background of the quota obligation considerations, and of the work on electric vehicles and rechargeable hybrids, the Government intends to put forward a more detailed description of how the country's renewable energy target is to be achieved. The Government also intends to put forward a proposal for incorporation of the Renewable Energy Directive in national legislation.

Concluded investigations

The main purpose given in the Government's instructions[11] to the *Energy Efficiency Improvement Commission* was to propose how Directive 2006/32/EC should be implemented in Sweden. The work of the Commission was presented in its report *The Road to a More Efficient Sweden*[12]. Parts of the Commission's proposals are discussed in *A coordinated climate and energy policy – Energy.*

The Government presented its *Advanced Consideration of Network Tariffs Bill*[13] to Parliament on 5th March 2009 for voting. The proposal, for new legislation, is based on the results of the Commission report, *Advanced consideration of the acceptability of network tariffs*[14].

The Energy Markets Inspectorate is investigating the ways in which a surveillance model for advanced setting of revenue limits could be developed, as instructed by the Government[15].

The Environmental Process Commission[16] submitted its report to the Ministry of the Environment on 3rd February 2009, and it is proposed that the new regulations should come into force on 1st July 2010. The proposals mean that applications would be considered by five administrative public authorities and five courts, together with a higher body. The Commission submitted its interim *Water Regulations*[17], together with its final report, *Areas of National Interest and Environmental Impact Descriptions*[18] on 6th May 2009.

The Commission investigating the connection of electricity from renewable sources to the grid presented its findings on 20th February 2008. The Commission has analysed whether the present regulatory structure is an impediment to large scale development and expansion of renewable electricity production. The Commission has put forward proposals for a simplified system for planning application approval in respect of such aspects as the requirement to prepare environmental

10 Swentec, Swedish Environmental Technology Council
11 Directive 2006:89
12 SOU 2008:110
13 2008/09:141
14 SOU 2007:99
15 N2009/1942/E
16 M2007:04
17 SOU 2009:42
18 SOU 2009:45

impact assessments before extending the grid connections. The Commission will continue to work on this until its final report.

The Swedish Energy Agency was instructed to investigate the conditions for, and consequences of, the introduction of a quota obligation system to accelerate the introduction of biobased motor fuels in the transport sector. The Agency's proposal[19] for quota obligations for these fuels is part of the work of achieving the EU objective of 10 % of renewable energy in the transport sector by 2020. The proposal includes a requirement, affecting mainly the oil companies, to supply a certain proportion of biobased motor fuels in relation to their supplied quantities of petrol and diesel fuel. The proposal would also mean that the present general tax exemption on such fuels would be removed. The proposal recommends that the Government should consider continued tax exemption for liquid high admixture biobased motor fuels, such as E85 and biodiesel.

The Agency proposes a four year period of economic support for demonstration development and activities intended to increase the number of electric vehicles and rechargeable hybrids on the market. The Agency proposes that the subsidy for such vehicles should be increased, and that it should be paid in connection with purchase of the vehicle. Both these proposals are based on the results of the report[20] that the Agency has prepared in conjunction with the Energy Markets Inspectorate, the Swedish Transport Agency and the Swedish Road Administration. The work was also carried out in conjunction with representatives of the automotive industry, electricity distributors, electricity producers, consumers, the Swedish Association of Local Authorities and Regions, and other relevant public authorities. The Agency's report was submitted to the Ministry of Enterprise, Energy and Communications in 2009.

19 Kvotpliktsystem för biodrivmedel. Energimyndighetens förslag till utformning, ER 2009:27

20 Kunskapsunderlag Angående Marknaden för Elfordon och Laddhybrider, ER 2000:20.

FACTS The Budget Bill

In its Budget Bill for 2010, the Government's proposals for allocation of funds include the following:

The Swedish Energy Agency's general administration grant will be increased by SEK 80 million/year with effect from 2010. This will be financed partly by a transfer of SEK 50 million/year from energy research, and partly by a transfer of SEK 30 million from the new energy efficiency improvement programme, with this latter contribution ceasing at the end of 2014. The increase in administration funding is intended to reduce the need to draw on other grants in Expenditure Area 21, Energy, in order to meet administration related costs. The Government proposes that SEK 237 million should be granted for 2010, rising to SEK 239 million for 2011 and SEK 241 million for 2012.

Under the terms of the Research and Innovation Policy Bill in the autumn of 2008, a further SEK 110 million was added to the energy research grant with effect from 2009. The Budget Bill proposes that the energy research grant should be increased by SEK 145 million, with the aim of facilitating demonstration and commercialisation of new renewable energy technology. The Bill expects the additions for this aspect to amount to SEK 380 million in 2010 and SEK 350 million in 2011.

New public funding of solar cells was introduced on 1st July 2009. Funding to support the development and use of biogas is at present being planned, with the aim of supporting as yet not commercially viable technology. The Government proposed that a sum of SEK 122 million should be made available in 2010, falling to SEK 117 million in 2011.

One of the prerequisites of achieving the targets for improving the efficiency of energy use is that appropriate new technology should be developed and implemented. The Government proposes that SEK 105 million should be granted for this purpose in 2010, followed by SEK 120 million in 2011 and SEK 115 million in 2012. The Government proposes that SEK 70 million should be granted for the market introduction of wind power over the period 2010–2012.

Funding was set aside in the Budget Bill in order to extend the support for connection of wind power for a further two years, with a further two years' support for planning work. The grant was increased by SEK 30 million for 2009, by SEK 40 million for 2010 and by SEK 20 million for 2011.

SEK 280 million was proposed in the Bill for support for conversion of direct electric heating systems in detached houses, apartment buildings and commercial premises linked to residential buildings. SEK 24 million for 2010 were proposed for support for installation of solar heating systems.

A grant of SEK 300 million/year over the five year period is proposed for the 2010–2014 Energy Efficiency Improvement programme. A range of measures is justified in order to reach out to all decision makers with the message that it is profitable for consumers and reduces the load on the energy system to conserve energy. The Bill proposed funding of SEK 140 million/year for the period 2010–2012 in order to continue this work.

As part of the work of the Rural Development programme, it is proposed to increase funding for investments in production of biogas to a total of SEK 200 million for the period 2009–2013.

Budget Bill no. 2009/10:1

Energy in the EU

The EU's Energy Policy is based on three main objectives: competitiveness, sustainability and security of supply. The first Strategic Energy Review, which was presented in January 2007, laid the foundation for the present concentration on EU energy policy, and resulted in the European Commission's conclusions in 2007, setting out the EU's 20-20-20 targets[21] for 2020 and an action plan for the period 2007–2009.

During 2007 and at the beginning of 2008, the Commission put forward proposals for meeting the three main objectives in the action plan, in the form of one package of measures for the single market and another for the energy and climate groups.

The Commission presented its second Strategic Energy Review in November 2008, concentrating on energy supply as its main theme, in accordance with the decision of the European Council.

If the EU is to achieve its objectives and tackle climate change, the whole way of producing and using energy must be radically changed. The EU therefore intends to concentrate its work on key areas such as the electricity and gas markets, renewable energy sources, consumer behaviour and closer international cooperation.

The EU's Climate and Energy Strategy goes hand-in-hand with its work on economic growth and new jobs. The fact that the EU is tackling the climate problem at an early stage also helps new commercial activities and research. The EU member states are being encouraged to act in their own spheres, but the EU will coordinate overall work to ensure that the burden is spread equally. Targets are binding, but have been set in accordance with the individual countries' abilities.

The energy and climate package

The Commission presented its second Energy and Climate package in 2008, in the form of proposals for directives and decisions in several areas concerned with energy and climate problems. In December 2008, after intensive negotiations, the Council and the European Parliament adopted the new legislation. The new decisions are briefly as follows:

- By 2020, 20 % of the EU's energy supply shall come from renewable energy sources. This is a binding target, and has been allocated between the member states with allowance for their ability to achieve it and for hitherto achieved results. For Sweden, the target is 49 % of renewable energy by 2020.
- By 2020, at least 10 % of energy use in the transport sector must be from renewable sources. However, in this case, allocations are not apportioned after ability; instead, the same target applies for all member states. In the case of biobased motor fuels, only those fuels that meet defined sustainability

21 20 % improvement in the efficiency of energy use, 20 % renewable energy, 20 % reduced greenhouse gas emissions

criteria can be counted towards achievement of the target. However, renewable electricity used in the transport sector can be counted.

- For the EU as a whole, emissions from large combustion plants and energy intensive industries must be 21 % lower in 2020 than they were in 2005. One of the ways in which this is to be achieved is by extending the European Union Emission Trading System (EU ETS). The intention is that reduction should continue at the same rate during the following years of 2020–2028.
- Emissions from sectors not covered by EU ETS (e.g. transport[22], agriculture, waste and domestic users) shall be 10 % lower in 2020 than in 2005. This target has been proportionately allocated, so that richer countries are required to achieve greater reductions than the poorest countries. In those sectors not covered by EU ETS, Sweden is required to reduce its emissions by 17 %.
- The EU will support and encourage the use of technology for carbon dioxide separation and geological storage. In the longer term, use of this technology can reduce carbon dioxide emissions from fossil fuels in power stations and industry.
- Emissions from the transport sector will be reduced by application of new regulations encouraging the use of energy efficient private cars. On average, private car emissions must not exceed 130 g of carbon dioxide per kilometre. A special rebate will be introduced for those member states having a high proportion of renewable motor fuels available at filling stations.
- A new directive will permit the admixture of a higher proportion of renewable motor fuels in petrol and diesel fuel than has previously been the case. At the same time, emissions along the entire chain from abstraction, conversion and use of motor fuels must fall by at least 6 % by 2020.
- Finally, the Commission has permitted new regulations governing state support as a consequence of more ambitious EU targets.

Most of the new regulations will come into force in 2010–2011. In several cases, more detailed regulations need to be prepared by the appropriate committees. The revised emission trading system will come into force on 1st January 2013, with one of the changes being that it will be centrally administered, rather than by each member state.

22 Except aviation, which will be covered by EU ETS in 2012

The second Strategic Energy Review (SER2)

The first Strategic Energy Review was presented in January 2007, and formed the basis for establishing the EU's joint 20-20-20 objectives. It also resulted in the 2007–2009 energy plan, to which priority was given when preparing it.

With this review, two of the three energy policy bases (with the Single Market having been the first) had been supported by a package of measures. After this, pressure arose from new member states to pay greater attention to security of supply. In November 2008, the Commission therefore launched its second Strategic Energy Review (SER2), concentrating particularly on security of supply.

SER2 contains a score or so of documents. The main document consists of an action plan for energy supply and solidarity, and includes a vision for the period 2020–2050. In addition, the package contains four legislative initiatives; three for energy efficiency improvement, and one for oil storage. Finally, the package includes several notices, a forward looking Green Paper of the TEN-e (Trans European Network, electricity), a notice concerning offshore wind power, and several evaluations of existing directives, e.g. the Cogeneration Directive from 2004.

In its package of measures, the Commission is looking for support for measures in five main areas:

- Infrastructure – six priority regions. A proposal for a revised financing system will be published in 2010.
- External relations – The EU aims to speak more with one voice in external energy dialogues, e.g. with Russia.
- Solidarity – For example, the Oil Storage Directive and possibly revision of the Gas Supply Directive.
- Energy efficiency improvement – See the four legislative proposals at the top of the list below.
- Indigenous energy sources – Primarily concerned with renewable energy sources and financing opportunities, e.g. via the European Bank for Reconstruction and Development (EBRD).

Energy efficiency improvement proposals

• Communication: "Energy efficiency improvement – deliver 20 %".

The Commission has noted that existing measures are not sufficient in order to achieve a 20 % efficiency improvement by 2020. A review of national action programmes reveals a shortfall between member states' political commitments and actual actions. In addition to the energy efficiency improvement package that has been presented, the Commission is considering new initiatives for financing the necessary efficiency improvement measures.

During 2009, the Commission plans to review the results of the efficiency improvement programme since 2006, with the aim of preparing a revised action plan.

• Proposal for a revised Directive Concerning the Energy Performance of Buildings

Energy declarations must be included in all sale and rental documents and advertisements. Requirement for energy efficiency for all buildings undergoing more substantial renovation (today applies only to those larger than 1 000 m²). Member states to draw up plans for the introduction of low energy houses and passive houses. Calculated energy savings as a result of these revisions estimated as 60–80 Mtoe, or 5–6 % of total EU energy use.

• Proposal: revised Directive Concerning Energy Labelling of Domestic Appliances

It is proposed that this should be extended to all energy related products (the same scope as that of the proposed expanded Eco design Directive). Used products and transport equipment excepted. As today, the detailed regulations for labelling are to be determined by committee procedure. This proposal is expected to result in annual energy savings of 27 Mtoe by 2020.

• Proposal for Directive Concerning Energy Labelling of Tyres

Labelling required for fuel efficiency, road grip on wet surfaces, and noise, to cover most tyres, apart from studded tyres and spare tyres. Tyres account for 20–30 % of vehicles' energy use. This measure would result in EU savings of between 0.56 and 1.51 Mtoe per year, depending on how quickly the range of products on the market responded.

- **Communication: "Europe can save more energy through combined heat and power production"**

Status report concerning combined heat and power in the EU, and development scope. Part of the Commission's reporting under the CHP Directive (2004/8/EC). Many member states have yet fully to implement the CHP Directive. The Commission sees the CHP Directive as an important tool, and states that it may make further proposals.

- **Decision concerning guidelines for calculating electricity production from CHP production in accordance with Appendix 2 of the CHP Directive (2004/8/EC)**

Green Paper for Trans European Energy Network (TEN-e)

The Green Paper is concerned with the creation of a safe and sustainable European energy network. The present network does not meet the requirements needed to achieve a fully integrated single European market, and it is also unsuited to handling large quantities of renewable energy. Investments of EUR 10^{18} would be needed in order to update the network to the necessary standards. The Green Paper is intended to launch a new direction of the EU's energy policy as a whole, with harmonised network construction, a holistic approach and joint planning.

The Commission mentions a new European supergrid, and the Green Paper includes the Baltic Interconnection Plan, a new southern gas corridor, the Mediterranean energy ring, solar and wind power generation in North Africa, a north south gas and electricity interconnection within central and south east Europe, and a North Sea offshore grid. The Green Paper also considers inclusion of oil pipes and CO_2 storage infrastructure in the TEN programme, and this new programme will probably be launched in 2010 under a new name.

Sweden's 2009 presidency of the EU

Sweden has held the presidency of the EU during the autumn of 2009. In addition to the finance crisis, its priority working areas have been to meet the climate challenge and to improve the competitiveness of the EU by moving towards an eco efficient economy. In the energy sector, implementation of the second strategic energy review is continuing, with particular concentration on improving the efficiency of energy use.

Energy matters continue to have a high priority, not least against a background of the international climate negotiations to be held in Copenhagen in December 2009. A change to an eco efficient European economy is essential, not only for competitiveness, but also for security of supply and for the environment.

The second Strategic Energy Review, together with the package of initiatives on security of supply, which was presented by the Commission in November 2008, will be the main determinant of work during autumn 2009. European energy ministers will continue their work on the action plan for security of supply and solidarity in the energy sector. The main concentration during autumn 2009 will be on improving the efficiency of energy use.

The EU's international relations and dialogues in the energy sector are becoming increasingly important. Upcoming negotiations include expansion of the Energy Community to include Moldavia, the Ukraine and Turkey, while other negotiations include energy cooperation between the EU and Nigeria. Development of the energy market around the Baltic is important, and it is the intention to complete the strategically important 'Baltic Energy Market Interconnection Plan'.

The move towards an eco efficient economy will be the main theme of the informal meeting of energy ministers, with particular concentration on efficient energy systems.

Some of the more important meetings in the energy sector during Sweden's chairmanship of the EU are:

- An informal meeting of energy ministers in Åre on 23rd–24th July, partly together with environment ministers.
- A high level conference on Efficient Bioenergy in Stockholm on 17th–18th September.
- A policy conference on offshore wind power in Stockholm on 14th–15th September.
- The EU Strategic Energy Technology Plan conference in Stockholm, 21st–22nd October.

Important dates in international climate cooperation

1992 The Climate Convention is formulated in Rio de Janeiro, Brazil.

1994 The Climate Convention comes into force after 166 countries have ratified it.

1997 The Kyoto Protocol is formulated in Kyoto, Japan.

2001 The Marrakech Accord sets out detailed regulations and guidelines for implementation of the Kyoto Protocol.

2005 The Kyoto Protocol comes into force.

2008 Start of the first commitment period.

For more information on international climate cooperation, see previous editions of *Energy in Sweden*, www.energimyndigheten.se or www.unfccc.int.

Climate policy

International climate cooperation

A major conference on climate change was held by the United Nations in Rio de Janeiro in 1992. The conference resulted in an agreement jointly to tackle the global threat of climate change, with the parties to the conference signing the United Nations Framework Convention on Climate Change (UNFCCC), also known as the Climate Convention. The Convention came into force in 1994, and was followed by the Kyoto Protocol, a number of agreements coupled to which have come into force.

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.

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 Protocol to come into force, it was necessary for it to have been 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. 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 November 2004, with the result that it came into force in February 2005.

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 EU15[23], which negotiated 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. Under the terms of the agreement, Sweden has a commitment not to increase its emissions by more than 4 %.

Flexible mechanisms

What are known as 'Flexible Mechanisms' are included in the Marrakech Accord and the Kyoto Protocol in order to facilitate more cost efficient emission reductions, and so also quantitatively greater commitments. They consist of emission trading (International Emission trading, IET), and the project-based mechanisms: Joint Implementation (JI) and the Clean Development Mechanism (CDM) (see below). Establishment of the flexible mechanisms has been fundamental in enabling the commitments of the Protocol to be met, and is assumed also to provide a basis for continuation of commitments after 2012, i.e. after the first commitment period under the Protocol.

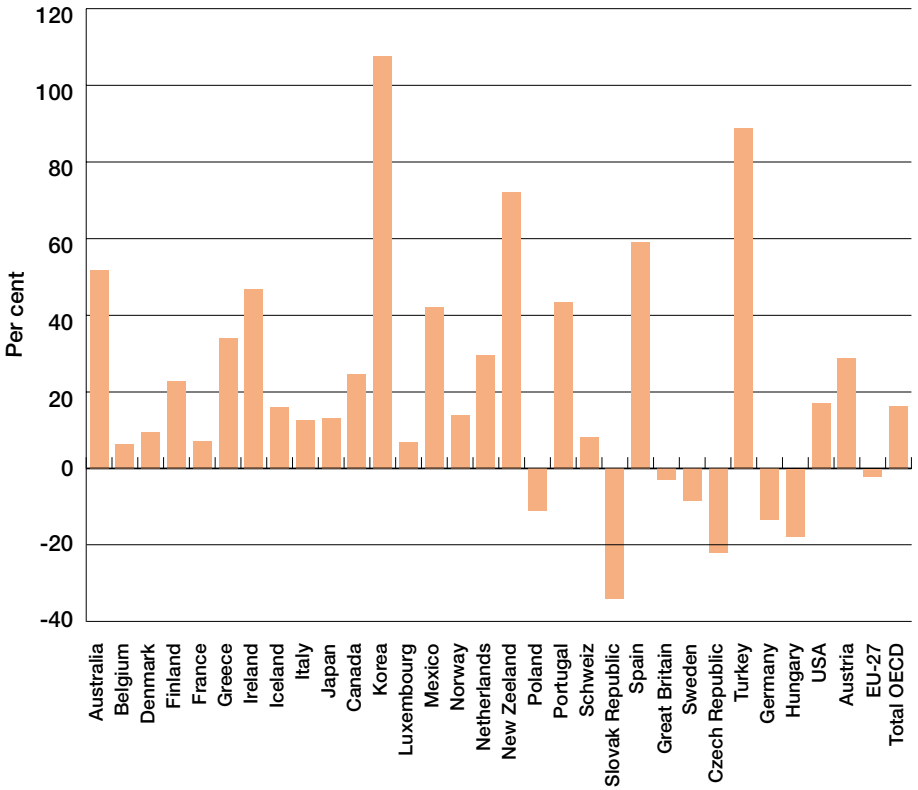
Project-based mechanisms

JI and CDM differ from emission trading 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 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 in accordance with priorities as indicated by the host country.

23 EU 15 refers to the 15 EU member states prior to the expansion on 1st May 2004.

Figur 1
Change in carbon dioxide emissions within the EU and OECD states, 1990–2006

SOURCE: OECD IN FIGURES, 2008 EDITION



The Clean Development Mechanism (CDM) is the one that has been operative for the longest, as the CDM agreement in the Marrakech Accord included a 'prompt start' element, effective from 2000, provided that a number of conditions had been met. An international Executive Board (EB) approves, registers and monitors CDM projects. As a result of the Board's activities, a number of detail regulations for CDM projects have been successively developed. JI is not covered by the prompt start arrangement, as it is dependent on the various countries' allocated emission allowances having been established, which has been the case only since the first commitment period started in 2008. Read more about Sweden's participation in CDMs and JIs in 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 Members of the Parties (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 met again in November 2006 at COP/MOP 2 in Nairobi in Kenya, and at COP/MOP 3 in Bali in December 2007. The results from the Bali meeting were presented in an action plan that describes the way forward towards agreement for the period after 2012, of which 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. COP/MOP 4 was held in December 2008 in Pozna□, in Poland, continuing the work as agreed in the Bali action plan and aiming for a new international climate agreement at COP15/MOP 5 in Copenhagen in December 2009.

”A new framework agreement must be in place at the end of the first commitment period under the Kyoto Protocol in 2012.”

A new framework agreement must be in place at the end of the first commitment period under the Kyoto Protocol in 2012. If this timetable is to be met, it is therefore hoped that the Copenhagen meeting will lay the basis for the framework to take over for the period after 2012. The elements of such a framework consist of a longer term global objective for emission reductions, with enhanced national and international measures to reduce climate change. A central point of this is how emission reductions and accommodation to climate change are to be financed. As Sweden will be holding the presidency of the EU in the autumn of 2009, the country will have an important part to play in the Copenhagen negotiations for a new climate agreement.

Swedish climate strategy

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

Swedish climate strategy was most recently set out in the Government's Bill no. 2008/09:162, A Coordinated Climate and Energy Policy – Climate. This strategy is based on the following Swedish contributions:

- Three action plans; for a fossil-independent transport sector, encouragement of renewable energy and improving the efficiency of energy use
- Green investments in developing countries
- Climate and development cooperation
- Greater awareness of society's vulnerability to 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 tackled at the international level. The Climate Convention makes it clear that the industrialised countries have a particular responsibility to lead the way in countering climate change. The Government therefore regards it as important that industrialised countries should 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. an actual reduction of 4 % in its emissions), achieving this without compensation for uptake in carbon sinks (uptake of greenhouse gases in vegetation and the ground), or by using flexible mechanisms. This objective was confirmed by Parliament in 2006. The EU's emission trading system, which started in 2005, and which applies to industries and electricity and heat producers, covers about one third of Swedish emissions. The trading system as a whole has a ceiling, but exactly where the reductions are effected depends on where there are cost efficient opportunities for doing so. This means that Sweden cannot decide on what the actual quantities of emissions from the trading sector in the country should be, but only

on the quantity of emission allowances allocated.

In 2007, Sweden's total emissions of greenhouse gases were 65.4 million tonnes of carbon dioxide equivalents, or about 7.2 tonnes of carbon dioxide equivalents per capita and year. The target is that, by 2050, Sweden's total emissions should be less than 4.5 tonnes of carbon dioxide equivalents per person and year, with the value continuing to decline. Globally, Sweden accounts 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.

Climate Bill 2008/09:162 sets out Sweden's national targets for the medium/long term (until 2020) as a 40 % reduction in climate emissions from the non-trading sector. In addition, at least 50 % of the country's non-transport energy must be from renewable sources by that date, and at least 10 % of transport energy also from renewable sources. All this is to be complemented by a 20 % improvement in the efficiency of energy use over the period.

”At least 50 % of the country's non-transport energy must be from renewable sources.”

Within the EU, the Council set emissions and renewables targets for the EU in March 2007 for the trading sector covered by the Emission Trading System. Through them, the EU as a whole has undertaken to reduce its emissions of greenhouse gases by 20 % by 2020 in comparison with 1990 emission levels. Starting from this decision, the European Commission published its energy and climate package in January 2008, setting out proposals for an allocation of emissions reductions between the trading sector (i.e. for companies in the EU Emission Trading System) of 21 % from 2005 until 2020, and of 10 % over the same period for the non trading sector. The reductions proportion for the non trading sector would then be apportioned between the 27 member states in accordance with their per capita GNP, to give percentage figures ranging from –20 % to +20 % for the different member states. Under this proposal, Sweden would be assigned an emissions reduction target of 17 %.

The above EU commitment is that which applies today, but there is also a clear ambition within the EU to aim for a reduction in emissions of 30 % as its contribution to an extensive global climate agreement for the period after 2012. This is conditional upon other industrialised countries also undertaking to achieve com-

parable emissions in their reductions, and on the more economically advanced developing countries making reasonable reductions in accordance with their ability and responsibility.

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, has played a considerable part in reducing effects on the climate in a socio economically effective manner. Other important instruments include state support for renewable electricity production and for use of biobased motor fuels.

”Swedish climate policy has been based on tackling problems on a broad front.”

Swedish climate work and its national objectives will be constantly monitored, with the results evaluated in the form of a number of Checkpoint Reports. The first of these reports was published in 2004, followed by the second in 2008. The Swedish Energy Agency and the Environmental Protection Agency have been instructed by the Government to provide material for the reports. The emphasis of the 2008 report has been on expected developments up to 2020.

The work included analysis of a Swedish emissions target of a 25 % reduction compared to 1990. The two agencies are of the opinion that this target can be achieved by a three pronged strategy: reduced Swedish allocation of emission rights within the framework of the EU emission trading system, further development of EU policy measures and incentives, and of national policy measures, in the sectors outside the EU trading system, and through the purchase of emission reduction units through investments in other countries. However, a change introduced by the package of energy and climate measures will mean that the allocations to the trading sector will be decided centrally, rather than by the individual member states.

In addition to the work being carried out within the framework of the regular Checkpoint reports, the Government appointed a parliamentary climate commission in April 2007, which submitted its first report (SOU 2008:24) at the beginning of 2008. The Committee’s action plan was largely based on the material that was prepared for the 2008 Checkpoint report. Other input for the Government’s

2009 Climate Bill, which set out further guidelines for Sweden's national and international climate policy, was provided by the Scientific Council for Climate Issues' report of September 2007.

Events and policies within the EU have become increasingly important for Swedish climate work. An example is the European Climate Change Programme (ECCP), in which the most important policy measure for reducing total EU emissions is the internal Emission Trading Scheme. Other important policy measures in EU strategy include the Directive on the Promotion of the Use of Biofuels and Other Renewable Fuels for Transport, and the Energy Performance of Buildings Directive.

In January 2008, the European Commission published a combined climate and energy strategy document, which was adopted in December of the same year. (This strategy is discussed in more detail in Section *'Energy in the EU'*.) In addition to its EU involvement and its national work on reducing greenhouse gas emissions, Sweden is also engaged in climate work at the international level. It has involved itself in work with the Kyoto Protocol's CDM and JI[24] project-based mechanisms in order to obtain experience of them and to contribute to their further development 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 since 2002 has been responsible for the Swedish International Climate Investment Programme. A total of SEK 1100 million has been made available for international CDM and JI climate investments for the period up to 2011.

Sweden's objective for CDM is to assemble a geographically balanced portfolio, concentrating on small or medium scale projects in the categories of energy use efficiency improvement and renewable energy sources. Special priority is given to projects in the least developed countries, particularly in Africa and South-East Asia, and to small island nations in the process of development. The Agency has entered into agreements concerning the purchase of emission allowances from CDM projects in China, Brazil and India. Agreements that have been reached include the purchase of emission reductions from 15 wind power projects in China, having a total installed capacity of more than 1200 MW. The wind farms are located mainly in the northern and western parts of China, i.e. in less developed areas. The emission reductions will result from replacement of coal fired electricity production by wind power, which will also have the effect of improving local air quality.

In the field of JI projects, the Agency has entered into purchasing agreements for two projects: one for an energy efficiency improvement programme in Romania, and the other for wind power in Estonia. The JI project in Romania was re-

24 CDM (Clean Development Mechanism), JI (Joint Implementation).

gistered under Romania's national approval process in 2008. Estonia has initiated a national approval process for JI projects, and the Agency hopes that the wind power project will soon be registered under it.

In addition to participation in individual projects, the Agency also participates in climate investment funds. The Testing Ground Facility (TGF) 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 in turn is a regional energy cooperation scheme between eleven countries in the Baltic Sea Region. 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 will play an important part in the negotiations for a climate agreement after 2012."

Sweden is a member of the World Bank's Prototype Carbon Fund (PCF). In the spring of 2009, the Agency was appointed by the Government to represent Sweden in the Fund. Started in 1999, the Fund 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. Its total capital amounts to USD 180 million, of which Sweden has contributed USD 10 million. In the early summer of 2009, the Agency decided to purchase further emission reductions to the value of USD 5 million. The fund has signed contracts for sixteen CDM projects and eight JI projects.

Together with six other European countries, Sweden is a member of the Asiatic Development Bank's CDM fund, known as the Asia Pacific Carbon Fund (APCF) and having a total value of USD 152 million. Of this, Sweden's proportion amounts to USD 15 million. The fund concentrates on CDM projects in developing countries in Asia, and on renewable energy supply, improving the efficiency of energy use and methane gas collection in particular. Some of the fund's capital will be used for purchasing emission reductions after the Kyoto Protocol's first commitment period, i.e. after 2012.

At the end of 2008, the Agency entered into partnership with the Future Carbon Fund, FCF. The fund is concerned with post 2012 emission reductions and, like APCF, concentrates on acquiring emission reduction units from energy efficiency improvement, renewable energy and reduced methane emission projects in deve-

loping countries in Asia and the Pacific area. Sweden has invested USD 20 million in the fund, and has a seat on the board.

The Swedish Energy Agency is responsible for Sweden's participation in the European Development Bank's Multilateral Carbon Credit Fund, which invests in CDM and JI projects in such areas as improving the efficiency of energy use, conversions to renewable fuels, and renewable energy sources in Central Asia and Eastern Europe. The fund's total capital amounts to EUR 165 million, of which Sweden has provided EUR 2 million.

It is expected that, as a result of Sweden's international climate investment programme, together with the country's share in multilateral funds and funding that has been earmarked for new projects in the future, the total emissions reduction will amount to about 11–14 million tonnes of carbon dioxide equivalents. The cost of purchasing emission reductions via CDM/JI projects is very much less than the marginal cost of effecting emission reductions in Sweden. Even in comparison with the estimated prices for emission rights in the EU trading system, these projects can be seen to be very cost efficient.

The Agency is the official Swedish Designated National Authority and Designated Focal Point[25] for the project-based mechanisms, with responsibility for approving Swedish companies and organisations wishing to participate in project based mechanisms. The role of the Project Authority also includes deciding whether proposed JI-projects in Sweden meet the requirements for purchasing emission reduction credits, in accordance with the rules set out in 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.

The climate problem will be one of the key working areas during Sweden's presidency of the EU, and it is expected that Sweden will play an important part in the negotiations for a climate agreement after 2012 at the COP15/MOP5 conference in Copenhagen in December 2009.

25 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 Swedish Energy Agency has been appointed as DNA and DFP, under the common designation of the Project Authority.

Figur 2
Carbon dioxide emissions in Sweden, 1980, 1990–2007

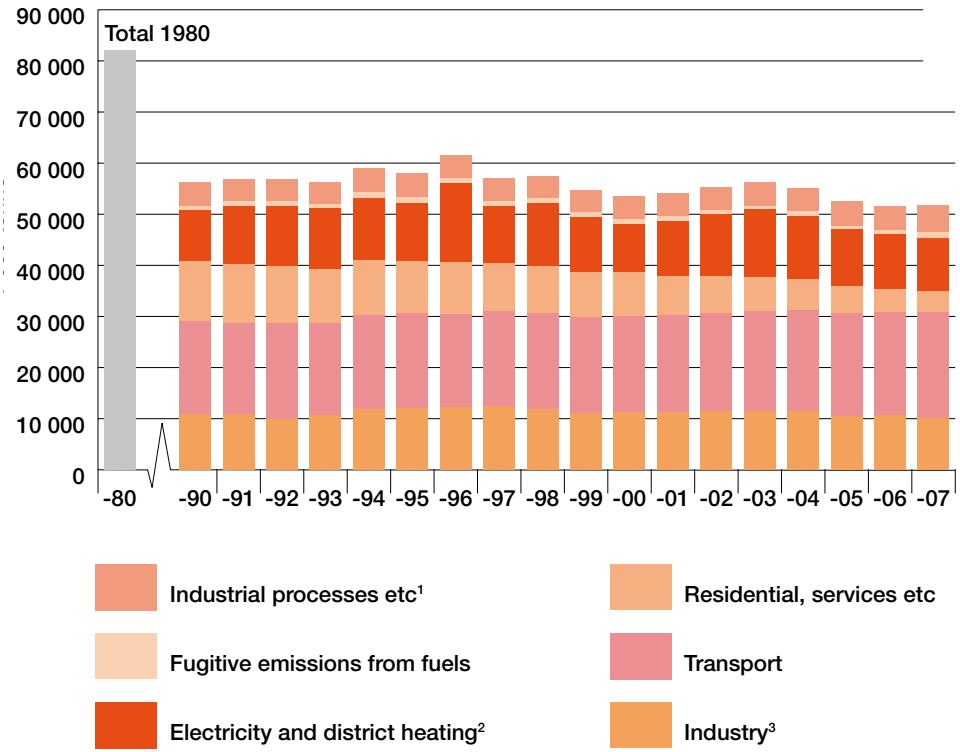
SOURCE, 1980: STATISTICS SWEDEN, STATISTICAL NOTICES, NA 18

SOURCE: 1990–2007: SWEDEN'S REPORTING TO THE UN CLIMATE CONVENTION, SWEDEN'S NATIONAL INVENTORY REPORT, 2009

NOTES:
1. INCLUDING INDUSTRIAL BACK-PRESSURE GENERATION.

2. INCLUDING COKING PLANTS AND REFINERIES.
3. INCLUDING SOLVENTS AND OWN USE OF PRODUCTS.

DETAILS FOR ALL YEARS HAVE BEEN REVISED, AND DIFFER FROM THOSE SHOWN IN PREVIOUS EDITIONS.



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Summary

The continued objective of Swedish energy policy is to ensure a reliable supply of electricity and other energy at competitive prices, by means of sustainable energy use and from energy supplies having minimum adverse effects on health, the environment or climate.

In January 2008, the European Commission published its second Energy and Climate Package, in the form of proposals for directives and decisions in several areas affecting work on energy and the climate. In December 2008, after intensive negotiations, the Council and the European Parliament adopted the new legislation. One of the decisions is that, by 2020, 20 % of EU energy supplies must come from renewable energy sources (Sweden's target is 49 % of energy from renewable sources by 2020), and that at least 10 % of energy use in the transport sector must also come from renewable sources by 2020. Another effect of the decisions is that emission ceilings set by the EU Emission Trading System will be progressively reduced, so that emissions from large combustion plants and energy intensive industries will be 21 % lower in 2020 than they were in 2005.

On 5th February 2009, the party leaders of Alliance for Sweden reached agreement on a long term and sustainable energy and climate policy for Sweden, and submitted the two A coordinated energy and climate policy bills. The Swedish agreement is based on the decisions in the EU Energy and Climate Package. The Bills include a target of providing at least 50 % of the country's energy needs from renewable sources by 2020. Among many other measures, there is a planning framework of 30 TWh of wind power by 2020 (20 TWh onshore and 10 TWh offshore), raising the target of the green electricity certificate system to 25 TWh of new renewable electricity by 2020, and replacing the purchase price subsidy for green cars with exemption from vehicle tax for five years.

The 2009/2010 Budget Bill allocates additional funding to the energy sector for research, development and commercialisation of energy technology, as well as for climate investments in other countries.

December 2009, while Sweden holds the presidency of the EU, will see a negotiation meeting in Copenhagen under the terms of the Climate Convention and Kyoto Protocol. This meeting is seen as that when the framework for a new climate agreement framework, covering the period after 2012 when the first commitment period of the Kyoto Protocol finishes, must be established. Such a framework will need to include a long term global objective for emission reductions, and stronger measures to reduce climate impact.

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 green electricity certificate 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. Emission trading was dealt with in Section *'Swedish Climate Policy'*. Research, development, demonstration and commercialisation projects constitute an important element of long term development strategy.

Various types of policy measures

Policy measures are divided into a number of main groups, depending on how they are intended to achieve their objectives. **Administrative policy measures** are controls in the form of prohibitions or requirements, issued by political or administrative bodies, and which are mandatory in nature. The control may be, for example, quantitative (emission conditions, limit values etc.) or technical. Those issued under the Environmental Framework Code form the basis of Swedish environmental policy. Regulations governing the energy efficiency of buildings are another administrative policy measure. **Economic policy measures** affect the cost and benefit of the choices available to parties concerned. They consist of taxes and fees, transferable emission rights or certificates, deposits as securities and various forms of grants and subsidies. **Information** can effect 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, demonstration and commercialisation** activities can also be said to be a form of long-term 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 achieve various energy and environmental objectives.

Energy taxation

The original objective of energy taxes was to help finance the State's public spending requirements, but in later years the emphasis has increasingly been on the need to control the supply 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, but today the aim is not only to reduce the use of oil for heating, but also to reduce the use of direct electric heating. The environmental element of energy taxation was given greater emphasis 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 guidelines for Swedish energy taxation are set by the EU's common framework, as expressed mainly by the Energy Taxation Directive[26], and have a complex structure. There are different taxes on electricity and fuels, on carbon di-

26 Directive 2003/96/EC of the European Parliament and of the Council, Restructuring the Community Framework for the Taxation of Energy Products and Electricity.

oxide and sulphur emissions, and a levy system on nitrogen oxide emissions. The tax rates can then vary, depending on whether the fuel is being used for heating or as a motor fuel, whether it is being used by industry, domestic consumers or the energy conversion sector and, in the case of electricity, what it is being used for and whether it is being used in northern Sweden or in the rest of the country. In 2008, revenues from energy taxes raised SEK 69 800 million, making up 8.6 % of State revenue or 2.2 % of GDP (see Table 2). There is also taxation expenditure (taxation relief) on the country's income budget. The definition of taxation expenditure is that the tax received is less than a certain specified standard.[27] 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, as set out in a Government Parliamentary Communication on Taxation Expenditure[28], amounted to over SEK 41 000 million in 2008.

”Information can effect changes in behaviour and attitudes.”

27 If a taxation expenditure item 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.

28 Parliamentary Communication no. Skr. 2007/08:123: Declaration of Taxation Expenditure, 2008. Total of all items under spot taxes, net.

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[29] taxes and those intended to achieve environmental objectives. This latter group of taxes includes the carbon dioxide and sulphur taxes, while the general energy tax is essentially a fiscal tax. However, there is no hard and fast boundary between the types, as both groups have an environmental effect as well as a fiscal function.

- The general energy tax, which has existed for several decades, and with varying purposes, is levied on most fuels, based on various factors such as their energy contents.
- The carbon dioxide tax, which was introduced in 1991, is levied on the emitted quantities of carbon dioxide from all fuels except biofuels and peat. The general rate of carbon dioxide tax was increased by 4 öre at the beginning of 2009, reaching a level of 105 öre per kg of carbon dioxide. Energy and carbon dioxide tax rates are indexed to track price developments.
- 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 for each tenth of a percent of sulphur by weight per cubic metre of oil. Oils containing less than 0.05 % of sulphur by weight are exempted from the tax.
- The environmental levy on the emission of nitrogen oxide was introduced in 1992, and since the beginning of 2008 has been applied at a rate of SEK 50/kg of nitrogen oxide, on emissions from boilers, gas turbines and stationary combustion plants supplying at least 25 GWh per annum. However, it is intended to be fiscally neutral, and is repaid to plant operators in proportion to their energy production and in inverse proportion to their nitrogen oxide emissions, so that only those with the highest emissions are net payers.

Electricity and heat production

Electricity production in Sweden is exempted from energy and carbon dioxide tax, although it is subject to the nitrogen oxide levy and sulphur tax in certain cases. However, the use of electricity is taxed. 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 24 % in 2008, to SEK 12 648/MW per calendar month[30]. In addition, there is a levy of 0.3 öre/kWh for sometime decontamination and decommissioning of the country's previous nuclear facilities at the Studsvik research centre[31], and a further levy that amounts to about 1 öre/kWh for financing future storage facilities for spent nuclear fuel[32]. Heat production

29 A fiscal tax is intended mainly to generate revenue for the national exchequer.

30 www.skatteverket.se.

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

32 Act (1992:1537)

attracts energy tax, carbon dioxide tax and, in certain cases, sulphur tax and the nitrogen oxide 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 marketable heat produced in simultaneous production of heat and electricity (also known as cogeneration or CHP [Combined Heat and Power] production) is taxed in the same way as in industry.

With effect from 1st July 2006, combustion of certain domestic refuse has also been brought within the remit of energy tax. In 2009, the energy tax element amounts to SEK 162 per tonne of fossil carbon, while the carbon dioxide tax element is levied at the rate of SEK 4031 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 increased from 1.2 % to 1.7 % at the beginning of 2008. Together with the temporary 0.5 % tax rate increase for the 2007–2011 tax years, this gives a total tax rate of 2.2 %.

”Electricity production plants are also subject to property tax.”

Taxation of use of energy other than heat

Manufacturing industry, horticulture, farming, forestry and aquaculture[33] pay no energy tax on fossil fuels, and only 21 % of the carbon dioxide tax[34]. 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 meet the 0.5 % rule definition of an energy-intensive company[35]. Mineralogical processes are totally exempted from carbon dioxide tax.

A further step by step reduction of the carbon dioxide tax on fuels used in plants covered by the EU emission trading system started on 1st July 2008. It increased the percentage tax reduction for industrial and CHP plants covered by the emission trading system by six percentage points, i.e. down to 15 %. A second stage of the reduction, on 1st January 2010, will further reduce the carbon dioxide tax rate so that industrial and CHP plants will pay a tax equivalent to 7 % of the general carbon dioxide tax level. Corresponding percentage reductions will be made for other heating plants covered by the emission trading system.

There are various tax levels for transport, depending on the type of fuel and the environmental class of the fuel. The tax on environmental class 1 for petrol and

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

34 Energy tax is levied, however, on unrefined tall oil and electricity.

35 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.

Table 1
Main groups of policy measures

Administrativa	Ekonomiska	Information	Forskning
Regulations	Taxes	Information	Research
Limit values for emissions	Support, grants, subsidies	Advisory service	Development
Requirements for types of fuels and energy effeincy	Lodgins of securities	Education	Demonstration
Long-term agreements	Emission allowance trading	Opinion-forming	Commercialisation
Environmental classification	Certificates trading		Procurement

Table 2
Revenues from energy taxes, by types of energy and tax, 2008, SEK 1 000 million

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.

Energy carrier	Energy tax	CO_2 tax	Sulphur tax	Total
Petrol	14 898	10 769		25 667
Oil products	5 827	12 909		18 736
Unrefined tall oil	17			17
Other fuels	94	1 343		1 437
All fuels			80	80
Electricity	19 281			19 281
Waste				646
Production tax, nuclear power *				3 968
Total	**40 117**	**25 021**	**80**	**69 832**
Proportion of the State's tax revenues				**8,6%**
Proportion of GDP				**2,2%**

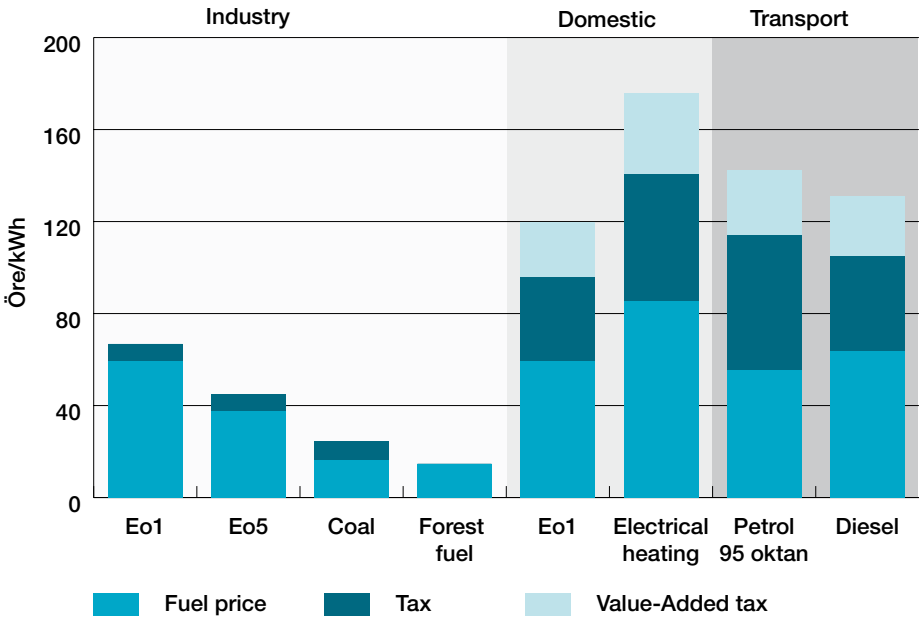


Figure 3
Total energy price for various user categories, 2008

SOURCE: SPI, STATISTICS SWEDEN AND THE NATIONAL TAX BOARD

NOTE: PRICES FOR INDUSTRY DO NOT INCLUDE ANY VOLUME DISCOUNTS.

diesel was increased by 23 öre/litre and 18 öre/litre (including VAT) respectively on 1st January 2009. 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. However, aviation fuel used for private traffic has been brought within the tax remit with effect from 1st July 2008. 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. Energy tax on electricity used by the domestic and service sectors in certain municipalities in northern Sweden was increased by 0.8 öre/kWh at the beginning of 2009, and increased by 1.2 öre/kWh for electricity used in other cases. In addition to the various spot taxes on energy, there is value added tax of 25 %, which is not paid by industry. In 2008, 51 % of the total cost of heating a detached house by oil was made up of tax. For drivers, 61 % of the cost of petrol was tax (including value-added tax). See Figure 3.

Table 3
General energy and environmental tax rates from 1 January 2009, excluding VAT

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

* THE PROPORTION OF FOSSIL CARBON IN DOMESTIC REFUSE IS ASSUMED TO BE 12.6 % OF THE WEIGHT OF THE REFUSE.

	Energy tax	CO_2 tax	Sulphur tax	Total	Tax, öre/kWh
Fuels					
Heating oil, SEK/m^3 (<0.05 % sulphur)	797	3 007	-	3 804	38,2
Heavy fuel Oil, SEK/m^3 (0.4 % sulphur)	797	3 007	108	3 912	36,9
Coal, SEK/tonne (0.5 % sulphur)	339	2 617	150	3 106	41,1
LPG, SEK/tonne	156	3 164	-	3 320	26,0
Natural gas, SEK/1000 m^3	258	2 252	-	2 510	22,8
Crude tall oil, SEK/m^3	3 804	-	-	3 804	38,8
Peat, SEK/tonne, 45 % moisture content, (0.3 % sulphur)	-	-	50	50	1,8
Domestic waste, SEK/tonne of fossil carbon*	162	3 869		4 031	16,2
Motor fuels					
Petrol, unleaded, environmental class 1, SEK/l	3,08	2,44	-	5,52	61,1
Diesel fuel, environmental class 1, SEK/l	1,33	3,01	-	4,34	48,0
Natural gas / methane, SEK/m^3	-	1,34	-	1,34	12,2
LPG, SEK/kg	-	1,65	-	1,65	13,2
Electricity use					
Electricity, northern Sweden, öre/kWh	18,6	-	-	18,6	18,6
Electricity, rest of the country, öre/kWh	28,2	-	-	28,2	28,2
Industry					
Electricity use, industrial processes, öre/kWh	0,5			0,5	0,5

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax, öre/kWh
Heating oil, SEK/m^3	-	631		631	6,3
Heavy fuel Oil, SEK/m^3	-	631	108	739	7,0
Coal, SEK/tonne	-	550	150	700	9,3
LPG, SEK/tonne	-	664	-	664	5,2
Natural gas, SEK/1000 m^3	-	473	-	473	4,3
Crude tall oil, SEK/m^3	631	-	-	631	6,4
Peat, SEK/tonne, 45 % moisture content, (0.3 % sulphur)			50	50	1,8
Domestic waste, SEK/ tonne of fossil carbon*	-	812	-	812	3,3

Table 4
Energy and environmental taxes for industry, agriculture, forestry, fisheries and heat production in CHP plants, from 1st January 2009

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

* MAXIMUM RELIEF FROM CARBON DIOXIDE TAX (%) REQUIRES AN ELECTRICAL EFFICIENCY OF 15 %. EXEMPTION FROM ENERGY TAX REQUIRES AN ELECTRICAL EFFICIENCY OF 5 %.

Green Electricity certificates

Sweden's Green Electricity certificate system[36] is a market-based support system to assist expansion of production of electricity from renewable sources and from peat in Sweden. Its objective is to increase, by 2016, the production of electricity from such sources on the level of 17 TWh relative to the production level in 2002. It is part of the country's overall objective of moving Sweden towards a more ecologically sustainable energy system.

Electricity production that qualified for Green Certificates in 2008 amounted to 15.0 TWh. However as, under Directive 2001/77/EC, peat is not counted as a renewable fuel, the 0.83 TWh of electricity generated from it must be subtracted when determining the amount of qualifying electricity production. This means that electricity production from renewable energy sources under the Green Electricity certificate system in 2008 amounted to 14.2 TWh. Of this amount, 6.5 TWh were already being produced in 2002, which means that the 2008 figure represents an increase of 7.7 TWh.

Electricity certificates are issued to operators of approved plants producing and metering electricity from renewable energy sources, or from peat, at the rate of one certificate unit per MWh. Electricity produced from the following energy sources qualifies for certificates: wind power, solar energy, wave energy geo-

36 Since 2006, the Swedish Energy Agency has published a report on the electricity certificate system in order to provide easily available information on the progress of the electricity certificate system. This year's edition, The Electricity Certificate System 2008, describes the state of the market and includes statistics for the period 2003-2007.

thermal energy, certain biofuels and certain hydro power. With effect from 1st April 2004, electricity produced from peat in cogeneration plants has also qualified for certificates. Table 5 shows the number of approved plants, installed capacity and renewable electricity production from each type of production. New plants receive 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.

Demand for certificates is created by the fact that all electricity suppliers, and certain electricity users, are required to buy certificates corresponding to a certain proportion (their quota) of their electricity sales or use. The proportion of certificates that users are required to buy (their quota obligation) varies from year to year, thus creating a growing demand for certificates, and so also increasing the incentive to produce more electricity from energy sources carrying entitlement to certificates. By selling their certificates, the producers of electricity from renewable energy sources can receive additional revenue, which provides further support for their production of electricity. In 2008, users had to buy certificates corresponding to 16.3 % of their electricity use. Figure 4 shows the price development of certificates over the period 2003–2009. The system covers only electricity produced in Sweden.

”By selling their certificates, the producers of electricity from renewable energy sources can receive additional revenue.”

Certain use of electricity is exempted from the quota obligation requirement, with the largest exemptions being for electrically intensive companies. In December 2007, the Swedish Energy Agency submitted a report that it had been instructed to prepare that investigated and defined the status of the terms ‘energy intensive’ and ‘electricity intensive’ in Swedish legislation, and which proposed changes to the electricity certificate system as far as exemptions from the quota obligation for electricity intensive companies were concerned. The work resulted in a new definition of electricity intensive industries’ exemption from the quota obligation. Under the new definition, the electricity intensity of an industry is determined by the amount of electricity used in a manufacturing process in relation to the company’s conversion or added value.

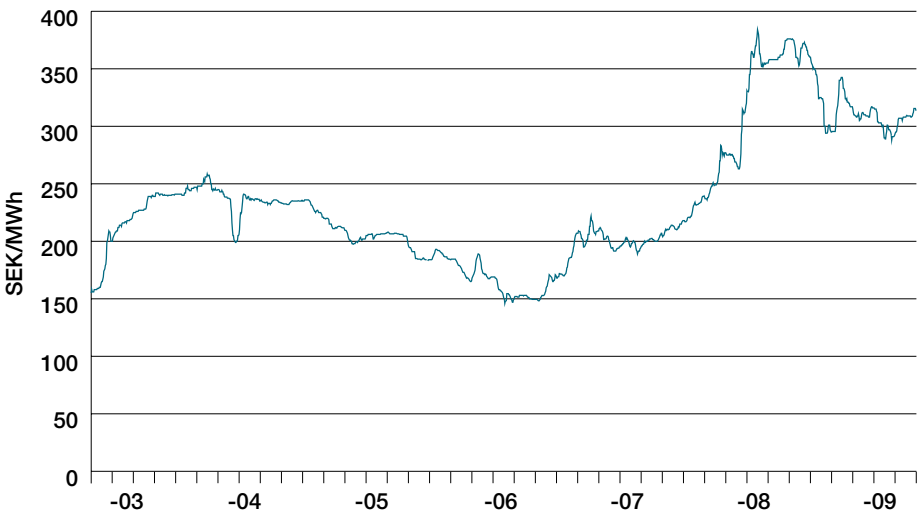


Figure 4
Average price of electricity certificates on the spot market, 2003–2009

SOURCE: SKM, SVENSK KRAFTMÄKLING

Under the new definition, companies carrying out activities that entitle them to a deduction for energy tax on electricity may be registered as electricity intensive industries. In addition to this, the possibility of registering only a part of a company, if it is a business in its own right or is engaged in an arm's length activity, was introduced. Electricity intensive industries may be registered for a period of one or three years. Those electricity intensive companies having a quota obligation of less than 60 MWh per year can apply to be relieved from the liability for making returns.

The changes in the definition of electricity intensive industries have resulted in more consistent regulations on the certificate market, simplification of the regulations, reduced administration and, to a certain extent, harmonisation of and with other legislation in the energy sector.

In 2007–2008, companies were defined as electrically intensive if their use of electricity in their production processes amounted to at least 40 MWh per million SEK of their total sales value of products and goods. In 2008, 490 companies were registered as electrically intensive, thus relieving them of quota liabilities of 41.6 TWh for the year.

Table 5
Production and installed capacity, by types of power production, 2003–2008

SOURCE: SVENSKA KRAFTNÄT AND THE SWEDISH ENERGY AGENCY.

1. NUMBER OF PLANTS ALLOCATED 1 OR MORE ELECTRICITY CERTIFICATES DURING THE YEAR SHOWN.
2. FOR PLANTS ALLOCATED 1 OR MORE ELECTRICITY CERTIFICATES.
3. 948 WIND POWER FARMS, WITH 1153 INDIVIDUAL TURBINES.

		2003 May–Dec	2004	2005	2006	2007	2008
No. of plants[1]		1 597	1 759	1 848	1 909	2 088	2 232
	Hydro	966	1 040	1 060	1 075	1 094	1 120
	Wind	543	613	668	706	846	948[3]
	Biofuels, peat	87	105	118	125	131	142
	Solar	1	1	2	3	4	9
Installed capacity [MW][2]		4 049	4 161	4 471	4 765	5 066	5 123
	Hydro	491	504	517	540	558	598
	Wind	401	472	530	583	831	1 074
	Biofuels, peat	3 157	3 185	3 424	3 643	3 676	3 451
	Solar	0,008	0,008	0,011	0,036	0,043	0,309
Electricity production – renewables and peat [MWh]		5 637 559	11 048 438	11 298 378	12 156 855	13 255 913	15 036 828
	Hydro	963 637	1 968 325	1 799 446	2 018 577	2 195 320	2 607 348
	Wind	455 642	864 546	939 125	988 340	1 431 644	1 995 846
	Biofuels	4 218 276	7 670 770	7 925 790	8 593 538	9 049 308	9 599 311
	Peat	-	544 791	634 012	556 380	579 622	834 194
	Solar	4	6	5	20	19	129

Emission trading

The emission trading scheme (EU ETS) is the foremost climate policy instrument in the EU's European Climate Change Programme (ECCP). The objective of the programme is to achieve the EU's commitment in respect of reduced emissions in accordance with its Kyoto Protocol obligations. The purpose of the trading system is to reduce greenhouse gas emissions at the lowest possible cost by allowing companies to trade in carbon dioxide emission allowances, subject to an uppermost ceiling. The first EU emission trading system period ran from 2005 to 2007. From 2008 to 2012, it runs in parallel with the Kyoto Protocol's first commitment period. EU emission trading is regulated by Directive 2003/87/EC, and covers all 27 member states.

Each country allocates emission allowances (EUA)[37] to emitting installations in its country in accordance with a predetermined number of allowances and in accordance with the rules set out in a national allocation plan (NAP)[38] for each trading period. These plans must be reviewed and approved by the European Commission. Aggregated, the member states' allocation plans form the joint ceiling for emission allowances. Each emission allowance allows its holder to emit one tonne of carbon dioxide during the specified trading period. As the allowances are transferable, carbon dioxide emissions will be preferentially reduced in those companies or countries in which the costs for reducing emissions are lowest.

The EU Emission Trading Scheme covers only a limited number of sectors, in energy intensive industries and electricity and heat producers, with the result that it covers only about 40 % of EU greenhouse gas emissions. In Sweden, about 35 % of greenhouse gas emissions are covered by the trading system[39]. Sweden has decided to allocate, over the 2008–2012 trading period, about 19.8 million emission allowances per year to existing installations. In addition to this, the State holds a reserve for new members of the system, amounting in total to 13.1 million tonnes of CO_2 equivalents for the period. The first trading period covered only carbon dioxide emissions but, with effect from 2008, nitrous oxide has also been included in some member countries. Under a proposal from the Commission, further greenhouse gases and activities would be included in the trading system when the Kyoto Protocol's first commitment period expires in 2012. A major change to the system will be the inclusion of commercial aviation with effect from 2012. In addition to the companies covered by the Trading Directive, other companies, individuals and organisations may trade emission allowances.

Each year, businesses having installations covered by the system are required to surrender emission allowances equivalent to their annual emissions. Those businesses that find that they need to hold more emission allowances to cover their

37 EUA, European allowances.

38 NAP, National Allocation Plan.

39 As set out in Sweden's national allocations plan 2008–2012. The figure applies for Swedish emissions in 2004.

emissions than they actually possess must either reduce their emissions, purchase emission allowances from others who have succeeded in reducing their emissions, or submit emission reduction credits from Clean Development Mechanism, CDM, or Joint Implementation, JI projects. For the 2008–2012 trading period, companies in the trading system may include only a limited proportion of emission reduction credits in their annual surrender quotas. The Commission decides how close each member state is to fulfilling its Kyoto Protocol undertakings and whether it has included national purchases of CDM or JI reduction credits. Swedish companies are permitted to use project credits to meet up to 10 % of the total national allocation. This limitation has been redistributed at installation level on the basis of carbon dioxide emissions in 2006, in order to allow a greater number of installations to submit reduction units instead of emission allowances.

Market prices of emission allowances

The market price of an emission allowance is determined by the balance of supply and demand. **Supply** consists of the total allocation of emission allowances, together with the use of credits from project based mechanisms, while **demand** is dependent on factors such as the demand for electricity and heat, fuel prices and general economic conditions.

When figures for verified emissions during the first year (2005) of the trading system were published in the spring of 2006, they were found to be less than the allocated quantities, which meant that there was a substantial surplus of emission allowances on the market, leading to the price falling from EUR 30 per unit to EUR 10 over a few days. At the end of the 2005–2007 trading period, the price of allowances actually fell to zero, as the number of allowances allocated was about 3.5 % higher than emissions[40].

For the 2008–2012 period, the Commission has reduced the total allocation of emission allowances from 2300 million per year to 2080 million allowances per year, equivalent to a 9.5 % reduction in comparison with the previous period. During the first half of 2008, the price of an allowance rose to just over EUR 30. One of the reasons for this was that the prices of oil and gas rose, so that coal fired electricity and heat production improved its viability in comparison with that from oil or gas firing. In addition, the EU Commission's proposal for a new trading directive with a limited supply of allowances for the 2013–2020 period can have affected the price. The finance crisis later in the year reduced the price of an allowance to below EUR 10 during the first quarter of 2009. The price stabilised during the second and third quarters of 2009, to about EUR 15.

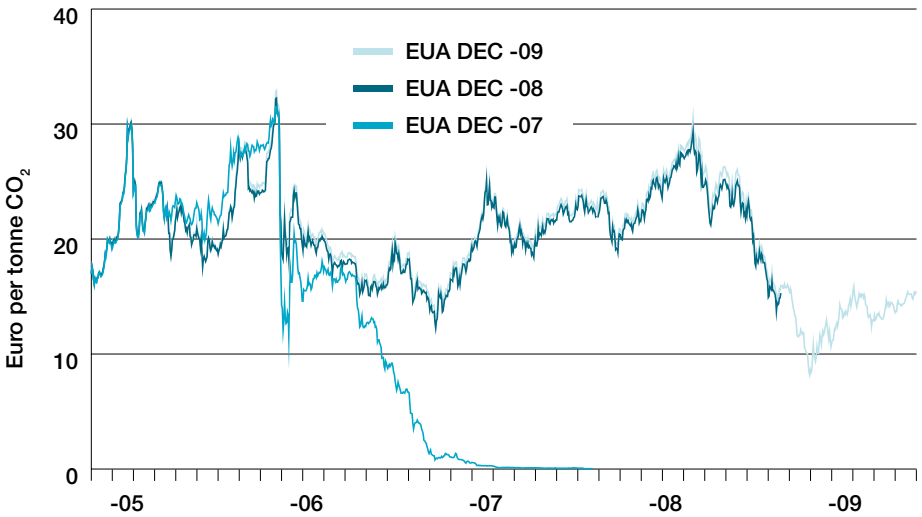


Figure 5
Prices of emission allowances, 2005–2009

SOURCE: EXC (WWW.CLIMATEEXXCHANGE.COM)

The 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) is 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[41]. 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 tabled a bill setting out an energy efficiency improvement programme, which came into force on 1st January 2005[42]. Companies participating in the five-year programme can receive a full rebate of the energy tax on electricity that they would otherwise have 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. They 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, which is more or less equivalent to the amount that the electricity tax would have raised.

41 Council Directive 2003/96/EC.

42 The Act (2004:1196) Concerning the Programme for Improvement of Efficiency of Energy Use etc.

A requirement for participation in the programme is that the company must be an energy intensive company, in accordance with one of the definitions as given in the Energy Taxation Directive, i.e. it must fulfil one of the following criteria:

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

The energy management systems and energy audits that form part of the programme will improve companies' 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 of their efficiency of energy use.

In January 2009, there were 111 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, through the programme, they will receive a total tax reduction of about SEK 150 million per year. Most of the participating companies are in the pulp and paper industry (45), the wood products industry (15) or the chemicals and plastics 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.

”Buildings must be designed and constructed to limit overall energy use.”

For the majority of the participating companies, the summer of 2009 marked the end of the first programme period, with the companies being required to submit a final report on their energy efficiency improvement work by not later than September 2009. Expectations of the results are high. As early as during the interim two year report in 2006, companies were declaring planned electrical efficiency improvement measures equivalent to a total saving of 1 TWh of electricity per year, for a total investment cost of somewhat over SEK 1000 million. Subsequent contacts with the companies have indicated that even greater savings will have been made or found by the time of their final reports. In addition, many companies have stated that they will also report savings or improvement measures applicable to forms of energy other than electricity, such as improvements in the efficiency of the use of heat or a greater proportion of renewable energy in their

production processes. The Agency will prepare an overall report on the result of the first five years of the PFE during the autumn of 2009.

Companies may sign up for a second five year period at the end of the first period, and new companies may also join the scheme. However, as the EU's public subsidy rules for environmental protection schemes have been changed, the Ministry of Enterprise, Energy and Communications must seek approval for a second five year PFE period from the EU Commission. This was done during the spring and summer of 2009. Everything indicates that the Commission will approve the continuation of PFE, and so the Agency has therefore already started to accept new applications for the programme. By July 2009, all except six of the first period companies had applied for continuation of membership of the scheme.

Buildings

Building regulations

A whole range of policy measures is used in order to influence energy conservation and management in buildings[43]. The National Board of Housing, Building and Planning's Building Regulations[44] are an administrative policy measure. In general, buildings must be designed and constructed to limit 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 include specific requirements for energy use in buildings

Energy declarations

Another administrative policy measure is that of the Act Concerning Energy Declarations for Buildings[45], which is based on an EU directive[46]. 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. Declarations have been required for apartment buildings and commercial premises since the beginning of 2009, while detached houses at present require them only in connection with sale of the property.

43 Most of the measures described here are administered by the National Board of Housing, Building and Planning and/or by the County Councils. See http://www.boverket.se/ for more information.

44 Most recent update: BFS 2006:22.

45 The Act (2006:985) Concerning Energy Declarations for Buildings. Introduced on 1st October 2006.

46 Directive 2002/91/EC.

Tax reduction for small-scale building work

The main purpose of this tax reduction is to reduce the amount of building work carried out in the black economy and to increase the demand for legitimate building work. The time selected for introduction of the change has been influenced by the general state of the economy. Under the change, several energy saving measures can now be classified as repair, maintenance, conversion or extension work, thus making them tax deductible. The new regime was introduced on 8th December 2008.

Investment grants for solar cells

The purpose of support for solar cells is to provide a further form of assistance towards changeover of the energy system, and also to assist commercial development and progress in the energy technology sector. The grants are available to companies, public organisations and private persons, for installations begun after 1st July 2009 and completed by 31st December 2011.

Grants for conversion of heating systems

The purpose of these conversion grants[47] 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 to district heating, to rock, earth or lake water heat pumps, or to bio fuelled boilers. The grant has been available since the beginning of 2006, and will continue until the end of 2010. It was previously also available to those replacing oil fired heating systems by one of these alternative heating systems, but this option has been withdrawn.

Transport

The transport sector is affected by policy measures issued by the EU and those issued nationally. On the EU level, 2008 has seen the introduction of a new fuel quality directive and a decision on a regulation concerning emission standards for new private cars. The fuel quality directive governs levels of low-admixture additives in motor fuels, increasing the permitted ethanol content in petrol from 5 % by volume to 10 %, and the permitted FAME content in diesel fuel to 7 %. The regulation on emissions from new private cars sets an overall average limit of 130 g carbon dioxide per kilometre. This comes into force for a certain proportion of private car sales in 2012, but it will not be until 2015 that it will have been extended to cover all private car sales in Europe.

47 Ordinances (2005:1255) and (2005:1256).

Swedish 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. The draft proposal[48] for changes to energy and carbon dioxide taxes recommends that the tax on diesel fuel should be raised in two stages in order to bring it more in line with the tax rate on petrol, but at the same time that the tax on diesel vehicles should be reduced.
Table 3 shows current energy tax rates.

The tax exemption for biobased motor fuels means that such 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 biobased motor fuels. The Agency has been instructed to investigate whether the general tax exemption could be replaced by a quota obligation system: its report was due on 15th September 2009.

”Carbon dioxide tax is intended to reduce carbon dioxide emissions from fossil fuels.”

The law requiring larger petrol stations to sell at least one renewable motor fuel since 1st April 2006 is also intended to support the growth of biobased motor fuels. The result of the law has been that particularly the sale of ethanol fuel (E85) has increased. An additional measure over the period 2006–2010 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, but since October 2006 the tax has been modified to provide an incentive to buy more energy 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. The draft proposal for changes to energy and carbon dioxide taxes proposes that the vehicle tax should be designed in such a way as to encourage a move towards lower carbon dioxide emissions. At the same time, vehicle tax for diesel cars should be reduced as compensation for an increase in energy tax on diesel fuel. Light goods vehicles, buses and motor caravans would also be included in carbon dioxide-based vehicle taxation structure.

With effect from 1st April 2007, a grant of SEK 10 000 has been available to private purchasers of low pollution vehicles. Its purpose is to encourage the purchase of fuel efficient vehicles and vehicles running on alternative motor fuels[49]. The

48 Ministry PM, More efficient taxes on climate and energy, DS 2009:24

49 National Road Administration, Annual Report 2006.

scheme has been very popular. However, the draft proposal for changes to energy and carbon dioxide taxes proposes that the subsidy scheme should not be extended, but that instead such vehicles should be exempted from annual road tax for five years.

The rules for the disposal of vehicles at the end of their lives changed 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 may return a vehicle for scrapping to the manufacturer, without charge, with the manufacturer being responsible for scrapping of the vehicle.

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 area.

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[50].

Technology procurement

Many policy measures and methods are used to encourage market introduction of energy efficient technology, designed or applied in such a way as to help overcome market obstacles. One type of policy measure to encourage the development of new technology is that of technology procurement.

Technology procurement is a process, rather than a project, consisting of a number of different phases (activities) and several different groups of parties. The phases are performance of a feasibility study, assembly of a purchaser group, drafting of performance specification, requests for tenders, evaluation of results, dissemination and continued development. The purpose of technology procurement is to encourage and accelerate the development of new technology. The aim is to develop new products, systems or processes that meet purchasers' needs better than do existing products on the market. Another way of describing this is to say that technology procurement is a policy measure intended to start market changes and to encourage the spread of new, efficient technology, i.e. new products and/or systems. It uses market conditions, and produces long term results for the industry concerned.

Technology procurement provides incentives for innovative companies, and several efficient products have been developed and spread by the process. Today, technology procurement is carried out in close conjunction with standing purchaser groups for residential buildings, commercial premises and food retai-

50 A complete review of economic incentives in the transport sector can be found in the Swedish Energy Agency's Interim Report no. 2 for Checkpoint 2008 (ER 2007:28).

lers (large groups of property owners). Other procurement projects are performed in conjunction with networks in the public sector, detached house owners, sector organisations etc.

Technology procurement projects are carried out mainly in the fields of heating and control systems, domestic hot water and sanitary systems, ventilation, white goods, lighting and industry. The Agency has prepared a list[51] of all technology procurement projects in the energy field that have been carried out by it or by its forerunners. Since the 1990s, 56 different technology procurement projects have been initiated and partly financed. Current technology procurement projects include heat recovery in existing apartment buildings, climate screen integrated systems for solar shading and daylight penetration, and the use of cooling towers rather than refrigerating plant in commercial premises.

Energy research, development and demonstration activities and commercialisation

The Government's 'Research and New Technology for Future Energy Systems' Bill[52] has been approved by Parliament for a long term programme of research, development, demonstration and commercialisation activities for the development of technologies and processes aimed at the establishment of a sustainable energy system. Responsibility for the public energy research programme has been vested in the Swedish Energy Agency[53].

The aim of business development and commercialisation activities is to identify and encourage business ideas and companies in the energy sector. This is an area with valuable potentials, where Swedish companies get help to develop good ideas through financing, technical competence, market knowledge and active business development.

In 2008, public funding for energy research amounted to almost SEK 875 million: for 2009, this has been increased to almost SEK 1 147 million, including complementary budgets[54]. In its 2009 autumn Budget Bill, the Government proposes almost SEK 1 332 million for 2010, but falling to about SEK 1 259 and SEK 906 million respectively for 2011 and 2012 in current price level. For 2009, the Government proposed that the grant for energy research should be increased by SEK 145 million in order to facilitate demonstration and commercialisation of new technology for renewable energy. Corresponding amounts for 2010 and 2011 are SEK 380 million and SEK 350 million. In accordance with what was specified in more detail in the Research and Innovation Policy Bill, which was presented in the autumn of 2009, the 2008 autumn Budget Bill proposed to increase the grant by a further SEK 110 million with effect from 2009.

51 The list can be downloaded from www.energimyndigheten.se.

52 Bill no. 2005/06:127, Research and New Technology for the Future Energy System.

53 Read more in the Agency's report, Swedish Energy Research 2009, ET 2009:20.

54 According to the 2009 supplementary budget (Bill no. 2008/09:49, 2008/09:FiU14, Bill no. 2008/09:97, 2008/09:FiU18, Bill no. 2008/09:99, 2008/09:FiU21, Bill no. 2008/09:124, 2008/09:FiU40) and proposal for a supplementary budget in connection with the 2009 Autumn Bill.

The objective of energy research is to *"... establish such scientific and technical knowledge and competence 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"*[55]. Energy research covers the entire chain from fundamental research and technical development through to demonstration activities and business development. Experience shows that it can take up to ten years before the results of research materialise into a commercial breakthrough.

The programme is constructed around 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 groups made up of experts from public authorities, industry and other relevant parties. Research in each area is organised into specific programmes, with the number of active programmes varying from year to year. 42 programmes were active in 2008, together with a large number of individual projects.

Research in the field of **energy system studies** is aimed at improving knowledge of, and competence in, the energy system and its dynamics and the effects of and on international climate policy. The research is largely multi-disciplinary, and the results constitute important resources for the provision of support material for decision-making related to energy and climate policy. Research covers areas such as energy and climate-related policy measures, the function of the energy markets, energy related climate issues, local and regional energy issues, behavioural science, and differences in behaviour between the sexes etc.

The **energy use in the built environment** theme area includes the supply and distribution of heating, electricity for domestic and building services systems and the underlying design and operation of 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 biofuels, 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 biobased motor fuels, combustion engines and electrical drive systems. Looking

55 See Energy Research in Sweden 2006 (ET 2007:01) for a more detailed presentation of Sweden's energy research programme and its constituents.

further ahead, biobased 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 prioritises improvements in the efficiency of energy use, particularly for energy intensive processes in the pulp and paper industry and in the steel industry. In addition to straightforward improvement of industrial processes as such, there are considerable opportunities for developing and improving the efficiency of recovery of waste products from the industry.

”Sweden is one of the world’s leading countries in the production and use of solid processed fuels.”

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 upland wind power production. The main thrust of the solar cell work is on development of cheaper and more efficient cells. Research into power transmission systems and energy storage in the power system is concentrated on creating a safe and efficient system suitable for supporting the new technologies and means of production that are expected to be increasingly employed.

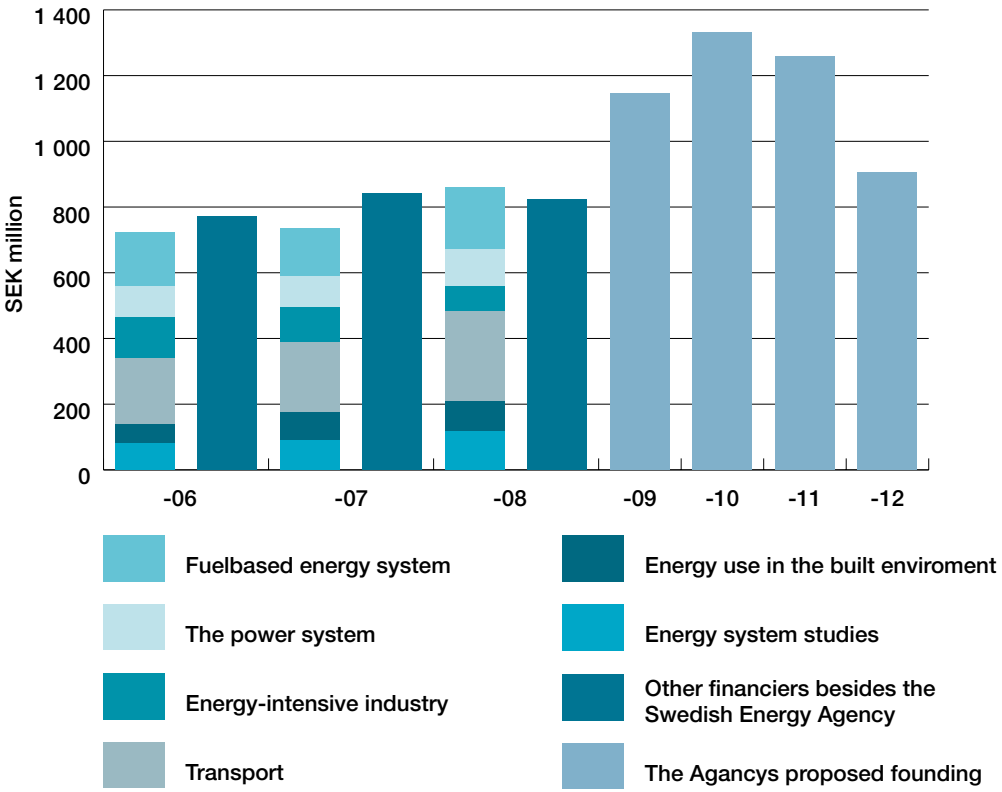
The **fuel based energy systems** working area includes research and development of sustainable biomass fuel supply and energy production, based mainly on biomass-fuelled systems. Research in the area is intended to help increase the quantities of fuels available, to improve the cost efficiency and resource 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 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

Figure 6
Funding for research, development and demonstration activities, 2006–2012

SOURCE: BUDGET BILL 2009/10:1 EXPENDITURE AREA 21, ENERGY

NOTE: FOR 2006–2008, THE FIGURE REFERS TO APPROVED FUNDING. FOR 2009, THE FIGURE SHOWS PROPOSED FUNDING, WHILE FOR 2010–2012 IT IS EXPECTED FUNDING. THE FIGURES ARE THEREFORE NOT STRICTLY COMPARABLE BETWEEN YEARS.



used to improve the efficiency of established technologies and to introduce new technologies with improved performance.

During 2009, the Agency's Energy Development Board has decided to prioritise five projects which will share the SEK 875 million that the Government has granted over a three year period for demonstration and commercialisation of new energy technology. The main emphasis is on demonstration plants for second generation biobased motor fuels, followed by demonstration and commercialisation of other energy technology of substantial national importance and export potential, such as that concerned with vehicles and electricity production. The companies carrying out work in the priority areas are Chemrec AB, Göteborg Energi AB, Seabased Industry AB, Södra Cell AB and Volvo Personvagnar AB. The Agency will decide on apportionment of the funding between the projects during the autumn of 2009.

Ecodesign and energy marking

Ecodesign is concerned with the setting of minimum requirements for energy efficiency, and selection of appropriate technology, right from the manufacturing stage of certain products. In many cases, new and more energy efficient technology is already available but, for cost reasons, is not always used. By setting the manufacturer specific requirements, energy hungry products will gradually disappear from the market. The ecodesign requirement applies for all member states of the EU, and is set out in the Ecodesign Directive[56] and in Swedish legislation[57].

Certain product groups, such as digital set top boxes, TV receivers and domestic lighting, have their own design requirements, while many other groups are at various stages of the process[58]. The Design Ordinance for Domestic Lighting came into force on 13th April 2009, with one of the effects thereof being that ordinary incandescent lamps will gradually be phased out, which has attracted considerable attention in the media.

Energy marking differs from ecodesign, in that all domestic white goods must be marked to show their energy efficiency. This marking is obligatory in all EU countries, and is regulated in Sweden by means of the Act[59] and Ordinance[60] concerning marking of domestic appliances. Marking is expressed in the form of a scale from A to G, with arrows ranging in colour from green to red. Refrigerators and freezers have energy classes A+ and A++, where A++ uses the least energy. For washing machines that are more efficient than A, the manufacturers have on their own initiative introduced classes A+ and A++. However, these two classes are not covered by the regulations, and so are used only in marketing, and not in the required formal energy labels. Other important properties, such as how well the machines wash, spin or wash dishes are shown on a scale from A to G, with A being the best.

56 Directive 2005/32/EC Establishing a Framework for the Setting of Ecodesign Requirements for Energy-Using Products.

57 The Act (2008:112) Concerning Ecodesign.

58 The Agency's web site has lists of all product groups in the approval process, showing how far they have come in the process.

59 The Act (1992:1232) Concerning Marking of Domestic Appliances

60 The Ordinance (1994:1774) Concerning Marking of Domestic Appliances

Information activities

Information is an important policy measure when the State wishes to raise awareness or create an understanding, to change attitudes or to influence the behaviour of persons. The Swedish Energy Agency employs many different channels and works with a large number of different parties in order to ensure that information reaches its target groups. The Agency supports, for example, the local authority energy and climate advisors, both economically and through the provision of training, in order to assist them in further raising awareness and passing on experience to domestic consumers and small and medium sized businesses all over the country. All local authorities throughout the country have energy and climate advisors, who provide cost free and impartial advice.

The Agency also supports the larger regional energy offices, whose duties include the arrangement of network meetings for the energy and climate advisors and coordination of regional information campaigns together with them.

In recent years, the Agency has provided a considerable quantity of information on its website aimed at households, small and medium sized businesses and property-owners and caretakers. It has also taken over the Energy Calculator web tool from the Swedish Consumer Agency, and developed it further so that it can calculate energy demand and performance.

During 2006–2007, instructed by the Government, the Swedish Energy Agency, the National Board of Housing, Building and Planning, the Swedish Consumer Agency and the Swedish Environmental Protection Agency together started and ran a programme of information activities 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 Agency has overall coordination responsibility for the work, which continued during 2008 and 2009, although without the Swedish Consumer Agency.

As part of the project, the *Energy Smart House* exhibition has travelled around the country, and has visited nine trade fairs and exhibitions in all parts of the country during 2009. The joint work has also included construction of a shared website (www.blienergismart.se), providing tips and advice.

2

Summary

Sweden has used economic policy measures for many years, traditionally with taxation being the most important of them. Although the original intention was to finance public services, the emphasis had shifted as early as during the 1970s towards using taxation to direct developments in the energy sector along the desired path. Today, taxes are used both for fiscal purposes and for achieving various objectives in energy and environmental policy.

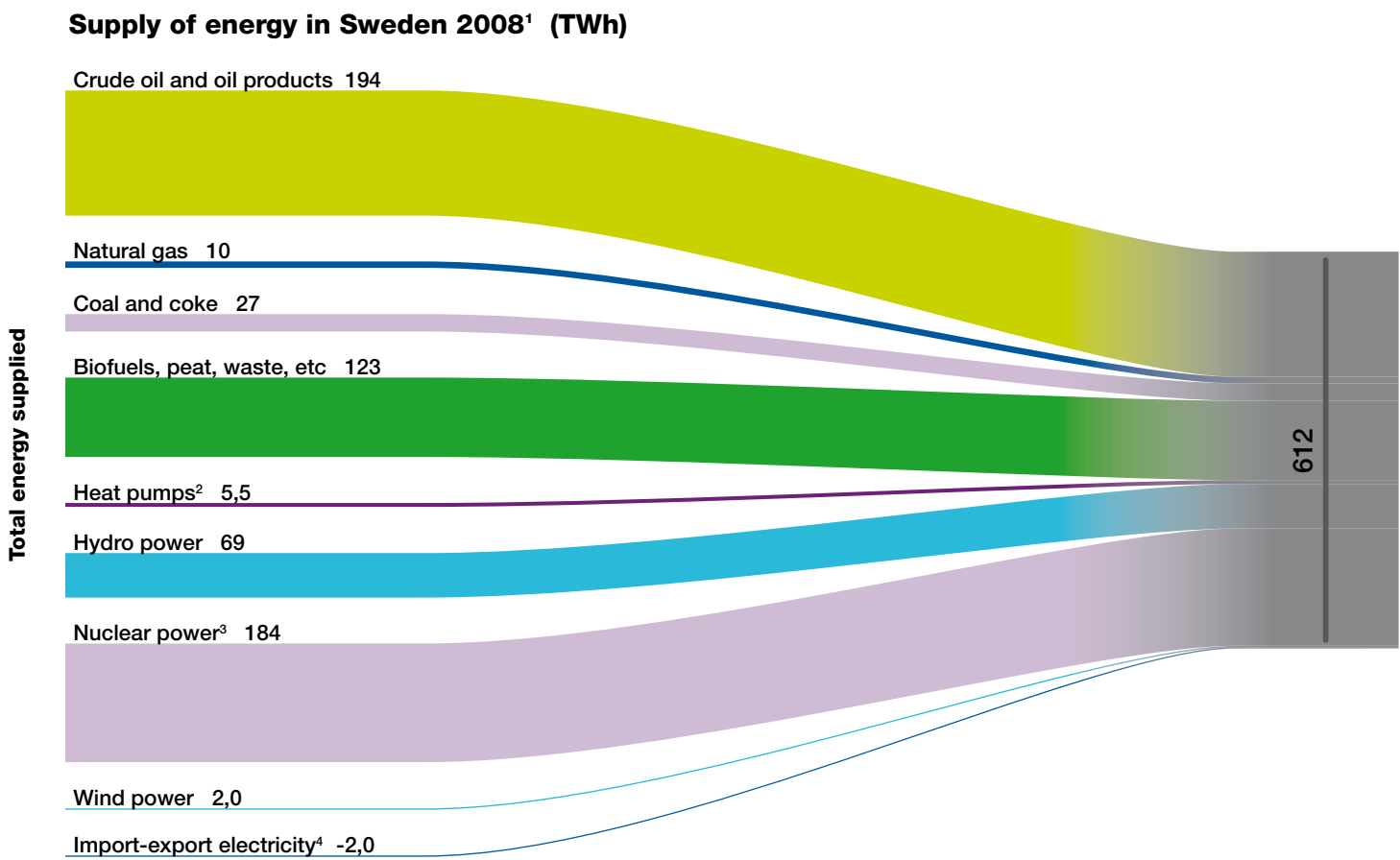
Major changes have occurred in the economic policy measures used by Sweden. Where taxes were previously the main means, more market based policy measures have now been introduced, as illustrated by the electricity certificate system, which was introduced in May 2003, and by the emission trading system which was introduced on 1st January 2005. The electricity certificate system introduces mandatory quotas for the proportion of renewable energy that the market must deliver, while emission trading sets a ceiling on carbon dioxide emissions. This means that the intended results are ensured as soon as the policy measure is introduced, while at the same time allowing the market to decide what actions to take in order to achieve the results, which in turn leads to cost efficiency.

There are, in addition, several other policy measures which affect the use of energy in buildings, transport and industry in various ways, or which tend to reduce emissions. Despite the differences in the many policy measures, they all work in the same overall direction towards a sustainable energy system.

Sweden’s energy balance

Energy can never be destroyed or consumed, but only converted. 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[61].

Figure 7 Energy supply and use in Sweden, 2007, TWh



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.
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.
5. INCLUDES FOREIGN AVIATION, AMOUNTING TO ABOUT 9 TWH IN 2008.

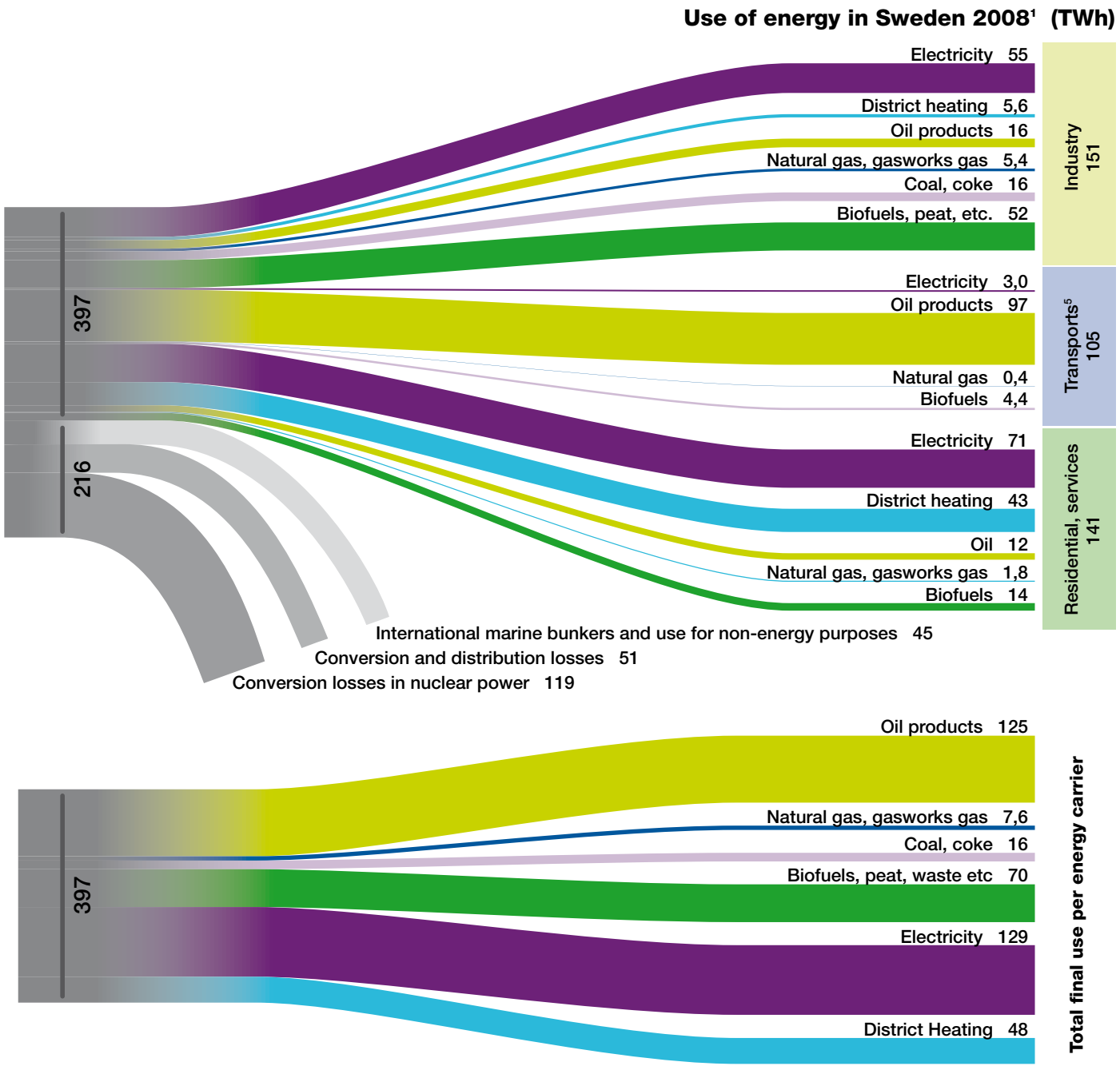

Use of energy in Sweden 2008[1] (TWh)
Electricity 55
District heating 5,6
Oil products 16
Natural gas, gasworks gas 5,4
Coal, coke 16
Biofuels, peat, etc. 52
Electricity 3,0
Oil products 97
Natural gas 0,4
Biofuels 4,4
Electricity 71
District heating 43
Oil 12
Natural gas, gasworks gas 1,8
Biofuels 14
International marine bunkers and use for non-energy purposes 45
Conversion and distribution losses 51
Conversion losses in nuclear power 119
397
216
Industry 151
Transports[5] 105
Residential, services 141
Total final use per sector
Oil products 125
Natural gas, gasworks gas 7,6
Coal, coke 16
Biofuels, peat, waste etc 70
Electricity 129
District Heating 48
397
Total final use per energy carrier

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 sectors, industry and transport, together with losses, international maritime transport, and energy materials used for non energy purposes. However, the figure does not show losses that occur in the final energy use stage, 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 of necessity removed by cooling when producing electricity in nuclear power stations. Other losses include conversion losses in energy plants[62] and distribution losses in connection with the supply of electricity, district heating, natural gas and town gas, coke oven gas 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[63], and fuels for nuclear power production. To this must be added changes that occur in storage stock levels and the country's net import (the difference between imports and exports) of energy materials and energy carriers, such as oil, natural gas, coal, biofuels and electricity.

"Energy is supplied in order to meet users' demand for energy."

61 Statistics for the 1970–2006 period are final. Those for 2007–2008 are preliminary, and may be adjusted later.

62 In this context, energy plants are those used for the production of electricity or district heating, refineries, gasworks, coking plants and blast furnaces.

63 But not heat to small heat pumps, such as for detached houses.

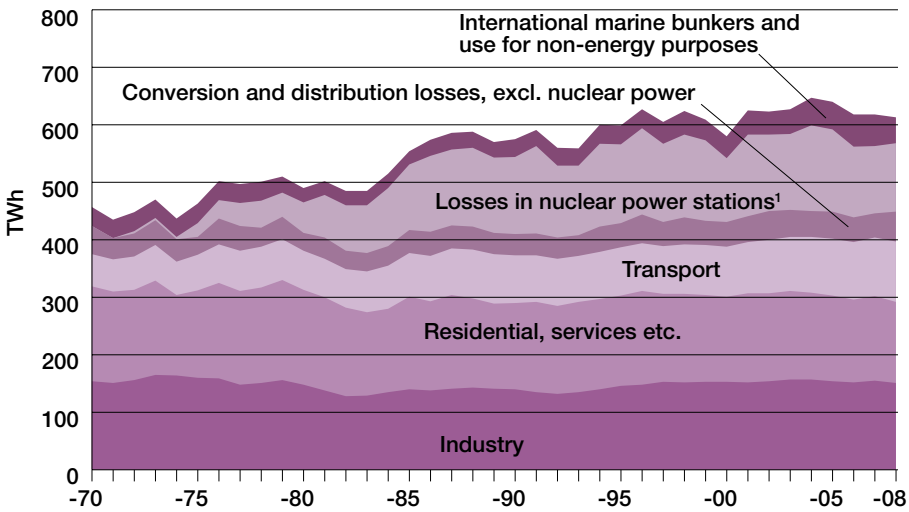


Figure 8
Sweden's total energy use, 1970–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY.

1. CALCULATED IN ACCORDANCE WITH THE UN/ECE METHOD FOR ENERGY SUPPLY FROM NUCLEAR POWER.

Total energy use

Total energy use in 2008 amounted to 612 TWh. Of this, total final energy use made up 397 TWh, and conversion and distribution losses made up 172 TWh, of which 119 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.

The main sources of energy used by industry are electricity and biofuels. Variations in energy use by the industrial sector from one year to another are due mainly to economic conditions. Industry uses more-or-less the same amount of energy now as in 1970, despite the fact that industrial production is considerably higher today.

The most important energy carriers for the residential and service sector are electricity and district heating. Variations in energy use are due partly to temperature differences from one year to another, but the sector has reduced its use of energy to some extent since 1970, due to several structural changes. The total heated floor area of commercial premises, for example, is greater, population numbers have risen, and 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.

Energy use in the transport sector is dominated by oil products. Total energy use by the sector (excluding foreign maritime traffic) has increased by about 99 % since 1970.

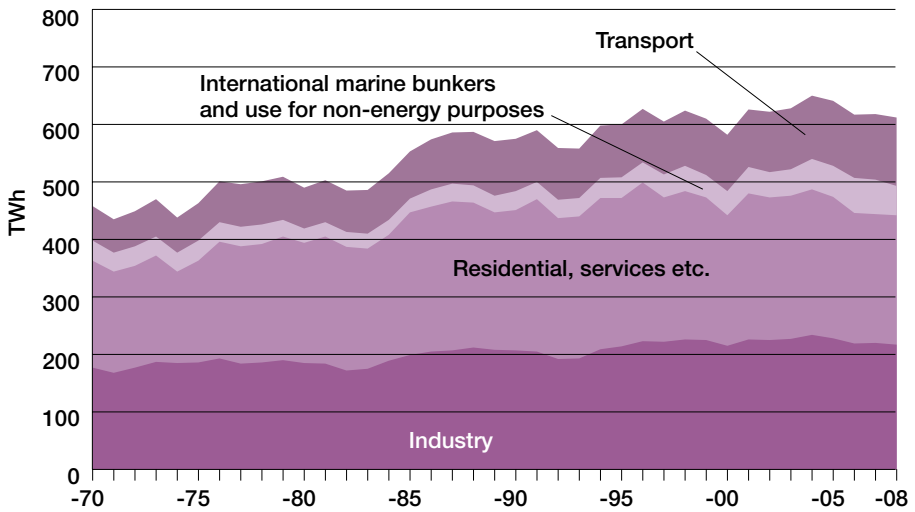


Figure 9
Total energy use in Sweden, 1970–2008. Conversion losses in the production sector are apportioned to end users

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

System boundaries

Since 1970 the demand for energy[64] has increased by 5.3 %, from 375 TWh to 395 TWh. However, over the same period, total energy supply has increased by 34.0 %, from 457 TWh to 612 TWh. The reason for the supply of energy increasing over six 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 and district heating as the main energy carriers 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 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 heating and in refineries. System boundaries provide an aid to analysing the energy system. 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 ways in which the information is shown in the two figures

64 'Demand' refers to the total final use of energy.

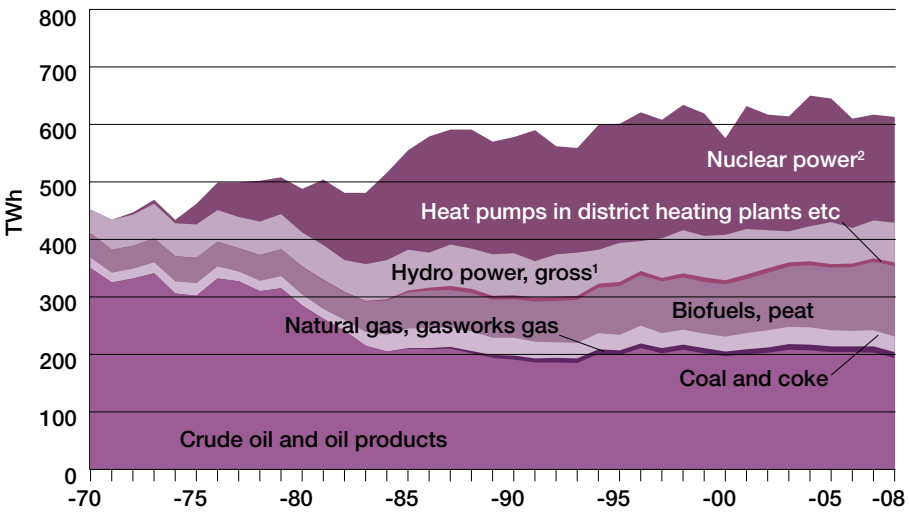


Figure 10
Total energy use in Sweden, 1970-2008, excluding net electricity exports

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

1. INCLUDING WIND POWER UNTIL 1996.
2. CALCULATED IN ACCORDANCE WITH THE UN/ECE METHOD FOR ENERGY SUPPLY FROM NUCLEAR POWER.

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 2008 was 612 TWh, including a net export of 2.0 TWh of electricity. 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 use of crude oil and oil products has fallen by about 45 %, while the net production of electricity has increased by about 147 % as a result of the construction of nuclear power stations and expansion of hydro power production. The supply of biofuels has increased by 186 %. 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 184 TWh of fuel energy input in 2008, to produce about 61.3 TWh of electricity.

65 Read more in the report Allt eller inget – systemgränser för byggnaders uppvärmning [All or nothing - System boundaries for heating of buildings], www.energimyndigheten.se

Hydro power production depends on the amount of precipitation during the year. In 2008, it produced 69.0 TWh of electricity, or somewhat over the statistically average annual production of 67.5 TWh[66]. Fuel based thermal power production produced 13.9 TWh of electricity, while wind power supplied about 2.0 TWh. 55 TWh of fuels were used for district heating production. The proportion of renewable energy sources in the country's total energy supply amounted to over 30 % in 2008. Renewable energy sources include biofuels, hydro power and wind power.

The proportion of renewables

The overall objective of Swedish energy policy is that of steadily working towards a sustainable energy system. Two important reasons for encouraging the use of renewable energy sources in Sweden are the minimisation of environmental and climate effects, together with improved security of supply resulting from greater diversity. In March 2007, the Council of Europe set an overall target of 20 % of energy to be supplied from renewable sources by 2020, as compared to the corresponding level of 8.5 % in 2005. In January 2008, the Commission published a proposal[67] as to how the 20 % target should be apportioned between the various member states. The proposal resulted in a new Renewables Directive, which was adopted in 2008 and came into force in June 2009. Under the terms of the directive, Sweden's target would be 49 % in 2020. However, the Government has higher ambitions, and has set a target of 50 % of Sweden's energy from renewables by 2020.

Sweden's total proportion of renewable energy use

In 1990, Sweden's proportion of energy use provided from renewable sources amounted to 33.9 %. By 2008, this had increased to 44.1 %[68]. The greatest contribution made by renewable energy sources is that to electricity production, of which a major proportion is supplied by hydro power. The next largest user of renewable energy is the industrial sector, followed by district heating production and the residential sector. Only a very small proportion of renewable energy is used by the transport sector, and the same applies for the production of district cooling. In total, it is wood fuels (including black liquors[69]) that are the renewable energy source that is used most in Sweden, followed by hydro power, heat absorbed by heat pumps, organic waste, biobased motor fuels and wind power. In proportion to its final energy use, Sweden uses the highest proportion of renewable energies among EU countries, and is in the top four countries that most increased their proportion of renewable energy sources over the period 2000–2005.

Calculations of renewable energy proportions are made on the basis set by the

66 As calculated by the Swedish Energy Agency, for the period 1985–2005.

67 Negotiations on the proposal are proceeding, with agreement expected in December 2008.

68 The Energy Indicators 2009 report (ET 2009:15) includes more detailed information on the use of renewables in the various sectors up to 2007. The report also includes an international comparison between EU member states up to 2005. It can be downloaded from the Swedish Energy Agency's website.

69 This category does not include peat.

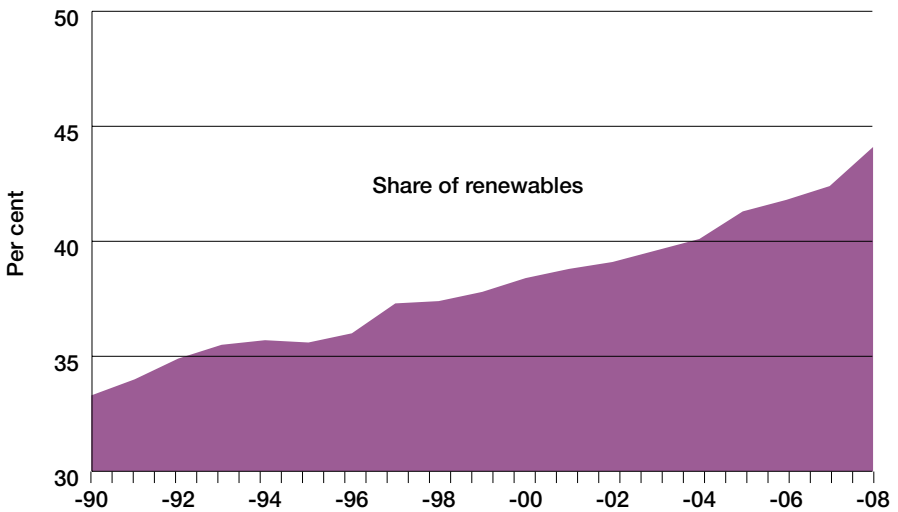


Figure 11
Sweden's total proportion of renewable energy sources, 1990–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

European Commission, according to which the proportion of renewable energy is calculated as the quotient of renewable energy and final energy use, including transmission losses and use of electricity and heat for internal purposes in electricity and heat production plants.

Causes and effects

That Sweden's proportion of renewable energy is considerably higher than the proportions in other countries is due not only to the fact that Sweden has major renewable energy resources, such as hydro power and biomass, but also to the fact that the country has pursued an active energy policy. This is shown clearly by developments from 2000 to 2005, where Sweden is one of the four countries that have most increased their proportion of renewable energy. Nevertheless, further efforts will be needed in order to meet the country's target of 49 % by 2020.

More details of policy measures such as carbon dioxide tax, the ban on the use of landfill, conversion grants, the Green Electricity certificate system, the climate investment programme and the emission trading system are described in the earlier parts of this report.

FACTS Renewable energy – definitions and assumptions for calculations

The following are defined as renewable energy sources: wind power, hydro power and wave power, solar energy, landfill gas, digester gas from sewage treatment plants, biogas, the biologically degradable part of products, waste and residual products from agriculture (including materials of vegetable and animal origin), forestry and associated industries, and the biologically degradable part of industrial waste and community waste. Peat is not defined as a renewable energy source in the Renewables Directive.

The numerator in the quota is defined as the sum of energy from renewable, non fossil sources: wind energy[1], solar energy, geothermal energy, aerothermal energy (air heat), hydrothermal energy (water heat) and sea energy, tidal energy, hydro power[2], biomass, landfill gas, digester gas from sewage treatment plants and biogas. According to the directive, heat collected by heat pumps (heat production, excluding energy input to drive the heat pumps) that use geothermal energy can be included in the numerator, provided that the final quantity of useful energy significantly exceeds the quantity of input primary energy as needed to drive the heat pump. However, it is at present unclear as to exactly how this is to be calculated. The Agency has elected to do so in the same way as it has previously done, i.e. heat absorbed by heat pumps from surface water, lake bottom waters, rock heat or ground heat as the heat source, together with those that use ambient air and meet the eco-labelling requirements, can be treated as renewable energy[3]. The proportion of renewable energy in the total quantity of absorbed heat has been based on data from previous years.

The denominator is defined in the directive as consisting of energy use in the industrial sector, the residential sector (including the service sector, agriculture, forestry and fisheries), and in the transport sector, plus internal use of electricity and heat in electricity and heat production plants and transmission losses in electricity and district heating distribution systems. When calculating the transport sector's contribution, only petrol, diesel fuel, biofuels and electricity used for land transport in each member country shall be included.

1 In order to reduce the effects of varying wind conditions, wind power production shall be corrected for a statistically average year, based on production from the last five years.

2 Hydro power production must be corrected to represent normal year conditions, as calculated from statistics for the last 15 years, in order to reduce the effects of year-to-year variations in precipitation.

3 See EC Regulation 1980/2000 and Decision 2007/742/EC.

3

Summary

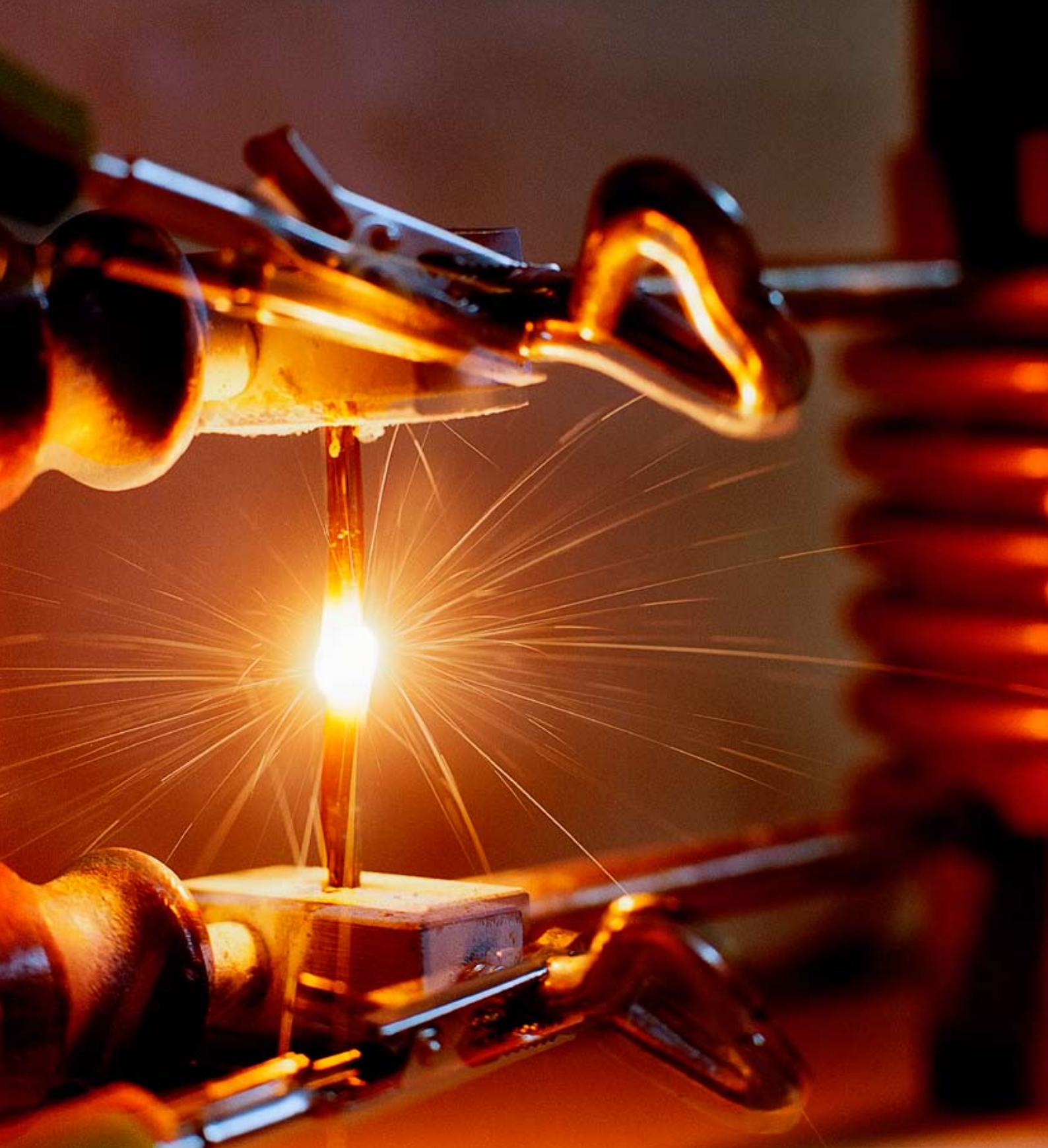
The mix of energy sources making up the country's energy supply has been changed with time, and also in response to changing needs. Total energy supply in 1970 amounted to 485 TWh, and had increased to 612 TWh in 2008, including a net export of electricity amounting to about 2 TWh.

The energy sources that today provide the greatest proportions of energy are oil and nuclear power, followed by biofuels and hydro power. The supply of crude oil and oil products has fallen by about 45 % since 1970, while net production of electricity has increased by almost 147 % over the same period. Much of the increase in production capacity has come from expansion of hydro power, but the main increase has been delivered by nuclear power production, which was built in Sweden over the period 1975–1985. In addition, the supply of biofuels has increased by over 186 % since 1970.

In 1990, 33.9 % of Sweden's energy demand was met by renewable energy, while in 2008 it was 44.1 % in accordance with the calculation method set by the European Commission. Electricity production makes the greatest contribution to Sweden's proportion of renewable energy, mainly from hydro power. The next largest contribution to the proportion of renewable energy comes from the industrial sector.

4 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 into three sectors: the residential and service sector etc., industry and transport. This chapter describes energy use in 2008[70], against the background of developments in energy use since 1970.



The residential and service sector

Energy use in the residential and service sector, amounting in 2008 to 141 TWh, accounts for 36 % of Sweden's total final energy use. The sector consists of residential buildings, holiday homes and non-residential premises (excluding industrial premises), land use[71], and other service activities. Other service activies include the construction sector[72], street lighting, sewage treatment plants, electricity and waterworks. Of the total energy use in the sector, about 86 % is used in residential buildings and non-residential premises, see Figure 13.

About 61 % 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 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[73]. The average temperature in 2008 was about 14 % higher than in a statistically average year. Adjusted to the corresponding value for a statistically average year, the equivalent energy use for 2008 is 149 TWh.

The number of dwellings (one- and two-dwelling buildings and apartments in multi-dwelling buildings) in the country steadily increases. In 2008, there were about 4.5 million dwellings[74], or about 40 % more than in 1970[75]. The rate of construction was relatively low during the latter half of the 1990s, but picked up during the 2000s, to the extent that 32 201 new dwelling units were completed in 2008, or 5 % more than during the previous year[76]. Despite the increase in the number of dwellings, total energy use in the sector has remained relatively constant.

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, after which electricity use has remained relatively constant at somewhat over 70 TWh (statistically corrected for climate conditions).

Much of the electricity used in the sector is for building services systems and for work activities in non-residential premises[77]. The amount of electricity used for this purpose has increased substantially, from 8.4 TWh in 1970 to over 30 TWh in 2008; a level that has remained relatively constant since 1999.

In order to obtain more detailed data of energy use in non-residential premises, the Swedish Energy Agency is part way through a seven year investigation (which started in 2005) of energy use in a sample of about 1000 premises. The investigation, under the name of STIL2, is intended to provide data on the use of energy and electricity in various types of premises (offices, schools, health care facilities

70 Statistics for 2008 are preliminary, and may be adjusted.

71 Land use includes agriculture, forestry, horticulture and fisheries. More detailed information on energy use in these sectors can be found in the publications 'Energianvändning inom jordbruket 2007' (STEM/SCB), 'Energianvändningen inom fiskesektorn 2005' (ER 2006:35) and 'Energianvändningen inom skogsbruket år 2005' (ER 2007:15). Information on energy use in the horticultural sector can be found in 'Trädgårdspriduktion 2005', which can be downloaded from www.jordbruksverket.se.

72 'Energianvändningen inom byggsektorn 2004', ER2006:02

73 Since 2003, the reference period for creating the statistically average data has been 1970 2000. Prior to that, it had been 1961/62 1978/79.

74 Calculated housing stock, 2008-12-31, Statistics Sweden Press Release 2009:109 of 2009-05-28.

75 Bostads- och byggnadsstatistisk årsbok, 1979..

76 Byggande. Nybyggnad: Färdigställda bostadshus 2008. SCB, BO 20 SM 0901

77 Electricity for building purposes is a statistical combination of electricity for building services systems and electricity for activities in non-residential buildings. The former is used for fixed equipment for climate control in the building, and for such applications as lifts, escalators and general lighting, while the latter is used for activities performed in the building, such as for computers, equipment and lighting.

and sports centres). At 62 kWh/m² (excluding space heating), the use of electricity is, on average, lowest in schools, as against 78 kWh/m² in health care premises, 102 kWh/m² in offices and 129 kWh/m^2 in sports centres. However, there are considerable variations in electricity use between buildings in the same category. Lighting, at 25 % in schools and health care premises, 22 % in sports centres and 21 % in offices, accounts for a major part of electricity use in all three types of premises. Ventilation is another major user of energy, amounting to 34 % in health care premises, 25 % in schools, 24 % in sports centres and 17 % in offices. The potential for further improvements in the efficiency of electricity use in these premises and facilities is regarded as considerable: it should be possible to save up to 30 % of total electricity use in the types of premises covered by the survey[78].

The use of electricity for domestic purposes[79] increased from 9.2 TWh in 1970 to 19.5 TWh in 2008, with most of the increase occurring during the 1970s and 1980s. This growing use can be explained by an increase in the number of households and greater ownership of electrical and electronic equipment. However, since 2001, the use of domestic electricity has remained relatively constant. In 2007, average domestic electricity use was estimated as amounting to about 6000 kWh in one-and two-dwelling buildings, and in multi-dwelling buildings to about 40 kWh[80] per m^2 and year.

Over the period 2005–2008, the Swedish Energy Agency carried out a study in 400 households to provide up to date data on the breakdown of uses of domestic electricity. The results are still being processed, but preliminary results indicate a wide spread in measured electricity use between households, varying from 2000 kWh/year to 7000 kWh/year for a one- or two-dwelling building, and from 1000 kWh/year to 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.

The use of electricity for heating in the sector increased gradually from 4.7 TWh in 1970 to 29 TWh in 1990 (statistically corrected values), reaching a peak at the beginning of the 1990s, and then falling somewhat. In 2008, electric heating amounted to 21.2 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.

78 As part of its 'Improved energy statistics in buildings' project, the Agency has created the eNyckeln web site, with information on energy statistics for multi-dwelling buildings and non-residential premises. See www.enyckeln.se.

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

80 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/m^2, year.

Space heating and domestic hot water production

A total of 78.2 TWh were used for space heating and domestic hot water production in 2007, equivalent to about 84 TWh after correction for a statistically average climate year. Of this, about 41 % (31.8 TWh) were used in one- and two-dwelling buildings, 32 % (25.2 TWh) in multi-dwelling buildings and 27 % (21.2 TWh) in non-residential premises.

The commonest form of heating in detached houses is electric heating, used in about a third of them in 2007. 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 one- and two-dwelling buildings is that it is cheap to install and simple to run. Its use increased substantially in the sector from 1970 to the middle of the 1980s, due to the move away from oil, 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 13.7 TWh in 2007 (14.8 TWh after adjustment for statistically average climate conditions).

”District heating is the commonest form of heating in multi-dwelling buildings.”

The use of direct electric heating in combination with some other form of heating is common in one- and two-dwelling buildings: about 23 % of detached houses had some form of combination heating system in 2007. The commonest combination, used in about 20 % of one- and two-dwelling buildings, was that of biofuels and electricity. The use of heat pumps has increased substantially in recent years, to the extent that they were used in about 37 % of one- and two-dwelling buildings in 2007.

About 9 % of the one- and two-dwelling buildings were heated solely by district heating, 13.5 % were heated solely by biofuels, and 3.3 % were heated solely by oil. Other one- and two-dwelling buildings had other combinations, or were heated by gas. 11.1 TWh of biofuels, 4.2 TWh of district heating, 2.6 TWh of oil and 0.2 TWh of gas were used for space heating and domestic hot water production in one- and two-dwelling buildings, making a total of 31.8 TWh.

District heating is the commonest form of heating in multi-dwelling buildings, with about 82 % of the area being heated by it in 2007[81]. Oil was used as the sole heat source for 1 % of the area, while 2 % were heated by electricity alone. 8 % were heated by combinations of systems with heat pumps. Other areas were heated by combinations of various heating systems, or by gas or biofuels. Total use

81 In addition to this, district heating was used in combination with other forms of heating for 3 % of floor areas.

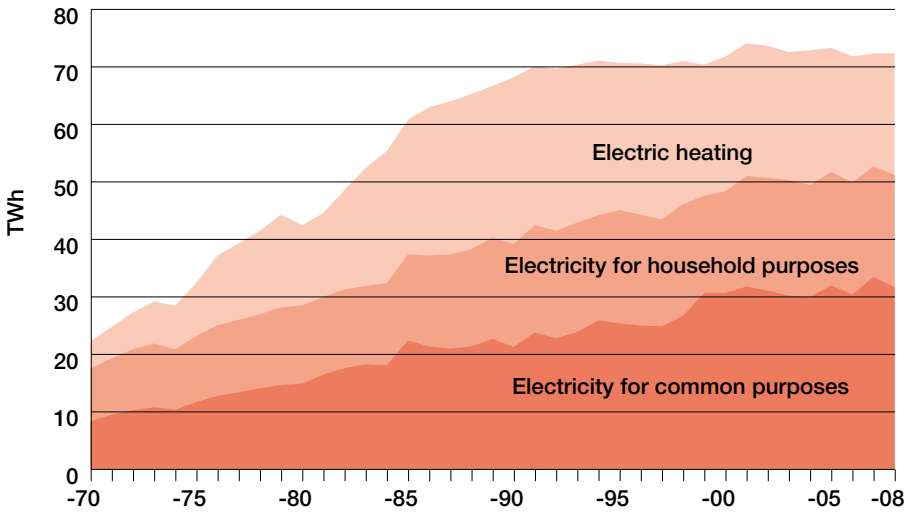


Figure 12
Electricity use in the residential and service sector, 1970–2008, corrected to a statistically average climate year

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

amounted to 22.8 TWh of district heating, 1.2 TWh of electric heating, 0.7 TWh of oil, 0.3 TWh of gas and 0.2 TWh of biofuels.

District heating is the main source of heat in non-residential premises and public buildings as well, with 66 % of the area in 2007 being supplied solely with district heating. About 8 % of this floor area were heated by electricity alone, and about 3 % by oil alone. Other heating systems included combinations of various energy carriers, or gas or biofuels alone. Total use amounted to 15.4 TWh of district heating, 3.3 TWh of electric heating, 1.4 TWh of oil, 0.4 TWh of gas and 0.6 TWh of biofuels.

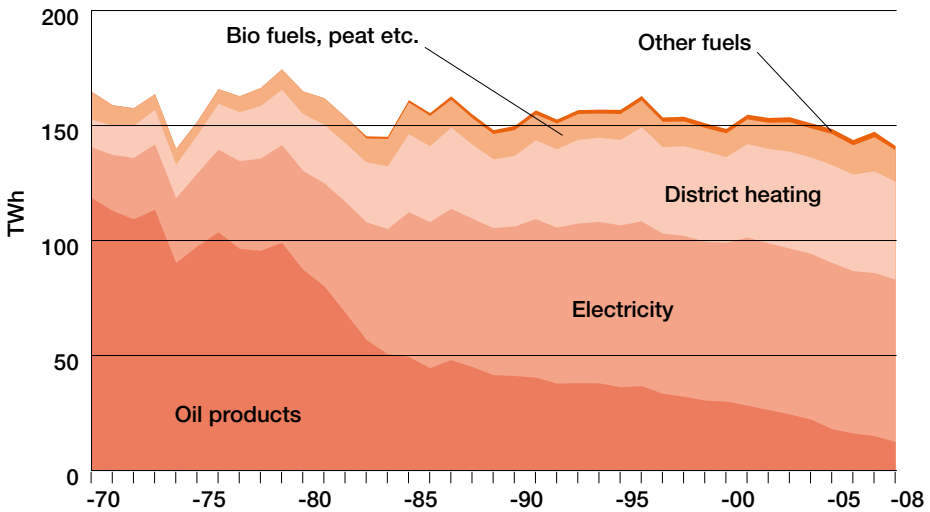
Changes in the residential and service sector

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, investment policies and changes in energy taxation have all affected the shift from oil to electricity, district heating and biofuels. Biofuels in particular are used for heating in one- and two-dwelling buildings: the commonest form of such fuel is logs, although pellets and wood chips are also used. In 2008, total use of oil fuels in the sector amounted to 12.4 TWh, a reduction of 90 % since 1970. About 38 % of this oil was used for heating.

The total statistically corrected energy use in this sector remained relatively constant 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

Figure 13
Final energy use in the residential and service sector, 1970–2008, corrected to a statistically average climate year

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY



water production. The main 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[82].

Another contributory reason for the reduction in energy use in the sector is the increase in the number of heat pumps. Heat pumps deliver about three times as much thermal energy as they use in the form of electrical energy for driving them[83], which means that their use reduces the metered use of energy for space heating and domestic hot water production in buildings. This 'free' heat is not included in the statistics of the total 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 non-residential premises include various energy conservation measures, such as retrofitting additional thermal insulation or upgrading windows in older buildings. The use of electricity – increase or decrease – in the domestic environment is affected by two opposing trends. Technical development is steadily improving the efficiency of equipment that replaces older products having higher energy consumptions. At the same time, many new items are given so many additional functions that they use more energy. In addition, the reduced energy consumption is offset by the increasing number of households, and by the fact that many households have more and more electrically powered items.

82 See also Chapter 3, Sweden's Energy Balance, under 'System boundaries'.

83 Heat pumps in energy statistics – Suggestions, www.energimyndigheten.se

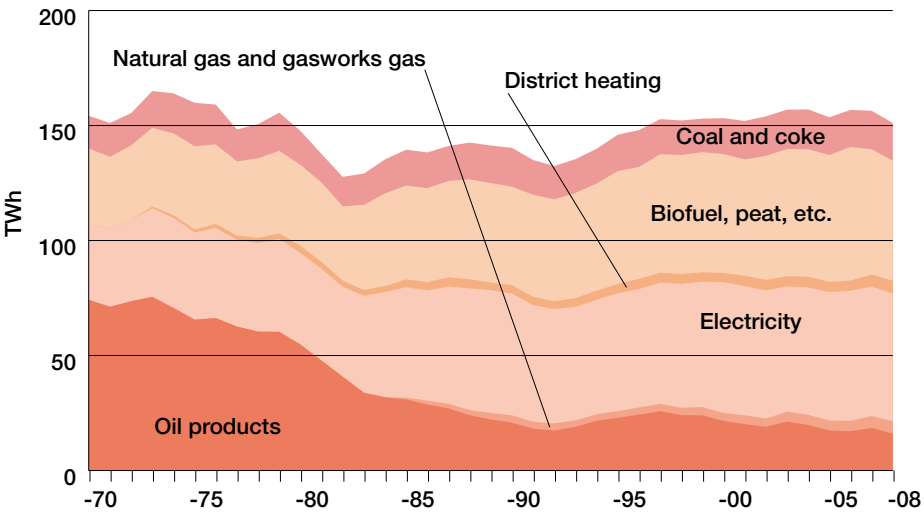


Figure 14
Final energy use in the industrial sector, 1970–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Industry

Energy use in industry in 2008 amounted to 151 TWh, which is a slight decrease in use from 2007, and represents about 38 % of the country's final energy use. The main energy providers in industry are electricity and biofuels, at 35 % and 37 % respectively, complemented by 25 % of energy from fossil sources. District heating provides about 4 % of the industry's energy use. Fossil energy was provided by 16 TWh of oil products, 16.4 TWh of coal and coke, and 5.4 TWh of natural gas, as shown in Figure 14.

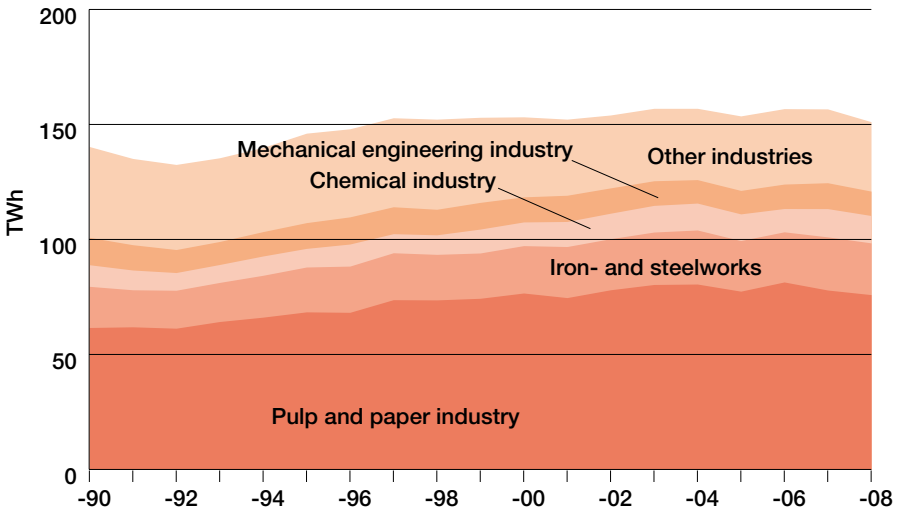
Energy and fuel use in various trades

In Sweden, a small number of trades accounts for the bulk of energy use in industry: see Figure 15. The pulp and paper industry uses about 50 %, primarily as electricity or from black liquors[84]. 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 is responsible for 8 % of industrial energy use: here, electricity is used mainly for electrolysis processes. Together, these three energy intensive trades account for almost three-quarters of total energy use in industry.

84 Black liquors are a byproduct of the sulphate process for pulp manufacture. Burnt in what are known as soda recovery boilers, they recover chemicals for re-use in the process and deliver thermal energy for steam raising and electricity production.

Figure 15
Energy use in industry, by sectors, 1990–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY



The engineering industry, although not regarded as energy intensive, nevertheless accounts for over 7 % of total energy use in industry, as a result of its high proportion of Sweden's total industrial output. The remaining 20 % or so of the energy used by industry meets the needs of other trades. Although some of them can be regarded as energy intensive, their total energy use is relatively low. Some trades are dominated by the use of fossil energy, such as the non- metallic mineral industry, while others, such as the basic metals industry, are dominated by the use of electricity. This category also includes trades mainly using a mix of fossil energy and electricity, such as the mining industry, and those which are dominated by biofuels, such as the wood products industry, which also uses a considerable proportion of electrical energy[85].

85 "Other sectors" include not only the mining industry, metals industries, the wood products industry, the non-metallic mineral industry, but also the food industry, the textiles industry, the graphics industry and "other industry" (NACE 2007 31-33).

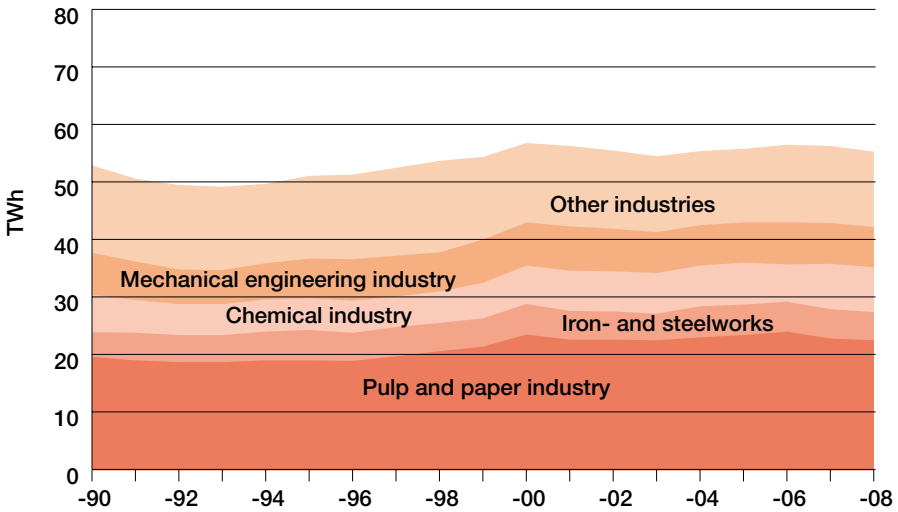


Figure 16
Electricity use in industry, by sectors, 1990–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

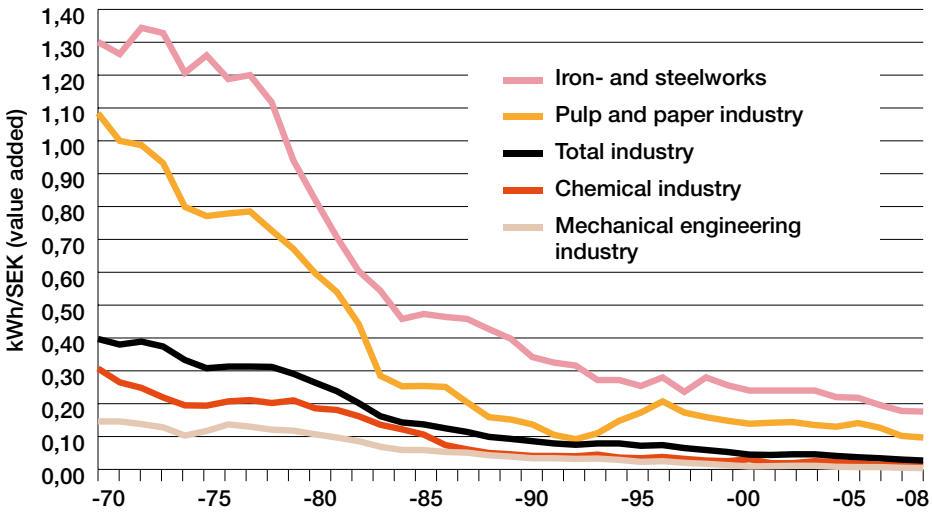
The relationship between supply and use of energy

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 within the trade and changes in the types of goods produced.

Between 1990 and 1992, industrial production declined by over 4 % per annum, which was reflected by a fall of over 3 % in energy and electricity use over the period: see Figure 15 and Figure 16. Output recovered in 1993, and continued to rise strongly until 2000, during which period it increased at over 9 % per annum. This was reflected in energy and electricity use, which rose by an average of 2 % per annum over the period. This period was followed by an economic downturn in 2001 and a recovery over the period 2002–2007. During the latter period industrial output increased by about 5 % per annum, while electricity and energy use remained almost unchanged. In total, industrial output has increased by 159 % between 1992 and 2007, for an increase of 17 % in total energy use and of over 13 % in electricity use. Industrial output in 2008 fell to a level below that of 2006, with the result that energy use fell to its lowest level for ten years. Most of the decrease was in the use of oil and biofuels.

Figure 17
Specific use of oil in industry, 1970–2008, prices as of 2000

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY



Changes in use of the most important energy carriers

Despite increasing 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 society in large 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 11 %. At the same time, that portion of industry's use of energy provided by electricity has increased from 21 % to 37 %, i.e. oil has been replaced by other energy carriers, maily electricity. Although the overall use of oil by industry has fallen by about 78% since 1970, there was an increase over the period 1992–1997, after which the downward trend resumed. In recent years, the use of oil has fallen, to the extent that its use in 2008 was less than in the previously record low year of 1992.

Biofuels are the main energy source in the pulp and paper industry and in the wood products industry. Between 1970 and 2008 the proportion of biofuels, peat etc. has increased from 21 % to 35 % of the industry's total energy use.

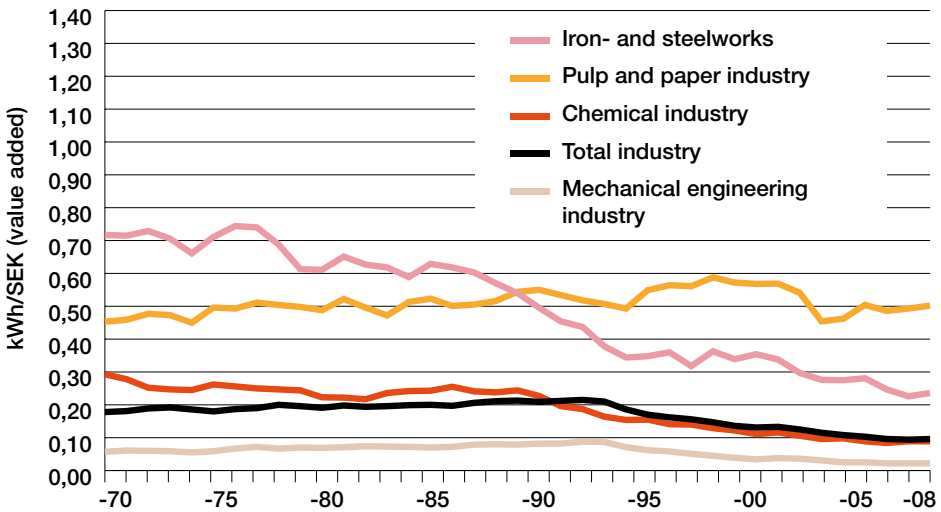


Figure 18
Specific use of electricity by industry, 1970–2008, prices as of 2000

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Changes in specific energy use

Specific energy use – i.e., the amount of energy used per value added – provides a measure of how efficiently the energy is being used. Since 1970, specific energy use in industry has fallen continuously: between 1970 and 2008, it fell by 68 %, or on average by 3 % per year, reflecting a clear trend towards less energy intensive products and production processes, together with structural changes. In general, the reduction in specific energy use is due to the fact that the value added by industry has increased considerably more rapidly than has energy use. 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. Specific use of oil fell by 81 % between 1970 and 1992, while specific use of electricity increased by 21 %. Ups and downs in the economy between 1992 and 2008, coupled with changes in the energy taxation of industry, are reflected in changes in specific energy use, which continues to fall. Over this period, specific energy use fell by 55 %, with specific use of oil falling by 64 % and that of electricity by 56 %. 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.

Transport

Total energy use for transport in 2008 amounted to about 129 TWh, or about 26 % of the country's final energy use. Of this, domestic transport used about 95 TWh, and foreign transport (including bunkering for foreign maritime traffic and air transport) used about 33 TWh.

Energy use in the transport sector is dominated almost entirely by oil products, primarily petrol and diesel fuel. In 2008, the use of these two fuels met 88.5 % of the country's energy requirement for domestic transport, with biobased motor fuels[86] accounting for 4.6 %, electricity for 3.1 % and aviation fuel for 2.6 %, with the remainder being met by gas oil, medium and heavy fuel oils, and natural gas. The use (both relative and absolute) of petrol has declined somewhat since 2002, which can be explained by a falling proportion of petrol engines in passenger cars and light goods vehicles. The reduction in the absolute use of petrol was greater in 2008 than in previous years. On the other hand, both the relative and the absolute use of diesel fuel have increased over the period 2000–2008, which is largely due to an increase in the numbers of diesel powered vehicles, whether private cars or light goods vehicles. In 2008, the proportion of new vehicles that were diesel-powered was about 35 %, or the same as in the previous year, but which is roughly a doubling of numbers from 2006, when about 20 % of new private cars were diesel-powered[87].

The use of aviation fuel decreased over the period 2000–2003, and then increased in 2004–2008. This increase over the last five 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, which increased over the period 2002–2007, declined in 2008.

The use of biobased motor fuels in road transport has increased substantially since 2005, due mainly to increases in the use of FAME and ethanol. In 2008, biobased motor fuels made up 4.9 % of fuels used for road transport.

86 Biobased motor fuels are ethanol, biogas and FAME. FAME is an umbrella name for fatty acid methyl esters, of which RME (rapeseed methyl ester) is the commonest in Sweden today.

87 SIKA, Fordon 2008

88 Banverket, Järnvägssektorns utveckling, Banverkets sektorrapport Report 2008

89 Vägverket, Sektorsredovisning 2007

Transport work

The total domestic passenger transport work in 2008 amounted to about 137.2 billion person-km, which is the highest value to date, and an increase of 0.1 billion person-km over 2007[88]. Road traffic dominates this, with about 87 % of passenger transport carriage, with railways and tramways carrying over 10 % of passenger traffic, aviation about 2.6 %, and domestic water traffic almost 0.6 %[89].

Long-distance passenger travel (i.e. over 100 km) amounted to 39.8 billion person-km, which is also the highest level to date. About 70 % of long-distance

passenger travel was provided by car traffic, one percentage point less than in 2007, while rail traffic carried 15 % and aviation carried 8 %. Short distance transport (regional and local) amounted to 97.4 billion person km. 77 % of these journeys were by car or motor cycle, 17 % by public transport and the remaining 6 % by foot, cycle or moped.[90]

Domestic goods transport in 2008 amounted to about 100.5 billion tonne km. Of this, long distance transport accounted for 92.3 billion tonne km, being in turn made up of 34.9 billion tonne km of road traffic, 23.3 billion tonne km by rail and 34.1 billion tonne km by water transport[91].

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, meant that all petrol stations selling more than 3000 m³ of petrol or diesel fuel per year must also supply at least one renewable fuel. Since the beginning of 2009, this requirement has been extended downwards to cover all petrol stations selling more than 1000 m³ of conventional fuels. The effect has been that the petrol stations have installed almost exclusively E85 pumps. A government grant was introduced to help petrol stations meet the cost of supplying renewable fuels other than ethanol, and has now been extended to the end of 2010. Up to April 2009, grants had been approved for 75 installations of biogas pumps around the country

> ”A government grant was introduced to help petrol stations meet the cost of supplying renewable fuels.”

With effect from 1st August 2006, admixture of 5 % FAME has been permitted in diesel fuel, which has noticeably increased its use. The increased use of ethanol is due at present to a growing number of ethanol powered vehicles, which is offsetting the decline in the use of ethanol as a low admixture constituent in petrol based fuels due to the decline in the use of petrol. 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. On 20th September 2009, a litre of 95-octane unleaded petrol cost SEK 12:13, a litre of diesel fuel cost SEK 11:48, and a litre of E85 fuel (consisting of 85 % ethanol and 15 % petrol) was SEK 9:59. 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

90 Banverket, Järnvägssektorns utveckling, Banverkets sektorrapport Report 2008

91 Banverket, Järnvägssektorns utveckling, Banverkets sektorrapport 2008

this, the cost of using E85 at that time was somewhat higher than the cost of using petrol. CNG[92] as a motor fuel was cheaper than petrol, with a difference on that date of about SEK 2:00 per litre (petrol equivalent)[93].

At the end of December 2008, there were 11 974 private cars, 3116 goods vehicles and 786 buses running on gas in Sweden. On the same date, there were also over 151 000 flexible-fuel cars, 744 flexible-fuel goods vehicles and 515 flexible-fuel buses in Sweden, with the majority being ethanol hybrids[94].

Developments in the transport sector

Several international vehicle manufacturers are planning to launch commercial rechargeable hybrids or electric vehicles. Initially, the price of battery hybrids and electric vehicles will be considerably higher than that of conventional vehicles, due mainly to the fact that the batteries are expensive. However, much work is being done on battery development, which should bring down prices and, in turn, encourage more large scale production.

”Several international vehicle manufacturers are planning to launch commercial rechargeable hybrids or electric vehicles.”

Several projects are in progress, or are being started, in order to provide better understanding of, and to investigate the effects of, electrification of road vehicles. *Mobilel* is a project being carried out jointly by the Stockholm City Environment Administration and Fortum, with the aim of testing various charging concepts, performing a behavioural study and constructing various charging ‘platforms’ for testing. *Bilel* is a joint three year project between Fortum in Stockholm and Göteborgs Energi, which is being carried out over the period 2009–2011. The purpose of the work is to improve knowledge of charging, payment, standards and other technologies for electrification of road vehicles, and how the various factors affect those involved. The results should also identify new business opportunities and technical solutions.

In the field of rail transport, a special wagon (Flexiwaggon) has been developed for the transport of heavy goods vehicles and other vehicles by rail, with a design that improves the flexibility of loading and unloading.

In conjunction with Swebus, Stockholm Public Transport (SL) is testing ethanol hybrid buses in urban duty over a two year period, with the aim of reducing fuel consumption and carbon dioxide emissions.

92 In Sweden over 50% of the CNG used as motorfuel consists of biogas.

93 Svensk Biogas, www.svenskbiogas.se, 2008-06-25.

94 SIKA, Fordon 2008.

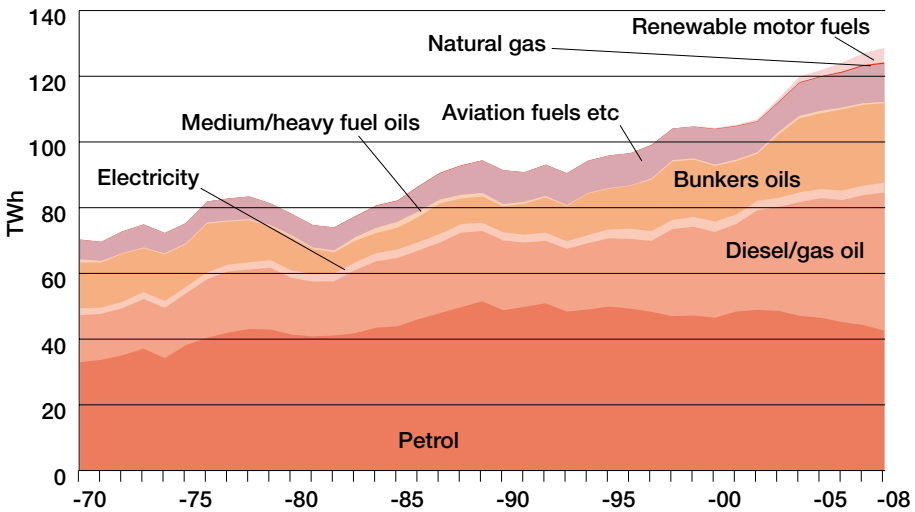


Figure 19
Final energy use in the transport sector, 1970–2008, including international marine bunkers

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

With effect from 2012, aviation within, to, and from the EU will be included in the Emissions Trading System. Allocations will be determined on the basis of average allocations in the sector over the period 2004–2006. 85 % of rights will be allocated (for free) and 15 % will be auctioned. A reserve for new airlines and/or those experiencing substantial growth will be established. Several airlines are reviewing their fuel consumptions and ways in which fuels can be saved: in addition to 'green approaches', savings can be made by such ways as reducing take off weight and by towing the aircraft when on the ground before and after flying. Several parties are testing the use of biobased fuels for aircraft, with a Japanese airline having tested fuel containing 50 % biobased fuel in one of the engines of a jumbo jet.

In its most recent Energy and Climate Policy Bill, the Government has stated that it intends to start a dialogue with those involved in the transport sector, with the aim of developing an appropriate plan of action. In March 2009, the Government appointed a Parliamentary Commission to suggest changes with the aim of improving the physical planning process for transport infrastructure.

Greater electrification of the transport sector is a priority working area, and the Swedish Energy Agency has recently concluded an investigation[95] of the market for electric vehicles and battery hybrids, among the conclusions of which are the following:

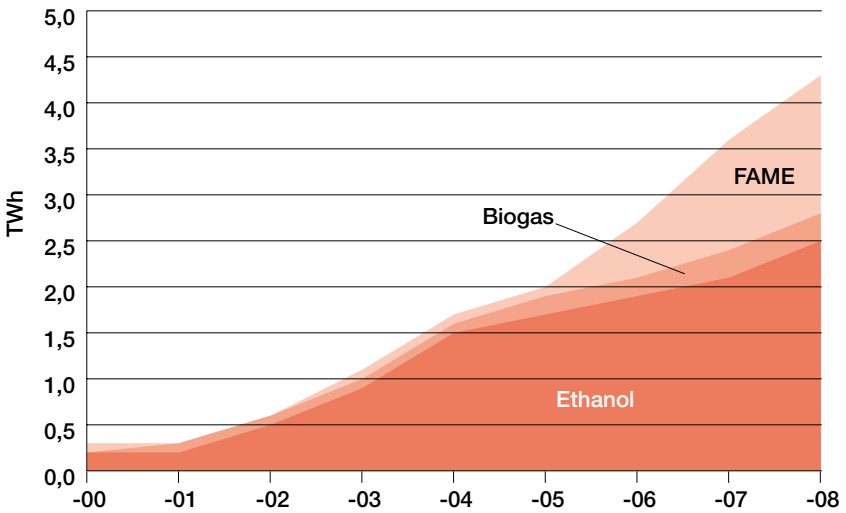
95 Knowledge base for the market in electric vehicles and plug-in hybrids, ER 2009:20

- A national demonstration programme for electric vehicles and battery hybrids, involving about 1500 vehicles and a budget of about SEK 500 million over a four year period in order to evaluate the technology, behaviour, Swedish conditions and needs for this revived technology.
- The Swedish Energy Agency also points out that a project of this type requires careful consideration of which specifically Swedish conditions should be evaluated, in that there are already several evaluation projects in progress around the world.
- As part of the work of the investigation, the Energy Markets Inspectorate analysed the legal aspects of charging vehicles in a public environment. The Inspectorate is of the opinion that there are no obstacles in the way of public recharging if such a requirement should arise in response to market pressures.
- The Swedish Energy Agency also concludes that support for introduction of electric vehicles should be investigated, and that it could be suitable for such support to be equal to the additional costs associated with such vehicles.

In general, the Swedish Energy Agency attaches high priority of the development of electric and battery hybrid vehicles in its long term energy policy programme.

Figure 20
Final energy use of renewable motor fuels, 2000–2008

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



4

Summary

This chapter has described energy use in the three sectors of residential and service, industry and transport. Total energy use of the three sectors together amounted to 395 TWh in 2008, of which over 129 TWh were electricity.

The residential and service sector uses 36 % (141 TWh) of the country's energy use. The energy is mainly supplied by district heating, electric heating or combustion of oil or biomass for heating of residential buildings or non-residential premises. 61 % of the energy use in this sector is for heating. The sector used the most electricity of the three sectors, amounting to over 70 TWh of electricity, or 50 % of total final energy use in the sector.

The industry uses energy not only directly as a 'raw material' (for example, in the manufacture of steel), but also for powering ancillary processes such as pumps, air compressors and lighting. In total, the industry sector used 151 TWh (38 % of final energy use) and over 55 TWh (39 %) of electricity.

In 2008, energy use for transportation of people and goods amounted to about 129 TWh of energy, or 26 % of the country's total energy use. The use of electricity for transports, amounts only to 3 TWh (2 %), instead transportation relies almost entirely on oil products.

The energy markets

Energy markets are changing in step with world-wide growth in energy demand, developments in technology and growing awareness of the effects of energy systems on the environment, society and the economy. The 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 events 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.

Electricity

Recent years have seen major changes in the electricity markets in the Nordic countries and the EU, 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 Nord Pool, the Nordic electricity exchange. 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.

Use of electricity

Between 1970 and 1987, electricity use in Sweden increased at an average rate of almost 5 % per year. However, this rate of increase has since declined, to about 0.2 % per year on average. Economic and technical development, changes in energy prices, business structure, population changes and the weather all affect electricity use. In 2008, total electricity use in Sweden amounted to 144 TWh, with the residential and service sector accounting for almost half of this, and industry for about 39 %. The remainder is accounted for by the transport sector, district heating, refineries and distribution losses.

Per-capita electricity use in Sweden amounts to about 16 000 kWh per year. Only Iceland, Norway, Canada and Finland 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 10 % lower than in Sweden, while average use in the EU-15 is about 54 % less than that in Sweden.

Electricity production

At the beginning of the 1970s, hydro power and conventional oil-fired cold condensing power plants produced most of the electricity in Sweden. The oil crises of the 1970s coincided with Sweden's construction of nuclear power plants. In 2008, nuclear power supplied 42 % of the country's electricity, hydro power supplied about 47%, and the remaining 11 % was made up of fossil-fuelled and biofuel-based production and wind power. Total production amounted to 146 TWh.

Hydro power production in 2008 amounted to 68.4 TWh, which is higher than

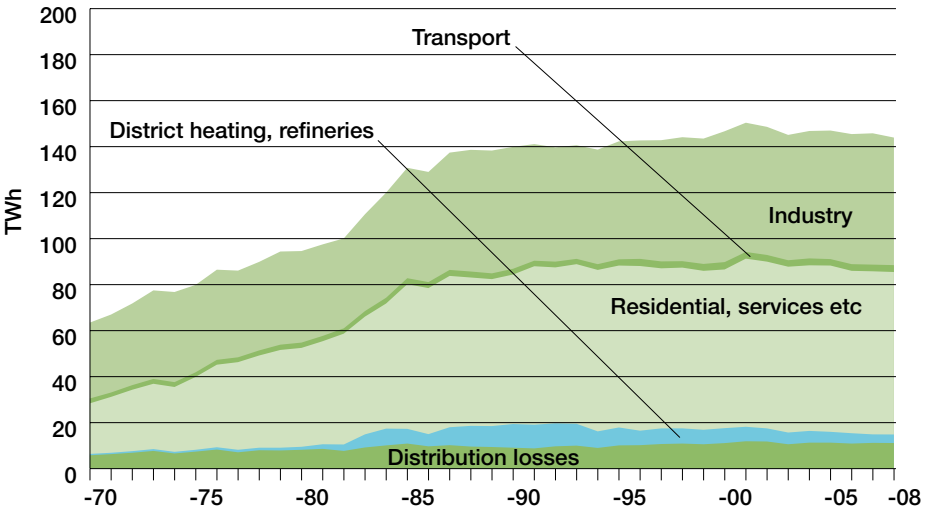


Figure 21
Electricity use in Sweden, by sectors, 1970–2008

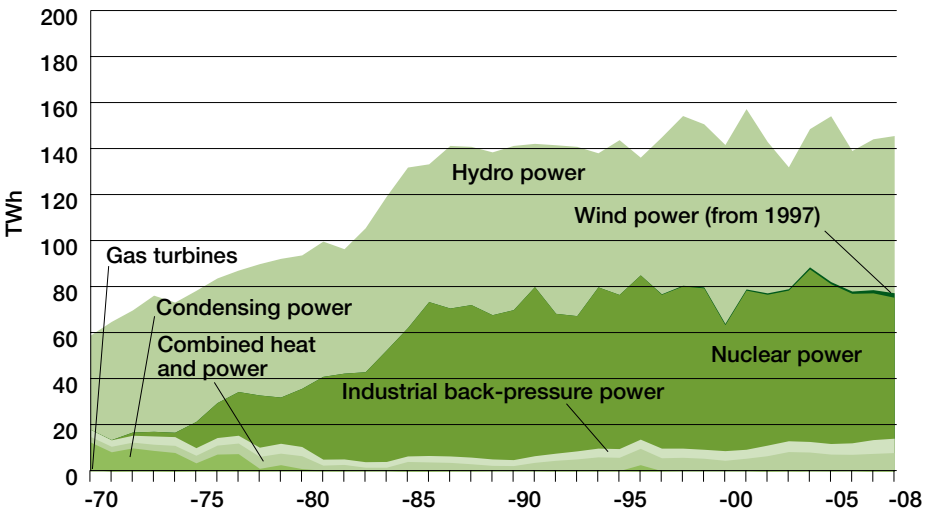
SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

the average production, which is about 67.5 TWh. The country's nuclear power stations produced 61.3 TWh in 2008, which is less than the average post-1985 production of about 65.8 TWh. Combustion based electricity production amounted to 14.3 TWh, with 70 % of the fuel input being in the form of biofuels, and the rest in the form of fossil fuels. This can be compared with production in 1998, when biofuels made up only 28 % of fuel input. Today, it is combined heat and power production (CHP) (at 7.7 TWh) and industrial back pressure production (at 6.2 TWh) 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 in 2008 increased considerably, to 2.0 TWh.

In neighbouring Norway, 98 % of electricity production is based on hydro power. In Denmark, most electricity (81 %) is produced from thermal power, although the country also has a relatively high proportion of wind power (19 %). In Finland, non-nuclear thermal power supplies about 47 % of electricity, with a further 30 % being produced by nuclear power and 22 % by hydro power. Sweden belongs to the group of countries having the highest proportions of hydro power and nuclear power for electricity production: in 2008, among the OECD countries, only Iceland, Norway, Canada, New Zealand, Austria and Switzerland produced a greater proportion of hydro power than did Sweden, and only France, Belgium and Slovakia had a higher proportion of nuclear power.

Figure 22
Electricity production in Sweden, by types of production plant, 1970–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY



Electricity transmission and maintenance of system balance

Electricity cannot be stored so there must at all times be a balance between demand and production. To do this there must be a party responsible for overall operation of the system. In Sweden, it is Svenska Kraftnät that is responsible for maintaining this balance: in addition, it is also responsible for operation of the country's bulk power transmission grid. Since January 2008, surveillance and monitoring of the electricity market has been in the hands of the Energy Markets Inspectorate.

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 is owned by Svenska Kraftnät, consists of 15 000 km of high voltage cables and overhead lines, carrying electricity over long distances and to neighbouring countries. The regional grids which consist of about 33 000 km of low-voltage lines are owned mostly by the three largest electricity utilities; Vattenfall, E.ON and Fortum. They carry electricity from the national grid to the local distribution networks and, in certain cases, directly to larger electricity users. The local distribution networks, amounting to about 479 000 km of lines, are owned mainly by the large power companies and by local authorities. Storm Gudrun, which struck southern Sweden in January 2005, destroyed over 30 000 km of overhead lines, plunging well over half a million households into darkness. As a

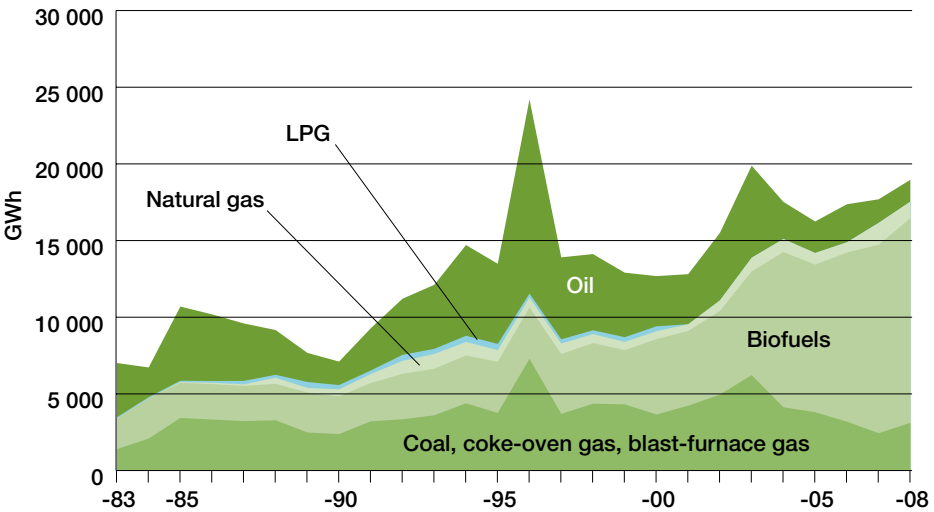


Figure 23
Fuel input for electricity production (excluding nuclear fuel), 1983–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

result, work on reinforcing local distribution networks has been further stepped up, with a change to buried cables as the main alternative. At present, about 54 % of the total of 527 000 km of local networks are in the form of buried cables.

There are at present cross-border links between Sweden and Norway, Finland, Denmark, Germany and Poland. The Nordel organisation[96] has identified a number of areas where the grid needs to be reinforced in order to increase transmission capacity between the Nordic countries, and to relieve bottlenecks in the system. In addition to the current projects, (Fenno-Skan, Great Belt, Nea-Järpströmmen, Sydlänken and the Skagerack Link), Nordel believes that links are needed in another three areas: the South-West Link, between Sweden and Norway, Ørskog-Fardal in Norway, and Ofoten-Balsfjord-Hammerfest, also in Norway. The grid also needs changes in order to suit new energy sources: expansion of wind power production calls for greater flexibility of the grid in order to enable major variations in power flows to be compensated from other sources in other places.

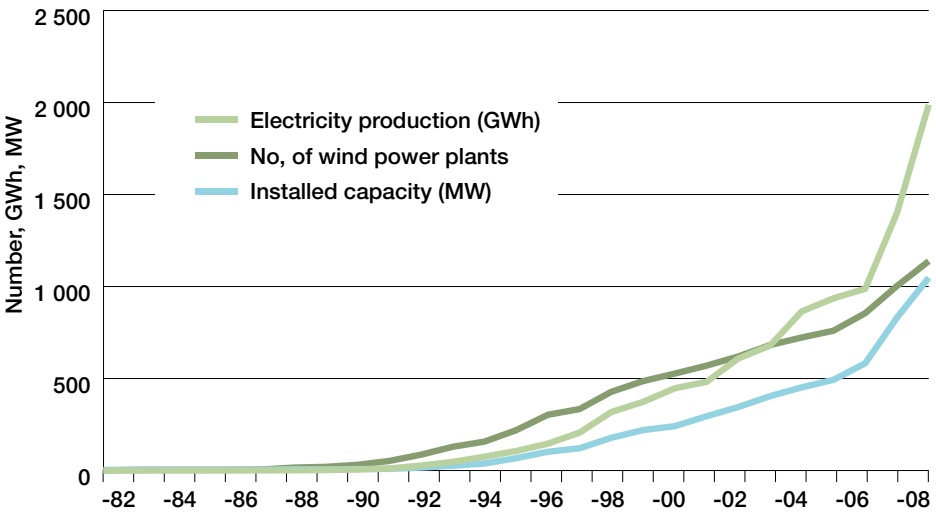
At present, the total transmission capacity from Sweden to other countries amounts to about 8 760 MW, and in the reverse direction to about 9 140 MW.

At the end of 2008, Sweden's total installed capacity was 34 181 MW, made up of 47.4 % of hydro power, 26.1 % of nuclear power, 3.0 % of wind power and 23.5 % of other thermal power. Maximum demand occurred on 16th January 2009 between 08.00 and 09.00, and amounted to about 24 900 MW. Sweden's own

96 Nordel was a pan-Nordic organisation for the national network operators in the Nordic and Scandinavian countries. In addition to Sweden's Svenska Kraftnät, it included the Norwegian Statnett, the Finnish Fingrid, the Danish Energinet and Iceland's Landsnet.

Figure 24
Wind power production, 1982–2008

SOURCE: ELFORSK AND THE SWEDISH ENERGY AGENCY'S ANNUAL REPORT ON THE ELECTRICITY CERTIFICATE SYSTEM



production at the time was 24 400 MW, and a net import of 500 MW made up the difference. This can be compared with Sweden's hitherto highest demand of 27 000 MW, which occurred in January 2001[97]. As a result of deregulation of the electricity market, electricity producers decommissioned a considerable amount of peak load capacity, 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 was 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. The arrangement applies until 15th March 2011, after which responsibility for maintaining system balance is expected to be transferred to the electricity sector. However, the Energy Markets Inspectorate believes that formally negotiated reserve capacity will still be needed after 2011.

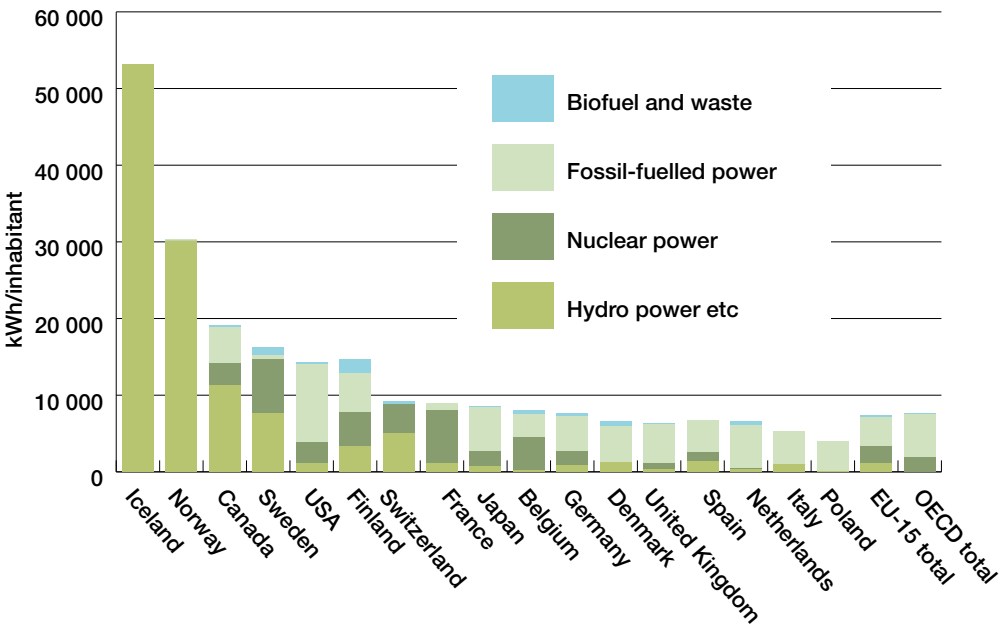


Figure 25
Per-capita electricity production, by types of production, 2008

SOURCE: ELECTRICITY INFORMATION, 2009 IEA/OECD

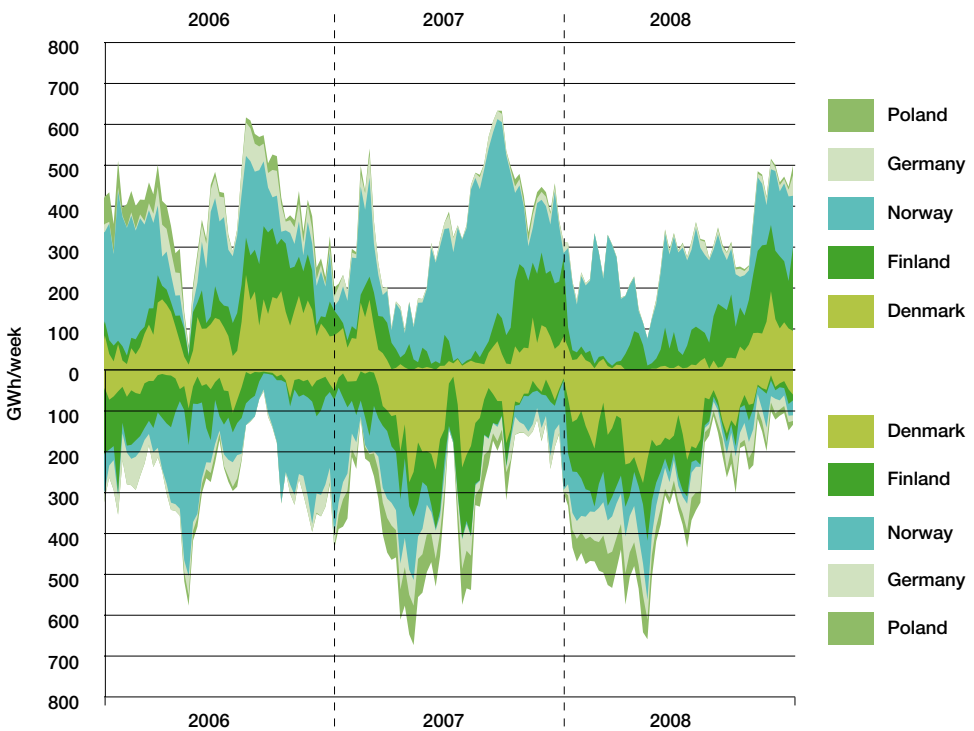


Figure 26
Swedish electricity import (+) and export (-), January 2006 – December 2008

SOURCE: SWEDENERGY AND THE SWEDISH ENERGY AGENCY

Electricity trading

Trading of bulk power supplies is vital in order to ensure a properly operating electricity market. The joint Nordic power exchange, Nord Pool, facilitates the optimum economic use of Nordic power plants and offers transparency of pricing. It has two main markets: one for trading in physical electricity (the spot market), and one for trading in financial instruments (the forward market). In 2008, 76 % of the electricity used in the Nordic countries was traded on Nord Pool's physical market (Elspot). The remaining electricity was traded internally between electrical utilities or via bilateral agreements outside Nord Pool. Nord Pool's financial market traded 1407 TWh in 2008, partly as a means of ensuring prices and partly for speculative purposes. This was an increase of 294 TWh over 2007. The members of Nord Pool consist of power producers, power suppliers, larger end users, portfolio managers, fund managers and brokers. Swedish Green Electricity certificates and EU emission rights are also traded on the exchange. The majority of all electricity consumers purchase their power from suppliers on the end user market.

”Trading of bulk power supplies is vital in order to ensure a properly operating electricity market.”

In 2008, Sweden had a net export of 2.0 TWh of electricity, as against a net import of 1.3 TWh in 2007. The change was due to increased production and to reduced use of electricity. Electricity trade flows between Sweden and its neighbours vary during the year and from one year to another, depending on price differences between Nord Pool areas, which can arise due to differences in (for example) precipitation and reservoir fill percentages. In 2008, Sweden was a net importer of electricity, mainly from Norway. As a whole, the Nordic countries were net exporters of 1.5 TWh, which can be compared to a net import of 2.7 TWh in 2007.

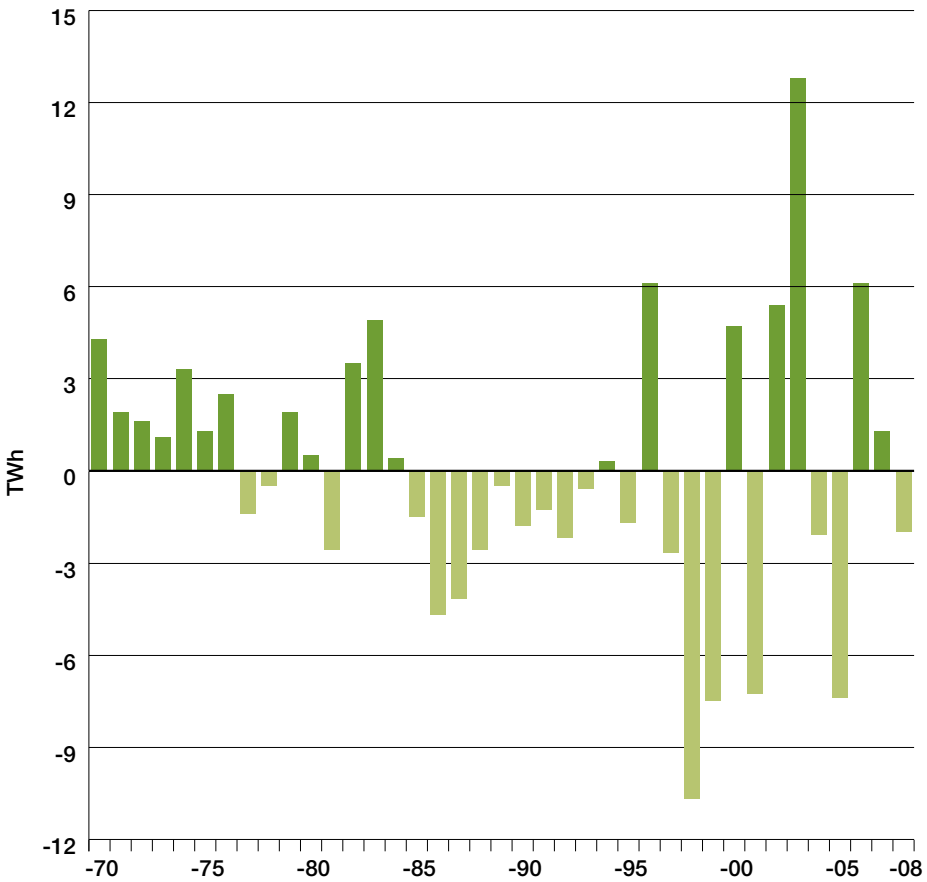


Figure 27
Sweden's net import (+) and net export (-) of electricity, 1970–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

Electricity price development and makeup

The price of electricity on the electricity exchange is not the same as the final price that a domestic customer sees on his or her bill. The total price to the customer consists of the price of the electricity (including the price of electricity certificates), the network price (the network tariff plus the fixed charge), energy tax and value added tax and the network company's profit. Of these, it is the price of the electricity that is subject to competition. In January 2009, the total price of electricity for domestic consumers in detached houses with electric heating was made up of about 48 % for the electricity, 15 % for the network charge, and 37 % for energy tax and value added tax. The commonest form of tariff, for over a third of consumers, is an open-ended period tariff. The number of variable-rate tariffs is

Figure 28
Spot prices on Nord Pool. Monthly and annual average prices for the system and for Sweden, January 1996 – May 2009

SOURCE: NORD POOL, FTP SERVER

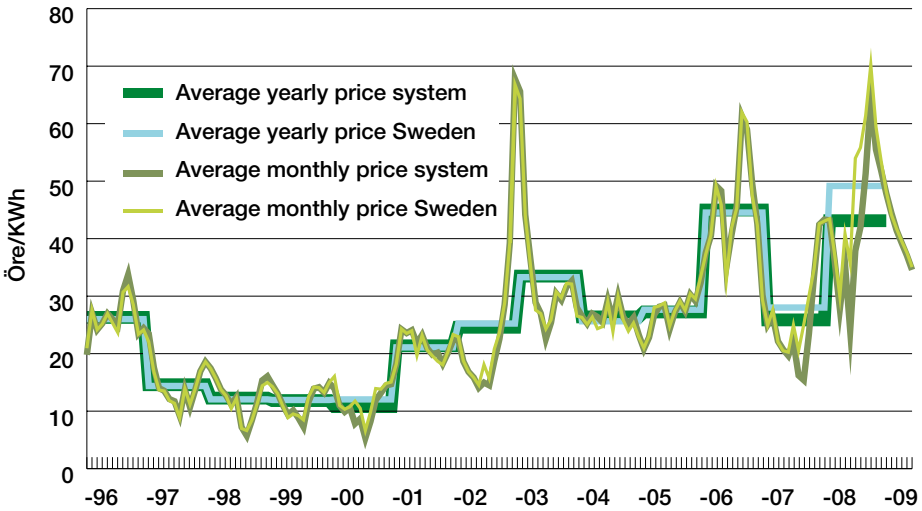


Table 6
Total price of electricity (excluding electricity certificates) for different customer categories, including network charges, tax and value-added tax, öre/kWh

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

NOTE: ELECTRICITY CERTIFICATE PRICES ARE INCLUDED IN THE FIGURES FOR AND FROM 2007. 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 160 A (3-PHASE)
2. ANNUAL USE 20 000 KWH, 20 A MAIN SUPPLY FUSE (3-PHASE)
3. ANNUAL USE 5 000 KWH, 16 A MAIN SUPPLY FUSE (3-PHASE)

	Small industry[1]	Det. house with electric Heating[2]	Det. house without electric Heating[3]
1st January 2002, total price	43,8	87,9	111,3
1st January 2003, total price	59,9	111,4	135,4
1st January 2004, total price	62,4	117,9	143,6
1st January 2005, total price	55,2	109,9	135,9
1st January 2006, total price	61,3	117,4	143,9
1st January 2007, total price	82,1	144,4	171,3
1st January 2008, total price	78,8	140,6	168,6
1st January 2009, total price	97,8	165,6	195,9

increasing, applying now to about 22 % of customers: of the other forms of tariffs, three-year or longer tariffs are the most common. The network price depends on where in the country the electricity is used and on the nominal supply rating. Domestic customers pay either 18.6 öre/kWh or 28.2 öre/kWh energy tax, depending on whether they live in the north or the south of the country. Electricity used in industrial manufacturing processes is taxed at a 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 during the winter of 2002/2003, reaching a record price of 104.1 öre/kWh on Nord Pool. In 2008, the average spot price on the Swedish sector of Nord Pool was 49.2 öre/kWh, as compared with 28.0 öre/kWh in 2007. As trade in electricity with countries outside the Nordic bloc has increased in recent years, the Nordic prices are increasingly affected by fuel prices in the rest of Europe. Electricity production in Germany and the rest of continental Europe is based largely on coal fired cold condensing power.

District heating and district cooling

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

District heating

District heating can be defined in technical terms as the centralised production and supply of hot water, distributed through a piping system and used for the space heating of buildings. It is the commonest form of heating for apartment buildings and commercial premises, and the main form of heating in the centres of 245 of the country's 290 municipalities[98]. 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 (CHP) production. A CHP power station produces both electricity and heat for the hot water distribution system. The use of district heating spread during the 1950s and 1960s as a result of the extensive investments in

98 The Nils Holgersson Survey, 2008. Formed by five large housing organisations, and monitors local authority charges for heating, domestic hot water, water, sewage treatment, electricity and waste disposal.

new housing that were being made during that period, in conjunction with a substantial need for modernisation or replacement of boilers in the country's existing building stock. Group heating systems[99] were gradually linked up to form larger systems, which were then in turn connected to district heating systems. There was a particularly substantial expansion of district heating over the period from 1975 to 1985, partly due to its ability to replace oil through its flexibility of fuel use. This was also the period of expansion of nuclear power generation, and the continued expansion of district heating resulted in it becoming a net user of electricity, in disconnectable boilers and large heat pumps, rather than a net producer of electricity, which is more common in most other countries with substantial district heating systems. However, in recent years, interest in CHP (now mainly 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."

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, to rock, lake water or earth heat pumps, or to 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 67 % of those converting from electric heating have converted to district heating.

Emissions of sulphur dioxide, particulates, soot and nitrogen oxide from heating of residential buildings and commercial premises, have been substantially reduced, thus improving the air quality in urban areas. This has been achieved by replacement of individual boilers by district heating plants having better flue gas cleaning.

District heating is not price controlled, although the heating market is undergoing changes. As district heating requires an expensive infrastructure, it is a de facto monopoly as far as distribution is concerned. This, in combination with the high cost of replacing heating systems in a building, effectively locks in customers to district heating suppliers, means that customers can be dependent on their

99 Boiler plants that supplies a single block or a small number of blocks. Previously common in the 1960s' 'Million New Homes' programme areas.

suppliers. However, the heating market can be regarded as a competitive market as far as the potential choices facing a new customer are concerned.

New legislation covering the supply of district heating came into force on 1st July 2008, applying to all those who produce or supply district heating as defined in the existing Electricity Act. District cooling is not covered by the legislation. It is intended to strengthen the position of district heating customers, in such ways as increasing the transparency of district heating production and supply activities. The requirements relate primarily to the relationship between companies and their customers. The new law includes a requirement for district heating companies to negotiate the terms of certain contract conditions with individual customers. If the parties cannot agree, they can apply for arbitration by the District Heating Council, which is an independent organizational unit within the Swedish Energy Agency, providing an arbitration function between companies and their customers. The Council will also arbitrate negotiations between district heating utilities and other parties wanting access to the district heating distribution mains. In addition, the new law provides protection for consumers against interruption of their supplies. It also includes regulations of general legal type: district heating utilities must, for example, provide details of operating and business conditions as needed for the derivation of key indicator data. It does not, however, include any requirements in respect of tariff approvals.

The Energy Markets Inspectorate monitors compliance with the regulations concerning district heating.

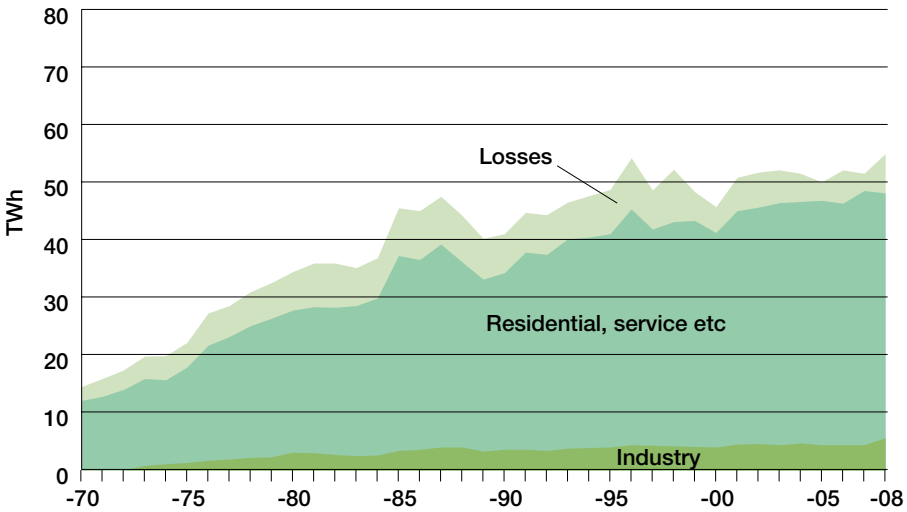
The regular price comparisons by the Public Service Fee Group and the Energy Markets Inspectorate's annual surveys[100] of the heating markets provide information on significant price differences between areas. Conditions for the construction of district heating systems vary from place to place, in respect of such aspects as the type of built environment and the type of ground conditions. A customer's choice of heating systems is very dependent on where the building is located. To assist consumers in obtaining an overview of prices, the Energy Markets Inspector has published new regulations that describe companies' liability to provide pricing information, and how such information must be provided. The new regulations came into force at the beginning of August 2009.

The amendment to the Electricity Act that came into force on 1st July 2005 includes 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. to prevent a company with activities in several fields from using its profits from district heating to compete in some other more competitive market, e.g. the electricity market. The results of an investigation of whether the present

100 Uppvärmning i Sverige 2009

Figure 29
District heating use, 1970–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY



requirements for separate accounting are sufficient to address the risks of cost subsidisation and price discrimination on the heating market would be published by the Energy Markets Inspectorate at the end of 2009.

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[101], 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 was removed. This, in combination with changed taxation of CHP production, has helped to open up the market for district heating production.

Today, district heating supplies over half of the total heating requirement of residential and commercial premises in Sweden. It is the commonest form of heating in apartment buildings, supplying heat to about 82 % of the heated floor area, while about 66 % of commercial and similar premises are heated by it. In detached houses, on the other hand, the proportion is only about 9 %[102].

Over 48 TWh of district heating were supplied in 2008, which is about the same as was supplied in 2007. 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. The effect is up-

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

102 Energy statistics for detached houses, apartment buildings and commercial premises, 2007.

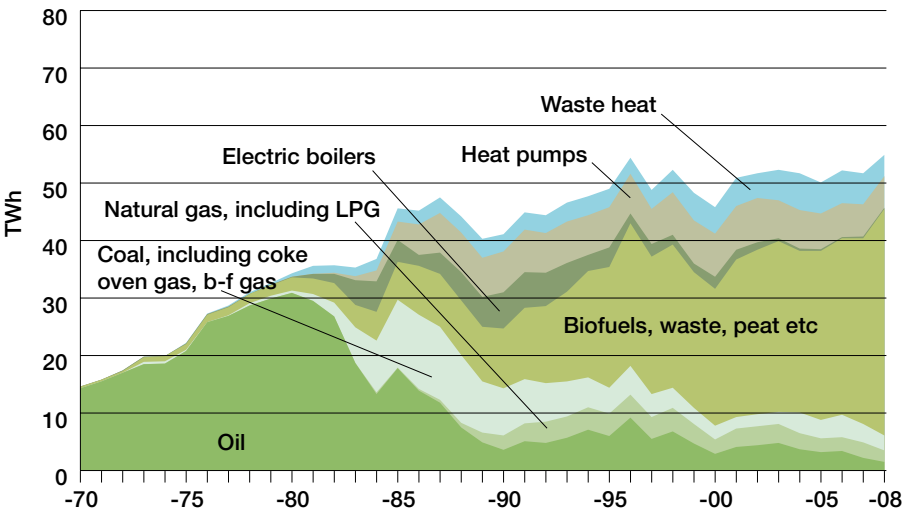


Figure 30
Energy input to district heating systems, 1970–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

ward distortion of 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. The total energy supply to the district heating sector in 2008 was almost 55 TWh. The proportion of biofuels (including waste and peat) was about 2 % in the 1970s, but has risen steadily throughout the period since. In 1990, biofuels supplied somewhat over 25 % of the total energy input: since then, the rate of increase has further accelerated. The introduction of carbon dioxide tax in 1991 has given biofuels a favoured position. Their use increased substantially in 2008, to almost 22 % more than in 2007, so that they supplied no less than 71 % of the total fuel input[103]. See Section *'Biofuels, peat and waste'*, for a more detailed description of the use of biofuels in district heating. The sizeable increase in the proportion of biofuels during 2008 was made up largely of an increase in the use of wood fuels, the use of which increased by over 31 % in comparison with 2007, to supply 64.6 % of total biofuel use. Waste, too, has become a steadily more important fuel for district heating production: the substantial growth in its use over the last two years can be credited partly to low costs for waste and to the policy measures[104] introduced to reduce disposal of waste in landfill, in combination with increased importation of waste.

The use of electricity in the district heating sector, particularly for supplies to

103 The statistics for 2008 are preliminary and unconfirmed.

104 The ban on landfill disposal of unsorted potentially combustible waste came into force in 2002, and that on organic waste in 2005.

electric boilers, and also for large heat pumps[105], has declined since deregulation of the electricity market. Since the 1980s, losses from district heating distribution systems have fallen as a result of improved technology and higher load factors. In 2008, distribution and conversion losses amounted to somewhat over 12 % of the total district heating input. In the 1980s, the losses amounted to almost 20 %. 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.

"The market for district cooling has expanded strongly since the first system was started up."

Until the beginning of the 1980s, most district heating plants were operated as local authority services. Most of them are still owned by local authorities, but have been turned into limited liability companies owned by the authority. 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. Today, 130 companies supply about 98 % of the country's district heating production.

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 property-owner being different companies. It is primarily district heating suppliers that have established commercial district cooling systems in Sweden. The commonest means of production in Sweden is to use waste heat or lake water as the heat source for heat pumps, with the cooled water from which heat has been abstracted 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 therefore increases the load factor of the district heating system in the summer. Since 1995, one of Europe's largest district cooling systems is that of central Stockholm.

105 i.e. as used for supplying heat to district heating systems etc. – not small domestic heat pumps.

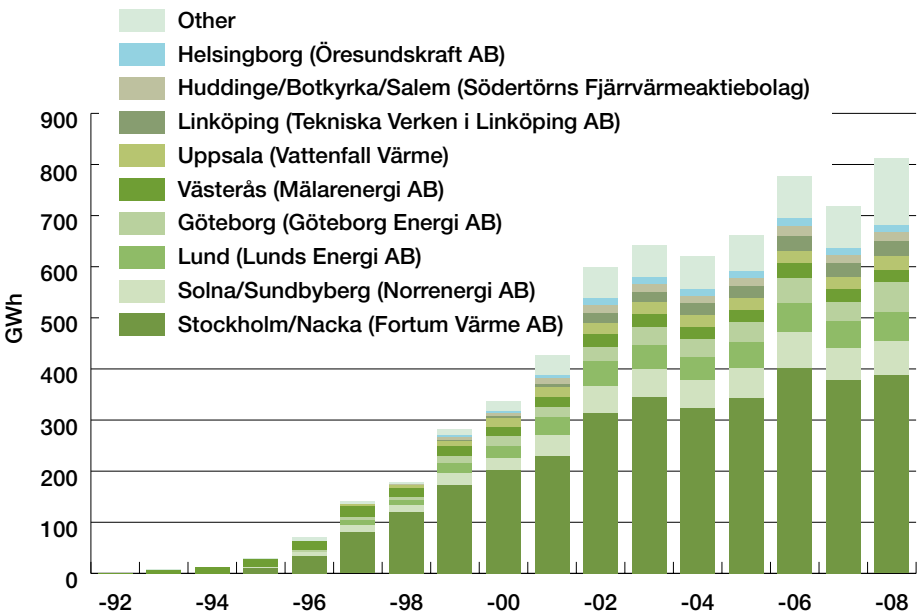


Figure 31
District cooling supplied, 1993–2008

SOURCE: SWEDISH DISTRICT HEATING ASSOCIATION

The market for district cooling has expanded strongly since the first system was started up in Västerås in 1992. Figure 31 shows district cooling supplies in Sweden, by supplier. The driving forces for expansion include 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. This latter factor has meant that property-owners must either convert existing equipment or invest in replacement systems. In 2008, there were 26 commercial district cooling suppliers, some operating more than one system. 811 GWh of district cooling were supplied, which is an increase of 13 % relative to 2007.

Energy gases

Natural gas is by far the most widely used energy gas[106], meeting about a quarter of the world's energy use. Sweden uses relatively small quantities of gas in comparison with many other European countries, although it should be borne in mind that most of mainland Europe has an extensive natural gas distribution network. The use of natural gas in Europe has increased by almost 50 % since the beginning of the 1990s.

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

Natural gas in Sweden

Natural gas was introduced to Sweden in 1985. Use increased rapidly until the beginning of the 1990s, and then levelled off. In recent years, use has again started to increase, as a result of extension of the natural gas grid.

In 2008, imports amounted to 866 million m³, equivalent to 9.6 TWh. Industry accounted for 74 % of total use, and the residential sector for about 20 %. A small amount of natural gas is also used as motor fuel. Total use of natural gas in 2008 amounted to 7.3 TWh in these user sectors, with a further 3.0 TWh being used by CHP and district heating plants, which was a reduction in comparison with the previous year, due to the general economic conditions and high gas prices.

Natural gas is distributed at present to about 30 municipalities, where it meets over 20 % of energy demand. On the national level, it supplies 1.6 % of total energy demand. The network extends from Trelleborg in the south to Göteborg, with a number of branches, such as to Gnosjö in Småland and Stenungssund, north of Göteborg. The trunk mains between Malmö and Göteborg have capacity for transportation of over 20 TWh of gas per year, but with compressors this capacity could be increased to about 30 TWh per year. The system has only one storage facility, in Halland, with capacity for the storage of over 0.1 TWh of natural gas. Plans exist for new infeed connections to the Swedish natural gas network, such as in the form of the Skanled project, which would involve laying a pipeline between the North Sea and southern Norway, continuing through Sweden to Denmark. However, this project has recently been put on ice. On the other side of the country, the Nord Stream project, which would link Russia and Germany, is being planned. It needs to obtain environmental approval in all the affected countries,

106 Energy gases are natural gas, LPG, biogas, town gas and hydrogen.

of which Sweden is one, before it can be constructed. On land, work has started on construction of a terminal for reception of liquefied gas in Nynäshamn, in order to provide a gas supply along the Mälardalen. Storage capacity is 20 000 m³, and the terminal is planned to open in 2011.

The use of natural gas by the energy sector is expected to increase in response to investments in gas fired CHP production. The Öresund power station in Malmö is being converted for gas fuelling, and is expected to consume over 5 TWh per year of natural gas when in full operation.

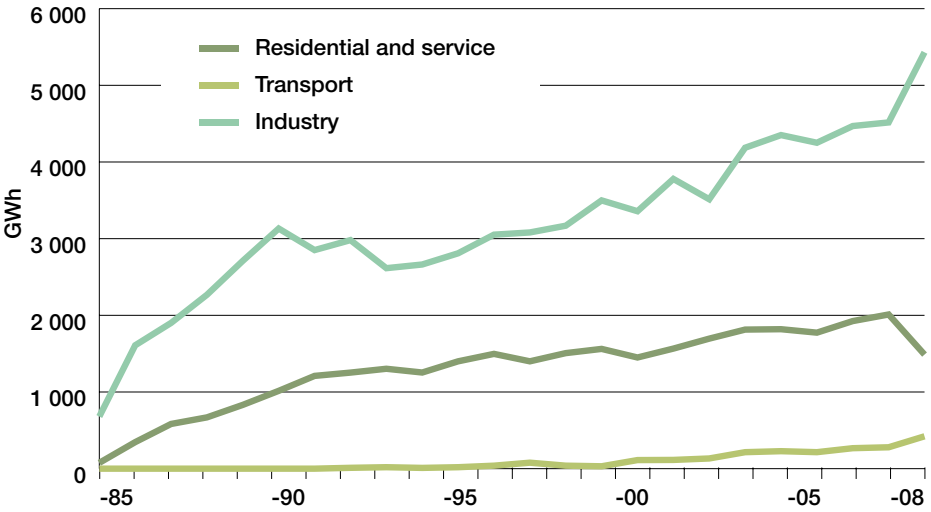
Since 2005, Svenska Kraftnät (a State utility) has system responsibility for the national market for natural gas. This means that it has overall responsibility for short term maintenance of the balance between supply and use of natural gas to the national system. However, responsibility for operation, maintenance and expansion of the mains rests with the owners of the respective sections.

International production and use of natural gas

Although natural gas is a marginal energy source in Sweden, it provides about 25 % 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 2008, commercially viable reserves amounted to about 185 000 billion cubic metres which would last for about 60 years at the present rate of use, with present technologies and present prices. Most of the reserves are in the former Soviet Republics (31 %) and in the Middle East (41 %). Rather less than 1.6 % of the world's natural gas reserves lie within the EU states: at the present rate of use, this would last for only 15 years. Over the last decade, natural gas supplies to the EU states have been increasingly based on production from the North Sea and imports from Russia and Algeria. In order to increase the security of supply, there is European interest in increasing the number of links between the Russian and the Norwegian natural gas fields and the continent. Today, the world's major producing countries are Russia, the USA and Canada. Within the EU, the major producers are the UK and the Netherlands. The proportion of total global energy supply met by natural gas has increased rapidly during the last decade, by about 33 % between 1998 and 2008. Consumption of natural gas is highest in the USA and Russia. In the EU, natural gas has a part to play in reducing environmentally hazardous emissions, primarily by replacing coal and oil.

Figure 32
End use of natural gas in Sweden, 1985–2008, by sectors, GWh

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY



Transport of natural gas

Pipeline transportation of natural gas is the main way of transporting it 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. 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 end users. Several Asiatic countries, particularly Japan and South Korea, are far from their sources of supply, and so 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 Swedish natural gas market has gone from being a local monopoly to a competitive market, where all natural gas customers in the country can now choose their supplier. The final step in deregulating the market was taken on 1st July 2007, on which date most of the natural gas markets in the EU were also deregulated.

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

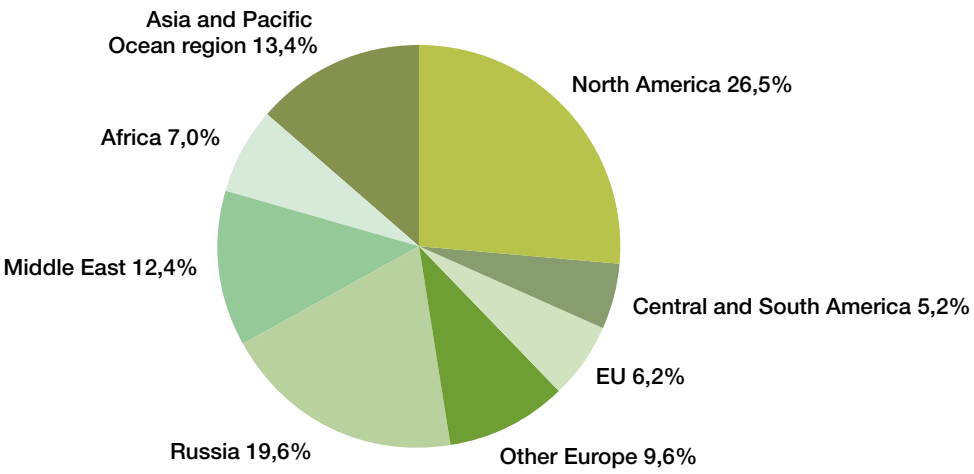


Figure 33
World natural gas production in 2008, total: 3 066 thousand million m^3

SOURCE: STATISTICAL REVIEW OF WORLD ENERGY 2009

introduced in order to ensure smoother operation of the markets. Some of the most important of these are unbundling and third party access.

Unbundling means that transport and sale of the gas must be operated as separate business entities. The purpose of this is to ensure correct apportionment of the costs for the two different activities, and thus prevent cross-subsidisation. Cross subsidisation is the practice of applying the revenue from one activity to support another, and is unacceptable, as otherwise revenues from the transport monopoly could be used to subsidise sales prices on the competitive market, thus distorting competition.

”The Swedish natural gas market has gone from being a local monopoly to a competitive market.”

Third party access requires the owners of transmission and distribution networks to allow other parties to use the networks, thus creating competition in the sale of natural gas. If third-party access is to work properly, it must also be accompanied by unbundling.

The Nord Pool Gas exchange in Denmark opened on 4th March 2008. The exchange trades in physical supplies of natural gas for delivery either the next day or the next month. Turnover at first was very limited, but started to rise towards the end of 2008, reaching a peak in March 2009.

Biogas

Biogas consists mainly of methane, and is used for electricity and heat production, and in transport. It is usually produced by the breakdown of organic materials under anaerobic (oxygen free) conditions. The process, known as digestion, occurs spontaneously in nature, e.g. in marshes. Today, biogas is produced mainly from indigenous raw materials such as waste or sludge from sewage treatment plants. In some cases, waste is digested together with plant matter, as is done, for example, in Växtkraft's plant in Västerås. However, other raw materials suitable for digesting, such as straw or waste, may be imported in order to meet growing demand. In 2006, 223 biogas production plants were in operation[107], most of them in sewage treatment plants, producing gas from the sludge, and from landfill sites, producing landfill gas.

"Biogas is sold today both as cleaned biogas and in the form of admixtures with natural gas."

The organic matter is first digested to raw gas, which has to be upgraded before it can be used in vehicles or for admixture with natural gas. The upgrading plants are often sited close to the production plants, although the raw gas from several different sources can also be upgraded in a common facility. This may become more common if the number of small producers of raw gas increases, which may become the case if, say, individual farms start to produce the raw gas. At present, biogas is upgraded to natural gas quality in about 30 plants in Sweden.

Biogas is sold today both as cleaned biogas and in the form of admixtures with natural gas. Consumers in southern Sweden, connected to the existing natural gas network, have the option of being able to purchase pure biogas. This requires accurate metering and reporting of the quantities of biogas supplied to the system and the quantities delivered by it. In purely practical terms, of course, it is not possible to distinguish between methane molecules from one source or other: instead, the system operates in the same way as for green electricity, with input and delivery quantities being paired, so that the consumer is guaranteed that the corresponding quantity of biogas is supplied to the system.

Recently, distribution of upgraded biogas has increasingly been provided by parties other than the producers themselves. There are at present four large distributors of biogas, using either road tankers or piped delivery. In many cases, biogas pumps in petrol stations are owned by the producer or distributor of the gas.

There are at present over 100 petrol station outlets selling motor fuel gas (biogas

107 See also the Agency's report "Produktion och användning av biogas 2006", ER. 2008:2, which can be downloaded from the Agency's web site, www.energimyndigheten.se.

or natural gas) in Sweden. However, coverage varies widely from one part of the country to another, with most of the outlets being in the south, or in the major urban areas. Together, four large operators are responsible for more than 75 % of the petrol station outlets selling gas. One of them has no petrol stations of its own, but is associated with other companies that operate the petrol stations. Other parties are individual local authorities or smaller local authority energy companies, together with a number of smaller companies and cooperatives.

In 2007, 54 GWh of biogas were used for electricity production, and 333 GWh for heat production. In 2008, the transport sector used 327 GWh.

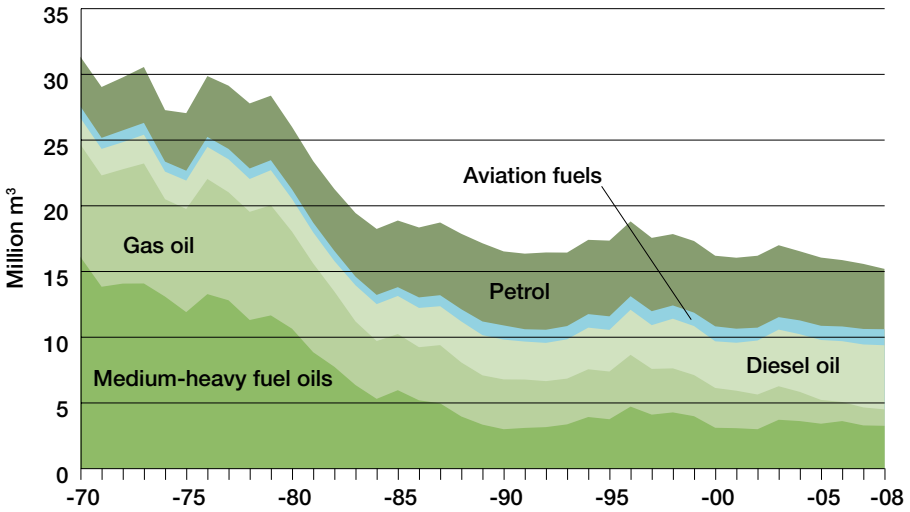
Other energy gases

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 2008, 4.4 TWh of LPG were used in industry, 1.1 TWh in the residential and service sector, and 0.1 TWh for electricity and district heating production.

Town gas (gasworks gas) is produced by cracking naphtha. Stockholm Gas AB is the only producer of such gas in the country: the town gas used in Malmö and Göteborg 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, while Malmö and Göteborg are modifying their gas distribution systems to suit pure natural gas. Town gas is used for heating detached houses, larger properties and industries, as well as for cooking in homes and restaurants. 0.28 TWh of town gas were used in 2008.

Figure 34
Use of oil products in Sweden, including international marine bunkers, 1970–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY



Oil

Oil in Sweden

2008 was an eventful year on the oil market, with major fluctuations in the price of oil. The price rose throughout the spring to a peak of USD 147 per barrel in July, only to fall steeply during the autumn and end up at about USD 40 per barrel at the end of the year.

In 2008, oil provided 31.7% 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 in the Swedish energy system has been reduced by almost 45 % since 1970. It is particularly the use of fuel oils that has been reduced (and especially in the detached house sector). 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.

Sweden imported somewhat over 20 million tonnes of crude oil in 2008, and net-exported 5.3 million tonnes of refinery products. Over 55 % of Sweden's total crude oil imports come from the North Sea – mainly from Denmark and Norway. In recent years, there has been a substantial increase in the proportion of Sweden's oil imported from Russia. Overall, 34.1 % comes from Russia, 27.1 %

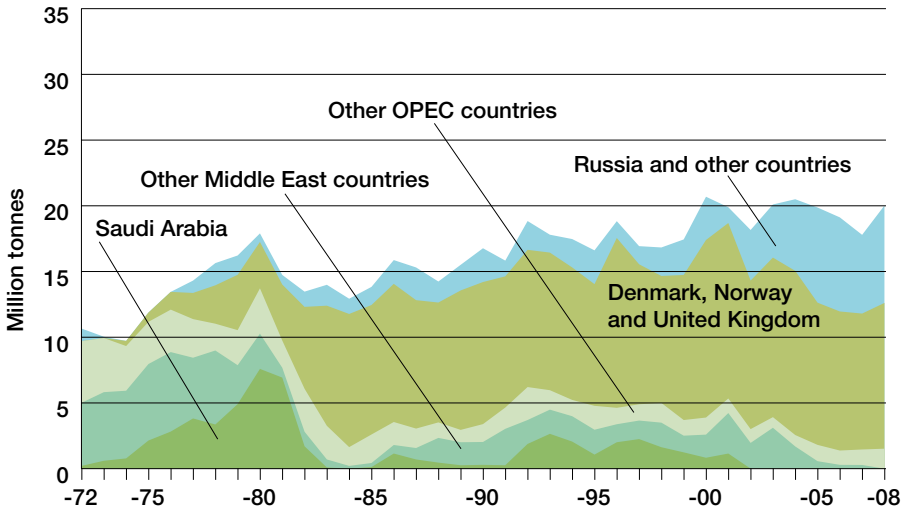


Figure 35
Swedish net imports of crude oil and oil products, by country of origin, 1972–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

comes from Norway, 23.8 % from Denmark, 5.8 % from Venezuela, 2.5 % from the UK, 2.0 % from Angola, 1.5 % from Nigeria, 1.0 % from Algeria, 0.9 % from Holland, 0.6 % from Libya, 0.4 % from Azerbaijan and 0.2 % from Australia. This substantial importation of oil is due to the fact that much of it is processed in Sweden before re export[108].

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 IEA[109] 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. On 12th June 2009, the EU energy ministers adopted a new proposal for the Oil Storage Directive. The Directive requires all member states to maintain strategic stocks of oil equivalent to 90 days' net import or 70 days' use, whichever is the greater. The Directive must be implemented as soon as possible, but by no later than 31st December 2012. Sweden's total strategic stores of crude oil and oil products already amount to an average of 145 days over the year. Implementation of the new directive will mean that the present Swedish Oil Storage Act and Ordinance will have to be rewritten.

108 See also "Oljeåret 2007"("The Oil Year, 2007" [in Swedish]) for additional facts and statistics from the oil sector, www.spi.se.

109 International Energy Agency.

Figure 36
Net imports (+) and exports (-) of refinery products, 1972–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

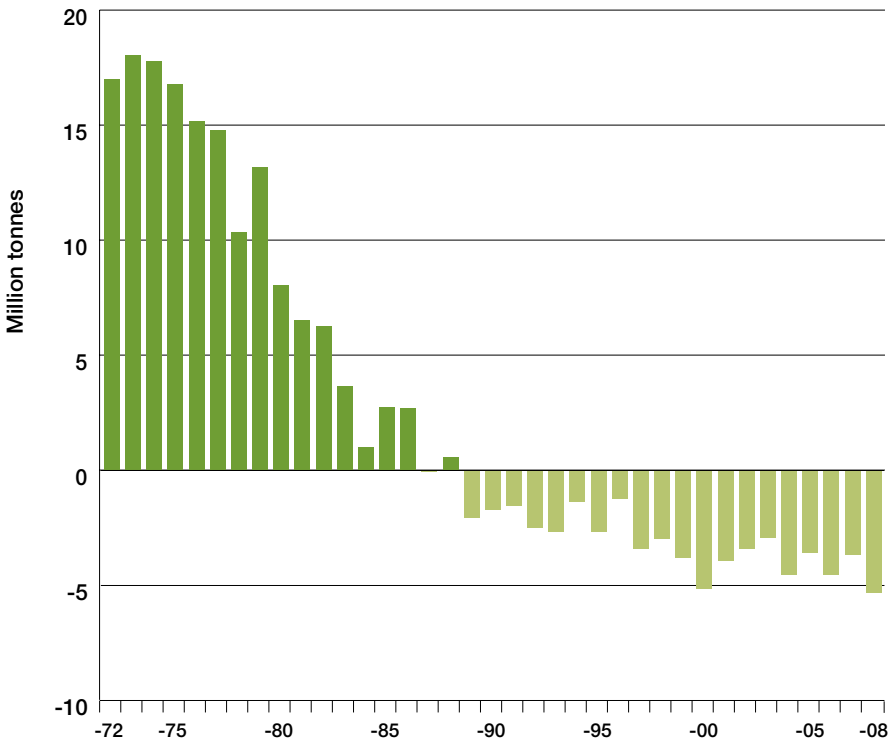


Figure 37
Nominal and real prices of light crude, 1970–2008, USD/barrel

SOURCE: WWW.BP.COM AND THE WORLD BANK

Coal

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), which is used in the iron and steel industry, and steam coal, which is sometimes also referred to as energy coal, and is used for energy purposes in industry and the energy sector.

”Coal supplies a quarter of the world’s primary energy.”

Coal supplies a quarter of the world’s primary energy, and is the next largest energy source after oil[110]. It is also the largest source of carbon dioxide emissions, having overtaken oil in this respect as recently as 2004[111]. World production and use of coal have increased considerably in recent years. China, the USA and India use the most coal, accounting – with Japan and Russia – for 73 % of total world use of coal. The largest producers of hard coal are China and the USA, with China alone producing 46 % of world output. The major exporting countries are Australia, Indonesia and Russia. Coal production in Europe is falling, and imports exceed production.

During the 1990s, the spot price of coal unloaded to quay in north western Europe varied between USD 26 per tonne and USD 46 per tonne. The price started to rise steeply in the middle of 2003, reaching USD 78 per tonne in July 2004, which was a record. Prices fell in 2005, but have since then again exhibited a rising trend. By the first half of 2007, they had again risen to USD 68–78 per tonne, but then took off dramatically, to reach a record level of USD 220 per tonne in July 2008. From this peak, the price fell very considerably, down to USD 60 per tonne in the middle of 2009. If production and consumption continue at the present rate, proven and economically recoverable world reserves would last for 157 years[112].

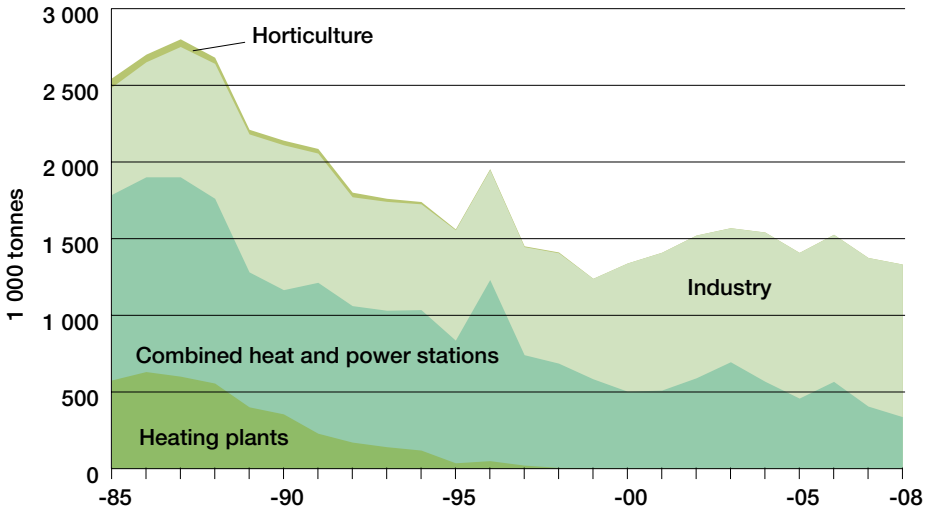
110 IEA, World Energy Outlook 2008

111 IEA, Coal Information 2008

112 IEA, Coal information 2008

Figure 38
Use of energy coal in Sweden, 1985–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY.



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. Since the end of the 1980s, the increasingly stringent environmental standards imposed on coal firing, together with rising taxation, meant that the use of coal for heat production has been substantially reduced. A total of 3.3 million tonnes of hard coal was used in Sweden in 2008. 2.0 million tonnes of this were coking coal, leaving 1.3 million tonnes for energy purposes, with 0.6 million tonnes being used in the iron, steel and metal industries, 0.4 million tonnes in other industry, and 0.3 million tonnes for CHP production. To this must be added a net import of 0.3 million tonnes of coke.

> ”A total of 3.3 million tonnes of hard coal was used in Sweden in 2008.”

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 from metallurgical coal in coking plants. 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 iron ore[113] 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 coking coal were used in industry in 2008, together with 1.0 million tonnes of energy coal and the country's entire net import of 0.3 million tonnes of coke. The quantity of energy coal provided an energy input of 7.5 TWh.

District heating and combined heat and power production

The use of coal for district heating fell considerably during the 1990s, when the carbon dioxide and sulphur taxes were introduced. Plants that supply only heat have abandoned coal almost entirely as a fuel due to the high taxes, replacing it by biofuels. CHP plants still use a certain amount of coal, as taxation on a combined production regime is less than on heat alone. This difference in taxation is intended to promote the competitiveness of CHP plants against that of plants producing only heat or electricity.

SSAB's steel mill in Luleå supplies coking gas and blast furnace gas to the town's 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.

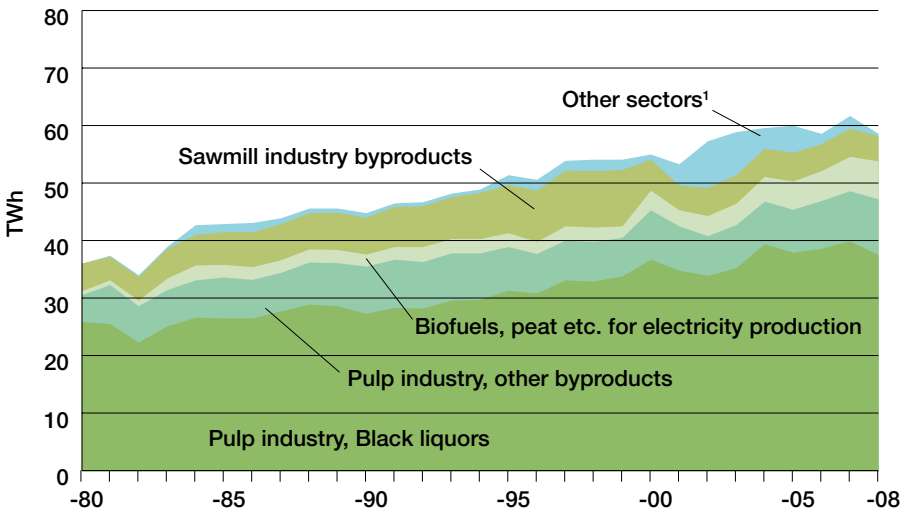
In 2008, the district heating sector used 0.3 million tonnes of energy coal (2.5 TWh) and 2.2 TWh of coke oven and blast furnace gas for electricity and heat production.

113 i.e. removing the oxygen from the iron ore.

Figure 39
Use of biofuels, peat etc. in industry, 1980–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY.

NOTE. THE STATISTICS FOR 2008 ARE PRELIMINARY AND SHOULD BE TREATED WITH CONSIDERABLE CARE: SEE "UNCERTAINTIES IN THE 2008 STATISTICS".



Biofuels, peat and waste

The proportion of biofuels used in the Swedish energy system has steadily increased, from a little over 10 % of total energy supply in the 1980s to 20 % in 2008. Most of the biofuels, peat and waste used in the Swedish energy system are indigenous, consisting mainly of:

- Wood fuels, not densified (logging residues, low quality wood, fire wood, bark, saw dust, dry chips, recycled wood, and biomass from short rotation Salix plantations), and densified (pellets, briquettes and powder),
- Black liquors and tall oil pitch (intermediate and by-products in chemical pulp mills),
- Grain, energy grass and straw (biofuels from agriculture),
- 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 ED95 motor fuels),
- FAME, an umbrella name for Fatty Acid Methyl Esters, of which the motor fuel RME (Rapeseed Methyl Ester) is the most common,
- Biogas.

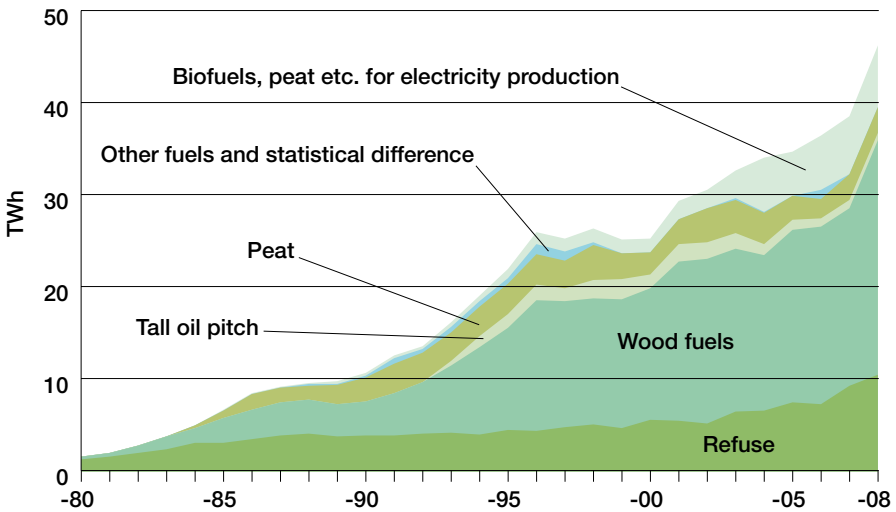


Figure 40
Use of biofuels, peat etc. in district heating plants, 1980–2008

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY.

NOTE. THE STATISTICS FOR 2008 ARE PRELIMINARY AND SHOULD BE TREATED WITH CONSIDERABLE CARE: SEE "UNCERTAINTIES IN THE 2008 STATISTICS".

Biofuels are used mainly in the forest products industry, in district heating plants, for electricity production and for heating of residential buildings. (See Section *'Development of alternative motor fuels'* 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 in district heating, although use is also increasing in the residential and transport sectors. In 2008, the total use of biofuels, peat and waste amounted to 123 TWh[114]. Industry used almost 52 TWh[115], the residential and service sectors used 13.8 TWh, and the transport sector used 4.4 TWh. About 39.4 TWh were used for district heating production, and 13.3 TWh for electricity production.

The forest products industry

The forest industry generates a large quantity of by products and waste products. Most of the wood fuels used in the energy sector come from forestry in the form of logging residues (branches and tops) and firewood, as well as material from the woodworking industry and the pulp and paper industry in the form of solid by products (e.g. bark and sawdust). Some of these by-products (such as sawdust) are converted to pellets, briquettes and powder in order to increase the energy density, simplify handling and reduce the cost of transport.

The forest products industry uses 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. Both the pulp industry and sawmills

114 The statistics for 2008 are preliminary and unconfirmed, and should therefore be treated with considerable care. See "Uncertainties in Statistics for 2008".

115 Fuel used for electricity and heat production in industry is not included in this figure, but is included in the electricity and heat statistics.

use wood fuels in the form of solid by-products such as sawdust and bark in their processes. As part of the overall process of producing chemical wood pulp for paper-making, pulp mills recover chemicals used in the process by burning the liquors extracted from the process, known as black liquors, and containing the digester chemicals, lignin and other substances extracted from 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). Crude tall oil and refined tall oil can be used as fuels, but are taxed as (fossil) fuel oils and are therefore used primarily as industrial raw materials. Tall pitch (oil), however, 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 2008, it amounted to 36.7 TWh, excluding electricity production.

”Waste has been used for district heating production since the 1970s.”

In 2008, the pulp and paper industry used 9.7 TWh of wood fuels, while sawmills and other woodworking industries used 4.4 TWh of wood fuels. The pulp and paper industry’s total use of biofuels, peat etc. amounted to almost 52.2 TWh during the year, equivalent to about 48 % the total use of these fuels in the energy system as a whole. In total, the forest products industry used nearly 58.8 TWh of various types of biofuels, peat etc. for heat and electricity production in 2008: see Figure 39.

District heating plants

46.2 TWh of biofuels, peat etc. were used for heat production (i.e. excluding electricity production) in district heating plants in 2008. Of this, wood fuels supplied 25.5 TWh, black liquors and tall oil pitch 0.8 TWh, waste 10.5 TWh and peat 2.8 TWh. The use of wood fuels in the district heating sector has increased by more than fivefold since 1990, as shown in Figure 40. The main biofuels are logging residues, low quality round wood and solid by-products from the forest products industry, although densified fuels such as briquettes and pellets are also being increasingly used.

Waste has been used for district heating production since the 1970s. Between 1990 and 2008, the quantity increased from 4 TWh to 10.5 TWh. This increase has been due mainly to the fact that it, since 2002, has been forbidden to dispose of unsorted combustible waste in landfills, and since 2005 has been forbidden to dispose of other organic waste in landfills.

Uncertainties in the 2008 statistics

Statistics on the use of biofuels, peat, waste etc. for 2008 are based on the official energy statistics' preliminary figures, which in turn are based on the results of quarterly investigations. Preliminary statistics for 2008 therefore incorporate a considerable degree of uncertainty, and should be treated with care. This applies in particular to the use of biofuels, peat, waste etc. by industry and district heating plants. It is thought that the use of these fuels in industry is underestimated, while their use in district heating plants is overestimated. Both these departures are estimated as amounting to about 10 %. The Swedish Energy Agency attempts to correct these systematic differences in the official energy statistics.

Statistics for 2007 and earlier years are based on annual reviews and processing of the official energy statistics. They are regarded as safer and more reliable.

Biofuels, peat and waste for electricity production

13.3 TWh of biofuels, peat and waste were used for electricity production in 2008. 6.7 TWh of this were used in CHP plants, and 6.6 TWh in industrial back-pressure plants.

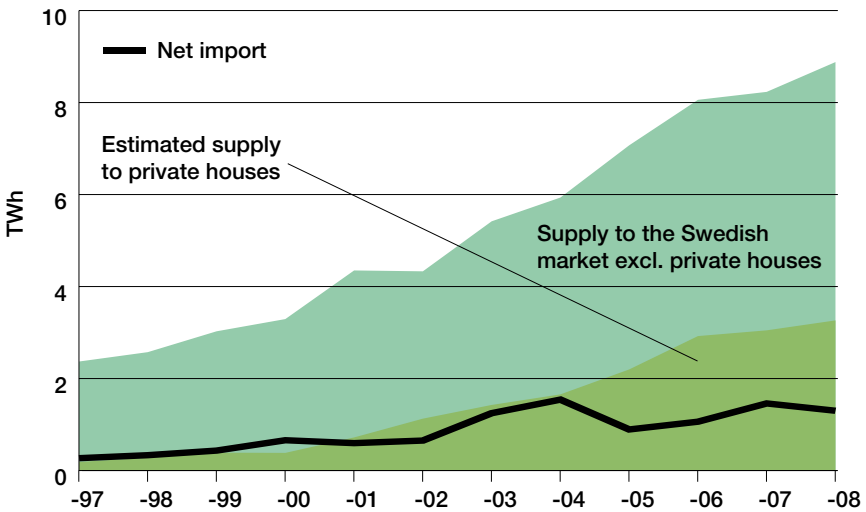
Since 1st April 2004, the use of peat in approved CHP plants entitles electricity producers to Green Electricity certificates. In 2008, electricity production from peat amounted to about 1.1 TWh.

Heating of residential buildings

Biofuels are used as a heating source for about 10 % of detached houses in Sweden. 11.4 TWh of biofuels, peat etc. were used in detached houses for this purpose in 2008. Most of this was in the form of split firewood, but a smaller proportion was provided by wood chips and a growing proportion by pellets and briquettes. Using wood as primary energy source is most common among property owners with good access to forests, e.g. in agricultural or rural areas. The Swedish Pellet Association statistics show that the use of pellets in the detached house sector increased by more than seven times over the period 2000–2008. According to the statistics, the use of pellets in the detached house sector increased by 7 % between 2007 and 2008. A total of 12.1 TWh of biofuels were used for heating residential and commercial premises in 2008.

Figure 41
Deliveries of pellets to the Swedish market, 1997–2008

SOURCE: THE SWEDISH PELLET ASSOCIATION (PIR)



International trade

Although most of the biofuels used in Sweden are of indigenous origin, there is also an extensive import of biofuels, such as bio ethanol, wood pellets and peat. It is estimated that, in 2008, 90 % of the bio ethanol used in or as motor fuels were imported. As far as pellets are concerned, it is estimated that almost a fifth of the quantity used consists of net imports, with about 362 000 tonnes being imported and about 91 000 tonnes exported. Peat imports amounted to 364 000 tonnes in 2008. Unfortunately, no reliable satisfactorily comprehensive import or export statistics for biofuels are at present collected, and so it is difficult to estimate the quantities. However, imports are included in the country's energy balance as indigenously produced, based on the statistics of use. Investigations that have been carried out about the import quantities indicate a figure in the range of 5–9 TWh, which means that the import of biofuels represents a significant contribution. Most of the imported material is used for the supply of district heating.

Some quantities of waste, recycled wood 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. Emission rights trading may also affect the scale of the trade. However, it is likely that the use of waste as a fuel in Sweden will continue to increase over the next few years.

An international comparison

About 20 % 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 the large-scale use of biofuels in the energy system: 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 use the highest proportions of biofuels in their respective energy systems.

"Commercial energy prices consist of several elements."

Energy prices

Commercial energy prices consist of several elements, such as the price of the fuel, operating and maintenance costs, capital costs, taxes and VAT. Taxes and charges can vary, depending on how and where the fuel is used. The following section describes the changes in real energy prices for various users. Using real prices allows for inflation: the prices are shown in 2008 levels. Figure 42 shows actual commercial energy prices, with further details in the corresponding table for Figure 42 in *Energy in Sweden in Figures.*

Figure 42
Actual energy prices in Sweden, including tax, 1970–2008

SOURCE: SPI, STATISTICS SWEDEN, SWEDISH ENERGY AGENCY AND EUROSTAT

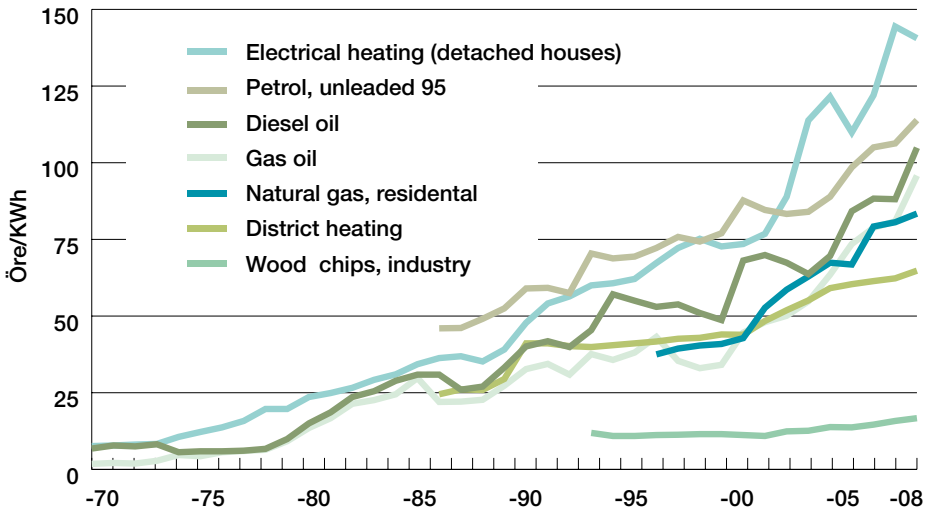
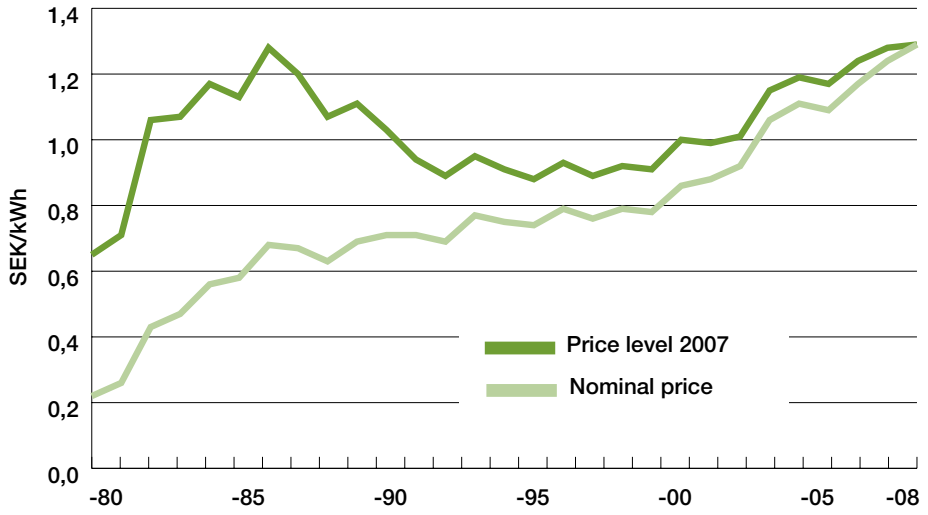


Figure 43
Price development of purchased energy (2008 price level), 1980–2008

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



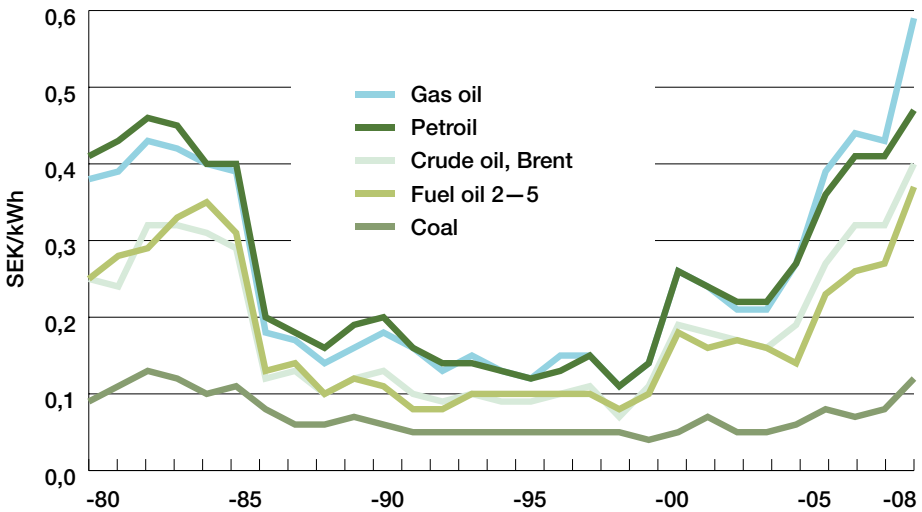


Figure 44
Import prices of fossil energy (weighted annual average), 1980–2008

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

The real price development

Nominally, the price of an average kWh of energy (the weighted price of all purchased energy, including all applicable taxes) rose by 4 % between 2007 and 2008. If the prices are corrected by the consumer price index[116], the real price increase was about 1 %: see Figure 43.

The rapidly rising international prices of energy were responsible for the greatest contribution to the rise in the real prices of energy, with the real price increase of fossil energy amounting to almost 30 %. However, by the time that this had worked through to consumers, it amounted only to 11 %, with the remainder of the price increase having been absorbed primarily by lower margins in the oil industry, and also through a continued reduction in the use of fossil fuels. The trading margins were also under pressure in the cases of electricity and district heating, which contributed to keep total energy prices down.

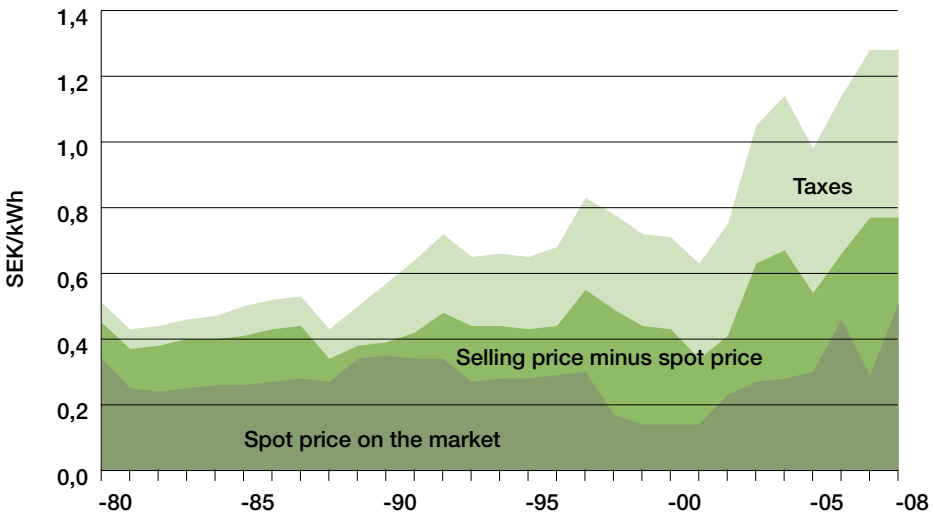
Overall, domestic users saw a fall of almost 2 % in their real costs of energy. A major contributor to this was falling electricity prices, although more efficient use of energy also helped. Industry, on the other hand, saw a real increase of 4 %, with the higher prices of fossil fuels having more impact on industry, coupled with a rise in the real price of electricity to industry at the same time. In the transport sector, the real price of energy rose by about 11 %, as the sector is dependent on fossil energy for 90 % of its energy use.

116 Methodologically, it can be questioned whether it is correct to adjust energy prices using the consumer price index, as the energy prices deliver a high weighting of the index, which means that the real price development is underestimated when energy prices rise more rapidly than other factors in the index.

Figure 45
Real price of electricity (2008 price level), 1980–2008

SOURCE: STATISTICS SWEDEN, BANK OF SWEDEN AND NORDPOOL

NOTE: THE PRICE OF ELECTRICITY FOR DOMESTIC AND INDUSTRIAL USERS HAS BEEN WEIGHTED IN PROPORTION TO THE RESPECTIVE SECTORS' PROPORTIONS.



5

Summary

An energy market can be a market for (for example) electricity, oil, coal, biofuels, district heating or energy gases. These markets change with time, reflecting changes in patterns of energy use, development of technologies, increasing customer awareness and changes in policy measures. This chapter describes historical developments in the various markets, with particular emphasis on developments in the markets today.

Deregulation has resulted in major changes in both the Swedish electricity market and the Swedish gas market. The electricity market was deregulated in 1996, and is becoming more closely integrated with the markets in other Nordic countries and in the EU. Several projects aimed at increasing cooperation between the countries and strengthening physical transmission links are in progress in the Nordic countries. In 1970, most electricity was produced by hydro power or oil fired cold condensing power. By 2008, this had changed so that hydro power and nuclear power supplied 89 % of the electricity, wind power supplied almost 1.4 % and fuel based processes supplied the remaining 9.6 %.

District heating has been supplied in Sweden since the 1950s, with substantial growth in recent decades. Today, it is the commonest form of heating for apartment buildings and commercial premises, and the dominant method of heating in the central areas of 85 % of the country's 290 municipalities. One of district heating's advantages is its flexibility in terms of fuel use. In 1970, only 2 % of the fuel used for district heating consisted of biofuels, waste or peat, while this proportion had risen to 72 % by 2008.

Secure energy supply

It is difficult to imagine a society without energy, as most of our daily activities require energy in some form or another. The energy system is complex, and the supply of some forms of energy affect supplies of other forms. Now and then, things happen which remind us of society's vulnerability to interruptions in energy supply caused by natural catastrophes, accidents or sabotage. Users vary in their ability to withstand interruptions; the concept of a secure energy supply is subjective. Just what is required of, or constitutes, a 'secure' energy supply therefore varies, depending on the user's needs and requirements, awareness of energy use and economic constraints.

Secure energy supply is closely linked to the environment and the economy

All users of electricity, whether private individuals or businesses, should be aware that interruptions can occur, and decide whether they can accept the resulting consequences, or whether they need to take pre emptive action[117].

The essentially public energy supply systems cannot meet every single user's varying requirements in respect of security of supply, as this would be neither technically nor economically feasible. With effect from 2011, electricity suppliers will be required to ensure that unplanned supply failures do not last for more than 24 hours[118]. After only twelve hours' failure, they will be liable to pay compensation to customers. In addition to this basic protection provided by the public sector and those on the energy markets, all users will need to think about their dependence on energy. If they require a higher level of protection than provided by these time limits, it can be a good idea to review additional solutions, such as arranging a special agreement with the electricity supplier or by purchasing stand by power generation equipment.

> "Most accidents and events in the energy system result only in brief interruptions to supply."

Security of supply is a subjective concept, which needs to be seen against each user's specific wishes and requirements. Achieving the necessary level of security involves not only preventive work in the technical infrastructure and in organisations and regulations, but also appropriate crisis management measures in order to tackle problems suffered by producers, suppliers or users. All these must, in turn, be balanced against the wish for a low pollution and cheap supply of energy. In the same way, environmental consideration and a desire for low prices have to be weighed against the collective need for security. All those concerned with energy matters, or who use energy in any form, have to make these judgements.

117 The Agency has produced specific advice and described good examples for householders in detached houses and apartment buildings, health care personnel and local authorities for dealing with, and reducing the impact of, interruptions to electricity and district heating supplies. See www.energimyndigheten.se/tryggenergi.

118 This performance requirement applies within the distribution system operator's control. Suppliers can also obtain a dispensation until 2014.

Major disturbances to the energy system

Most accidents and events in the energy system result only in brief interruptions to supply, although they can sometimes affect many consumers. However, some events are more serious and affect, or could have affected, large parts of the country or even the entire country. A number of events of interest occurred in 2008: if conditions had been different, some of them could have had serious consequences. The following list gives a number of examples.

- In February, storm Tuva resulted in loss of supply to about 75 000 consumers in southern and western Sweden.
- Over 100 000 consumers in Stockholm suffered loss of power for about four hours in June.
- A storm at the beginning of August caused a power failure for up to about 20 000 consumers. It is unusual for such severe storms to occur during the summer.
- The price of oil fluctuated widely, ranging from a peak of USD 147 in July for Brent Crude to a low of about USD 40 at the end of the year.
- A lightning strike in Gislaved in October caused a natural gas leak and fire, but did not affect gas supplies to consumers.
- Unusually heavy snowfalls of wet snow occurred in Västernorrland in December, cutting off power to over 15 000 households.
- Cracks in reactor control rods resulted in several months outages in nuclear power production at Forsmark and Oskarshamn during the autumn and Christmas period.

The energy system is complex, with many interdependent links between parts. Events that occur can, in combination or, in some cases, individually, result in energy shortages, power failures or damage to distribution systems. Although the underlying causes of interruptions in energy supply can vary, the problems that arise for end-users can essentially be summarised by high prices, limited availability of energy or power failure, as shown in Figure 46. High prices occur if insufficient energy is available and demand is high, or if market forces are generating high speculative prices. A limited availability of energy can be due to a long lasting shortage, necessitating either a reduction in use or rationing. The third consequence, of interruption of supply, can be due to damage to overhead lines or supply routes, or to intentional disconnection due to a power shortage.

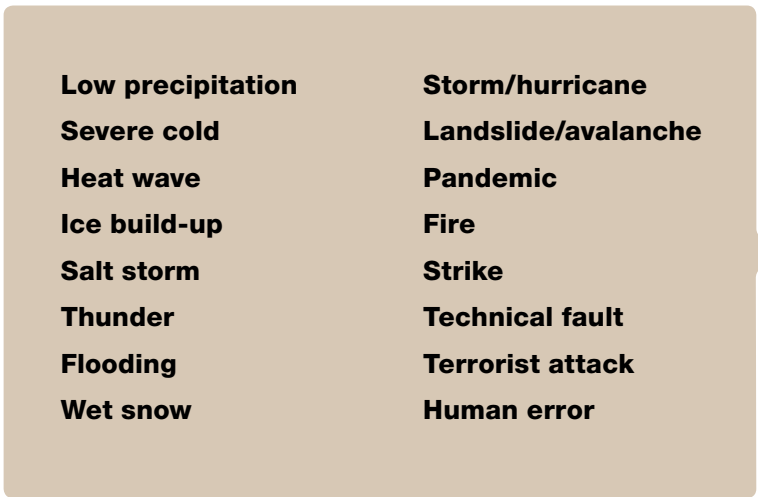
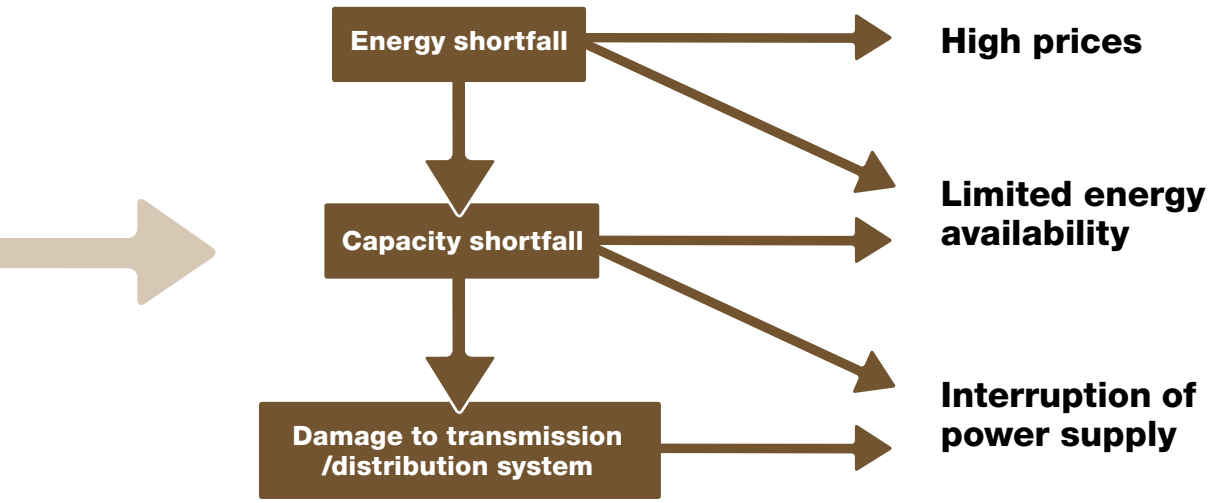


Figure 46
Cause and effect relationships between events, and consequences for end users

Risk factors in electricity and heat supply

As electricity is often essential in order to ensure that all other forms of energy supply can work, it is a particularly important element of the entire energy system. In many cases, electricity is needed for other physical systems to operate. Disturbances in the electricity supply system (see Figure 47) often have immediate consequences, as supply and use must always be kept in balance (the power balance).

Linking a country's energy system to those of neighbouring countries can be very important for security of supply, as electricity can be imported or exported depending on where it is needed. In Sweden, the maximum demand for electricity occurs during periods of very cold winter weather. However, as our nearest neighbouring countries also have higher power demands during cold weather, Sweden cannot rely on always being able to import electricity. In principle, power shortages can occur at any time, as they are due to the actual production or transmission capacity at any instant. In the worst case, Svenska Kraftnät may be forced to disconnect supplies to some users.



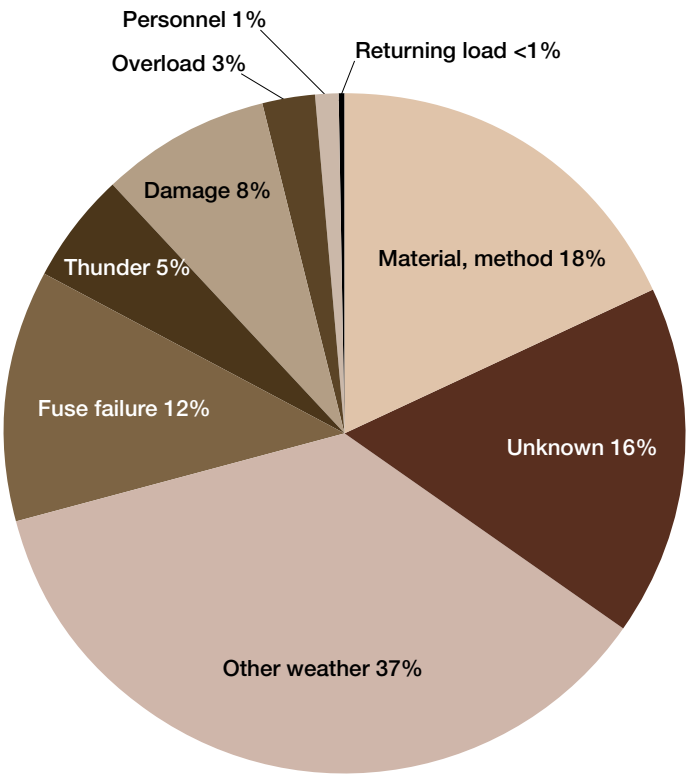
Much of the heating in the country depends on electricity. District heating systems require electricity for both production and distribution, while users need electricity to operate the systems in their buildings. In cold weather, it does not take very long before buildings become chilled: at an outdoor temperature of -5 °C, it takes about two days for the temperature in a normal detached house from the 1970s (brick outer wall and 95 mm insulation) to fall from +20 to +5 °C. Any extended interruption in the supply of district heating can mean that evacuation may be necessary.

The two most important production sources in Sweden, hydro power and nuclear power, are associated with various types of risks. Hydro power depends on inflow to reservoirs and on the level of the reservoirs, while nuclear power is dependent on availability. Strict safety regulations for nuclear power stations mean that if a fault occurs in a reactor, it may be necessary to close other plants of the same type in order to inspect to see if the same type of fault has occurred in them.

Figure 47
Causes of power failures in Sweden, 2007

SOURCE: OPERATIONAL PROBLEMS AND POWER FAILURE STATISTICS, DARWIN

NOTE: THE DIAGRAM INCLUDES ONLY POWER FAILURES LASTING FOR MORE THAN THREE MINUTES.



Oil and motor fuels

The transport sector is essentially entirely dependent on oil based fuels, mainly petrol and diesel fuel. In the short term, there is nothing that can replace or significantly complement the use of oil in transport.

Several other sectors depend on road transport. The use of bioenergy, for example, requires transport of materials to incineration plants or district heating plants. In the event of a severe crisis in the supply of oil, there would be effects on transport and thus also consequential effects on the use of other fuels. The distribution of motor fuels is also dependent on a reliable supply of electricity, as electricity is needed, for example, to power the pumps at petrol stations.

The most serious risks in the field of oil and motor fuel supplies are those connected to geopolitical actions and factors that are difficult to influence.

6

Summary

Energy is needed in order to deliver many human needs, such as heating, food preparation, communication and transport. Interruptions to energy supply can thus affect a large part of society and the population.

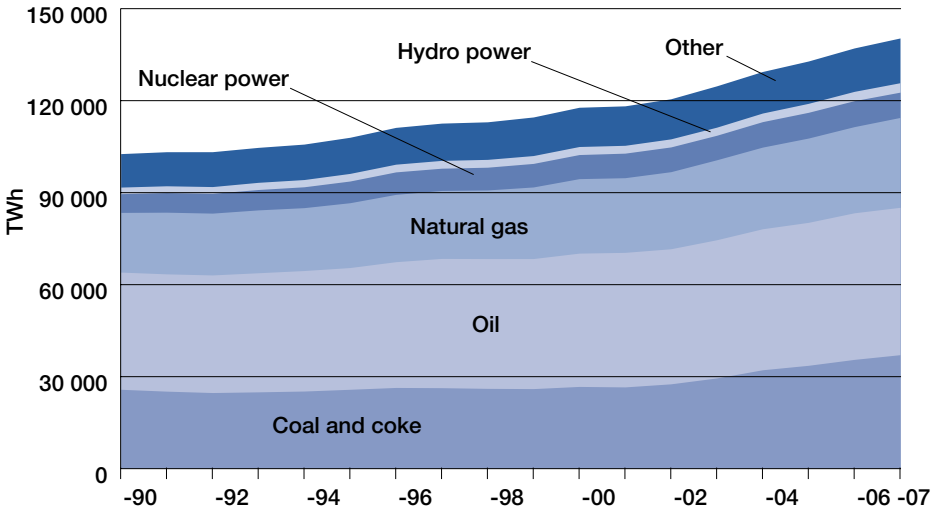
Electricity occupies a particularly important place in the overall energy system, as it is a prerequisite for virtually all other forms of energy supply. The energy system cannot meet the reliability requirements of every single user. With effect from 2011, electricity distributors will have an obligation to ensure that power failures do not last for more than 24 hours. Consumers must be able to withstand the consequences of a power failure of this duration: if not, they should consider alternative means of dealing with problems associated with loss of power.

An international perspective

World energy supply is still dominated by fossil fuels (over 80 %), with oil being the most important of them (34 %), followed by coal (26 %) and natural gas (21 %). The proportion of renewable energy (including hydro power) has remained at about 13 % over the last ten years, with nuclear power, at almost 6 %, 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 circumstances in terms of availability of energy, economic development, infrastructure and climate. Any imbalance between supply and demand of some form of energy supply in a region quickly spreads via the price system to neighbouring energy markets and regions, and affects the whole world market.

Figure 48
Global primary energy supply, 1990–2007

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009; IEA, ENERGY BALANCES OF OECD COUNTRIES, 2009, AND BP STATISTICAL REVIEW OF WORLD ENERGY, 2009



Overview

2008 was dominated and marked by the financial crisis and the general global economic downturn, which severely affected the world's economies during the second half of the year.

The extremely rapid price rises on all raw materials markets in recent years culminated in the spring of 2008, before changing to an even greater price crash. As the economic crisis worsened, so did the demand for energy falloff. For the year as a whole, the total increase in energy demand amounted to only about 1.5 % or, in round figures, a 30 % decline in the rate of increase over the last five years. In 2008, for the first time since 1993, oil usage fell by 0.5 %: a development which, according to preliminary statistics, is continuing in 2009.

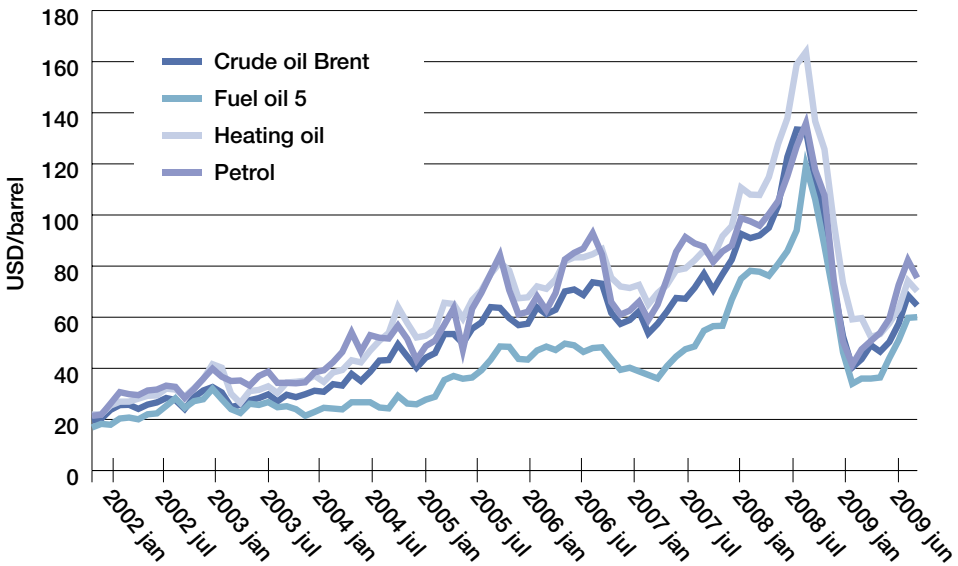


Figure 49
Oil prices in Europe, 2002–June 2009

SOURCE: IEA OIL MARKET REPORT

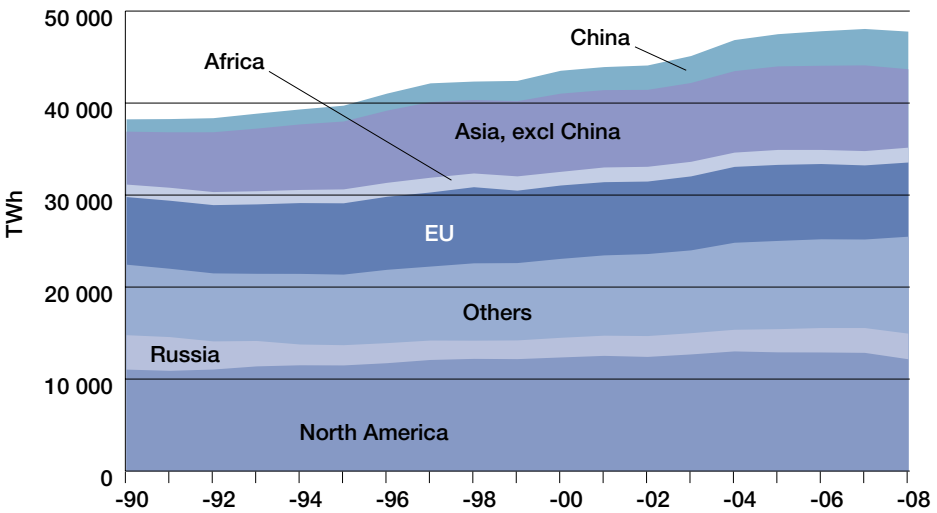


Figure 50
World use of oil, 1990–2008

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009; IEA, ENERGY BALANCES OF OECD COUNTRIES, 2009, AND BP STATISTICAL REVIEW OF WORLD ENERGY, 2009

Figure 51
Coal prices in the EU, USA and Japan, 1999–2008

SOURCE: IEA ENERGY PRICES & TAXES, QUARTERLY STATISTICS, SECOND QUARTER 2009

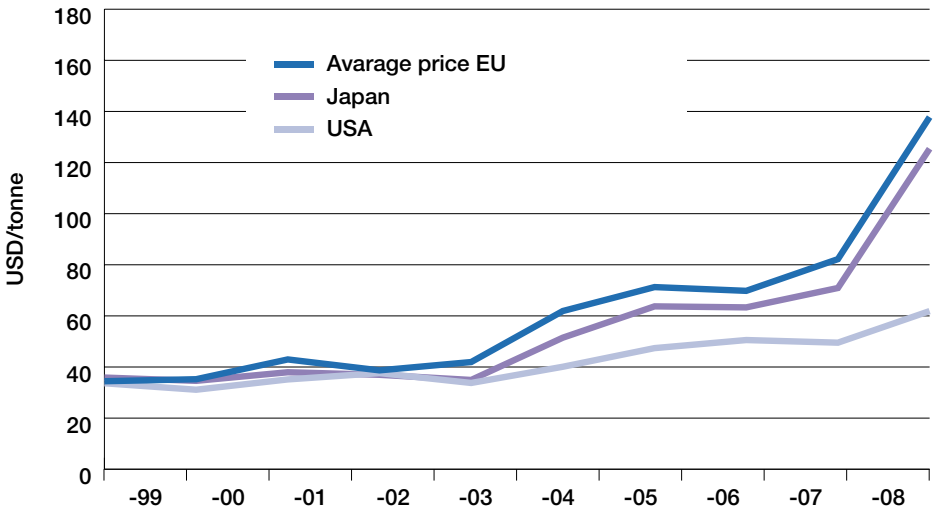
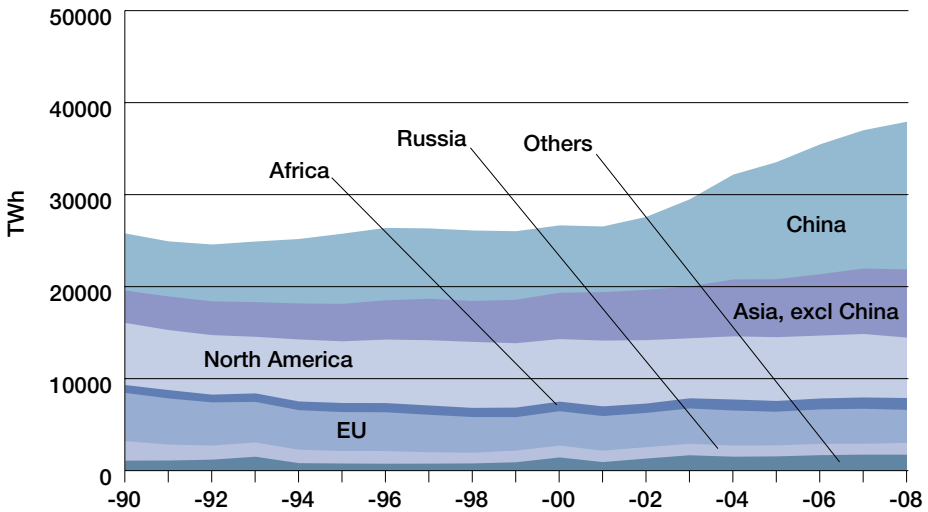


Figure 52
World use of coal, 1990–2008

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009; IEA, ENERGY BALANCES OF OECD COUNTRIES, 2009, AND BP STATISTICAL REVIEW OF WORLD ENERGY, 2009



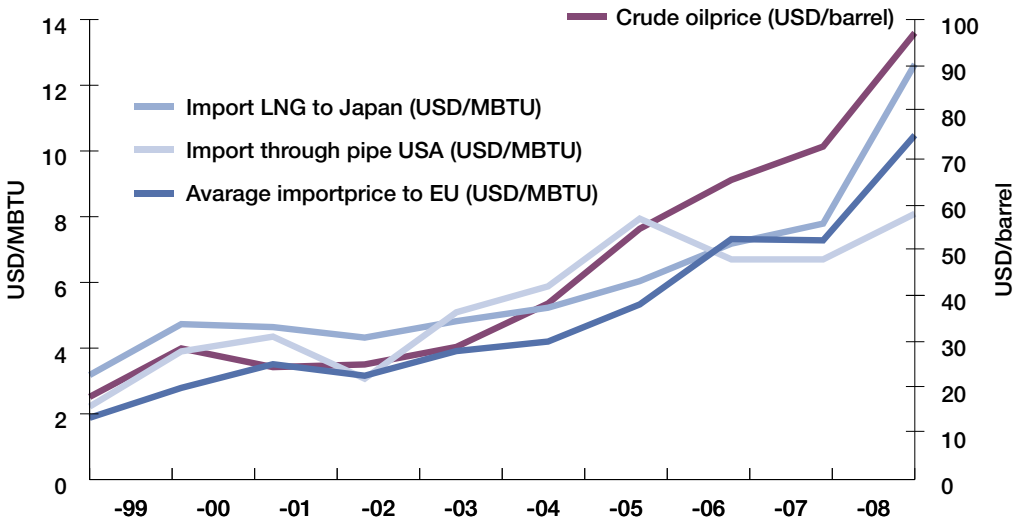


Figure 53
Import prices of natural gas and crude oil, 1999–2008

SOURCE: IEA ENERGY PRICES & TAXES, QUARTERLY STATISTICS, SECOND QUARTER 2009

Energy use and energy supply

Although complete statistics for the total use of renewable energy for 2008 are not yet available, everything indicates that the market continued to grow at the same rate as before, i.e. at almost 3 %, although some decline in the demand for bio-based motor fuels could be noted at the end of 2008.

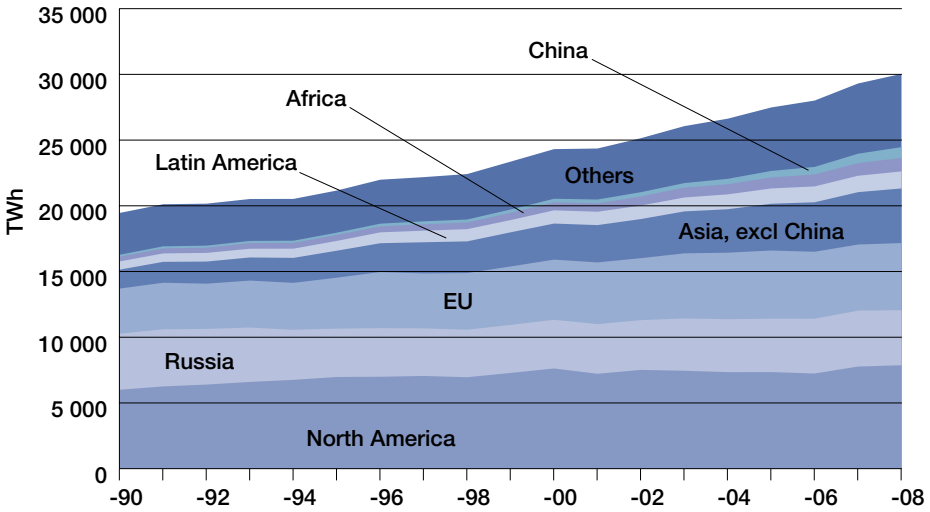
In the oil segment, the proportion accounted for by petrol (about 31 %) has remained essentially constant for the last ten years. On the other hand, the proportion of heavy fuel oils is falling steadily, and is now less than 11 %. However, this reduction is offset in its entirety by an increase in the use of intermediate distillate – i.e. mainly diesel fuel – of which the proportion has increased from 35 % to 37 % over the ten year period.

Although the use of coal increased by no less than 9 % in 2003, it has subsequently fallen back, so that the rate of increase in 2008 was 3 %, although this is still higher than the historic rate of increase of coal, at about 2 %.

The use of natural gas increased during the year by 2.5 %, which is a little below the historic rate of increase of about 3 %.

Figure 54
World use of gas, 1990–2008

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009; IEA, ENERGY BALANCES OF OECD COUNTRIES, 2009, AND BP STATISTICAL REVIEW OF WORLD ENERGY, 2009



The rapidly rising prices of commodities, particularly of cereal products, started a debate on the production of biobased motor fuels. The debate was based on the arguments that valuable virgin forests were being replaced by monocultures, mainly either palm oil trees or sugar cane, and that the cultivation of vegetable products for energy production reduced the availability of foodstuffs, while the high prices of cereals in any case caused increased hunger in the poorest countries.

The severe drop in the price of oil, from USD 147 per barrel in July 2008 to USD 36 per barrel in December of the same year, resulted in a severe loss of viability for both biobased diesel fuel and ethanol as motor fuels on the world market. A number of ethanol plants were forced to close, and planned new investments were postponed. The viability of biobased motor fuels has gradually improved during 2009. However, as the exceptional expansion in their production was interrupted, the discussion on their suitability has been toned down.

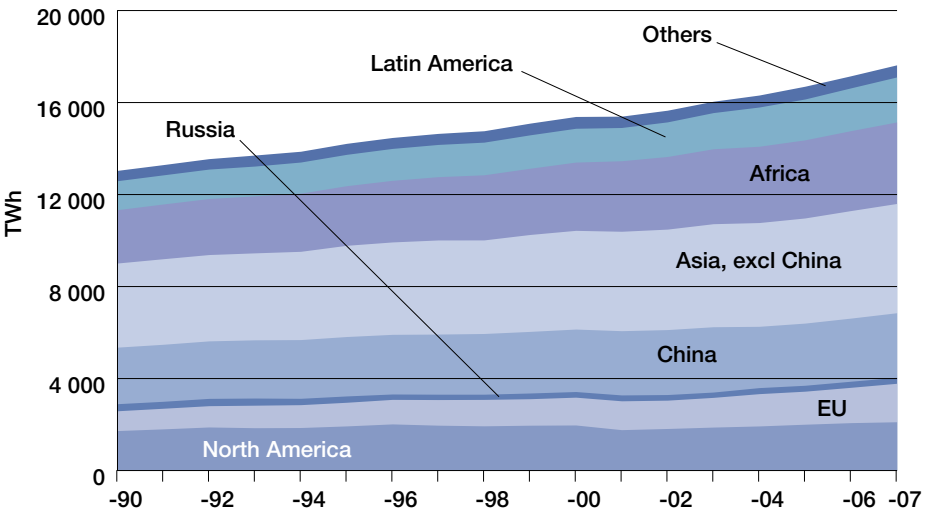


Figure 55
World use of renewable energy, 1990–2007

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009; IEA, ENERGY BALANCES OF OECD COUNTRIES, 2009

Regional and sectorial developments

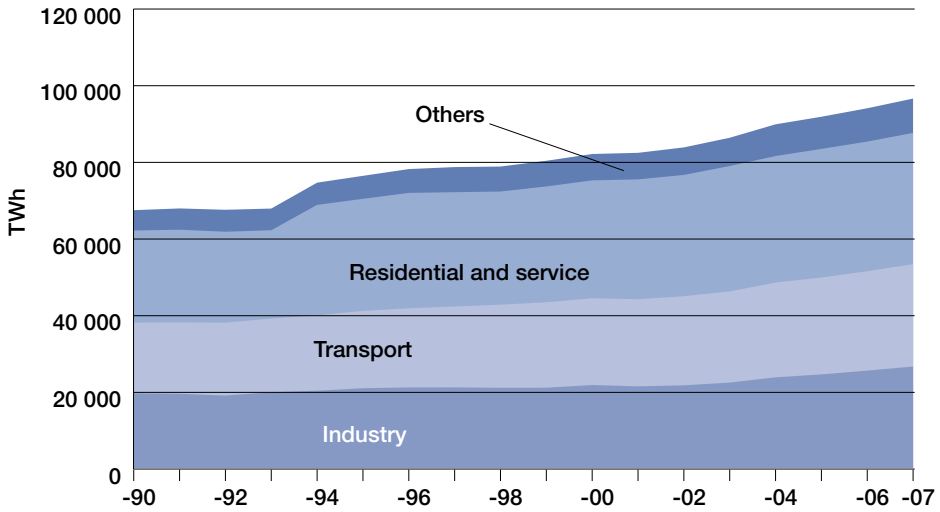
China continues to increase its total use of energy more rapidly than any other country or region. In 2008, it accounted for over 40 % of the world's total use of coal, and almost 90 % of the increase in the use of coal. Together with the Middle East and India, China increased its use of oil by almost 5 % (about 420 TWh), while global use of oil fell by the equivalent of 300 TWh.

China accounted for almost half of the world wide increase in the use of electricity. No complete statistics are yet available for 2008, but preliminary figures indicate that China used more electricity during the year than did the EU.

World wide use of oil has steadily increased for many years, although the rate of increase has varied. The increase was greatest in 2004, after which it has declined year on year, leading to an actual reduction in use in 2008.

Figure 56
World energy use, by sectors, 1990–2007

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009



The amount of energy used by the industrial sector has continued to increase the most rapidly in actual numbers, in comparison with other sectors. Most of the increase is due to rising industrial output in Asia, and particularly in China. In recent years, the proportion of total world energy used by the industrial sector has risen modestly, accounting for 27 % in 2008.

Energy use in the transport sector is increasing at a somewhat slower rate than in the industrial sector. Over the last decade, the proportion of total energy use accounted for by the transport sector has remained relatively constant at around 28 %.

The rate of energy use in the domestic and service sector is considerably lower than in the transport and industrial sector, as can be seen in Figure 56. In 2008, almost 36 % of total energy use was by the domestic sector.

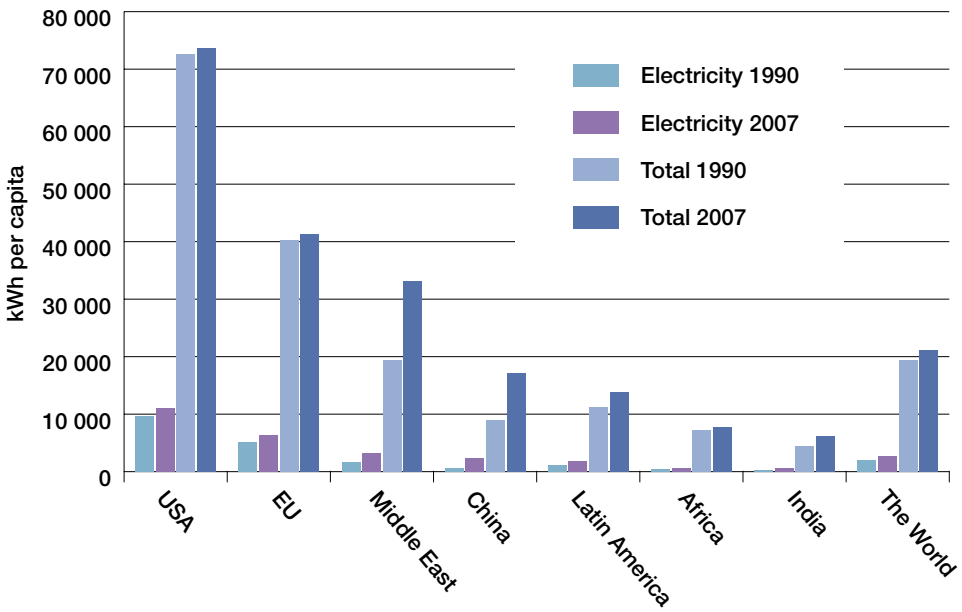


Figure 57
Regional per-capital energy use, 1990 and 2007

NOTE: THESE STATISTICS, WHICH ARE TAKEN FROM THE IEA, ARE BEING EXTENSIVELY REVISED. HISTORICAL VALUES MAY BE CHANGED BY UP TO 5 % FORM ONE YEAR TO ANOTHER, AND SHOULD THEREFORE BE REGARDED WITH CAUTION. HOWEVER, THEY DO INDICATE APPROXIMATE QUANTITIES AND RELATIONSHIPS BETWEEN COUNTRIES.

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009; IEA, ENERGY BALANCES OF OECD COUNTRIES, 2009, AND BP STATISTICAL REVIEW OF WORLD ENERGY, 2009

”The amount of energy used by the industrial sector has continued to increase the most rapidly in actual numbers.”

Figure 58
World electricity production, by type of plant, 1990–2007

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009; IEA, ENERGY BALANCES OF OECD COUNTRIES, 2009

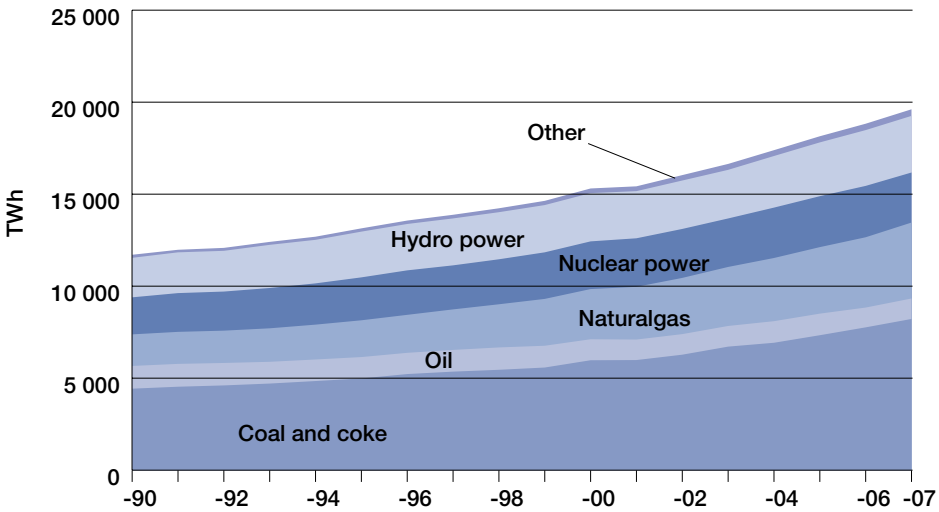
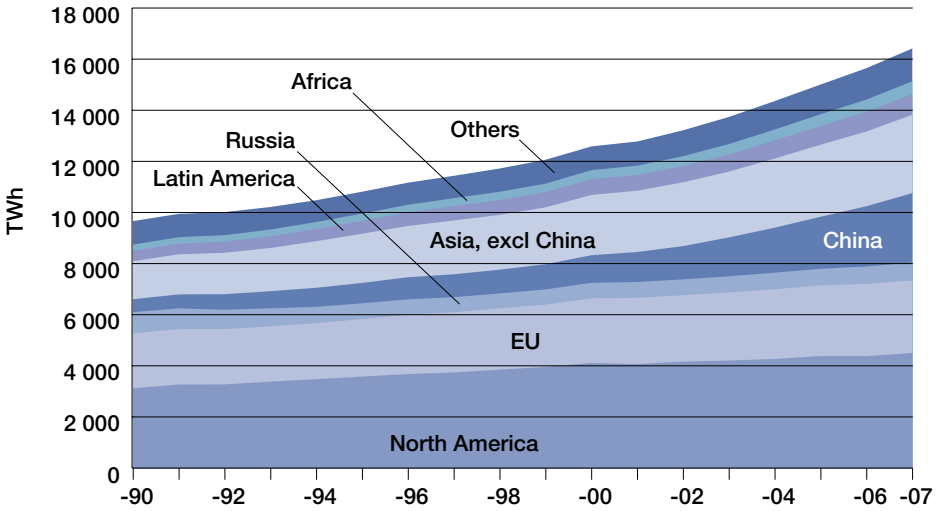


Figure 59
Regional electricity use, 1990–2007

SOURCE: IEA, ENERGY BALANCES OF NON-OECD COUNTRIES, 2009; IEA, ENERGY BALANCES OF OECD COUNTRIES, 2009



7 Summary

2008 was dominated by the economic crisis. The extremely rapid rise in prices which culminated in the spring of 2008 was followed by an even greater fall in prices. As the economic crisis evolved, so the demand for energy fell off. Nevertheless, the rate of increase in the demand for energy continued to follow a stable trend in 2008.

Preliminary statistics for 2008 show, for the first time since 1998, a reduction in world use of oil, amounting to about 0.5 %.

China is the country showing the greatest increase in its total use of energy. 90 % of the total world increase in the use of coal in 2008 was accounted for by China. China was also responsible for half of the global increase in the use of electricity.

In 2007, the use of renewable energy increased by about 3 %, and continues to follow a relatively stable trend.

The environmental situation

All recovery, conversion and use of energy or energy materials have 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 can help to ameliorate some environmental problems, they may have some other adverse environmental impact, such as in the form of their impact on nature and the landscape.

Environmental activities in Sweden

Sweden has a long history of awareness and consideration of the environment. It is, for example, 100 years since the first national park was created, and the first Nature Conservation Act passed. These events have been commemorated by marking 2009 as Nature Year, with many events arranged around the country to celebrate it.

Environmental problems such as climate change affect the entire world population, and therefore require an international response. This was started at the UN conference on the environment and development in Rio de Janeiro in 1992, at which time the Framework Convention on Climate Change was agreed. In addition to its international undertakings, Sweden is affected by the common decisions (directives) taken in the EU, and subsequently implemented in Swedish legislation.

> ”Sweden has a long history of awareness and consideration of the environment.”

Chapters 1 and 2 of this report described conditions and actions intended to achieve Sweden’s energy and climate policy targets. This chapter describes Sweden’s work for a better environment in more detail, presenting the progress of the work, together with synergy effects and counter effects that can arise with or between the various environmental quality targets.

Swedish environmental targets

Parliament has set objectives for environmental quality in sixteen areas. 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). Each of the sixteen environmental objectives has a number of sub-targets, expressed in concrete and quantifiable form. The environmental quality objectives must be considered at all levels: national, regional and local. Through its work with the environmental quality objectives, together with existing legislation, application of EU directives and international agreements, Sweden hopes to achieve sustainable development.

The environmental objectives describe the quality and state of Sweden's environment, nature and cultural assets that are regarded as ecologically sustainable in the long term. The work of achieving these objectives is a joint effort, requiring central authorities, such as the Swedish Energy Agency or the Swedish Environment Protection Agency, County administrative board, local authorities and other parties to contribute to the common cause. The Swedish Environmental Objectives Council[119] is responsible for coordination and evaluation of the work, publishing an annual progress report under the name of *de Facto*.

The purposes of the environmental objectives are to:

- Promote human health
- Safeguard biological diversity and the natural environment
- Preserve the cultural environment and cultural heritage
- Maintain the long-term productivity of ecosystems
- Ensure wise management of natural resources.

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

- Reduced climate impact
- Clean air
- Natural acidification only
- A good built environment
- Flourishing lakes and streams
- A magnificent mountain landscape.

119 The Swedish Environmental Objectives Council consists of a Chairman and not more than seventeen other members, representing central public authorities, county councils and other parties.

A strategy for more efficient energy use and transport has been produced, in order to assist the work of achieving the first five targets. The National Rail Administration, the Swedish Energy Agency, the Swedish Civil Aviation Authority[120], the Swedish Environmental Protection Agency, the Swedish Maritime Administration and the National Road Administration were instructed by the Government in 2007 to produce a strategy to complement a more in-depth evaluation of the country's environmental targets. The Swedish Institute for Transport and Communications Analysis (SIKA) and the National Board of Housing, Building and Planning also assisted the work, which resulted in the following priority actions to achieve the five environmental targets: general improvements in the efficiency of energy use, improved SO_x and NO_x flue gas cleaning, and targeted actions to reduce air pollution.

Reduced climate impact

The UN Framework Convention on Climate Change provides for the stabilization of concentrations of greenhouse gases in the atmosphere at levels which ensure that human activities do not have a harmful impact on the climate system. This goal must be achieved in such a way and at such a pace that biological diversity is preserved, food production is assured and other goals of sustainable development are not jeopardized. Sweden, together with other countries, must assume responsibility for achieving this 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. In 2006, emissions were 8.5 % less than in 1990.

The greatest reduction in greenhouse gas emissions has occurred in the residential and service sector. Less use of oil has resulted in a reduction in emissions of about 6.5 million tonnes of CO_2-equivalents since 1990. At the same time, there has been an increase in the use of district heating, but as this increase has resulted primarily from an increase in the use of biofuels, emissions from district heating production have not increased.

120 Nowadays part of the Swedish Transport Agency.

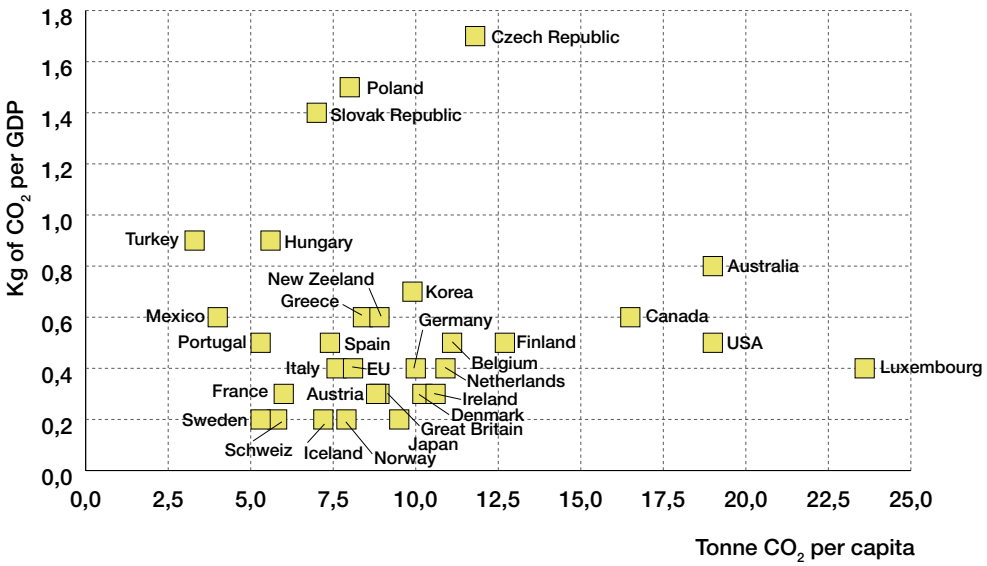


Figure 60
Per-capita and per-GDP emissions of carbon dioxide from combustion in EU and OECD countries in 2006

SOURCE: OECD IN FIGURES, 2008 EDITION

Progress

Figure 60 shows emissions of carbon dioxide from combustion, expressed as specific per capita emissions and as per GDP emissions in 2006 for EU and OECD countries. The forecast for 2020, as presented in the Environmental Objectives Council's *de Facto 2009* report, shows that this objective will be very difficult or impossible to achieve, even if more improvement actions are implemented. Many actions contributing to the whole, but having only limited effect, are described in Chapter 2.

Continued work to achieve the target

In March 2009, the Government presented two bills concerning climate and energy to Parliament, setting out (among other points) how Sweden intends to achieve its targets under the EU Energy Services and Renewables Directive. In December 2009, world countries will meet at the fourteenth UNFCCC conference in Poland, followed later in the month at Copenhagen by negotiations for a successor to the Kyoto Protocol.

Clean air

The air must be clean enough not to represent a risk to human health or to animals, plants or cultural asset.

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 low-level ozone. A number of volatile organic compounds and sub-10 µm particles (PM10) can also cause these effects. Acidifying pollutants also affect buildings and other structures and objects through acceleration of breakdown processes in the materials. In addition, compounds such as oxides of nitrogen and sulphur contribute to eutrophication of water bodies and acidification.

Progress

The forecast for 2020, as presented in *de Facto 2009*, shows that this objective will be very difficult or impossible to achieve, even if additional actions are performed. The trend towards improved air quality in urban areas has halted.

Continued work to achieve the target

A new directive for air quality has resulted in the Environment Protection Agency preparing a new proposal for an Ordinance for environmental quality standards for outdoor air. The greatest difference between this and present regulations is that it will also include very small particulates (PM2.5). The new regulations will come into force by not later than the summer of 2010.

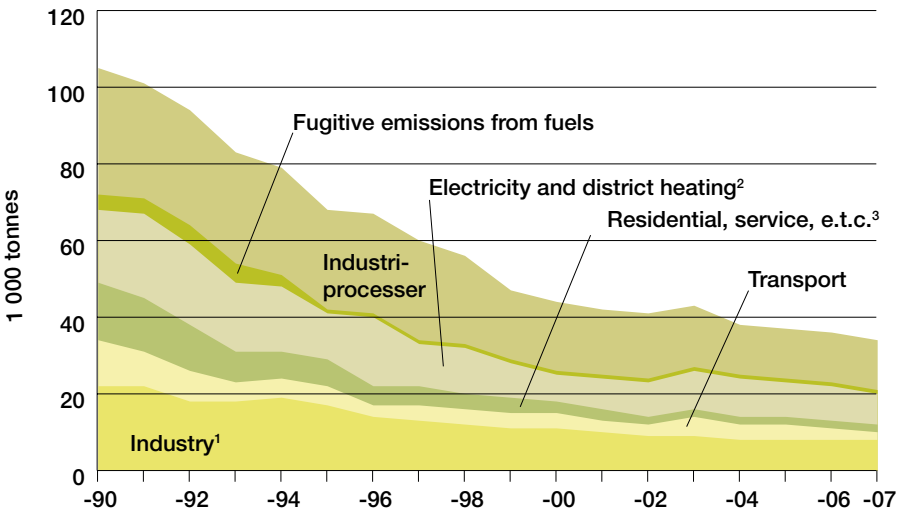


Figure 61
Sulphur dioxide emissions in Sweden, 1990–2007

SOURCE: SWEDEN'S REPORT TO THE UN AIR POLLUTION CONVENTION, SWEDISH ENVIRONMENTAL PROTECTION AGENCY, 2009. 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 THE PREVIOUS ISSUE 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.

Natural acidification only

The acidifying effects of deposition and land use must not exceed the limits that can be tolerated by soil and water. In addition, deposition of acidifying substances must not increase the rate of corrosion of technical materials or cultural artefacts and 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 (NO_x) also contributing to the effect. Sulphur dioxide emissions arise from the presence of sulphur in fuels, while oxides of nitrogen are formed mainly by the effects of combustion on the nitrogen in 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 – some-

times 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 country's own emissions. On the other hand, Sweden 'exports' about 60 % of its own sulphur emissions to the ground and water in other countries.

Progress

Figure 61 shows the trend for sulphur dioxide emissions in Sweden over the period 1990–2007. The forecast for 2020, as presented in *de Facto 2009,* shows that this objective will be very difficult or impossible to achieve, even if additional actions are applied. However, the general trend in environmental conditions is positive, with SO_x and NO_x emissions from other countries in Europe declining. However, emissions must be further reduced if this target is to be achieved.

Continued work to achieve the target

Reducing SO_x emissions on the wider scale that is needed requires continued international cooperation. In order to assist nature in countering wet precipitation, many lakes and waterways in Sweden have been limed for many years. It is the responsibility of the County administrative board to review and update liming plans. The problem of acidification falls within the remit of the river water management which means that additional assistance is being provided. The work of the river water management is Sweden's way of complying with the Water Framework Directive, and means that, by not later than 22nd December 2009, identified water bodies[121] will be given environmental quality standards that must be achieved by 2015 or by not later than 2027. Acidification is one of the factors that are considered when setting the environmental quality standards for water bodies.

> "The general trend in environmental conditions is positive."

121 According to the River water management, a 'water body' is the smallest entity for describing and assessing water. It can, for example, be a lake, or part of a larger lake.

A good built environment quality

Cities, towns and other built-up areas must provide a good, healthy living environment and contribute to a good regional and global environment. Natural and cultural assets must be protected and developed. Buildings and amenities must be located and designed in accordance with sound environmental principles and in such a way as to promote sustainable management of land, water and other resources.

The objective 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. The target is to reduce specific energy use (i.e. per m^2) of heated areas by 20 % by 2020, and by 50 % by 2050. 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.

Progress

The forecast for 2020, as presented in *de Facto 2009,* shows that this objective will be very difficult or impossible to achieve, even if additional actions are performed. However, the interim target for reduced energy use in buildings could be achieved if additional actions are taken.

Continued work to achieve the target

Since 1998, local authority energy and climate advisors have provided cost free information and advice to domestic consumers on ways of improving their efficiencies of energy use. The parts of the Building Regulations concerning energy conservation (BFS 2008:20, BBR 16) were revised on 1st February 2009 so that, for example, buildings must make better use of their energy input. On 2nd July 2009, the Government published a new Ordinance requiring public authorities and courts to improve their efficiencies of energy use, with effect from 1st September 2009. The Swedish Energy Agency is responsible for coordinating and assisting this work. These measures are intended to achieve the target set by the Energy Services Directive, and also have a beneficial effect on achieving the climate target.

Figure 62
NO_x emissions in Sweden, 1990–2007

SOURCE: SWEDEN'S REPORT TO THE UN AIR POLLUTION CONVENTION, SWEDISH ENVIRONMENTAL PROTECTION AGENCY, 2009. 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 THE PREVIOUS ISSUE OF ENERGY IN SWEDEN.

1. INCLUDES INDUSTRIAL BACK-PRESSURE PRODUCTION AND WASTE INCINERATION.
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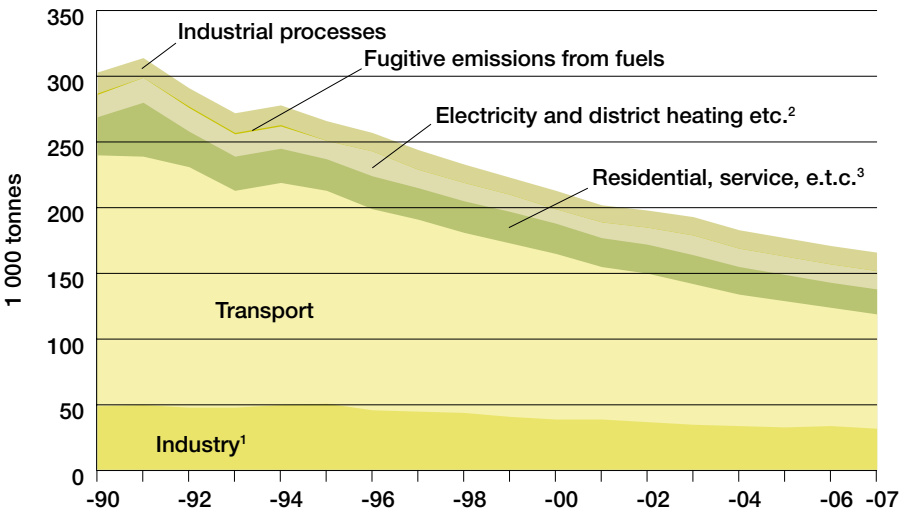

Flourishing lakes and streams

Lakes and watercourses must be ecologically sustainable and their variety of habitats must be preserved. Natural productive capacity, biological diversity, cultural heritage assets and the ecological and water-conserving function of the landscape must be preserved, at the same time as recreational assets are safeguarded.

Much of Swedish electricity production is provided by hydro power. However, the presence of hydro power stations affects the ecosystems along the rivers, and can constitute an obstacle for fish. A research project, under the title of 'Hydro power and the environment', with the aim of ensuring that the environmental impact of hydro power production is as low as possible, has been sponsored by the Swedish Energy Agency. This problem is an example of conflicts that can arise between two environmental targets. In order to arrive at the best solution it is important to evaluate costs and benefits in order to give priority to whichever solution has the greater net benefit.

Progress

Figure 62 shows the trend for NO_x emissions in Sweden over the period 1990–2007. The forecast for 2020, as presented in *de Facto 2009,* shows that this objective could be achieved, if additional actions are performed.

Continued work to achieve the target

Fish (i.e. if an expected species of fish is present) and physical factors (e.g. obstacles to the migration of fish) are factors that affect the status of a water body. Water bodies that are affected by electricity production (generally by the presence of dams) can be classified as what are known as Heavily Modified Waters (HMW), for which the target is then good potential instead of good status. However, it is difficult to see the effects of this classification. The proposals that the River basin district authorities have circulated for comments include 349 HMWs, of which 341 are so classified due to power production. Decisions on the number of HMWs, environmental quality standards and actions to achieve the necessary environmental quality standards must be taken by not later than 22nd December 2009

A magnificent mountain landscape

The pristine character of the mountain environment must be largely preserved, in terms of biological diversity, recreational value, and natural and cultural assets. Activities in mountain areas must respect these values and assets, with a view to promoting sustainable development. Particularly valuable areas must be protected from encroachment and other disturbance.

In recent years, municipalities and energy companies have shown increasing interest in establishing wind farms in upland areas. Some Sami communities have also investigated the feasibility of constructing wind power farms. Such installations should be arranged in areas that can be regarded as suitable in the light of conflicting land use interests. Production of wind power in upland environments should not affect the prospects for sustainable populations of sea eagles and golden eagles.

Progress

The forecast for 2020, as presented in *de Facto 2009,* shows that this objective could be achieved if additional actions are performed.

Continued work to achieve the target

The Environment Protection Agency's 2008 plan for national parks proposes that nature reserves should be upgraded to national parks status. This would provide these areas with stronger protection against exploitation, e.g. in connection with the construction of wind farms.

The work with the Environmental Objectives is undergoing evaluation

At the beginning of 2008, the Government appointed a commission to investigate the structure, organisation and allocation of responsibilities for the environmental objective system. The Commission will investigate if and how coordination with other environmental work can be improved, how the link between environmental monitoring and monitoring of progress towards achievement of environmental targets can be improved, and how greater importance can be attached to work within the EU and other international working areas. The Commission was due to submit its report on 30th September 2009.

FURTHER INFORMATION IS AVAILABLE FROM:

WWW.MILJOMAL.NU
WWW.NATURVARDSVERKET.SE
WWW.SOU.GOV.SE
WWW.VATTENMYNDIGHETERNA.SE

8 Summary

Effects on the environment occur at many different levels: local, regional and global. The borders between them are diffuse and fluid, depending not only on the type of effect, but also on how the pollution spreads.

At the national level, Sweden has been working with environmental objectives since 1999 as a way of structuring the work aimed at improving the environment. They provide a national measuring stick, against which progress towards ecologically sustainable development can be measured. In addition to providing an indication of how actual conditions in the Swedish environment compare with the objectives, they are also suitable for supporting the national perspective in international contexts.

Energy units and conversion factors

This chapter presents and defines units and conversion factors. Relationships between various energy units are also given, in order to make it possible to compare statistics with other international statistics.

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). It should be noted that the calorific values and conversion factors are average values for the various fuels, and that there are variations between quality grades. This applies particularly to wood fuels and coal.

Table 8
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 9
Prefixes used with energy units

Prefix		Factor	
k	Kilo	10^3	thousand
M	Mega	10^6	million
G	Giga	10^9	thousand million
T	Tera	10^{12}	million million
P	Peta	10^{15}	thousand million million

Fuel	Physical quantity	MWh	GJ
Wood chips	1 tonne	2,00–4,00	7,20–14,4
Peat	1 tonne	2,50–3,00	9,00–11,0
Pellets, briquettes	1 tonne	4,50–5,00	16,0–18,0
Coal	1 tonne	7,56	27,2
Coke	1 tonne	7,79	28,1
Nuclear fuel	1 toe	11,6	41,9
Crude oil	1 m^3	10,1	36,3
Topped crude oil	1 m^3	11,1	40,1
Petroleum coke	1 tonne	9,67	34,8
Asphalt, road dressing oil	1 tonne	11,6	41,9
Lubricating oils	1 tonne	11,5	41,4
Road fuel petrol	1 m^3	9,04	32,6
Aviation petrol	1 m^3	9,08	32,7
Virgin naphtha	1 tonne	8,74	31,5
Petroleum naphtha	1 m^3	9,34	33,6
Aviation paraffin and intermediate oils	1 tonne	9,58	34,5
Other paraffins	1 m^3	9,54	34,3
Diesel and gas oil	1 m^3	9,96	35,9
Heavy fuel oils and bunker oil	1 m^3	10,6	38,1
Propane and butane	1 tonne	12,8	46,1
Gasworks gas and coking 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
Ethanol	1 m^3	5,90	21,2
Biogas	1 000 m^3	9,70	34,9
FAME	1 m^3	9,33	33,6

Table 7
Calorific values (heat values) in MWh and GJ per physical quantity

NOTE: THE TABLE GIVES CONVERSION FACTORS TO THREE FIGURES: THE CALCULATIONS IN THE REPORT USE GREATER ACCURACY.

1. THE VALUE FOR NATURAL GAS IS THE NET (LOWER) CALORIFIC VALUE, I.E. WITHOUT RECOVERY OF THE LATENT HEAT OF CONDENSATION IN THE COMBUSTION PRODUCT GAS.

Our target – better use of energy

The Swedish Energy Agency's work is aimed at the establishment of a reliable, low-environmental-impact and efficient energy system. Energy and climate are closely linked: through international cooperation and engagement, we can help to achieve climate targets. The Agency finances research and development of new energy technologies. We provide pro-active support for commercial ideas and innovations that can lead to the establishment of new companies. We also run information campaigns and demonstrations to show Swedish companies and domestic users how they can make better use of energy.

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 provided more in-depth information. They can be ordered or be downloaded from our web site www.energimyndigheten.se – webbshop.

Energiläget 2009 – printed
Energiläget 2009 – PDF
Energiläget i siffror 2009 – printed
Energiläget i siffror 2009 – PDF
Energiläget i siffror 2009 – Excel
OH-bilder (svenska) – PDF
Energy in Sweden 2009 – printed
Energy in Sweden 2009 – PDF
OH pictures (English) – PDF

Energy in Sweden is the English translation of *Energiläget.*

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

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

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