Energy in Sweden 2010

Books and reports published by the Swedish Energy Agency
can be ordered via the Agency's web site, or by fax.
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ET2010:47
Print run: 1000 copies

Translation: Angloscan Manuscript Ltd.
Layout and production: Granath Euro RSCG
Print: CM Gruppen AB, 2010

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 emissions 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, which 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 2009, complemented where possible by input reflecting current events and decisions up to the autumn of 2010.

Project manager has been Helen Lindblom and assistant project manager Helen Magnusson.

Eskilstuna, November 2010

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1 Current energy and climate policy activities

Increasingly, Swedish energy and climate policy is affected by decisions at international level. At the EU level, the Renewables Directive and the Trading Directive are examples of directives that affect Swedish policy. The Kyoto Protocol, too, has considerable importance at national level, in setting guidelines for industrial countries' greenhouse gas emissions up to and including 2012. However, the most recent negotiations in Copenhagen for a continued climate agreement after 2012 did not deliver the results for which many had hoped.

1.1 EU decisions affect Sweden's energy and climate policy

The Government states that Swedish energy 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. Energy supply is a key area in the work of moving Sweden towards a sustainable society. It involves work on security of supply, improving the efficiency of energy use, renewable energy and efficient energy technology.

Climate and energy policy should not be separated

During 2009, Parliament approved a new climate and energy policy on the basis of the Government's Bills No. 2008/09:162 and 2008/09:163. The two bills go under the common name of A joint climate and energy policy.

The new climate and energy policy sets a number of targets and strategies for future development. The proportion of energy supplied by renewable sources shall amount to at least 50 % of the country's total energy use by 2020. This is in line with EU Directive No. 2009/28/EC promoting the use of energy from renewable sources, which imposes binding requirements on the proportion of renewable energy.

In addition, the new policy sets a target for the transport sector, requiring at least 10 % of its energy use to be met from renewable sources by 2020. The long-term ambition is that vehicles in Sweden should be independent of fossil fuels by 2030. Parliament has also approved a target for improving the efficiency of energy use, for an overall reduction of 20 % in energy intensity between 2008 and 2020.

A new emissions target has been decided upon, of a 40 % reduction in greenhouse gas emissions by 2020 in comparison with 1990. This target expressly covers activities not included in the EU Emission Trading System. The vision for 2050 is that Sweden should have no net emissions of greenhouse gases to the atmosphere. This decision complements the environmental quality target for limited climate effect.

Ways in which these targets might be met have included suggestions by the Government of changed taxes and more stringent economic policy measures. EU-wide decisions are also seen as an important means, as are green investments in developing countries.

New directives to promote renewable energy

The Renewables Directive creates a common framework for the promotion of the use of renewable energy throughout the EU. It sets out a binding requirement that

49 % of Sweden's total energy use must be met by energy from renewable sources by 2020. The directive has required changes to Swedish legislation in the form of Parliament's decision on a new law concerning guarantees of origin for electricity, the purpose of which is that it should be possible for end-users clearly to see where their electricity has been produced. Parliament has also approved certain changes to the Electricity Act and the Natural Gas Act, concerning access to, and operation of, the electricity and gas networks. These changes will come into force on 1st December 2010.

The Renewables Directive includes requirements for the sustainability criteria for biobased motor fuels. If motor fuels do not meet the criteria, they may not be counted towards fulfilment of the national targets, and nor may they be included in the quotas for energy from renewable sources or receive financial support in the form of tax exemption. One criterion is that use of the fuel must result in at least a 35 % reduction in exhaust gases in comparison with corresponding use of fossil fuels. During the spring of 2010, Parliament approved a new law governing the sustainability criteria for biobased motor fuels and for liquid biobased fuels[1]. In addition, decisions have been taken concerning changes to the Act (2003:113) Concerning Electricity Certificates and to the Act (1994:1776) Concerning Tax on Energy in order to bring them into line with the Directive's requirements for sustainability criteria.

Greater emphasis on energy efficiency improvement measures in Sweden

A five-year energy efficiency improvement programme will be carried out over the period 2010-2014, with one of the aims being to bolster regional-level and local-level energy and climate work. The public sector is expected to set an example in terms of energy efficiency improvement. A decision was taken in April 2010 on the provision of subsidies for energy surveys, covering 50 % of the costs of the surveys.[2]

The Energy Efficiency Improvement Programme (PFE) is a policy measure that was introduced in 2004. A first five-year period of the programme was concluded in June 2009, and was followed on 1st July 2009 by a new five-year programme period. Companies that have already participated in the first programme period, as well as completely new entrants to the programme, can take part.

During 2010, the Swedish Energy Agency has investigated the conditions for, and the consequences of, the introduction of a system of 'white certificates' in Sweden[3]. The results were presented to the Government Offices in September 2010.

1 The Act (2010:598) Concerning Sustainability Criteria for Biobased Motor Fuels and Liquid Biobased Fuels.
2 Se also the Ordinance 2009:1533 Concerning Public Funding Support for Energy Efficiency Improvements in Local Authority and County Council Properties, and Ordinance 2009:1577 Concerning Public Funding Support for Energy Surveys.
3 White certificates can be briefly summarised as a trading-based policy measure for improving energy efficiency.

During the year, the Agency has also identified existing financing instruments at national and EU level that could be used for funding energy efficiency improvement measures in buildings. This work was carried out in conjunction with the National Board of Housing, Building and Planning and with the National Housing Credit Guarantee Board, and the results were reported to the Government Offices in October 2010.

Directive 2002/91/EC Concerning the Energy Performance of Buildings has been reworked, and now imposes new requirements. As a result of this reworking, Swedish legislation and associated regulations have been reviewed. Working with the National Board of Housing, Building and Planning, and with other concerned parties in the construction and properties sector, the Agency has developed a national strategy for promotion of low-energy buildings[4]. A joint information and advisory portal will be set up in conjunction with the Ministry of Housing, Building and Planning at the end of 2010. The actions proposed in the energy surveys are not being carried out at the desired rate: one reason for this may be lack of information or knowledge. The portal will provide tailor-made information and advice for various groups of property-owners.

The green electricity system: important for reaching the renewable energy target

In accordance with Bill No. 2009/10:133[5], Parliament has decided to extend the green electricity certificate system until the end of 2035. The Bill was a result of the overview of the system carried out by the Energy Agency on behalf of the Government during 2009 and 2010. Among the points covered by the review were adjusted and new quotas, together with the possibility of expanding the market for electricity certificates to additional countries.[6]

The Renewables Directive requires all member states to draw up national action plans for renewable energy. In its annual funding document for 2010, the Energy Agency was instructed to prepare a proposal for such a plan, which was submitted to the Government in February 2010.[7]

During 2009, Parliament approved a national planning framework for wind power equivalent to 30 TWh in 2020, of which 20 TWh would be onshore and 10 TWh would be offshore. A number of simplifications of the planning process for wind power have been introduced. The purpose of an overall planning framework is to position wind power interests in the physical planning process.

4 The targets and conditions for this strategy are in line with the Government's view in the Coordinated Climate and Energy Policy bill – Energy (Bill no. 2008/09:163) and with the requirements in the Energy Performance of Buildings Directive, 2002/91/EC.
5 Raised targets and further development of the electricity certificate system.
6 For further information, see the coming publication, The Electricity Certificate System, 2010.
7 Report: Sweden's national action plan for assisting the use of renewable energy in accordance with Directive 2009/28/EC, reference no. 2010/74/E

Changes to the law open the way to new nuclear power production

The legislatory framework covering Swedish nuclear power production will be modified in order to allow a controlled generation renewal of Swedish nuclear power. During 2010, Parliament has approved the proposals put forward by the Government in Bill No. 2009/10:172 – Nuclear Power – Opening the Way to a Generation Change. The changes will come into force at the beginning of 2011, with the following effects:

- the Act (1997:1320) Concerning Phase-out of Nuclear Power Production to be repealed;
- the ban on new construction in the Act (1984:3) Concerning Nuclear Technology Activities to be lifted;
- approval may be given for the construction of a maximum of ten new nuclear power reactors, provided that each new build replaces an existing reactor.

Parliament has asked the Government to propose a bill to make it clear that no public funding or subsidies will be available for the construction of new nuclear power reactors. Parliament has also approved the introduction of unlimited liability for the operators of nuclear facilities and the owners of nuclear power reactors in the event of a nuclear accident. This means that, if necessary, a company's entire assets may be distrained upon. Companies must also hold insurance or other economic security against third-party claims up to EUR 1 200 million.

An investigation has been initiated by the Government into the possibility of simplifying and improving the structure and application of current regulations.[8] The aim is to coordinate the nuclear and radiation protection regulations without watering down public requirements in respect of nuclear safety and radiation protection. The feasibility of combining the requirements of the Nuclear Activities Act (1984:3) and the Radiation Protection Act (1988:220) has been investigated. The results will be reported by not later than 22nd December 2010.

Updating the gas market regulations

EU work on drawing up rules to ensure security of supply has resulted in the Government establishing a commission (N 2010:05) to investigate options for future management of system responsibility for gas supplies. Rules for the single market in natural gas will be drawn up, and the Swedish commission will investigate whether any changes are needed to the Swedish market model. The commission is due to report to the Government by not later than 31st May 2011.

8 See the additional instructions (2009:74) for the Investigation of Coordinated Regulation of Nuclear Technology and Radiation Protection (M 2008:05).

In response to a Government instruction, and working in conjunction with the Swedish Environmental Protection Agency and the Swedish Board of Agriculture, the Swedish Energy Agency has prepared a proposal for a sector-wide strategy for biogas. In the report, which was presented to the Government on 31st August 2010, the authorities suggest that priority should be given to waste products that can be used in such a way as to close a cycle. It is suggested that biogas from stable manure should be given a production subsidy, as closing this particular cycle would have considerable climate and environmental benefits. One of the investigation's conclusions is that biogas would be of greatest environmental benefit when used in heavy urban traffic, such as for city-centre buses. For their part, local authorities should give priority to digestion rather than combustion of organic waste.

The report of the new electricity and gas market investigation (SOU 2010:30) was presented to the Government in April 2010. The investigation has followed the EU's work on drawing up common rules for the single markets in electricity and natural gas. The report has presented proposals for legislation and necessary regulations as needed in order to implement the revised Electricity and Gas Market Directive[9] into Swedish legislation. In addition, it proposes changes in the instructions to the Swedish Energy Agency, the Energy Market Inspectorate, Svenska Kraftnät, the National Price and Competition Board and the Swedish Consumer Agency.

Swedish environmental technology companies to be supported

Swentec, the Swedish Environmental Technology Council, was established in 2005 in order to support Swedish clean technology companies. Swentec has been instructed by the Government to investigate how Swedish clean technology companies can be supported, with particular concentration on export and increased growth. This investigation, which started in April 2008, will continue until the end of 2010. An interim report[10] was submitted in December 2009, with 82 concrete proposals for achieving a vision in which Sweden plays a leading part, supplying world-leading solutions in energy and environmental technology for a sustainable future.

9 Directives 2009/72/EC and 2009/73/EC.
10 Action plan for Swedish environmental technology.

1.2 A new strategy for the EU's energy and climate policy

EU 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 direction of EU energy policy, and resulted in the EU's 20/20/20-targets[11] and an action plan for the period 2007-2009. The Commission presented its second Strategic Energy Review in November 2008, concentrating on security of supply and improving the efficiency of energy use.

In June 2010, the European Council adopted a new strategy for the EU, aimed at supporting employment and smart and sustainable growth[12]. Energy, efficient use of resources and innovation are key areas in the new strategy, complementing the earlier 20/20/20 targets, which remain unchanged.

An energy policy action plan

In order to give concrete form to achievement of energy targets, a new energy policy action plan for the period 2011-2020 will be prepared by the EU. A first draft is expected in November 2010, and it is hoped that the entire plan will be adopted at the spring summit in 2011. The plan is expected to concentrate on infrastructure and the need for investment, implementation of existing legislation[13], and international relations. Other elements of the plan will include energy conservation measures and low-carbon innovation, all in general accordance with the long-term objectives established for 2050 (80-95 % reduction in greenhouse gas emissions by 2050). The material has been out for open consultation, the results of which can be seen on the EU Commission's website[14].

Increasing importance of energy matters

Energy is becoming an increasingly important part of EU policy, mainly in order to enable the EU to achieve its targets and to help to tackle climate change. Energy also plays an important part in actions to support economic growth and create new jobs.

Several organisational changes linked to the EU's energy policy have been carried out over the last year. The Treaty of Lisbon[15] came into force on 1st December 2009, giving the energy sector its own article, Article 194. The new commission started its duties at the beginning of 2010. Energy and climate matters are closely linked, which has been recognised by appointing (for the first time) a commissioner

11 20 % improvement in the efficiency of energy use, 20 % renewable energy, 20 % reduced greenhouse gas emissions
12 The EU 2020 strategy. See also http://ec.europa.eu/eu2020/index_en.htm
13 The energy and climate package, third single market package, the energy efficiency improvement package
14 http://ec.europa.eu/energy/strategies/consultations/2010_07_02_energy_strategy_en.htm
15 http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm

for climate matters. The international aspects of energy matters are becoming steadily more important, which means that it is likely that external affairs and security policy will become increasingly important parts of the EU energy policy and its relations with third countries.

Organisational aspects have also been changed within the EU Commission. Transport and energy were previously gathered under one directorate, DG TREN, but energy matters have had their own directorate, DG ENER, since the beginning of 2010.

Sweden's presidency concentrated on energy efficiency improvement

The foremost priority during Sweden's presidency of the EU in the autumn of 2009 was to tackle the climate problem. EU competitiveness should be enhanced by the change to an eco-efficient economy. In the energy sector, priority was given to performing the second strategic energy overview, with particular concentration on improving the efficiency of energy use.

Security of supply was also in the spotlight during the Swedish presidency, mainly due to the after-effects of the gas conflict between Russia and Ukraine in January 2009. The EU Commission brought forward a proposal for improved security of gas supply, which was given priority treatment by the Swedish presidency in order to enable negotiations to be concluded under the Spanish presidency in the spring of 2010.

In the energy sector, a completely new joint programme was started between the EU and USA under the name of the EU-USA Energy Council. Meetings will be held at ministerial level about twice a year, with work being carried out between these meetings by working parties concentrating on energy policy, technology, security of supply and markets.

There were also negotiations during the presidency period on membership of the Energy Community by Ukraine, Moldavia and Turkey, and on development of the energy market around the Baltic Sea. The strategically important work on the Baltic Energy Market Interconnection Plan constituted an important part.

It was decided during the Swedish presidency period that the EU's new compliance monitoring authority for the electricity and gas markets, ACER[16], should have its seat in Ljubljana in Slovenia. The authority will start work in March 2011.

Recent directives and regulations

Agreement was reached with the EU Parliament during Sweden's presidency period concerning all three legislative proposals in the energy efficiency improvement

16 European Agency for Cooperation of Energy Regulators

package. This includes the revised Directive Concerning the Energy Performance of Buildings, the Directive Concerning Marking of Energy-related Products, and the regulations concerning the marking of tyres. Regulations concerning security of gas supply were also agreed in the autumn of 2010. The following is a list of some of the new directives and regulations that have been recently agreed.

- Regulation Concerning the Marking of Tyres (Official Journal, 22nd December 2009). Marking of tyres to indicate their fuel efficiency, grip of wet road surfaces and noise, for passenger car and commercial vehicle tyres. Special marking will be agreed for studded tyres. These regulations will come into force with effect from November 2012.
- Revised Directive Concerning the Energy Performance of Buildings (Official Journal, 18th June 2010). With effect from 2020 (or from 2018 for buildings owned by the public sector), all new buildings must be close to zero-energy buildings. Member states must develop strategies to increase the proportion of low-energy buildings, and energy declarations must be included in all sale and rental negotiation contracts and in advertisements. The directive will be implemented in stages in Swedish legislation, starting in 2012.
- Revised Directive Concerning the Marking of Energy-related Products (Official Journal, 18th June 2010). Marking of domestic equipment will be expanded to apply to all energy-related products and industrial equipment, i.e. having the same scope as that of the expanded Eco-design Directive. The highest classification will be A+++, and the best available class will be indicated by dark green colour. Energy classes must be indicated in advertisements if the advertisements include energy-related information or price information. This directive must be implemented in Swedish legislation by the middle of 2011.
- Regulations concerning the security of supply of gas. These regulations are intended to improve the security of supply of gas within the EU by requiring each member state to meet special standards for infrastructure and gas supply, as well as making arrangements for ensuring that protected customers are guaranteed a supply of gas even in crisis situations. Member states are encouraged to work to gether regionally and to show solidarity in crisis situations.
- Regulations concerning notification of investments in infrastructure. New regulations have been produced in order to achieve better overview of planned investments in energy infrastructures. Member states will be required to submit reports to the Commission at two-year intervals concerning new and phased-out plants and facilities for the production and transmission of energy.

New legislatory proposals from the Commission on the way

A large number of legislatory packages such as the energy and climate package, the third single market package and the energy efficiency improvement package have been decided in recent years. The focus in the near future will therefore be mainly on implementation of recently agreed legislatory proposals. The national action plans for renewable energy over the period 2011-2020 form an important milestone in implementation of the energy and climate package. Details of these plans can be found on a special website[17]. The following is a selection of coming proposals from the EU Commission.

- The infrastructure package (expected in November 2010). This package will contain two notices: one concerning EU infrastructure development over the period 2020-2030, and one concerning the six priority infrastructure projects and the actions needed in order to be able to realise them. The purpose is to remove bottlenecks and to assist the establishment of links that ought to be available in a European perspective. The package also aims to assist the establishment of smart networks, which may help to resolve several obstacles in the way of a smoothly operating single market for energy, and thus contribute to achievement of the 20/20/20 targets.
- Proposal for transparency and independence of the wholesale electricity and gas markets (expected in November 2010).
- A revision of the Energy Taxation Directive.
- A revised action plan for energy efficiency improvement (expected in February 2010). A revised action plan for energy efficiency improvement was originally to have been presented in the autumn of 2009, but has been delayed and is now unlikely to be put forward before early 2011. Key points are the need for standards, whether there should be quantified targets, whether targets should be binding, methodology of evaluating improvements, and financing.
- Action plan for a low-carbon energy system by 2050. This action plan is expected to be ready some time in 2011, and will be preceded by a public consultation.
- Energy marking and ecodesign. New implementation measures for ecodesign and marking will be presented in the autumn of 2010: they will include washing machines, refrigerators and freezers.
- SET plan – launching of industrial initiatives. A further two industrial initiatives within the Strategic Energy Technology Plan will be launched. The two – bioenergy and fission – will complement the four industrial initiatives that were launched in the spring of 2010 (wind, solar, smart grids and carbon capture and storage). A fifth initiative, for smart towns, is next in line for launching, probably in 2011.

17 http://ec.europa.eu/energy/renewables/transparency_platform/action_plan_en.htm

A joint climate strategy for member states

Development in the EU has increasingly affected Swedish climate work. One of these is the European Climate Change Programme, of which the most important policy measure for reducing total carbon dioxide emissions within the EU is an internal system for emission rights trading.

The EU's emission rights trading system covers about a third of Swedish emissions, and applies to industries, electricity and heat producers. An overall emissions ceiling applies for the trading system as a whole. Exactly where the reductions are made depends on where they can be most cost-effective.

In March 2007, the Council of Europe agreed on emissions and renewables targets for the trading sector. With these targets, the EU has undertaken to reduce its greenhouse gas emissions by 20 % in 2020, as compared with emissions in 1990.

Starting from this decision, the EU Commission put forward an energy and climate package in January 2008, which proposed that responsibility for emissions should be shared by the trading sector and by the non-trading sector. Under the proposal, the trading sector would reduce its emissions by 21 % between 2005 and 2020, while the non-trading sector would reduce its emissions by 10 % over the same period. The respective permitted emissions for the non-trading sector would then be split between the 27 member states in proportion to their per-capita GDPs. For Sweden, this means a 17 % reduction in emissions, as compared with 2005.

Land use, land use change and forestry (LULUCF), is not included in the EU's 20 % target. If an international agreement is reached at the end of 2010, the Commission will decide by 30th June 2011 whether LULUCF is to be included in the emissions reduction commitments or not. The Commission has started a general consultation process on these matters. The results can affect how greenhouse gas emissions from the agricultural and forestry sector are accounted, as changes in carbon storage in the ground form a part of LULUCF and can also affect the decision concerning sharing of reduction commitments in the non-trading sector.

Discussions are at present in progress within the EU on increasing reduction targets to 30 %, instead of the present 20 %, as a contribution to a comprehensive global climate agreement for the period after 2012. However, this will require other industrial countries to commit themselves to making comparable emission reductions, and the more economically advanced developing countries to make reasonable contributions in accordance with their responsibility and capability.

1.3 International cooperation is important for tackling climate problems

A major conference on climate change was held in 1992, resulting in an agreement to tackle the global threat of climate change, with the parties to the conference signing the United Nations Framework Convention on Climate Change (UNFCCC)[18], 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.

FACTS – IMPORTANT DATES IN INTERNATIONAL CLIMATE COOPERATION

1992 The Climate Convention is adopted in Rio de Janeiro, Brazil
1993 Sweden ratifies the Climate Convention
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 rules and guidelines for implementation of the Kyoto Protocol
2004 Russia ratifies the Kyoto Protocol, thus bringing the number of ratifying countries over the number required for the Protocol to come into force
2005 The Kyoto Protocol comes into force
2012 Conclusion of the first commitment period

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.

Continuing climate cooperation negotiations

Negotiations on climate cooperation for the period after 2012 were started in Montreal in 2005, which was the first combined Conference of the Parties and Members of the Parties (COP/MOP 1). At this meeting, the Protocol acquired its final form in terms of rules for compliance. Subsequent meetings have been held in Nairobi, Bali, Poznan and Copenhagen. The results from the Bali meeting were presented in an action plan that describes the way forward towards agreement for the period after

18 United Nations Framework Convention on Climate Change, UNFCCC

2012, of which the aim was that the working programme that was initiated at the Bali meeting should culminate in a global climate regime, bringing in not only the USA but also large developing countries such as China, India and Brazil, at the meeting in Copenhagen in 2009.

No legal status for the results of the Copenhagen climate negotiations

The results from the Copenhagen meeting failed to produce the legally binding agreement that many of the parties had hoped for. Instead, the negotiations merely resulted in a political agreement with no actual legal status. The agreement contains indicative emission reduction targets and a recognition that the world's average temperature must not rise by more than two degrees. It was also decided that the developed countries should contribute USD 30 000 million over the period 2010-2012 as seed funding for climate measures in developing countries. With effect from 2020, financial support must amount to USD 100 000 million per year.

The Copenhagen Agreement includes establishment of a new technology transfer mechanism and a proposal for establishment of a new fund, the Copenhagen Green Climate Fund. The purpose of this fund is to handle financial assistance to developing countries in their work of necessary changes, emission reductions and technology transfer. The Copenhagen Agreement also includes paragraphs on immediately establishing a mechanism to reduce emissions from deforestation in developing countries[19].

Hopes for a legally binding agreement inn South Africa in 2011?

The mandate for the working programme that was initiated at the Bali conference has now been extended. Discussions are now considering whether it will be possible to achieve a legally binding agreement at the next COP/MOP meeting in South Africa in 2011. This would need to be built around a long-term global target for emission reductions, together with enhanced national and international actions to reduce climate effects. A central question in the negotiations is what a future climate regime should be based on, as certain parties have indicated that they will consider only a second Kyoto Protocol commitment period. Other parties want to see a future climate regime based on the results of the Copenhagen Agreement. However, the emission reduction targets from Copenhagen are not thought to be sufficient to counter a two-degree temperature rise. This means that a major question will be whether developed countries such as the USA, together with large developing countries such as China, India and Brazil, will commit themselves to ambitious legally binding reduction actions.

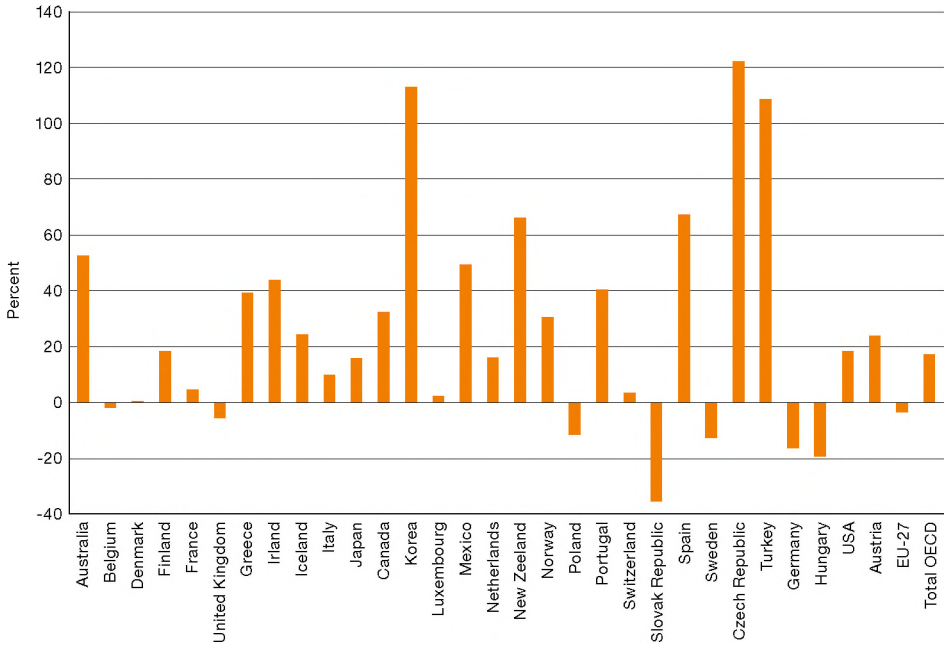
19 See the Copenhagen Accord, www.unfccc.int

Emission reductions set by the Kyoto Protocol

The Kyoto Protocol specifies that the industrial countries' total greenhouse gas emissions shall be reduced by at least 5 % relative to 1990 levels. For the EU15[20] , the first commitment period (2008-2012) requires their emissions to be reduced by 8 %. The EU states have reached agreement on internal burden-sharing, allocating the reductions between the countries with allowance for such factors as per-capita emissions, industrial structure and energy supply systems.

The Kyoto Protocol and the Marrakech Accord include what are known as 'Flexible Mechanisms'. They consist of emission trading (International Emission trading, IET), Joint Implementation (JI) and the Clean Development Mechanism (CDM). 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.

Figure 1 Changes in carbon dioxide emissions in EU and OECD states, 1990–2007



Source: OECD in figures, 2009 edition.

International cooperation is vital if climate objectives are to be achieved

In 2001, as part of Sweden's climate strategy, Parliament set a Swedish objective for greenhouse gas emission reductions that went 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

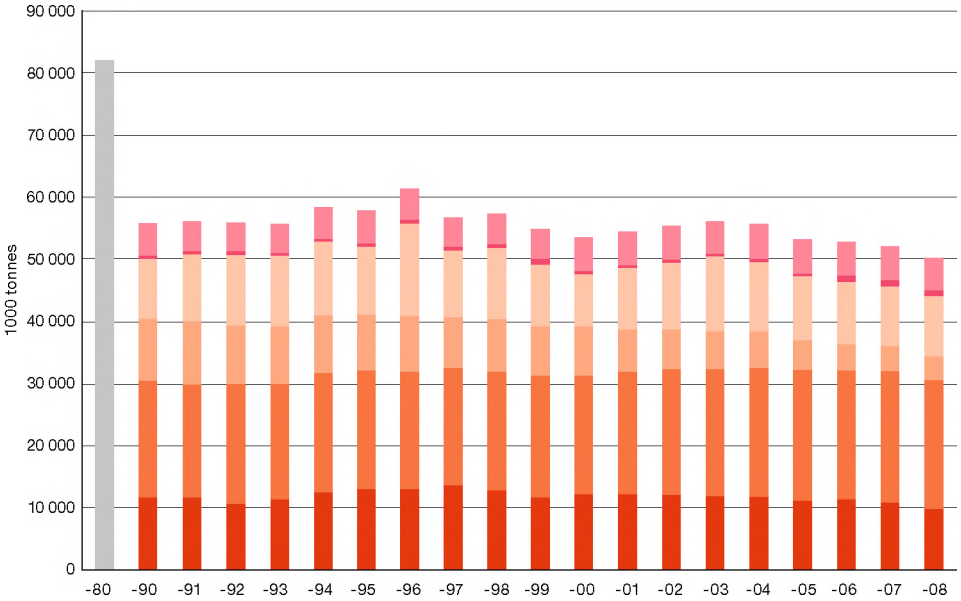
20 EU 15 refers to the 15 EU member states prior to the expansion on 1st May 2004.

its 1990 emissions. Sweden went further and, as its target, stated that its greenhouse gas emissions should not exceed 96 % of 1990 emissions (i.e. an actual reduction of 4 % in its emissions).

In 2008, Sweden's total emissions of greenhouse gases were 50 million tonnes of carbon dioxide, a reduction of 3,6 % relative to 2007, and of 10,9 % relative to 1990[21], see Figure 2.

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. 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 counte-

Figure 2 Carbon dioxide emissions in Sweden in 1980, 1990–2008



Note.
1. Including electricity production from industry.
2. Including cokeovens, refineries and waste incineration.
3. Including solvent and other products use.

Details are revised compared to earlier editions.

Source, 1980: Statistics Sweden, Statistical Notices, NA 18.
Source, 1990-2008: Sweden's report to the UN Climate Convention, National Inventory Report 2010.

21 Swedish Environmental Protection Agency: Climate in Change; http://www.naturvardsverket.se/sv/Klimat-i-forandring/Utslappsstatistik-och-klimatdata/

ring 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.

Flexible mechanisms complement actions at national level

The JI and CDM flexible mechanisms complement other actions intended to reduce greenhouse gas emissions at national level. They make it possible for one country to contribute to emission reductions in another country by means of concrete projects in a number of plants, 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 project 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[22].

The Swedish Energy Agency is the official Swedish Designated National Authority for the project-based mechanisms, with responsibility for approving Swedish companies and organisations wishing to participate. The role of the project authority also includes deciding whether proposed JI-projects in Sweden meet the requirements of the rules set out in the Kyoto Protocol[23]. The accumulated funds for international CDM and JI climate actions amount to about SEK 1 500 million for the period 2008-2012.

The total emission reductions achieved as a result of Sweden's CDM and JI programmes, together with the contribution from its participatory share in multilateral funds, amounts to 12-16 million tonnes of carbon dioxide-equivalents. Acquiring emission reduction credits through CDM/JI is cost-effective, as the cost for doing so via the project-based mechanisms is lower than the marginal cost of emission reductions in Sweden.

CDM and JI focus on energy efficiency improvement and renewable energy projects

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 should be 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

22 For further information, see www.unfccc.int

23 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.

has entered into purchasing agreements for emission reductions from CDM projects in Rwanda, Malaysia, Brazil, India, Vietnam, Mauritius, Tanzania and China.

In the field of JI projects, the Agency has entered into 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 registered in 2008, and the Estonia project was registered at the end of 2009.

Sweden participates in several multilateral funds

In addition to participation in bilateral projects, the Agency also participates in multilateral CDM and JI funds, a selection of which is shown below.

- The Testing Ground Facility (TGF) is a fund of which the purpose is to finance shared JI projects 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.
- The World Bank's Prototype Carbon Fund's (PCF) total capital amounts to USD 180 million, of which Sweden has contributed USD 10 million. The Agency has represented Sweden since the spring of 2009, and decided in that year to purchase further emission reductions to the value of USD 5 million.
- The Asiatic Development Bank's CDM fund, the Asia Pacific Carbon Fund (APCF), concentrates on CDM projects in developing countries in Asia. Together with six other European countries, Sweden has invested a total of USD 152 million, of which Sweden's contribution is USD 15 million. Projects are concentrated on renewable energy supply, improving the efficiency of energy use, and methane gas collection.
- At the end of 2008, the Agency entered into partnership with the Asiatic Development Bank's Future Carbon Fund, FCF. As with the APCF, the fund concentrates on acquiring emission reduction units from energy efficiency improvement, renewable energy and reduced methane emission projects in developing countries in Asia and the Pacific area. Sweden has invested USD 20 million in the fund.

Constant evaluation of Sweden's climate work

Swedish climate work and the national targets must be constantly monitored and evaluated. Sweden reports its greenhouse gas emissions to the UN climate secretariat and to the EU Commission once a year. In addition, it submits a national report on climate changes once every five years, describing what it is doing in order to achieve the commitments and requirements agreed in the Climate Convention and the Kyoto Protocol. The report includes emissions data, emissions forecasts and information on assistance to developing countries. All industrial countries that have ratified the Kyoto Protocol must submit a national report.

2 Policy measures and incentives

Various policy measures are employed in order to achieve the targets set up in the country's energy and climate policy. Those used today are intended to support development towards greater use of renewable energy, although reduced greenhouse gas emissions and improved efficiency of energy use are also priority areas.

2.1 Four main groups of policy measures

Policy measures are normally divided into four main groups, depending on how they work. The four groups are administrative, economic, informative and research-based: examples are shown in Table 1.

Table 1 Main groups of policy measures

Regulations	Taxes	Information	Research
Limit values (emissions)	Subsidies, grants	Advisory services	Development
Requirements for types of fuel and energy efficiency	Sureties	Training	Demonstration
Long-term undertakings	Emission rights trading	Opinion-forming	Commercialisation
Environmental classification	Electricity certificate trading		Procurement

Administrative policy measures are such as prohibitions or compulsory requirements issued by political or administrative bodies, and being mandatory in their nature. They may be quantitative, such as emission conditions, or technical, such as a requirement to use a particular fuel. Regulations forming part of the environmental framework code are examples of administrative policy measures, and form the basis of Swedish environmental policy.

Taxes, subsidies and sureties are examples of economic policy measures, acting by affecting the costs of an item. This in turn affects the behaviour of individuals and companies when considering purchases.

Information can modify attitudes or behaviour, and can create a more positive picture of, for example, economic policy measures. As opposed to administrative or economic policy measures, information is not mandatory.

Research and development is a form of policy measure in a long-term perspective. Technical development and knowledge of the effects of various changes are necessary in order to achieve various energy and environmental objectives in the long term.

2.2 The effect of taxes on the supply and use of energy

Originally, the primary aim of energy taxes was to assist financing of public activities. However, the environmental element of energy taxation has become increasingly important since the beginning of the 1990s. Present energy taxation is aimed at:

- Improving the efficiency of energy use.
- Favour the use of biofuels.
- Create incentives to reduce companies' environmental impact.
- Create conditions supporting indigenous production of electricity.

Since Sweden's accession to the EU, there has been a progressive alignment of Swedish taxation with that of the EU, as expressed mainly by the Energy Taxation Directive[24].

There are taxes on electricity and fuels, on carbon dioxide and sulphur emissions, and a levy system on nitrogen oxide emissions. The tax rates 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, on what it is being used for and whether it is being used in northern Sweden or in the rest of the country.

In 2009, revenues from energy and carbon dioxide taxes[25] raised SEK 73 000 million, making up 9.3 % of State revenue, see Table 2. There is also taxation expenditure[26] (tax relief) on the country's income budget[27]. Examples of taxation expenditure include energy tax relief for biofuels and peat, tax reductions for certain environmentally beneficial improvement installations in detached houses, and the reduction of the carbon dioxide tax for industry. All told, the sum of the energy-related items of taxation expenditure amounted to over SEK 40 000 million in 2009[28].

Table 2 Energy tax revenues, 2009, million SEK

Energy source or carrier	Energy tax	Carbon dioxide tax	Sulphur tax	Total
Petrol	13 895	11 037		24 932
Oil products	6 605	15 803		22 408
Crude tall oil	1			1
Other fuels	91	1 449		1 540
All fuels			56	56
Electricity	19 915			19 915
Waste				609
Production tax, nuclear power*				4 031
Total	**40 507**	**28 289**	**56**	**73 492**
Proportion of national tax revenue				*9,3%*
Proportion of GDP				*2,4%*

Source: Swedish Tax Board, Swedish National Financial Management Authority, Statistics Sweden.
*This tax is on power output at production level. It must not be confused with the energy tax on electricity paid by consumers.

24 Directive 2003/96/EC of the European Parliament and of the Council, Restructuring the Community Framework for the Taxation of Energy Products and Electricity.
25 The total of tax revenues from energy, carbon dioxide, other energy taxes and taxes on sulphur and raw tall oil.
26 The definition of taxation expenditure is that the tax received is less than a certain specified standard.
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 Government Parliamentary Communication on Taxation Expenditure 2009/10:195. Declaration of taxation expenditure 2010. Total of all items under spot taxes, net.

Energy taxes – both environmental and fiscal

'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 distinct boundary between the types, as both groups have an environmental effect as well as a fiscal function.

- General energy tax is levied on most fuels, based on various factors such as their energy contents.
- Carbon dioxide tax 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 1 öre on 1st January 2010, bringing it to 105 öre per kg of carbon dioxide.
- Sulphur tax 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 exempt from the tax.
- The environmental levy on the emission of nitrogen oxides amounts to SEK 50/kg of nitrogen oxides 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.

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

Table 3 General energy and environmental taxes from 1st January 2010, excluding VAT

	Energy tax	CO_2-tax	Sulphur tax	Total tax	Tax öre/kWh
Fuels					
Gas oil, SEK/m³ (<0,05 % sulphur)	791	3 013	-	3 804	38,2
Heavy fuel oil no. 5, SEK/ m³ (0,4 % sulphur)	791	3 013	108	3 912	36,9
Coal, SEK/tonne (0,5 % sulphur)	336	2 622	150	3 108	41,1
LPG, SEK/tonne	155	3 170	-	3 325	26,0
Natural gas, SEK/1000 m³	256	2 256	-	2 512	22,8
Crude tall oil, SEK/ m³	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*	160	3 840	-	4 000	16,1
Motor fuels					
Petrol, unleaded, environmental class 1, SEK/l	3,06	2,44	-	5,50	60,8
Diesel fuel, environmental class 1, SEK/l	1,33	3,01	-	4,34	43,6
Natural gas/methane, SEK/ m³	-	1,35	-	1,35	12,3
LPG, SEK/kg	-	1,67	-	1,67	13,1
Electricity use					
Electricity, northern Sweden, öre/kWh	18,5	-	-	18,5	18,6
Electricity, rest of Sweden, öre/kWh	28,0	-	-	28,0	28,2
Industry					
Electricity use, industrial processes, öre/kWh	0,5	-	-	0,5	0,5

Source: Swedish Tax Board, additional processing by the Swedish Energy Agency.
* The proportion of fossil carbon in domestic waste is assumed to be 12,6 % by weight.

Electricity and heat production are taxed differently

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. Since 1st July 2000, nuclear power plants have been taxed on the maximum permissible thermal power rating of their reactors: since 2008, this tax has been SEK 12 648 per MW and calendar month.

Heat production attracts energy tax, carbon dioxide tax and, in certain cases, sulphur tax and the nitrogen oxide levy. In principle, biofuels and peat used for electricity production are tax-free, but marketable heat produced in simultaneous production of heat and electricity[30] is taxed in the same way as in industry.

30 Simultaneous production of heat and electricity is known as cogeneration or CHP (Combined Heat and Power) production.

Combustion of certain domestic refuse is now also within the remit of energy tax. In 2010, the energy tax element amounts to SEK 160 per tonne of fossil carbon, while the carbon dioxide tax element is levied at the rate of SEK 3 840 per tonne of fossil carbon. Electricity production plants are also subject to property tax: for hydro power plants, for example, this amounts to 1.7 %.

Fuel use determines taxation

The carbon dioxide tax rate for industries that are not in the EU emission trading system (ETS) is 21 % of the general carbon dioxide tax level, which is reduced to 15 % for industries that are covered by ETS. The energy tax rate is zero for fuels used for heating purposes by energy-intensive industries outside ETS, as well as for fuels used in market gardening, agriculture, forestry and aquaculture[31], see Table 4. A further reduction of the carbon dioxide tax can be allowed under the 0.8 per cent rule[32], which applies to companies for which the carbon dioxide tax exceeds 0.8 % of their turnover. Tax above this cut-off point is levied at 24 % of the tax which would otherwise have been due[33].

Table 4 Energy and environmental taxes for industry, agriculture, forestry, aquaculture and heat production in CHP plants not in the EU emission trading system, from 1st January 2010

	Energy tax	CO_2 tax	Sulphur tax	Total tax	Tax öre/kWh
Gas oil, SEK/m^3	-	633	-	633	6,4
Heavy fuel oil no. 5, SEK/m^3	-	633	108	741	7,0
Coal, SEK/tonne	-	551	150	701	9,3
LPG, SEK/tonne	-	666	-	661	5,2
Natural gas, SEK/1000 m^3	-	474	-	474	4,3
Crude tall oil, SEK/m^3	799	-	-	799	8,1
Peat, SEK/tonne, 45 % moisture content (0,3 % sulphur)	-	-	50	50	1,8
Domestic waste, SEK/tonne of fossil carbon*	-	806	-	806	3,2

Source: Swedish Tax Board, additional processing by the Swedish Energy Agency.
* Maximum carbon dioxide tax relief (%) is obtained for an electrical efficiency of 15 %. Exemption from energy tax is obtained for an electrical efficiency of 5 %.

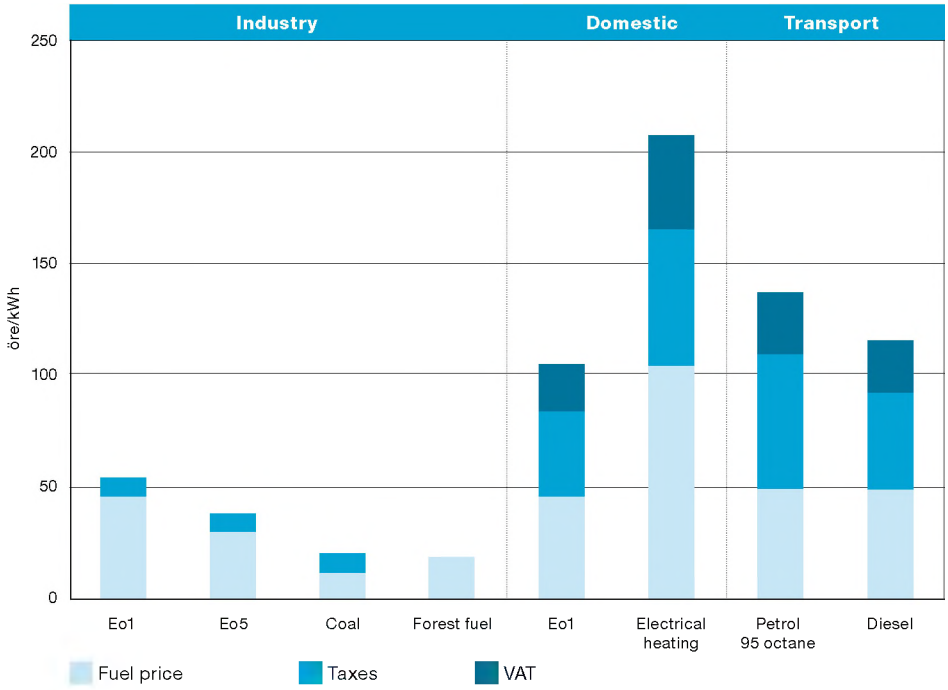
31 Aquaculture is concerned with the growth/cultivation of all kinds of aquatic creatures and plants in water.
32 The 0,8 per cent rule is being phased out, starting on 1st January 2011, when it will be increased to 1,2 % before being entirely eliminated in 2015.
33 Government Bill No. 2009/10:41.

There are various tax rates for transport, depending on the type of fuel, its environmental class, and its application. No energy tax is payable on the use of diesel fuel or fuel oils used in commercial maritime traffic or rail traffic, or on aviation petrol or aviation paraffin for commercial flights. Electricity for rail (and tram) traffic is also exempt from tax. 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 but does pay carbon dioxide tax.

In 2010, tax is charged at 0.5 öre/kWh on electricity used in manufacturing processes or in professional market gardening under glass. Electricity used in northern Sweden is taxed at 18.5 öre/kWh, as against 29 öre/kWh in the rest of the country. In addition to these taxes, value-added tax is also payable, at 25 %. VAT is not payable by industry.

In 2009, 50 % of the total cost of heating a detached house by oil was made up of tax. For drivers, 65 % of the cost of petrol was tax (including value-added tax). See Figure 3.

Figure 3 Total energy price for various customer categories, 2009



Source: SPI, Statistics Sweden and Swedish Tax Board.
Note: Prices for industry do not include any volume discounts.

Agreed changes to energy taxation

Various changes to the taxation system have been agreed, in accordance with the Government's Bill No. 2009/10:41, Certain Spot Taxation Considerations in Connection with the Budget Bill for 2010. The purpose of these changes is to achieve the country's targets for greenhouse gas emissions, for the proportion of renewable energy and for more efficient use of energy. The changes relate to fossil motor fuels and fuels used for heating purposes, as covered by the EU Energy Taxation Directive.

One of the changes to taxation of fossil motor fuels is that the energy tax on diesel fuel will increase by 20 öre per litre in 2011, as compared with the tax rate in 2010, and by a further 20 öre per litre in 2013. In addition, the carbon dioxide tax on natural gas and LPG will increase from 59 % of the general carbon dioxide tax level to 70 % in 2011, and to 80 % in 2013.

Both the energy tax and the carbon dioxide tax will increase for fuels used for heating purposes. In 2011, the energy tax will increase from 0 to 2.4 öre/kWh, and the carbon dioxide tax from 21 % of the general carbon dioxide tax level to 30 % for industry, agriculture and forestry outside the emission trading sector. The tax will be further raised to 60 % of the general carbon dioxide tax level in 2015. Industries covered by the EU ETS will be exempted from the carbon dioxide tax but will be subject to the energy tax of 2.4 öre/kWh. Heat production from combined heat and power plants will be taxed at the same energy tax rate as industries, but will also have to pay carbon dioxide tax which, with effect from 2011, will be levied at a rate of 7 % of the general carbon dioxide tax level[34]. These new tax changes are part of the Government's efforts to reduce exceptions to the energy taxation system, and thus make energy and carbon dioxide taxation more effective.

It has been decided that the rules governing taxation of biogas and other gaseous fuels delivered by piped services will be changed, in order to support a move towards a higher proportion of biogas in the country's energy system. The Government believes that tax exemption on biogas will increase the use of biogas in preference for natural gas. This will have the effect of improving the prospects for achieving the target for the proportion of renewable energy used by 2020. Today, biogas is tax-exempt, under the provisions of Article 16 of the Energy Taxation Directive. Under the new taxation rules this tax exemption will follow the gas right through to the end-user, as a result of agreements between the end-user and the supplier of biogas to the natural gas network. The current exemption for biogas will be abolished with effect from 1st January 2011: instead, tax exemption for biogas will be effected through a deduction in the tax payer's tax return. The new rules will require changes to the Energy Taxation Act (1994:1776)[35].

34 Government Bill No. 2009/10:41
35 Government Bill No. 2009/10:144

2.3 The Green Electricity certificate scheme supports renewable electricity production

Sweden's Green Electricity certificate scheme is a market-based support system to assist expansion of production of electricity in Sweden from renewable sources and from peat. The objective of the system is to increase the production of electricity from such energy sources by 25 TWh by 2020 (as compared with production in 2002). The scheme is intended to run until the end of 2035.

Rising proportion of renewables

Electricity produced from wind power, solar energy, wave energy, geothermal energy, certain biofuels and certain hydro power qualifies for green electricity certificates. With effect from 1st April 2004, electricity produced from peat in cogeneration plants has also qualified for certificates. Electricity production that qualified for Green Certificates in 2009 amounted to 15.6 TWh, see Table 5.

Table 5 Production and installed capacity, by type of production, 2003–2009

	2003 May-Dec	2004	2005	2006	2007	2008	2009
Number of plants[1]	1 597	1 759	1 848	1 909	2 075	2 219	2 419
Hydro	966	1 040	1 060	1 075	1 094	1 120	1 144
Wind	543	613	668	706	846	948	1 108[3]
Biofuels, peat	87	105	118	125	131	142	156
Solar	1	1	2	3	4	9	11
Installed capacity [MW][2]	4 049	4 161	4 471	4 765	5 066	5 123	5 935
Hydro	491	504	517	540	558	598	602
Wind	401	472	530	583	831	1 074	1 440
Biofules, peat	3 157	3 185	3 424	3 643	3 676	3 451	3 892
Solar	0,008	0,008	0,011	0,036	0,043	0,309	0,369
Electricity production - renewable and peat [MWh]	5 637 559	11 048 438	11 298 378	12 156 855	13 255 913	15 036 828	15 569 665
Hydro	963 637	1 968 325	1 799 446	2 018 577	2 195 320	2 607 348	2 441 624
Wind	455 642	864 546	939 125	988 340	1 431 644	1 995 846	2 490 409
Biofules	4 218 276	7 670 770	7 925 790	8 593 538	9 049 308	9 599 311	9 765 983
Peat	-	544 791	634 012	556 380	579 622	834 194	871 437
Solar	4	6	5	20	19	129	212

Source: Svenska Kraftnät and the Swedish Energy Agency.

Note: 1) Number of plants allocated one or more electricity certificates in the respective years
2) For plants allocated one or more certificates
3) 1 108 wind farms, with a total of 1 319 individual wind power turbines

However, under Directive 2001/77/EC (on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market), peat is not counted as a renewable fuel, which means that electricity production from renewable energy sources under the green electricity certificate scheme in 2009 amounted to 14.7 TWh.

Electricity suppliers and users must buy certificates

Producers of renewable electricity receive one certificate unit from the state for each MWh of electricity that they produce. This provides an incentive to expand electricity production from renewable energy sources and/or using new technology. In 2009, users were required to buy certificates corresponding to 17.0 % of their electricity use. New plants receive certificates for 15 years, while those plants started up before 1st May 2003 will be progressively phased out of the scheme at 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. Certain use of electricity is exempted from the quota obligation requirement, with the largest exemptions being for electricity-intensive companies[36].

Figure 4 Average spot traded price for electricity certificates, 2003–2009

Source: Svensk Kraftmäkling.

36 For a definition of electricity-intensive companies, see the Swedish Energy Agency's annual Electricity Certificate System report.

The price of certificates depends on the interaction of supply and demand on a competitive market. Several factors affect the price levels, such as the expected demand for electricity and expected bringing on line of new production. Changes to the certificate system as a result of political decisions also affect pricing. All these factors are considered by the parties on the market, with the result that the actual trading prices become an indicator for expected supply and demand of certificates. If the market is expecting, for example, a shortage of electricity, then the price of certificates will rise, and vice versa. Figure 4 shows the spot price of electricity certificates since the start of the system on 1st May 2003.

2.4 Emission rights trading – an important climate policy instrument

The EU Emission Trading System (ETS) is an important 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 a limited ceiling. From 2008 to 2012, the ETS 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.

Sweden will allocate 19.8 million emission rights (EUA – European Union Allowances) per year to existing plants during the 2008-2012 trading period. A further 13.1 million units will be held back to provide a reserve for new entrants to the scheme during this period. These proposed allocations are detailed in the National Allocation Plan (NAP), which must be submitted to, and approved by, the EU Commission. Taken together, the various member countries' allocation plans form a total ceiling for the number of emission rights.

With effect from 2008, a limited number of EU countries have included nitrous oxide in the system in addition to carbon dioxide. More greenhouse gases and activities will be brought into the ETS with effect from 2013. Aviation will be brought within the remit of the system with effect from 2012.

Energy-intensive industries and producers of electricity and heat covered by the system at present

The Emission Trading System covers only energy-intensive industries and electricity and heat producers, although other companies, individuals and organisations may also participate. In total, about 40 % of greenhouse gas emissions in the EU are within the remit of the system. In Sweden, about 35 % of greenhouse gas emissions are covered by the trading system[37].

Each year, businesses having installations covered by the system are required to surrender emission allowances equivalent to their emissions for the year. One emission right unit corresponds to one tonne of carbon dioxide. Businesses that exceed their allocation must either reduce their emissions or buy surplus rights from some other source. It is also permitted to use emission reduction credits from Clean Development Mechanism, CDM, or Joint Implementation, JI projects.

Companies' rights to use reduction units during the 2008–2012 trading period have been limited by the EU Commission, with the limit depending on how close the member state is to fulfilling its Kyoto targets, and on whether the state itself is also purchasing reduction units. Swedish companies are permitted to use project credits to meet up to 10 % of the total national allocation. This limitation has been redistributed at plant level on the basis of carbon dioxide emissions in 2006, in order to allow a greater number of plants to submit reduction units instead of emission allowances.

Supply and demand determine the market price of emission rights

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.

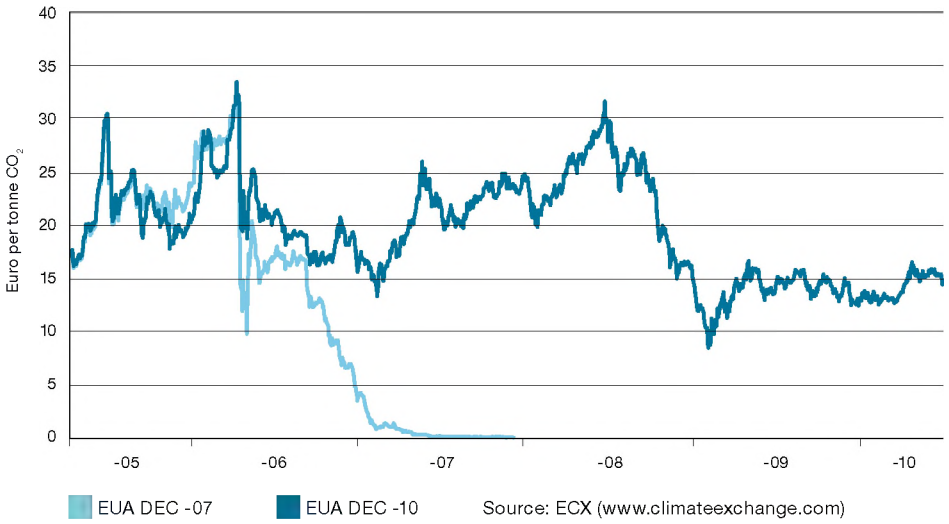
Emissions during the first period of the trading system, from 2005 to 2007, were 3.5 % less than the allocated allowances[38], which means that there was a substantial surplus of emission rights on the market. As a result, the price of rights dropped towards zero for the remainder of the trading period. A contributory factor to the price drop was that emission rights were valid only until the end of the 2005–2007 period.

For the 2008–2012 period, the Commission has reduced the total allocation of emission rights to 2080 million allowances per year, equivalent to a 9.5 % reduction in comparison with the 2005–2007 period. During the first half of the 2008–2012 period, the price of emission rights varied widely. When the prices of oil and gas rose,

37 In accordance with Sweden's national allocation plan for 2008-2012. The 35 % figure is based on Swedish emissions in 2004.
38 Point Carbon

for example, the price of an emission right unit rose to about EUR 30. Prices started to fall as the 2008 finance crisis evolved, reaching a minimum of about EUR 8 at the beginning of 2009. The market had recovered somewhat by the spring of 2009, with the price of a unit settling in the range of EUR 12–16. The gradual improvement in economic conditions is one of the explanations for the rise in price. The price can also have been affected by a political factor in the form of the new trading directive, which restricted the amount of rights available for the period 2013–2020. It is now permitted to carry emission rights forward to the next trading period, to use them as a buffer to cover a possible future deficit.

Figure 5 Prices of emission allowances, 2005–2010



2.5 Start of a new period in the Energy Efficiency Improvement Programme

The overall objective of the Programme for Energy Efficiency Improvement in Energy-Intensive Industry (PFE) is to support efficient use of energy. The 97 companies that have been involved in the programme since it started in 2004 have now submitted their reports on the results of their energy efficiency improvement work. The total results substantially exceed the original target, and the companies are now continuing to work in a new programme period.

Good results from the first period

The first PFE period has resulted in a total annual electricity saving of 1.4 TWh. This is equivalent to the annual electricity use of 80 000 detached houses having electric heating, or the entire annual electricity demand of the city of Uppsala. The companies have achieved this result through their efficiency improvement measures and improved procedures for energy-efficient purchasing and project designs.

During the programme period, the companies invested SEK 636 million in almost 1 100 efficiency improvement measures. These measures alone are calculated as having resulted in savings of SEK 429 million per year. The average payback time for the various measures is 1.5 years.

In addition to the direct improvement in the use of electricity, the companies have also been able to increase their internal electricity production by 1 TWh per year, through such means as reducing the amount of process steam that they need, and thus having more steam to put through their turbines. In total, the PFE companies produce 6 TWh of electricity per year.

Reduced electricity tax

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[39]. With effect from that date, manufacturing industry, which had hitherto enjoyed a zero tax rate on electricity used by it for its processes, became liable to an electricity tax of 0.5 öre per kWh. In June 2004, the Government tabled a bill setting out an energy efficiency improvement programme, which came into force on 1st January 2005[40]. 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.

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. The energy management systems and energy audits that form part of the programme 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. They also undertake to implement, within the five-year duration of the programme, all the energy efficiency improvement measures that have

39 Council Directive No. 2003/96/EC

40 The Act (2004:1196) Concerning a Programme for Energy Efficiency Improvement etc.

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.

Start of a new period

Companies are welcome to participate in a new five-year period after completion of the previous period. Completely new companies may also join the new programme period. As the EU's public subsidy rules for environmental protection have been changed, the Government has had to apply to the EU Commission for new approval for a further five years of PFE. While waiting for approval from the Commission, the Swedish Energy Agency has accepted new applications. All except six of the previously participating companies have applied to join the new programme period immediately following on from the previous period. As of January 2010, 92 companies were involved in the programme, with more than 200 separate plants.

2.6 Legislation and financial support to influence energy use in buildings

There are several policy measures to influence energy conservation in buildings. Some of the more important are building regulations, energy declarations and financial incentives in the form of tax relief for repair and maintenance. Other measures include various forms of grants and subsidies for solar cells and conversion grants for replacement of heating systems.

Building regulations and energy declarations to reduce energy use

The Building Regulations[41] include specific requirements concerning the energy use of new buildings, describing how buildings must be designed in order to limit their energy use. With the help of the advice in the energy declarations, the owners of existing buildings can also work towards low heat losses, low cooling requirements, efficient use of heating and cooling services and efficient use of electricity.

Owners of detached houses, apartment buildings and commercial premises are required to provide information on the building's energy use. The declaration is prepared by an authorised energy inspector together with the building's owner. The inspector fills in the form, which gives details of the amount of energy required to run the building. The declaration may also provide advice on how the energy efficiency of the building can be improved. Declarations have been required for apartment buildings and commercial premises since the beginning of 2009. Since the beginning of 2009, declarations have been required for detached houses when they have been put up for sale.

41 Latest change, BFS 2006:22, Section 9

Economic support for reduced energy use and a greater proportion of renewable energy

The main purpose of tax relief for repair, maintenance and conversion/extension work is to help to create jobs in the building industry. Several energy-saving measures are included, thus making them tax-deductible. The new regime was introduced on 8th December 2008.

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

The purpose of grants for conversion of heating systems[42] 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 biofuelled boilers. The grant has been available since the beginning of 2006, and will run until the end of 2010.

2.7 Developments in the transport sector affected by EU requirements

There are many policy measures that affect development of the transport sector in Sweden. At the EU level, measures include the Renewables Directive (2009/28/EC), which specifies the use of at least 10 % of renewable energy in the transport sector by 2020. The Fuel Quality Directive (2009/30/EC) specifies permitted levels of low-admixture additives in motor fuels: 7 % by volume of FAME in diesel fuel, 10 % by volume of ethanol in petrol, and 3 % by volume of methanol in petrol. The directive also requires suppliers of fossil fuels for the transport sector to reduce their life cycle greenhouse gas emissions per energy unit of fuel by 6 % by 2020, from a base value that has not yet been decided.

Regulation EC No. 443/2009 Setting Emission Performance Standards for New Passenger Cars means that new passenger cars sold within the EU must not, on average, emit more than 130 g CO_2/kilometre. The requirement will be introduced progressively, applying to 65 % of all new vehicles in 2012 and to all new vehicles in 2015. With effect from 2012, aviation will also be included in the EU emission trading system, applying to all aircraft landing or starting from an airfield in the EU.

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

Economic policy measures in the transport sector to increase numbers of low-carbon vehicles

Motor vehicle tax was changed in October 2006, to be based on the vehicle's carbon dioxide emissions instead of, as was previously the case, on the vehicle's weight. The purpose of this change is to encourage the sales of more low-carbon vehicles. With effect from 2011, the carbon dioxide multiplier will be increased from SEK 15 to SEK 20 per gram of CO_2 per km. The emission level above which the charge will apply will be increased from 100 to 120 gram CO_2 per km. Some relief will be provided for vehicles capable of running on biobased motor fuels by reducing the carbon dioxide multiplier to SEK 10 per gram CO_2 per km instead of SEK 20. Starting in 2011, the vehicle tax for newly registered light goods vehicles, buses and motor caravans will also be subject to the carbon dioxide tax charge. The vehicle tax for heavy goods vehicles does not include a carbon dioxide multiplier element, but depends on the vehicle's weight and exhaust levels.

The notional benefit of a free vehicle is subject to income tax and the social insurance and related tax paid by employers. Free fuel may also be included, and is also subject to tax. The actual tax levels for these benefits affect the sales and use of vehicles. The present structure of notional value tends to even out the effect of price differences between cars, with the result that cars provided as a benefit to employees emit more carbon dioxide per km than the average for new cars[43].

Heavy goods vehicles and trailers weighing more than 12 tonnes are subject to a toll charge. The charge is based on the vehicle's exhaust emissions category and the number of axles, and is payable for one year at a time. Some offset relief is provided by a reduction in the vehicle tax.

Biobased motor fuels pay no energy or carbon dioxide tax, which affects the profitability of using such fuels. The availability of biobased motor fuels has been affected by the requirement that filling stations selling more than a certain volume of fuel must also sell a renewable-based alternative. As this requirement resulted mainly in an increase in the number of E85 pumps, a grant was also introduced for investment in other pumps. This grant is no longer available.

With effect from 1st July 2009, clean vehicles are exempted from vehicle tax for five years: in addition, their notional taxable value is also reduced. Public authorities are also required to ensure that passenger cars that they purchase or lease must be clean vehicles (SFS 2009:1), and that their light goods vehicles must have emission levels less than 230 g CO_2/km.

43 Swedish Energy Agency, ER2007:28

FACTS – DEFINITION OF CLEAN VEHICLES

The following requirements must be fulfilled if a car is to be classified as a clean vehicle:

- For conventional passenger cars, including hybrids, carbon dioxide emissions must not exceed 120 g/km. For diesel cars, there is an additional requirement that particle emission must not exceed 5 mg/km.
- For cars running on alternative fuels (i.e. other than petrol, diesel oil or LPG), fuel consumption must not exceed 0.92 litres of petrol per 10 km or 0.97 m^3 of gas per 10 km.
- For electric cars, electrical energy use per 100 km must not exceed 37 kWh.
- The definition for reduction of a car's notional taxation value, for taxation at 20-40 %, is that the vehicle can be wholly or partly powered by alcohol, gas (not LPG) or electricity. This means that, for example, all types of hybrid vehicles are included.

Regional policy measures

A congestion charge was introduced in Stockholm in 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. Gothenburg will introduce a congestion charge on 1st January 2013, but differing from the Stockholm charge in that its revenue will also assist investment in the railway network and in public transport.

Other regional or local policy measures exist or are planned. A couple of examples are exemption of clean vehicles from parking charges and subsidies for public transport.

2.8 Technology procurement supports development of new technology

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 in the form of new products and/or systems. Technology procure-

ment is intended to work within normal market forces and limitations, with the aim of creating long-term results for the particular industry in focus. It 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 permanent purchaser groups for residential buildings, commercial premises and food retailers. Other procurement projects are performed in conjunction with networks in the public sector, detached house owners, sector organisations etc.

Most technology procurement projects are carried out 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[44] of all technology procurement projects in the energy field that have been carried out by it or by its forerunners.

Since the 1990s, about 60 different technology procurement projects have been initiated and partly financed. Current technology procurement projects include heat recovery in existing apartment buildings, additional insulation for apartment buildings by means of prefabricated wall elements, climate screen-integrated systems for solar shading and daylight penetration in commercial premises, and the use of cooling towers rather than chillers in commercial premises.

During 2010, the Agency agreed to provide an SEK 62 million subsidy to the city of Stockholm which, in conjunction with Vattenfall AB, is planning to perform Sweden's largest technology procurement project for electric vehicles. The purpose of the procurement is to start a Swedish market for electric vehicles, and thus assist the country's changeover to a sustainable energy system. The target of the procurement project is that 1050 electric vehicles should be in operation in Sweden by the end of 2012.

2.9 Research for conversion of the energy system

Research, technical competence and employment of the correct technology are needed in order to convert the country's present-day energy system and to strengthen its competitiveness. With an investment proportion of 3.8 % of BNP, Sweden is among the world leaders in terms of investment in research and development[45].

Energy research is carried out under the Energy Research Programme, which covers the entire chain from fundamental research and technical development to demonstration and commercialisation activities. The work includes development of technology and services that can be commercialised by Swedish industry for the international market[46].

44 The list can be downloaded from www.energimyndigheten.se, under företag [companies].
45 www.energimyndigheten.se
46 For a more detailed presentation of Sweden's energy research programme and its constituents, see Energiforskningsläget 2006, ET 2007:01.

Energy research includes such aspects as large-scale renewable electricity production, electrical drive systems, hybrid vehicles, biobased motor fuels and energy combinates. Some of the financing will be invested in fundamental energy research in the fields of nuclear technology and carbon capture and storage (CCS)[47]. For the 2010 budget year, the Agency's grant for energy research amounts to SEK 1 320 million[48].

Improved energy utilisation in the residential, industry and transport sectors

Research into energy systems in buildings includes the supply and distribution of heat and electricity, as well as overall systems aspects of buildings. The target is to reduce the need for energy and to develop supply and distribution technologies.

Research in connection with energy-intensive industries is concentrated on more efficient use of energy in energy-demanding process stages and on the capture and beneficial use of waste products. This applies particularly for energy-demanding process stages in the pulp, paper and steel industries. There is also considerable potential for increasing the collection of waste products from industry.

In the transport sector, research is concentrated on the production of alternative motor fuels and energy-efficient vehicles. For combustion engines, development is concentrated primarily on reducing the fuel consumption of passenger cars and heavier vehicles. Research into electrical drive systems is concentrated on electric vehicles, hybrid vehicles and fuel cells. Development and commercialisation of hybrid vehicles has been intensified, and now extended so that it also includes rechargeable hybrids.

The results of research into energy systems are important when making policy decisions relating to energy and climate. This work is aimed at improving knowledge of, and competence in, the energy system and its dynamics and the effects of and on international climate policy.

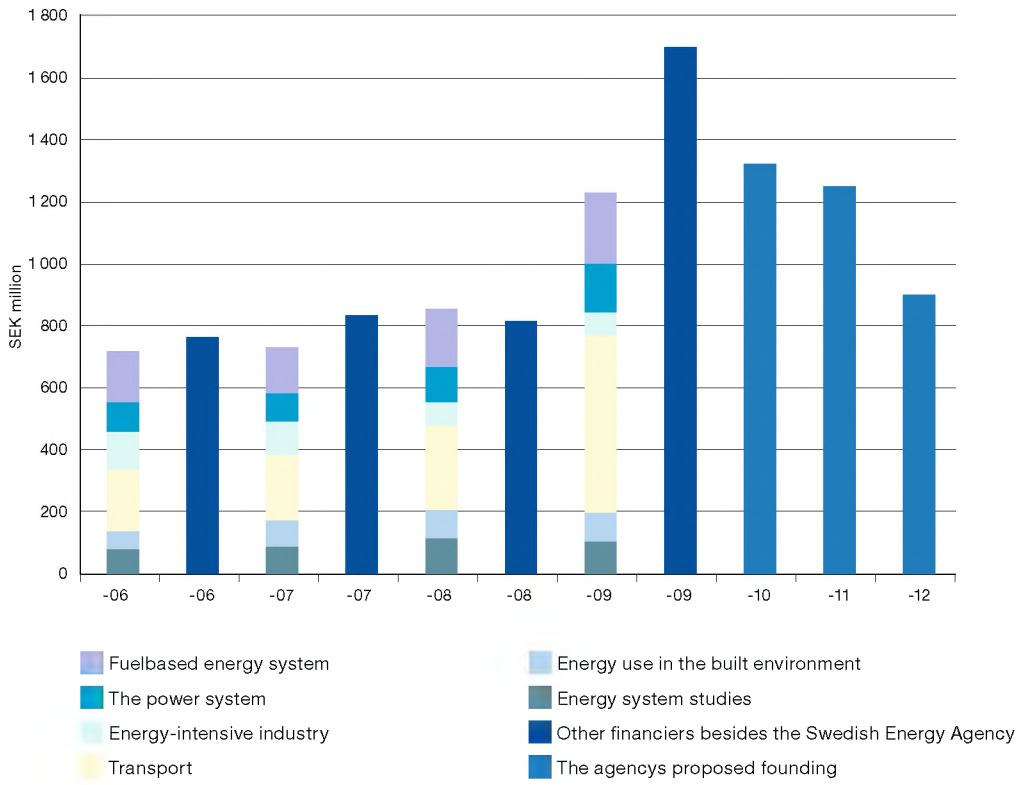
The importance of cost efficiency in increasing renewable electricity production

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. In the field of solar cells, work is concentrated 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.

47 Government Bill No. 2008/09:163 – A Coordinated Climate and Energy Policy - Energy
48 The Agency's funding allocations document for the 2010 budget year.

As far as fuel-based energy systems are concerned, we need to increase the availability of fuels and to improve the cost efficiency and resource efficiency of the entire chain from raw material to finished product. Electricity yield needs to be improved, and new energy conversion technologies need to be commercialised. Sweden is one of the leading countries in the production and use of solid processed fuels, such as pellets. Heating and combined heat and power technology are being investigated in order to find ways of improving the efficiencies of established technologies. Work also includes investigation of the necessary conditions for the introduction of new technologies with improved performances.

Figure 6 Research, development and demonstration funding, 2006–2012



Source: Swedish Energy Agency's Annual Report, 2009 (ER 2010:01), Budget Bill 2009/10:1 Expenditure Area 21, Energy.
Note: For 2006–2009, the figure refers to approved funding. For 2010, the figure shows proposed funding, while for 2011–2012 it is expected funding. The figures are therefore not strictly comparable between years.

Sweden and international energy research

Sweden participates in several different international cooperative research projects, particularly within the framework of Nordic energy research, the Seventh EU Framework Programme, and the IEA's Implementing Agreements. 2010 saw the launch of the first four European Industrial Initiatives within the framework of the EU's Strategic Energy Technology Plan. Cooperation between industries in the field of energy research must be increased if the energy-related and climate-related targets are to be achieved. The four areas that have now been started are wind, solar, smart grids and carbon capture and storage. The SET plan runs until 2020, and both public and private funding of European energy research need to increase by EUR 50 000 millions.

2.10 The Rural Development Programme – supporting sustainable development

The Rural Development Programme is intended to support sustainable economic, ecological and social development of Swedish rural areas. The programme, which is financed both by the EU and by Sweden, has a total budget of SEK 35 000 million for the period 2007–2013. SEK 200 million has been earmarked for investments in agricultural production of biogas by digestion of manure for the period 2009–2013.

2.11 Information campaigns to improve awareness and understanding

In addition to being a useful means of raising awareness or improving understanding, information can also help to change the attitudes and behaviour of persons or groups. 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.

New web sites launched

The most substantial information campaigns have been run on the internet. The Agency has, for example, created the Vindlov and Nätverket websites for wind power, both intended to provide information for various parties on wind power. In addition, a completely new and expanded version of the energy calculator has been launched, together with a re-worked and improved website for children and teachers. The Vindlov website, which is a shared site for about 20 public authorities and organisations, provides an overall view and approach to the planning process for wind power plants. The national Nätverket wind power site supports expansion of wind power production by providing knowledge and information on wind power, as well as by supporting regional initiatives of national importance.

Updated information to consumers

The completely new version of the energy calculator can be used both by detached house owners and apartment occupiers. It provides suggestions for improvements to suit each particular home, and shows potential savings in SEK, kWh and CO_2 reductions.

The site for pupils and teachers has been given a new format and an expanded content. It includes web pages on different forms of energy, and provides answers to common questions. The 'Energy in Schools' brochure has been produced for Year 9 students, and includes a guide on how to measure the amount of electricity and heat being used by a school.

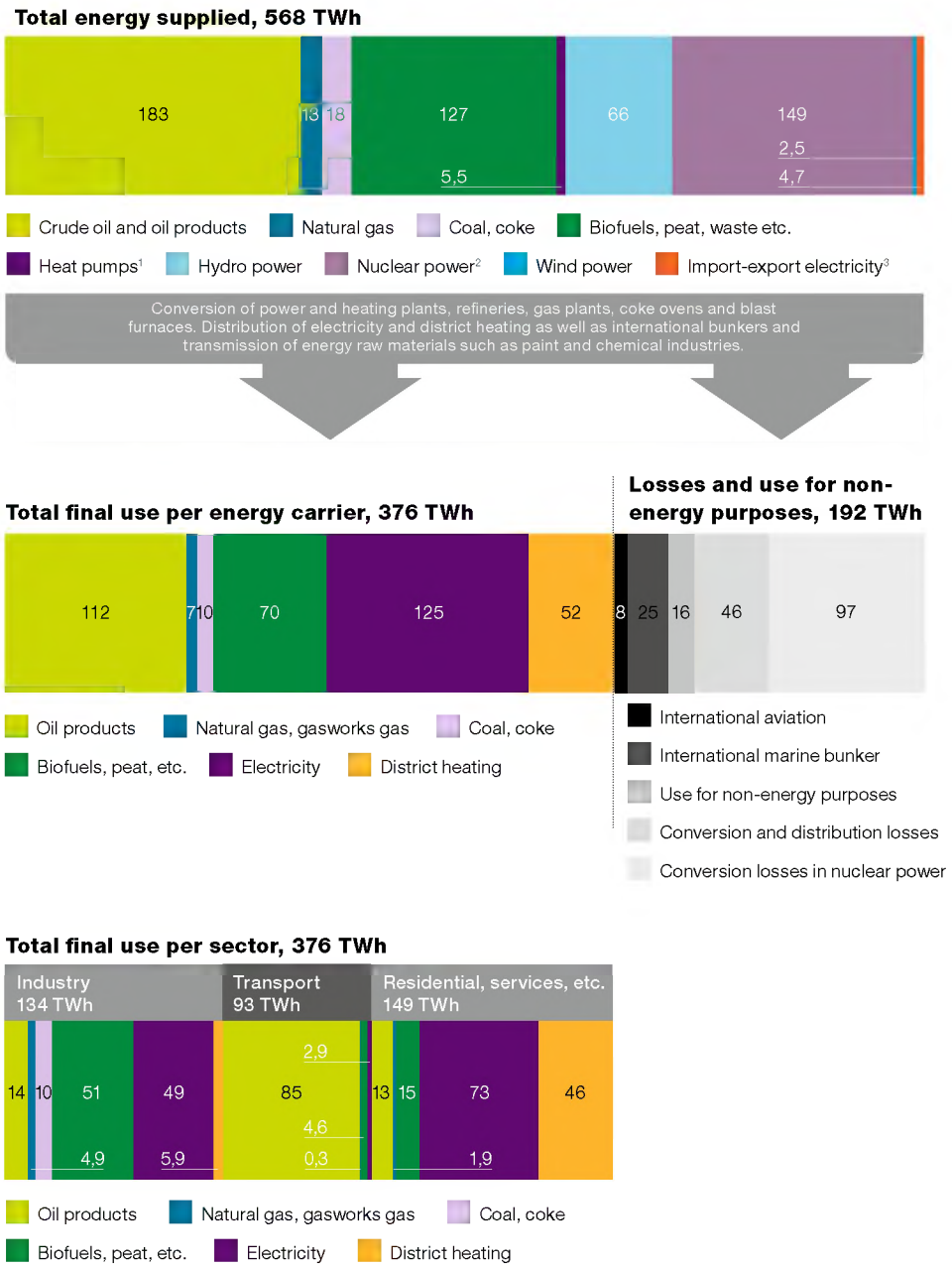
Web information for domestic users, small and medium-sized companies and property-owners has been expanded. The Agency is also active in providing information on tests of energy-using products such as lighting and heat pumps, with this information being much in demand by its target groups.

The Agency supports the work of regional and local authority energy and climate advisors, who provide a link to householders and small and medium-size companies. Covering the entire country, they provide cost-free and impartial advice.

3 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. The supply of energy in Sweden is increasing more rapidly than the demand for it, but this is a statistical effect due to certain losses having been moved from the user side to the supply side. Sweden's proportion of renewable energy is considerably higher than the proportions in other countries, which is due largely to the fact that Sweden has major renewable energy resources, such as hydro power and biomass.

Figure 7 Energy supply and use in Sweden, 2009, TWh



Source: Statistics Sweden and the Swedish Energy Agency.
1. These are large heat pumps in the energy sector. 2. Nuclear power is shown as gross power, i.e. as the nuclear fuel energy input, in accordance with the UN/ECE guidelines. 3. Net import of electricity is treated as supply.

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.

FACTS – ENERGY STATISTICS

As far as energy statistics are concerned, there are short-term statistics and yearly statistics. At the time of writing, only short-term statistics are available for 2009: for annual statistics, 2008 is the most recent year of publication. This edition of Energy in Sweden therefore presents annual statistics up to and including 2008, complemented by short-term statistics for 2009. There are differences in level between these two, as they are based on different investigations and because the methods of allocating energy between different energy carriers and sectors differ to some extent. There are also differences for individual energy carriers, as well as for the total energy use per sector.

3.1 End use in constant change

Energy use consists of the total final energy use in various user sectors, energy losses, the provision of fuels for foreign maritime and aviation transport, and the use of energy materials for non-energy purposes. Total energy use in 2009 amounted to 568 TWh: of this, total final energy use in industry, transport and the residential sector amounted to 376 TWh.

The remainder, 192 TWh, consisted of losses, the use of fuel oils for overseas transport[49], and use for non-energy purposes. The losses that are shown in Figure 7 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[50] and distribution losses in connection with the supply of electricity, district heating, natural gas and town gas, coke oven gas and blast furnace gas. Note that losses that occur in connection with final use are included in their respective user sectors and are therefore not shown separately. Losses in hydro power production, too, are excluded.

49 Includes international maritime and air transport.

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

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 use for these purposes amounted to just under 16 TWh in 2009.

Electricity and oil are today's main energy carriers

Electricity is the dominating energy carrier. Final use of electricity in 2009 amounted to 125 TWh, of which the industry sector used 49 TWh and the residential and services sector used 73 TWh. Use of electricity in the transport sector amounted to 2.9 TWh.

Final use of oil products in 2009 amounted to 112 TWh, with most of this use being in the transport sector. The use of biofuels, peat and waste amounted to 70 TWh, with almost 51 TWh being used in industry[51], 15 TWh being used in the residential and services sector, and 4.6 TWh being used in the transport sector.

Almost 52 TWh of district heating were supplied in 2009. Of the total quantities, about 90 % were used for heating in the residential and services sector, and 10 % were used in industry. Some industries sell 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, which has the effect of upward distortion of the short term statistics for industrial use of district heating. A corresponding decrease appears in industry's use of biofuels.

Final use of coal and coke in 2009 amounted to 10 TWh, all of which was used in industry, where coal and coke are used as the reducing agents in blast furnaces.

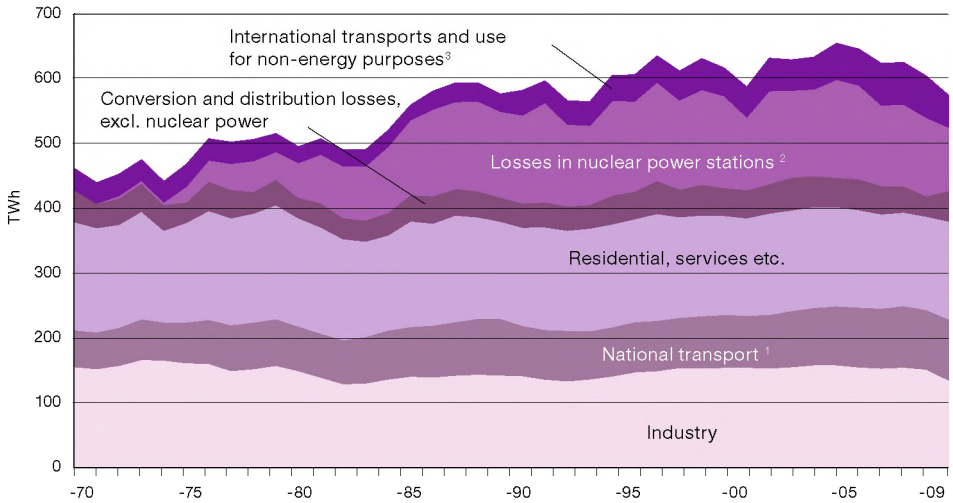
Final use of natural gas increased in comparison with earlier years, to the extent that it now supplies 2 % of total energy use. Industry accounted for 71 % of its use, and the residential and services sector for 24 %. A small amount of natural gas is also used as a motor fuel.

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

Sweden's total energy use is declining

Figure 8 shows Sweden's total energy use from 1970 until 2009. Recent years show an overall decline in energy use, although trends differ between sectors. Industry uses about the same amount of energy today as it did in 1970, despite the fact that industrial production is considerably higher today. The residential and services sector has reduced its use of energy since 1970, but this is due to several structural changes. The change from oil to electricity, for example, has meant that some of the losses have been transferred to the supply side of the energy system. Energy use in the transport sector has increased by almost 70 % since 1970.

Figure 8 Sweden's total energy use, 1970–2009



Source: Statistics Sweden and the Swedish Energy Agency.
Note: 1. Foreign aviation included in this item until and including 1989. 2. Nuclear power is shown as gross power, i.e. as the nuclear fuel energy input, in accordance with the UN/ECE guidelines. 3. Foreign aviation included in this item from and including 1990.

3.2 The balance of supply and use

The quantity of energy used always corresponds to the quantity supplied. In 2009, Sweden's energy supply amounted to 568 TWh.

Low nuclear and hydro production in 2009

During 2009, major work was carried out in several of the country's nuclear reactors to increase their outputs. The reactors were shut while the work was carried out and as a result the amount of electricity supplied by them during the year was less than in previous years. A total fuel input of 149 TWh was used, producing somewhat over 50 TWh of electricity.

Hydro power production depends on the amount of precipitation during the year. In 2009, it produced 66 TWh of electricity, or somewhat less than the statistically average annual production of 67.5 TWh.[52]

Fuel-based thermal power production produced 15.5 TWh of electricity, while wind power supplied 2.5 TWh. Almost 60 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 34 % in 2009. Renewable energy sources include biofuels, hydro power and wind power.

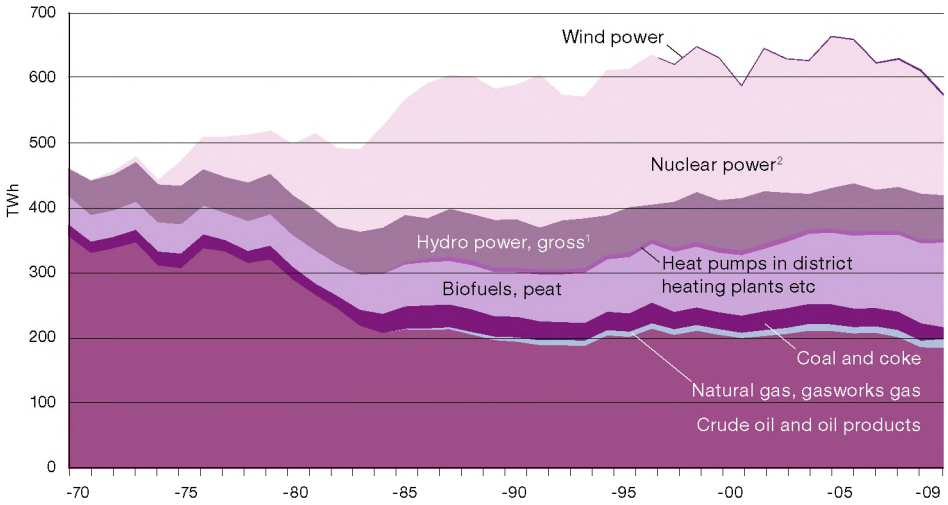
Use of oil declining and that of biofuels increasing

Figure 9 shows Sweden's energy supply from 1970 until 2009. Over this period, the mix has changed substantially, so that the use of crude oil and oil products has declined by over 47 %. Expansion of nuclear power and hydro power production has increased the net production of electricity by 126 % since 1970.

The supply of biofuels has increased by over 195 % since 1970. 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.

52 The Agency's calculations based on the period 1985–2005.

Figure 9 Total energy supply in Sweden, 1970–2009, excluding net electricity exports



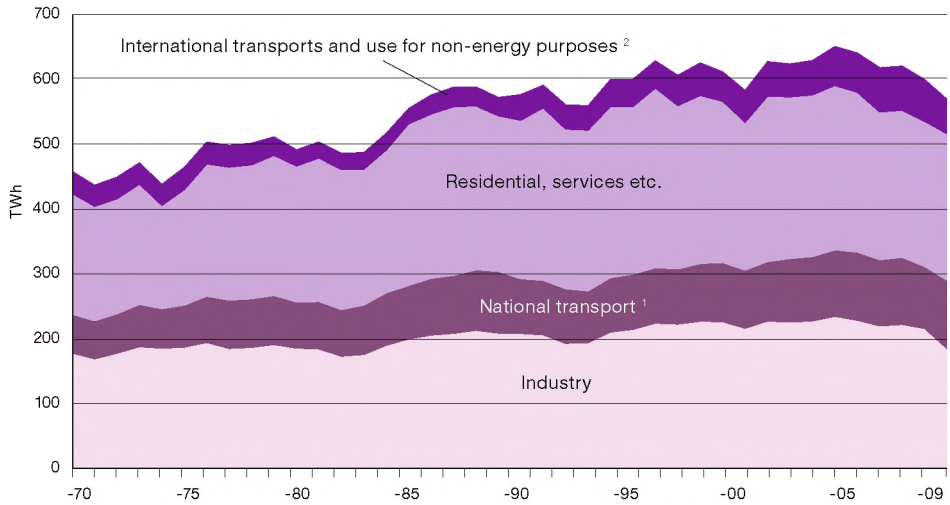
Source: Statistics Sweden and the Swedish Energy Agency.
Note: 1. Includes wind power until and including 1996. 2. Nuclear power is shown as gross power, i.e. as the nuclear fuel energy input, in accordance with the UN/ECE guidelines.

3.3 Losses in a system perspective

Between 1970 and 2009, final energy use increased from 375 to 376 TWh, while total energy supply increased over same period from 457 TWh to 568 TWh. From this, it can be seen that the increase on the supply side has been considerably greater than the increase in final energy use. The reason for this is because there has been a major shift by the user sectors (and particularly by the industry and residential and services sectors) 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, particularly 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: see Figure 8. Losses occur, for example, in electricity and district heating production, and in refineries.

We can obtain a different view of how energy use in the various sectors has evolved by including the losses in the sectors, to give a picture as shown in Figure 10. This is based on exactly the same statistics as Figure 8, but without showing the losses separately. In the diagram, the losses have been assigned proportionally to the respective uses by the user sectors of electricity, district heating and oil products. The difference between the two ways of presenting the information, as shown in Figures 8 and 10, depends on where the system boundaries are drawn. If they are set at the factory gate, or at a residential building wall, we obtain the result as shown in Figure 8. On the other hand, if the boundary is drawn where the electricity, district heating or oil products are produced, we obtain Figure 10. Other system boundaries can also be considered[53].

Figure 10 Total energy use in Sweden, 1970–2009. Conversion losses in the production sector are apportioned to end users



Source: Statistics Sweden and the Swedish Energy Agency.
Note: 1. Foreign aviation included in this item until and including 1989. 2. Foreign aviation included in this item from and including 1990.

53 All or Nothing – Systems Boundaries for the Heating of Buildings. www.energimyndigheten.se.

3.4 Increasing use of renewable energy

In 1990, Sweden's proportion of energy use provided from renewable sources amounted to 33.3 %. By 2009, this had increased to 44.7 %[54]. However, the share for 2009 is based on short-term statistics and is therefore subject to change. 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. In total, it is wood fuels and black liquors[55] that are the renewable energy sources that are used most in Sweden, followed by hydro power, heat absorbed by heat pumps, organic waste, biobased motor fuels and wind power.

Calculations of renewable energy proportions are made on the basis set by the European Commission[56], 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.

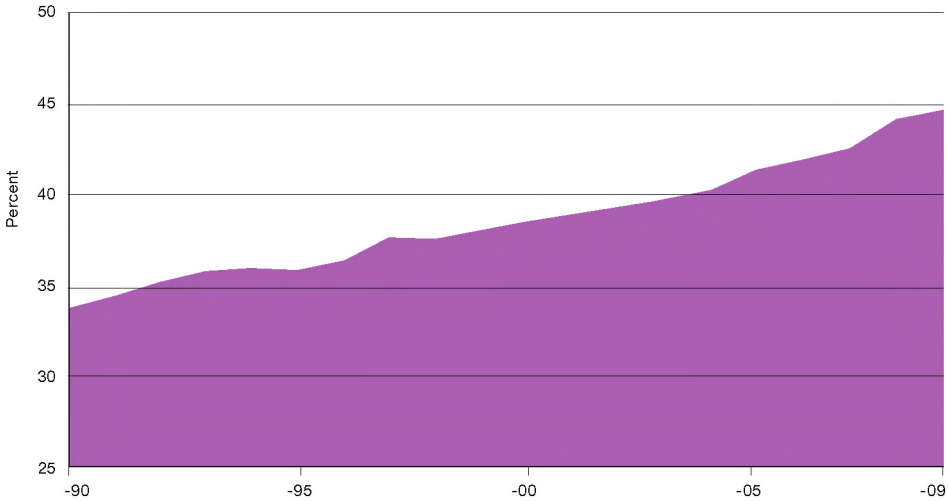
Sweden uses the highest proportion of renewable energy in relation to final energy use of any country in the entire EU. That Sweden's proportion of renewable energy is considerably higher than the proportions in other countries is due not only to the fact that the country has major renewable energy resources, but also to the fact that it 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.

54 The Energy Indicators 2010 report includes more detailed information on the use of renewables in the various sectors up to 2008. The report also includes an international comparison between EU member states up to 2005. It can be downloaded from the Agency's website.

55 The wood fuels and black liquors category does not include peat.

56 Directive 2009/28/EC of the European Parliament and of the Council of 23 April 2009 on the promotion of the use of energy from renewable sources, Article 2. See also the Energiindikatorer 2010 report [Energy Indicators 2010].

Figure 11 Sweden's total proportion of renewable energy use, 1990–2009



Source: Statistics Sweden and the Swedish Energy Agency.
Note: The proportion for 2009 is based on short-term statistics, and is therefore subject to change.

Summary

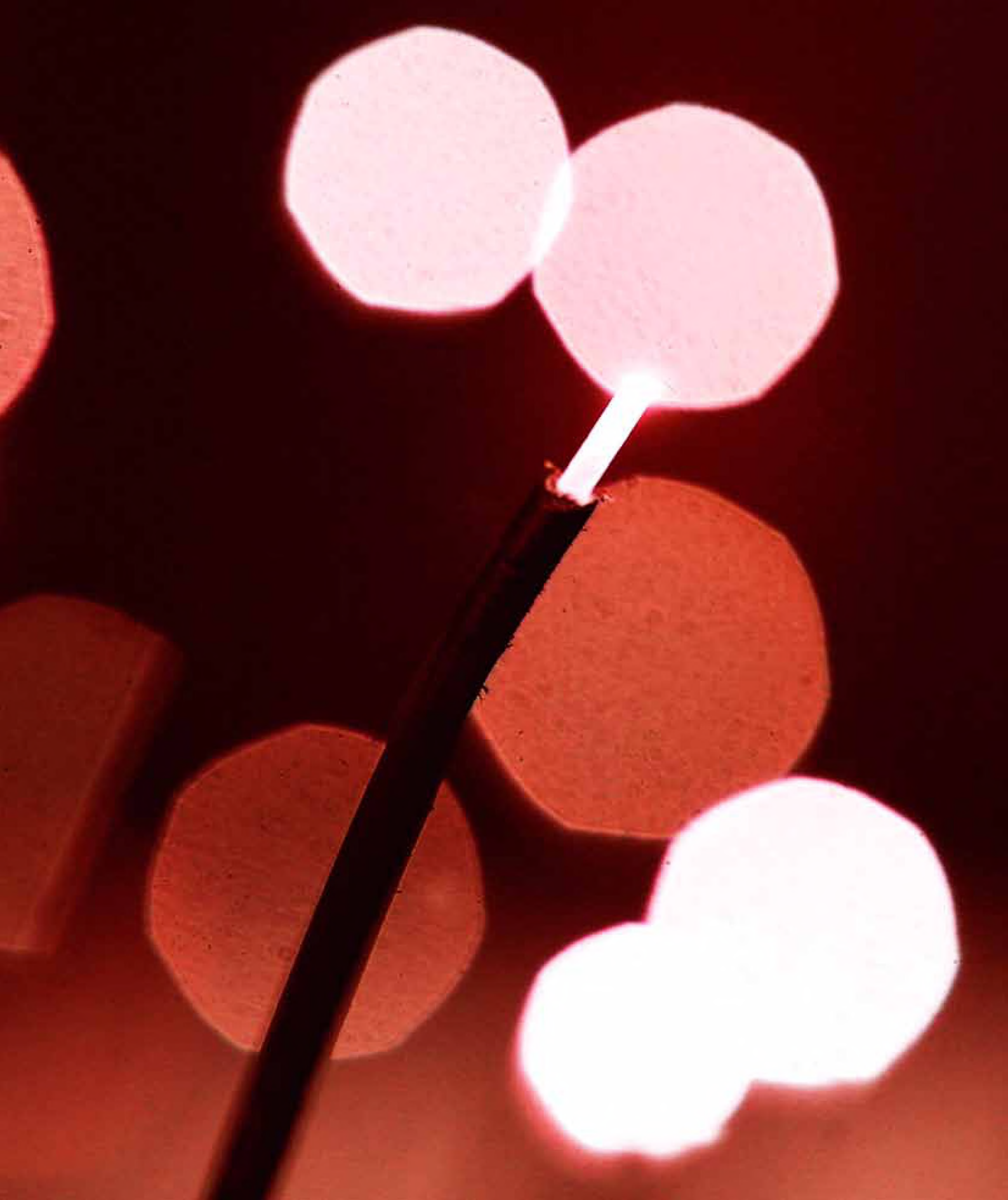
In 2009, the total energy input to the Swedish system amounted to 568 TWh, which included a net import of 4.7 TWh of electricity. Oil and nuclear power still account for the greatest proportions, closely followed by biofuels and hydro power.

The proportions of the various energy system input elements have changed with time, in step with changes in energy demand. Total energy supply in 1970 amounted to 457 TWh, which can be compared with 568 TWh in 2009. Despite this rise, there has been a 47 % decrease in the supply of crude oil and oil products since 1970. Over the same period, net production of electricity has increased by almost 126 %, mainly as a result of the expansion of hydro and nuclear power production. In addition, the supply of biofuels has increased by over 195 % since 1970.

As the energy system must always be in balance, i.e. as the quantity of energy supplied must equal the quantity of energy used, any reduction in the use of fossil energy sources, such as oil, must be offset by an increase in contribution from some other energy source. These increases have been provided by the renewable energy sources, primarily biofuels and wind power, as can be seen by the increasing proportion of renewable energy that is being used in Sweden.

4 Energy use

All sectors of society are very dependent on energy: for heating and cooling, for lighting and domestic equipment, for travel and for the production and distribution of goods and services. Over the last 20-30 years, the use of energy has remained fairly constant, although the economic upheavals of recent times have had a significant effect on energy use in some sectors.



4.1 Heating is the major energy demand in the residential and services sector

The residential and services sector[57] consists of residential premises, holiday homes and commercial premises (excluding industrial premises), land use and other service activities. Land use includes agriculture, forestry, market gardening and fisheries. Other service activities include the construction sector, street lighting, sewage treatment plants, electricity and waterworks. In 2009, energy use in the sector amounted to 149 TWh, which is 39 % of the country's total final energy use. Within the sector, residential buildings and commercial premises account for 87 %, land use for almost 7 %, and other services for the remainder.

Almost 60 % of 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 relatively substantial variations in energy demand from year to year. A cold winter increases the energy demand for heating, and vice versa. To be able to compare energy use from one year to another, regardless of the ambient temperatures, it is necessary to correct for climatic conditions in order to arrive at a statistically average year in terms of the climatic conditions[58]. 2009 was about 6 % warmer than a statistically average year, which therefore meant that the equivalent corrected energy use for 2009 is 153 TWh.

The number of dwelling units (single-family houses and apartments in apartment buildings) in the country steadily increases. In 2009, there were over 4.5 million dwelling units[59], or about 40 % more than in 1970[60]. The rate of construction was relatively low during the latter half of the 1990s, but picked up during the 2000s, to the extent that nearly 23 000 new dwelling units were completed in 2009, although this is a reduction of 29 % in comparison with 2008[61].

57 More detailed information on energy use in these sectors can be found in the publications: "Energianvändning inom jordbruket 2007" [Energy Use in Agriculture 2007] (STEM/SCB), ER2006:35, ER 2007:15 and ER2006:02. Information on energy use in greenhouse cultivation can be found in "Trädgårdsproduktion 2005" [Market Gardening Production 2005], which can be downloaded from www.jordbruksverket.se.

58 Correction of energy use data to correspond to that which would be used in a statistically average year enables comparison of energy use data between periods, regardless of the actual ambient weather conditions and temperature.

59 The calculated housing stock as of 2009-12-31. Statistics Sweden Press Release no. 2010:145, dated 2010-05-31

60 Housing and Construction Statistics Yearbook 1979

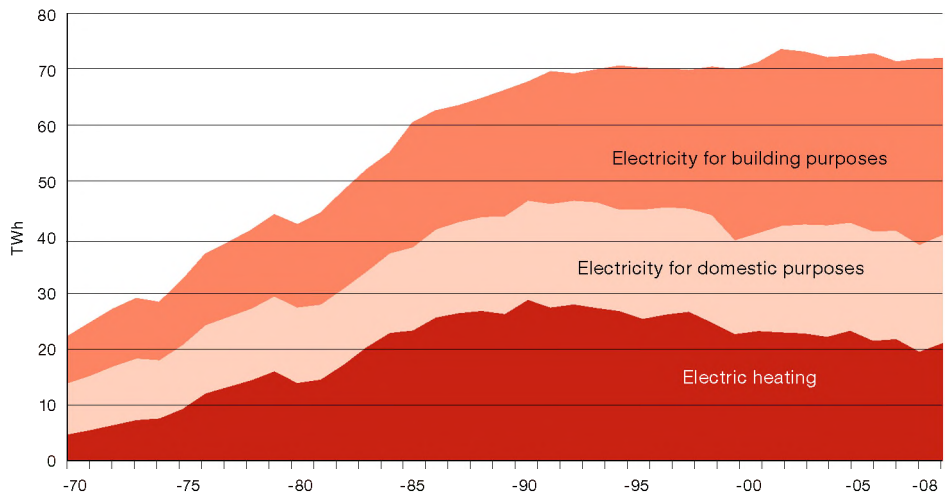
61 Construction. New building: completed residential buildings, 2009. Statistics Sweden, BO 20 SM 1001.

Electricity use has remained relatively constant over the last ten years

Figure 12 shows the total electricity use in the sector since 1970, broken down into domestic electricity, electricity for building services systems, and electric heating. Electricity use grew steadily from the 1970s until the middle of the 1990s, after which it 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 buildings/commercial premises[62]. The amount of electricity used for this purpose has increased substantially, from somewhat over 8 TWh in 1970 to over 30 TWh in 2008; a level that has remained relatively constant since 1999. Since 2005, the Swedish Energy Agency has been conducting surveys of electricity use in different types of premises. A common feature found in all of them is that lighting and ventilation account for a substantial proportion of electricity use. A possible reason for the increase in the amount of electricity use for building services systems can be that greater importance has been attached to good indoor environment conditions. Higher ventilation rates and longer running times increase electricity use, as does the equipment needed for heat recovery.

Figure 12 Electricity use in the residential and services sector, 1970-2008, climate-corrected



Source: Statistics Sweden and the Swedish Energy Agency

62 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.

The use of electricity for domestic purposes[63] increased from somewhat over 9 TWh in 1970 to almost 20 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. Over the period 2005–2008, the Agency conducted a study to measure the amount of domestic electricity used for different purposes. 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[64].

The use of electricity for heating in the sector increased 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 over 21 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.

Electric heating and district heating predominate in the residential and services sector

A total of 75.3 TWh were used for space heating and domestic hot water production in 2008, equivalent to about 82 TWh after correction for a statistically average climate year. Of this, about 42 % were used in detached houses, 32 % in apartment buildings and 26 % in commercial premises and public buildings.

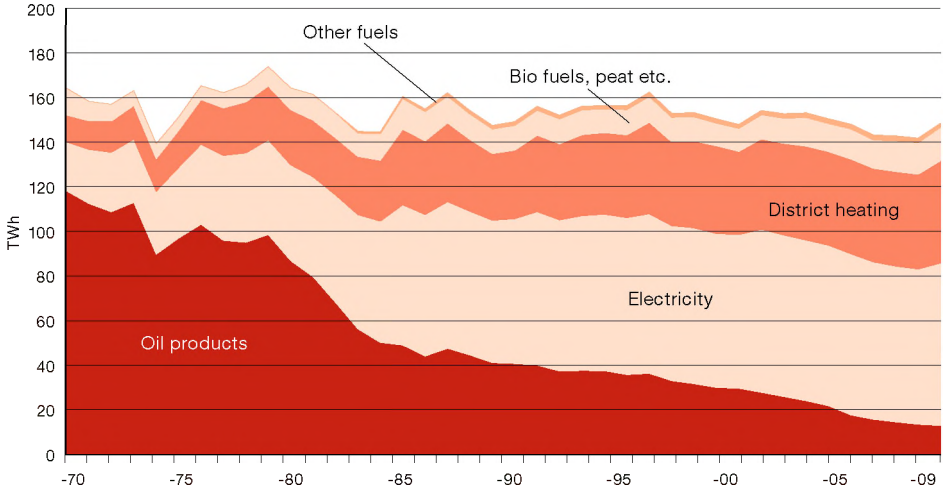
The commonest form of heating in detached houses is electric heating, used in about 31 % of them in 2008. The use of direct electric heating in combination with some other form of heating is common in detached houses: about 22 % of detached houses had some form of combination heating system in 2008. The commonest combination, used in about 20 % of detached houses, was that of biofuels and electricity. About 12 % of detached houses were heated solely by district heating, 14 % were heated solely by biofuels, and 3 % were heated solely by oil. Other detached houses had other combinations, or were heated by gas. 12.9 TWh of electric heating, 11.4 TWh of biofuels, 5.4 TWh of district heating, 2.0 TWh of oil and 0.2 TWh of gas were used for space heating and domestic hot water production in detached houses. The use of heat pumps has grown rapidly in recent years, to the extent that, by 2008, almost 40 % of detached houses were using them.

63 Domestic electricity is that which is used for lighting, white goods, domestic appliances and other electrical equipment in a home.
64 For further information on the survey, see the Agency's website:
http://www.energimyndigheten.se/sv/Energifakta/Statistik/Forbattrad-energistatistik-ibebyggelsen/ Matning-av-hushallsel-pa-apparatniva-/

District heating is the commonest form of heating in apartment buildings, with about 82 % of apartments being heated by it in 2008. Oil was used as the sole heat source for 1 % of apartments, while 3 % were heated by electricity alone. 6 % 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 amounted to 22.3 TWh of district heating, 0.8 TWh of electric heating, 0.5 TWh of oil, 0.2 TWh of gas and 0.2 TWh of biofuels.

District heating is also the main source of heat in offices, commercial premises and public buildings, with 68 % of such buildings in 2009 being supplied solely with district heating. About 6 % of this floor area was heated by electricity alone, and about 2 % by oil alone. 7 % of the floor areas were heated by combinations with heat pumps. Other heating systems included combinations of various energy carriers, or gas or biofuels alone. Total use amounted to 14.8 TWh of district heating, 2.9 TWh of electric heating, 0.8 TWh of oil, 0.3 TWh of gas and 0.5 TWh of biofuels.

Figure 13 Final energy use within the residential and service sectors etc, 1970–2009



Source: Statistics Sweden and the Swedish Energy Agency.

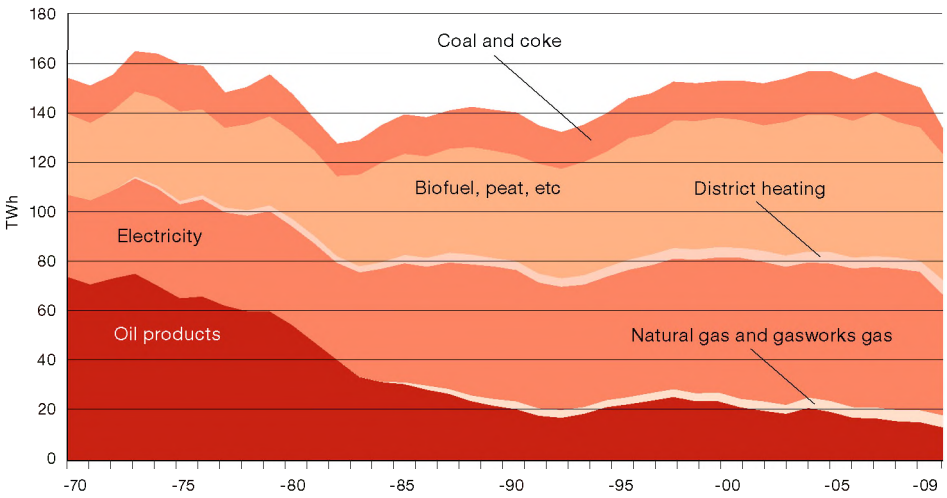
Gradual phase-out of oil

The relative proportions of the different energy carriers have changed over time, as can be seen in Figure 13. Availability of particular energy carriers and the application of various policy measures have affected the relative prices of different energy carriers, resulting in a shift from oil to electricity, district heating and biofuels. In 2009, total use of oil fuels in the sector amounted to 13.3 TWh, a reduction of almost 90 % since 1970. About 26 % of this oil was used for heating.

It can be seen from Figure 13 that energy use in the sector has fallen over the period 2000-2008, but has been followed by an increase in 2009. A contributory reason for the decline in energy use until 2008 was that all these years were warmer than normal. If we correct for climate conditions, we find that energy use in the sector has decreased somewhat over the longer period of 2000–2009. It is particularly energy used for space heating and domestic hot water production that has declined, for which there are at least three reasons.

Firstly, a reduction in total final energy use in the residential and services sector, due to the replacement of oil by electric heating or district heating, results in increased losses in the conversion sector. Secondly, an increase in the number of heat pumps.

Figure 14 Final energy use in industry, 1970–2009



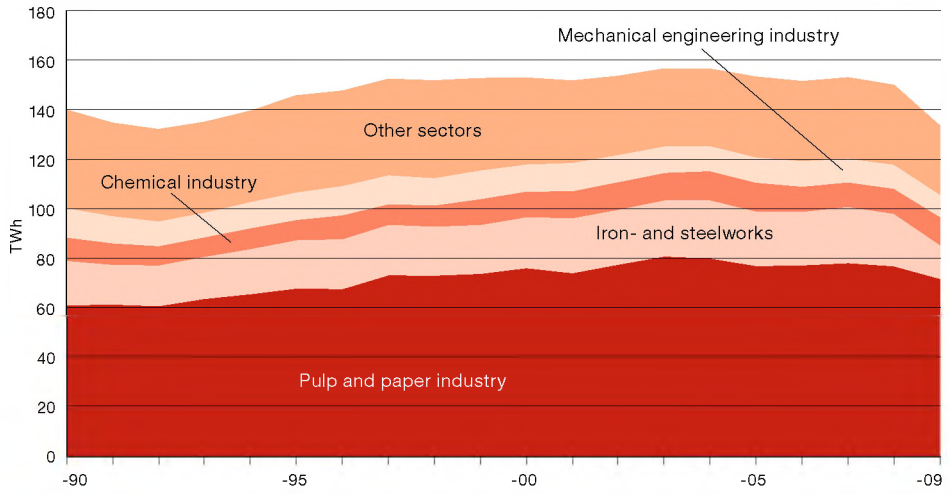
Source: Statistics Sweden and the Swedish Energy Agency.

Heat pumps deliver about three times as much thermal energy as they use in the form of electrical energy for driving them[65], 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. Thirdly, energy conservation measures, such as retrofitting additional thermal insulation or upgrading windows in older buildings, also contribute to reduced use of energy.

4.2 Use of energy in industry declines

Use of energy by industry in 2009 fell by 11 % to 134 TWh, which is about 36 % of Sweden's total energy use. At 36 % and 38 % respectively, the main energy providers in industry are electricity and biofuels. Fossil fuels are made up of oil products, coal, coke and natural gas and provided 21 % of the energy use in industry. District heating provided about 4 % of energy use: see Figure 14.

Figure 15 Energy use in industry per sector 1990-2009



Source: Statistics Sweden and the Swedish Energy Agency.

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

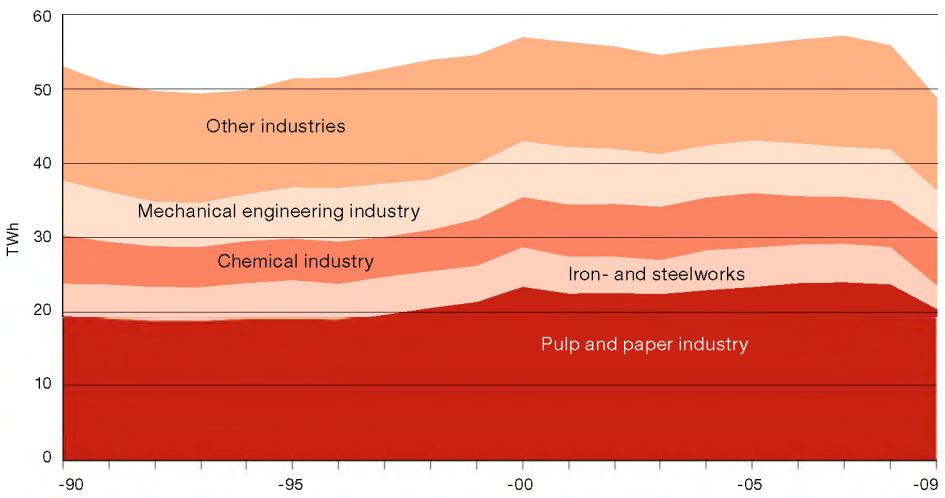
The bulk of industrial energy use is accounted for by a few sectors

In Sweden, a small number of sectors accounts for the bulk of energy use in industry: see Figure 15. The pulp and paper industry uses about 50 %, primarily as electricity or from black liquors[66]. 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, mainly in the form of coal, coke and electricity. Coal and coke are used as the reducing agents in blast furnaces, while the electricity is used chiefly for arc furnaces for melting steel scrap. The chemical industry is responsible for 7 % of industrial energy use: electricity is used by it mainly for electrolysis processes. Together, these three energy-intensive sectors normally account for almost three-quarters of total energy use in industry.

The mechanical 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 sectors[67]. Although some of them can be regarded as energy-intensive, their total energy use is relatively low. Some sectors are dominated by the use of fossil energy, such as the sand and gravel industry, while others, such as metal-machining industries, are dominated by the use of electricity.

Figure 16 Use of electricity in industry 1970-2009



Source: Statistics Sweden and the Swedish Energy Agency.

66 Black liquors are a by-product 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.

67 "Other sectors" includes the mining industry, metals industries, the timber industry, sand, gravel and quarrying, the food industry, the textiles industry, the graphics industry and "other industry" (SNI 31-33).

Reduced industrial output reflected in reduced 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 in the sector and changes in the types of goods produced.

2009 was marked by the fallout from the previous year's economic upheavals, with reduced output from Swedish industry and therefore a corresponding reduction in the use of energy. The effect of production volumes on energy use during 2008 and 2009 can be clearly seen. Industrial output in 2009 fell by 18 % in comparison with the previous year: energy use fell by 11 %. Some industry sectors were affected more than others: energy use in the iron and steel industry, for example, fell by 40 % in 2009 in comparison with the previous year.

Industry using increasing proportions of electricity and biofuels

Energy use by industry has remained relatively constant since 1970, despite increasing industrial output. This is a result of improvements in the efficiency of energy use, coupled with a progressive change from oil to electricity. Electricity use has increased from 21 % to 36 % of total energy use by industry since 1970. This trend started in connection with the oil crises of the 1970s, which resulted in both state and business starting intensive work aimed at reducing the use of oil. In 1970, the use of oil provided 48 % of industry's total energy use, which can be compared with the present proportion of 10 %. The use of oil increased over the period 1992–1997, after which the downward trend resumed. The use of both electricity and oil was lower in 2009 than in the record low year of 1992.

Between 1970 and 2009 the proportion of biofuels, peat etc. has increased from 21 % to 38 % of total energy use by industry. Biofuels are the main energy source in the pulp and paper industry and in the wood products industry.

Steady fall in specific energy use

Specific energy use – i.e. the amount of energy used per monetary unit of output value – provides a measure of how efficiently the energy is being used. Since 1970, specific energy use in industry has fallen continuously: between 1970 and 2009 it fell by 66 %, or on average by 3 % per year, reflecting a clear trend towards less energy-intensive products and production processes, together with structural changes in the sector. Both energy use and added value fell over the years 2008-2009, although added value fell more than did energy use. A certain quantity of energy must be used, regardless of lower production volumes or lower capacity utilisation, which account for the lower added value. Specific energy use therefore increased in 2009.

The change from oil to other energy carriers, particularly electricity, is reflected

in the specific use of oil and electricity per unit of output value. Specific use of oil fell by 81 % between 1970 and 1992, while specific use of electricity increased by 21 %. The economic downturn that occurred in 2008 and 2009 clearly made its mark on specific energy use, which increased by 8 % in 2009. Specific use of oil and electricity also increased, by 3 % and 7 % respectively, as can be seen in Figures 17 and 18. When economic conditions improve, it is very likely that specific energy use will again fall.

Figure 17 Specific use of oil in industry, 1970–2009, kWh per SEK of value added, 2000 price levels

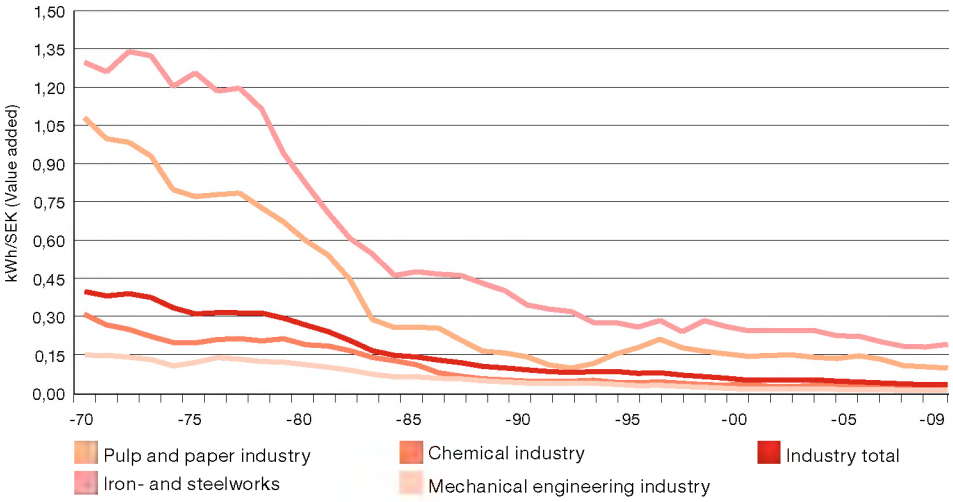
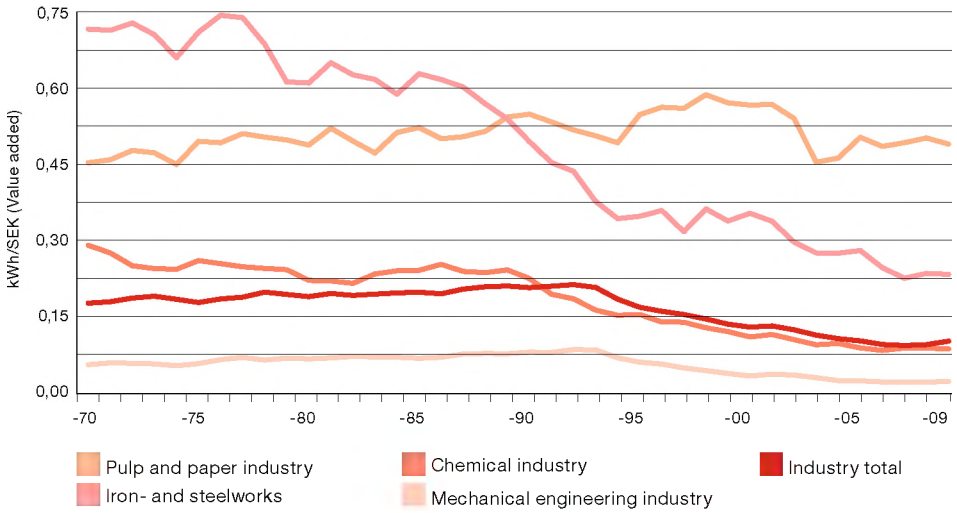


Figure 18 Specific electricity use in industry 1970–2009, kWh per SEK of value added, 2000 price levels



Source figure 17-18: Statistics Sweden and the Swedish Energy Agency.

4.3 Increasing use of diesel fuel and decreasing use of petrol in the transport sector

Energy is used in the transport sector for road traffic, rail traffic, aviation and shipping. Domestic transport in 2009 used 93 TWh, or 25 % of the country's total energy use. Bunkering for foreign maritime traffic amounted to 25 TWh and fuel for non-domestic aviation accounted for 8 TWh. Total energy use in the transport sector, including foreign transport, amounted to 127 TWh. Energy use in the transport sector is dominated entirely by oil products, primarily petrol and diesel oil. In 2009, these two fuels met 88 % of the country's energy requirements for domestic transport.

Substantial fall in goods transport quantity in 2009

The need for goods transport is directly linked to activity in society in general, which meant that the transport sector was severely affected by the economic downturn during 2009. Domestic goods transport fell from 103.6 x 10^9 (103.6 thousand million) tonne-km in 2008 to 87.7 x 10^9 tonne-km in 2009[68], which exceeds any percentage drop in transport work that has previously occurred.

Passenger transport work was not affected as severely by the economic conditions, which can be explained by the fact that real disposable income increased by 2 % in comparison with 2008. The total domestic passenger transport work in 2009 amounted to 137.9 x 10^9 (137.9 thousand million) person-km in 2009, which is the highest value to date, and an increase of 0,8 x 10^9 person-km in comparison with 2007 and 2008[69]. Road traffic accounted for 87.4 % of total passenger transport carriage, with railways and tramways carrying over 9.7 % of passenger traffic, aviation about 2.2 %, and domestic water traffic 0.7 %[70].

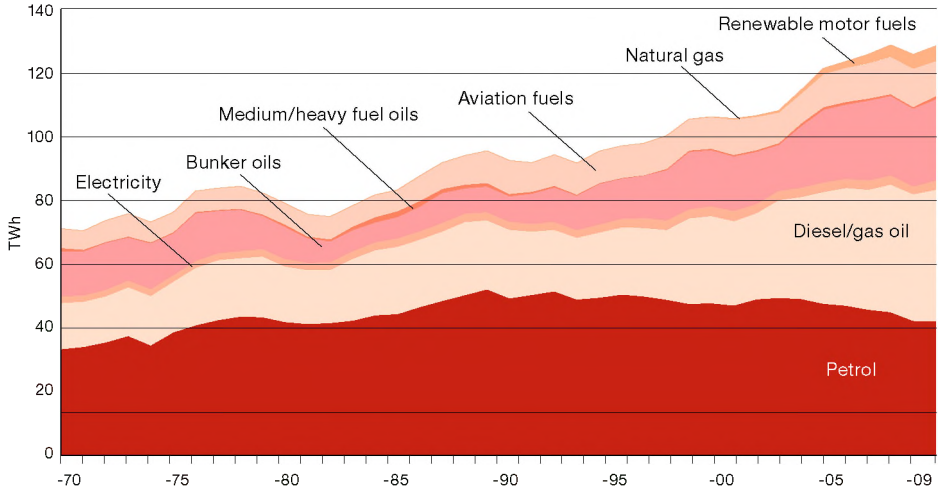
Long-distance passenger travel (i.e. over 100 km) amounted in 2009 to 39.7 x 10^9 person-km, which is a reduction of 0.1 x 10^9 person-km in comparison with 2008. Long-distance passenger travel by road has increased somewhat, while long-distance rail and air travel has fallen. Short-distance transport (regional and local) amounted to 98.2 x 10^9 person-km, which is an increase of 0.9 x 10^9 person-km over 2008. 77 % of these journeys were by car or motor cycle, 17 % by public transport and the remaining 6 % by foot, cycle or moped[71].

68 National Rail Administration, Railway Sector Development, Sector report 2009
69 National Rail Administration, Railway Sector Development, Sector report 2009
70 National Road Administration, Sector report 2009
71 National Rail Administration, Railway Sector Development, Sector report 2009

Rapidly changing pattern of energy use

Energy use in the transport sector has changed relatively rapidly since the beginning of the 2000s. Between 2000 and 2008, the use of diesel fuel has increased by 56 %, while that of petrol has fallen by 10 % over the same period. One reason for this is the change in the mix of type of vehicles on the road, both private cars and light goods vehicles. One example of the rapid rate of change is that the proportion of new vehicles that were diesel-powered amounted to 41 % in 2009, as compared with 20 % in 2006[72].

Figure 19 Final energy use in the transport sector 1970–2009, including international transports



Source: Statistics Sweden and the Swedish Energy Agency.

Energy use in the transport sector may seem to have increased between 2008 and 2009, from 124.2 TWh in 2008 to 126.8 TWh in 2009. However, this is not a fair picture, as the statistics for 2008 and earlier years have a different basis from those for 2009. This is also explained in the Sweden's Energy Balance chapter which describes the difference between short-term and annual statistics. For the transport sector, it is particularly petrol and diesel fuel that show differences between their short-term and annual statistics. The short-term statistics are always higher than the annual statistics, which means that a better picture of the difference between 2009 and 2008 can be obtained by comparing the short-term statistics for both years. Such a comparison reveals a 2 % reduction in the use of petrol in 2009 in comparison with 2008, together with a 3 % reduction in the use of diesel fuel.

72 Bil Sweden

FACTS – DIFFERENCES BETWEEN SHORT-TERM AND ANNUAL STATISTICS FOR THE TRANSPORT SECTOR

Put simply, the difference between short-term and annual statistics for the transport sector is that the short-term statistics reflect deliveries of petrol and diesel fuel to the market, while the annual statistics reflect their use. Differences between deliveries and use arise as the petrol and diesel fuel supplied to the market can be used for a range of purposes, not all of which are transport-related. The short-term statistics are based on data from the suppliers, which means that a certain amount of use for other applications (mainly for contractors' machinery) is included in the transport sector instead of in the residential sector or industry sector. The annual statistics are better able to distinguish the uses of fuels in different sectors, which mean that the breakdown between sectors is considerably more detailed in the annual figures. However, the total volume of petrol and diesel fuel is the same – it is only the breakdown between sectors that differs.

Substantial increase in the use of renewable motor fuels

The proportion of renewable motor fuels used by road vehicles has increased substantially in recent years. In 2009, the proportion of renewable motor fuels amounted to 5.4 %: the corresponding proportion for 2008 was 4.9 %. In this context, the proportion of renewable motor fuels is calculated as the quantity of biobased motor fuels divided by the quantity of biobased motor fuels, petrol and diesel fuel.

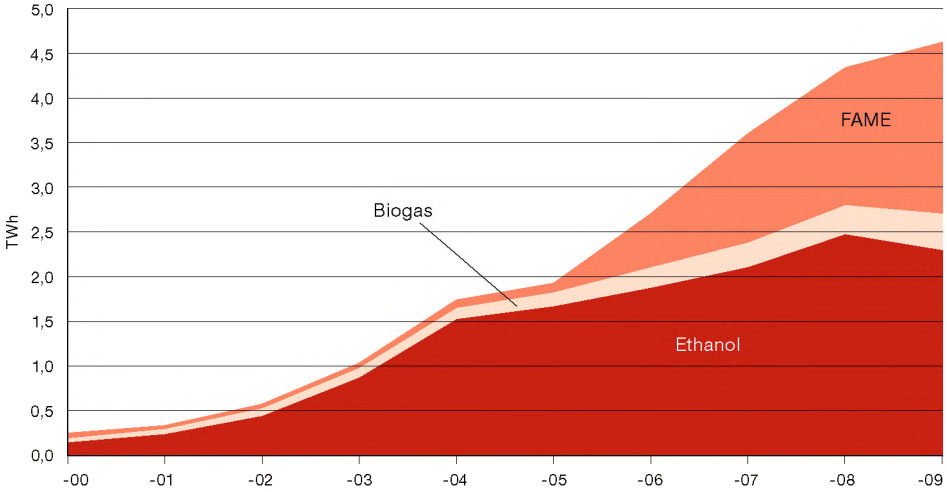
The alternative motor fuels that are at present used for vehicles are mainly natural gas, biogas, ethanol and FAME. Natural gas and biogas go under the common name of motor fuel gas, and are used mainly as a fuel for buses and private cars. Ethanol finds uses as a low-admixture constituent of petrol, and as a constituent in fuels such as E85 and ED95. FAME is used as 100 % FAME and as an admixture constituent in diesel fuel.

Low admixture ratios of ethanol and petrol increased progressively at the beginning of the 2000s, reaching 5 % admixture in 2005 in almost all petrol on the Swedish market. Low admixture of FAME in diesel fuel was permitted with effect from 1st August 2006, since when it has steadily increased. Statistics for 2009 show that 5 % FAME was mixed into 80 % of all diesel fuel delivered to the Swedish market.

Motor fuel gas consists either of straight biogas, straight natural gas or a mixture of the two. The proportion of natural gas in motor fuel gas varies, depending on where one is in the country, and is generally higher in those parts of the country covered by the natural gas grid. In terms of total use of motor fuel gas in 2009, its constituent proportion of biogas was almost 65 %.

The use of E85 has fallen in 2009 in comparison with the previous year, as a result of E85 prices over much of the year being higher than the price of petrol when compared on the basis of petrol equivalence. As private cars that can run on E85 can also run on petrol, there was an immediate effect on the use of E85 when its price rose above that of petrol. On 17th August 2010, a litre of 95-octane unleaded petrol cost SEK 12:68, and a litre of E85 (which consists of 85 % ethanol and 15 % petrol during the summer) cost SEK 9:14. However, as ethanol has a lower energy content than petrol, it takes about 1.25–1.35 litres of E85 to provide the same energy as a litre of petrol. Allowing for this, the cost of using E85 at that time was somewhat lower than the cost of using petrol.

Figure 20 Final energy use of renewable motor fuels, 2000-2009



Source: Statistics Sweden, the Swedish Energy Agency and the Swedish Gas Association.

Summary

This chapter has covered the three sectors of residential and services, industry and transport. Total energy use in 2009 amounted to 376 TWh, of which 125 TWh were electricity.

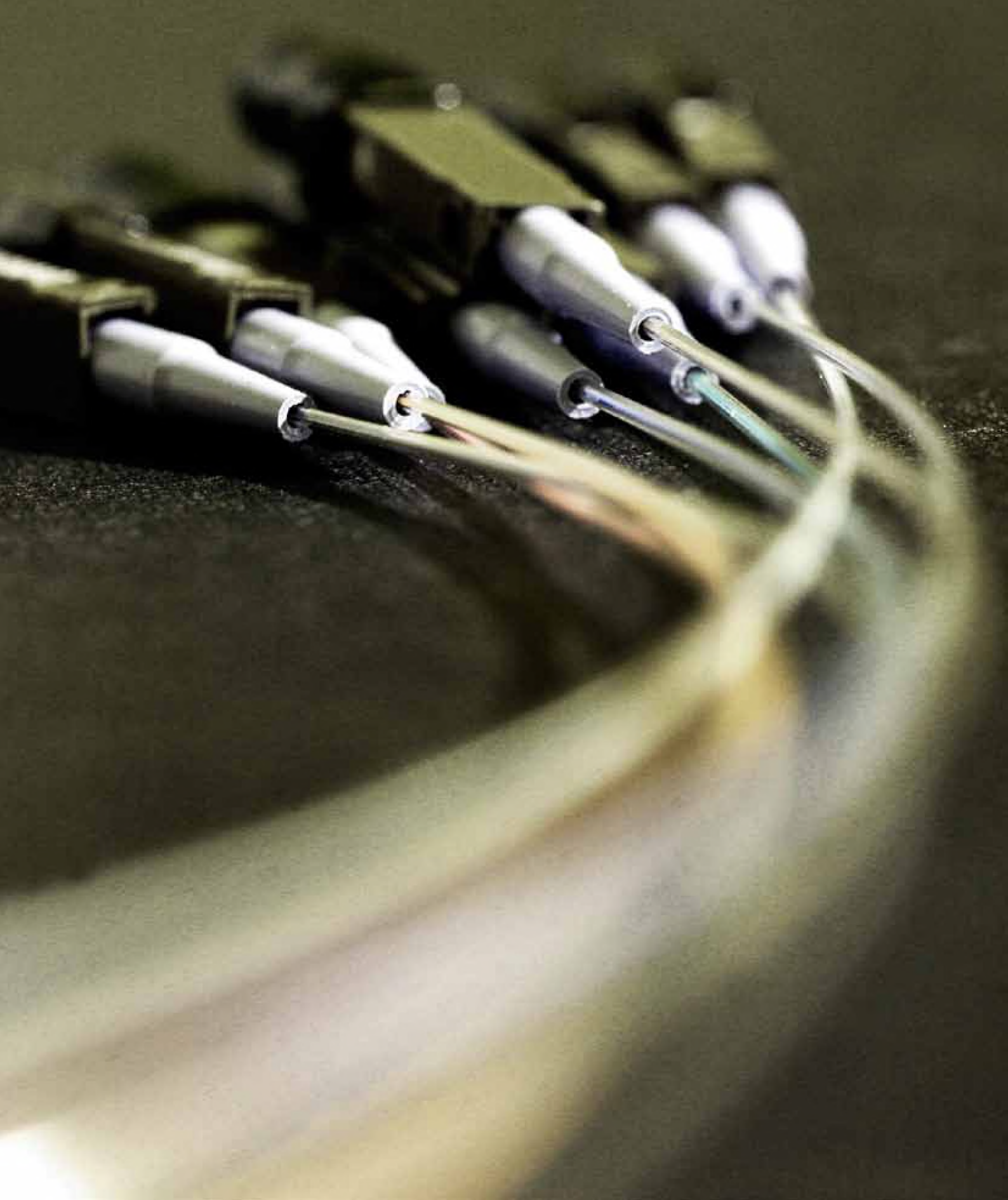
During 2009, the residential and services sector used 149 TWh of energy, or 39 % of the country's total energy use. Most of this energy was supplied via district heating networks, by electric heating or by combustion of oil or biomass for space heating of houses and work premises. Almost 60 % of energy used in the sector is used for heating purposes. In addition, the residential and services sector is the sector that uses the most electricity, amounting to 73 TWh in 2009.

Total energy use by the industry sector during 2009 was 134 TWh, or 36 % of the country's total energy use. Energy is used in industry both as a 'raw material' and to power ancillary processes such as pumps, air compressors and lighting.

Transport of persons and goods used 127 TWh in 2009. Domestic use (i.e. excluding fuel for foreign maritime traffic and air transport) amounted to 93 TWh, or 25 % of the country's total energy use. Energy use in the transport sector is dominated almost entirely by oil products, primarily petrol and diesel fuel. Electricity use in the sector amounted to 3 TWh.

5 The energy markets

The market for energy is becoming increasingly globalised, as exemplified by deregulation of the market and increased cooperation with other countries. Common regulations affect the choice of fuel used by Swedish energy suppliers.



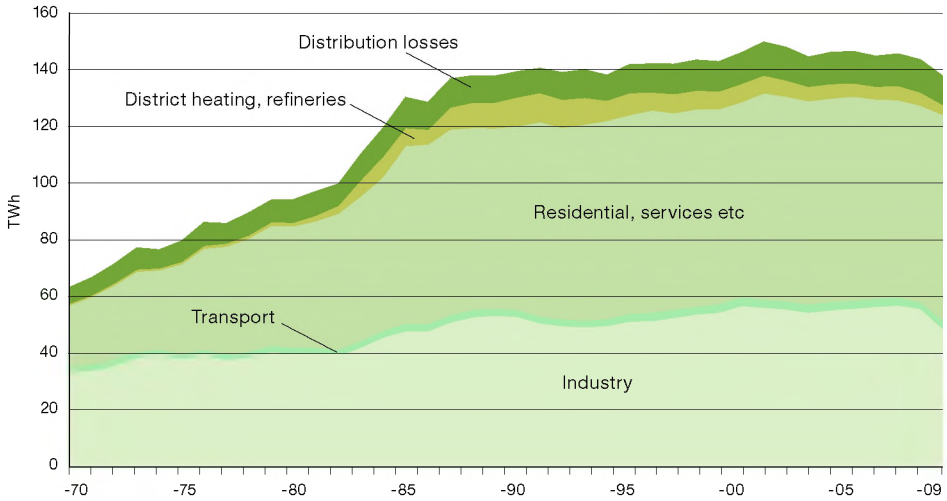
5.1 Increasing internationalisation of the electricity market

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 with 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.

Electricity use has levelled off

Between 1970 and 1987, electricity use in Sweden increased at an average rate of almost 5 % per year, and has largely levelled off since then. Economic and technical development, changes in energy prices, business structure, population changes and the weather all affect electricity use.

Figure 21 Electricity use in Sweden, by sectors, 1970–2009

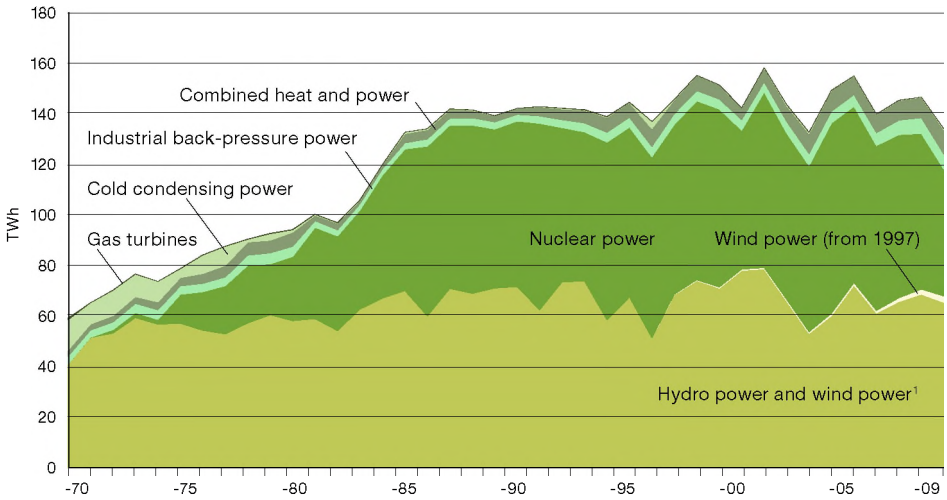


Source: Statistics Sweden and the Swedish Energy Agency.

Swedish electricity production is dominated by hydro and nuclear power 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 2009, nuclear power supplied 37 % of the country's electricity, hydro power supplied 49 % and wind power almost 2 %, with the remaining 12 % being made up of fossil-fuelled and biofuel-based production. Total production amounted to 134 TWh.

Figure 22 Electricity production in Sweden, by types of production plant, 1970–2009

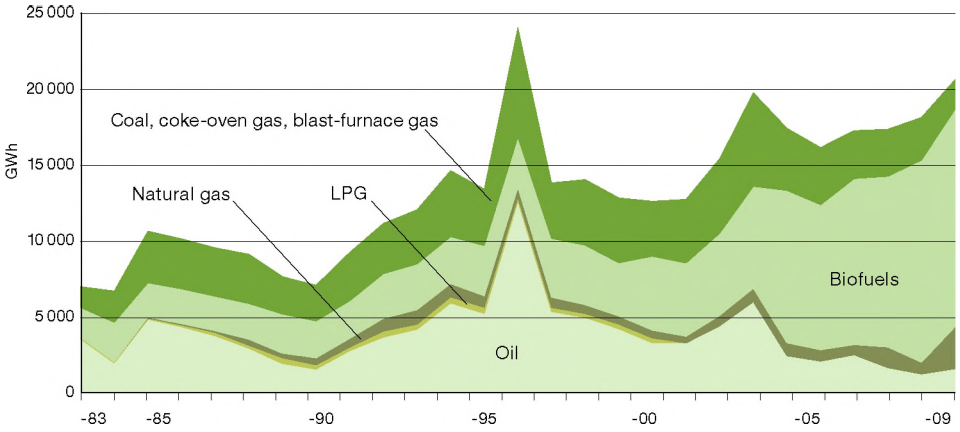


Source: Statistics Sweden and the Swedish Energy Agency.
Note: 1. Windpower is included in the series up and until year 1996.

Combustion-based electricity production amounted to 15.9 TWh, with 70 % of the fuel input being in the form of biofuels and the rest in the form of fossil fuels: see Figure 23. This can be compared with production in 1999, when biofuels made up only 27 % of fuel input. Today, it is combined heat and power production (CHP) (at 9.7 TWh) and industrial back-pressure production (at 5,9 TWh) that dominate combustion-based electricity production, while oil-fired cold condensing power plants and gas turbines serve primarily to provide reserve capacity.

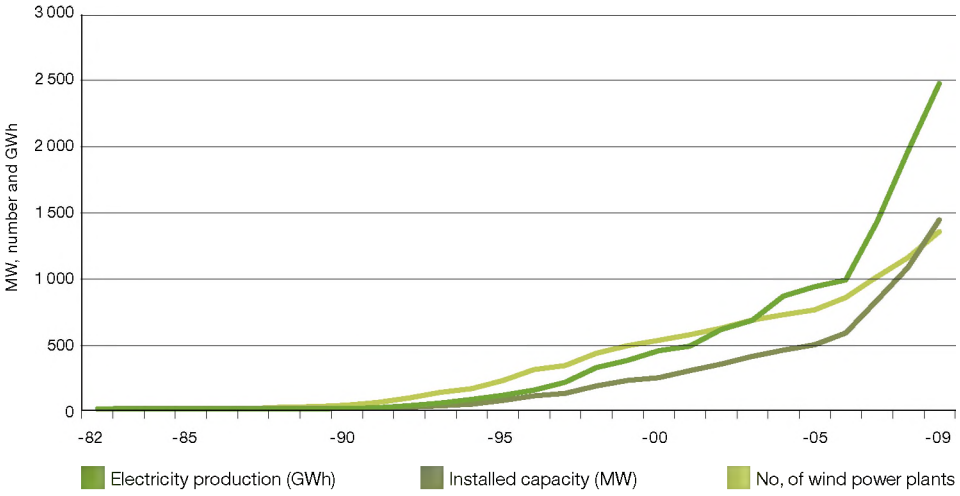
Wind power production in 2009 amounted to 2.5 TWh: see Figure 24. Corresponding figures for 2007 and 2008 were 1.4 TWh and 2 TWh, from which it can be seen that wind power production has increased substantially over the last few years.

Figure 23 Fuel input for electricity production (excluding nuclear fuel), 1983–2009



Source: Statistics Sweden and the Swedish Energy Agency.

Figure 24 Wind power production, 1982–2009



Source: Wind power statistics, 2009, ES 2010:03

Production and use must be balanced

As electricity cannot be stored, there must at all times be a balance between demand and production on the national electricity 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.

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 mainly 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 community local authorities. At present, about 57 % of the total of 528 000 km of the Swedish electricity distribution system are in the form of buried cables.

There are at present cross-border links between Sweden and Norway, Finland, Denmark, Germany and Poland. A new cable link between Finland and Sweden, Fenno-Skan 2, is expected to become available in 2011. The South-West Link project will assist power transfer in southern Sweden. A new high-voltage link between Nea in Norway and Järpströmmen in Sweden was commissioned in 2009. 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.

The grid also needs reinforcement in order to suit new energy sources: expansion of wind power production calls for greater flexibility of the grid as it must be possible to compensate for major production variations by power from other sources.

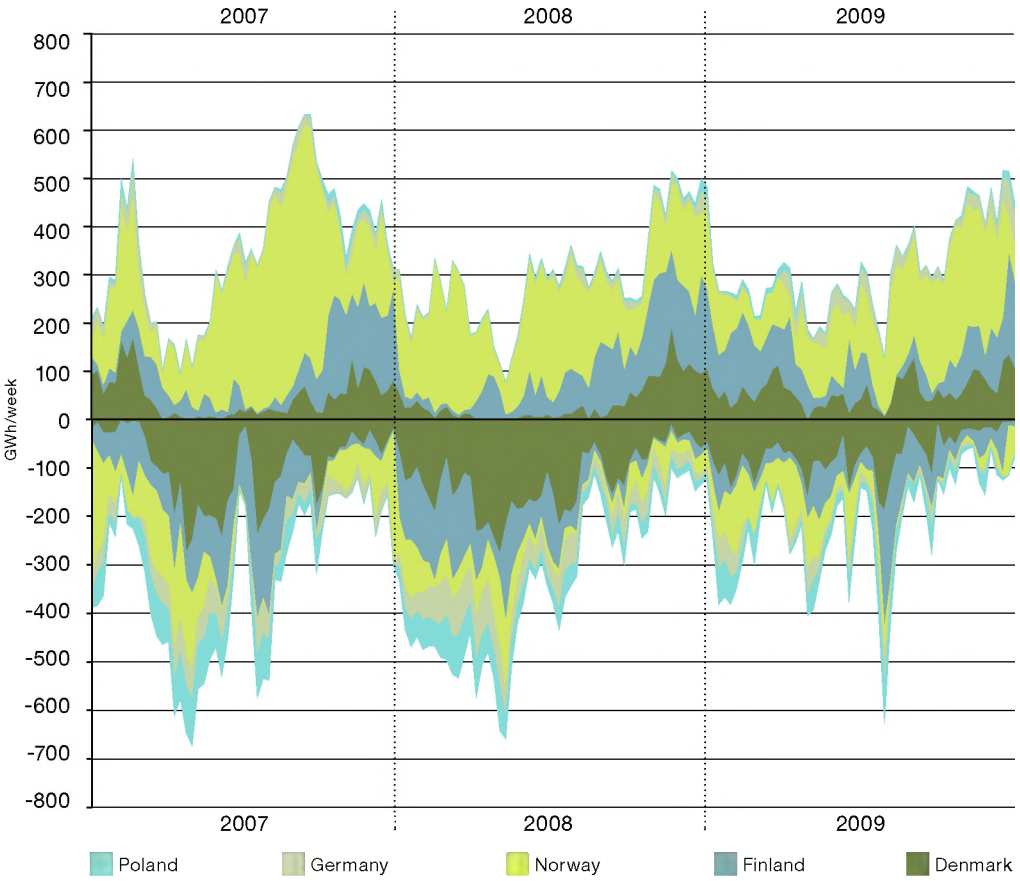
Increased power imports to Sweden and the Nordic countries in 2009

In 2009, Sweden had a net energy import of 4.7 TWh of electricity, which can be compared with a net import of 2.0 TWh for the previous year. 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 levels. In 2009 Sweden had a net import of electricity, most of which came from Norway. The Nordic countries as a whole had a net import of 8.2 TWh, which can be compared with a net export of 1.5 TWh in 2008.

Sweden's total installed capacity in December 2009 was 35 713 MW, made up of 45.4 % of hydro power, 4.4 % of wind power, 26.1 % of nuclear power and 24.1 % of other thermal power. Maximum demand occurred on 8th January 2010, and amounted to 26 219 MW. This can be compared with Sweden's hitherto highest demand of 27 000 MW, which occurred in January 2001[73].

73 Svenska Kraftnät.

Figure 25 Swedish electricity import (+) and export (-), January 2007–December 2009



Source: Svensk Energi, additional processing by the Swedish Energy Agency.

Record electricity price during the 2009/2010 winter

The joint Nordic power exchange, Nord Pool, facilitates the optimum economic use of Nordic power plants and provides 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 2009, 72 % 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. The members of Nord Pool consist of power producers, power suppliers, larger end-users, portfolio managers, fund managers and brokers.

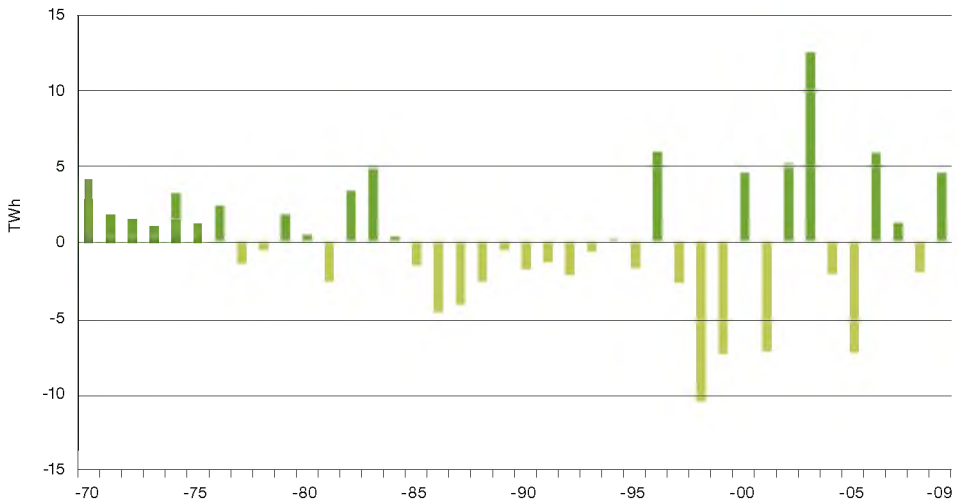
The majority of all electricity consumers purchase their power from suppliers on the end-user market. Swedish green electricity certificates and EU emission rights are also traded on the exchange. As trade in electricity with countries outside

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. Since 2008, the electricity market has been monitored and supervised by the Energy Market Inspectorate.

Electricity prices reached record levels on a number of occasions during the winter, with the highest hourly price exceeding SEK 14 per kWh, which occurred on 17th December 2009 between 17.00 and 18.00. The highest average daily price, of almost SEK 5 per kWh, was noted on 22nd February 2010. On both these occasions, standby capacity in the form of oil-fired power stations and other plants was started up. The reason for the high prices lay primarily in low availability of the nuclear power stations and the unusually cold winter.

The average Nord Pool spot price for Sweden in 2009 was 39.3 öre per kWh, a decrease from 49.2 öre per kWh in 2008.

Figure 26 Sweden's net import (+) and net export (-) of electricity, 1970–2009



Source: Statistics Sweden and the Swedish Energy Agency.

Figure 27 Spot prices on Nord Pool. Monthly and annual average prices for the system and for Sweden, January 1996–August 2010

Source: NordPool.

Variable-rate tariffs are commonest

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 trading company's profit. Of these, it is only the price of the electricity that is subject to competition. In January 2010, the total price of electricity for domestic consumers in detached houses with electric heating was made up of about 41 % for the electricity, 19 % for the network charge, and 40 % for energy tax and value-added tax[74].

Variable-rate tariffs, with about 30 % of consumers, have overtaken fixed-rate tariffs (with about 25 %) as the commonest form of tariff[75]. Among the 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 18.5 öre/kWh or 28.0 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.

74 The Energy Markets Inspectorate
75 As of March 2010.

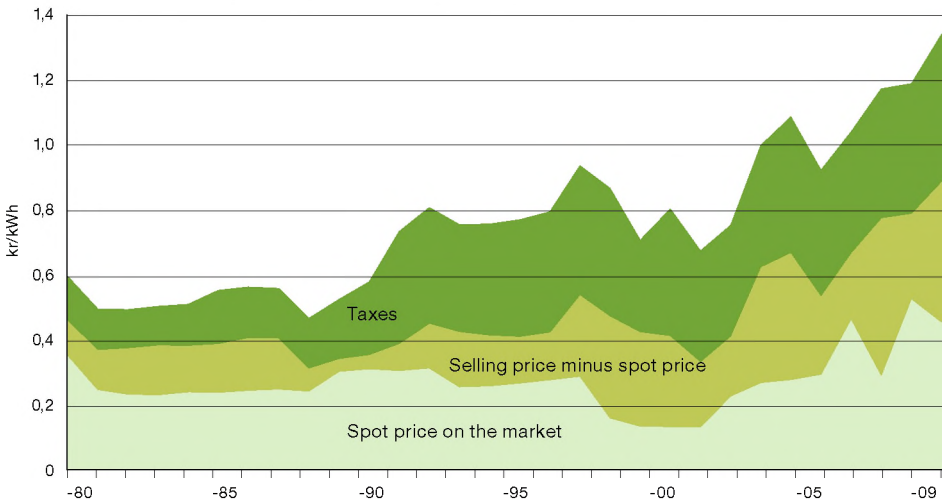
Tabel 6 Total price of electricity (excluding electricity certificates) for different customer categories, including network charges, taxes and value-added tax, öre/kWh

	Small industry[1]	Det. house w. electric heating[2]	Det. house w'out el. heating[3]
1 January 2002, total price	43,8	87,9	111,3
1 January 2003, total price	59,9	111,4	135,4
1 January 2004, total price	62,4	117,9	143,6
1 January 2005, total price	55,2	109,9	135,9
1 January 2006, total price	61,3	117,4	143,9
1 January 2007, total price[4]	82,1	144,4	171,3
1 January 2008, total price[4]	78,8	140,6	168,6
1 January 2009, total price[4]	97,8	165,6	195,9
1 January 2010, total price[4]	85,7	151,1	183,0

Source: Statistics Sweden and the Swedish Energy Agency
Note: Electricity certificate prices are included in the figures from and including 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)
4. Including price of electricity certificates

Figure 28 Real price of electricity (2009 price level), 1980-2009

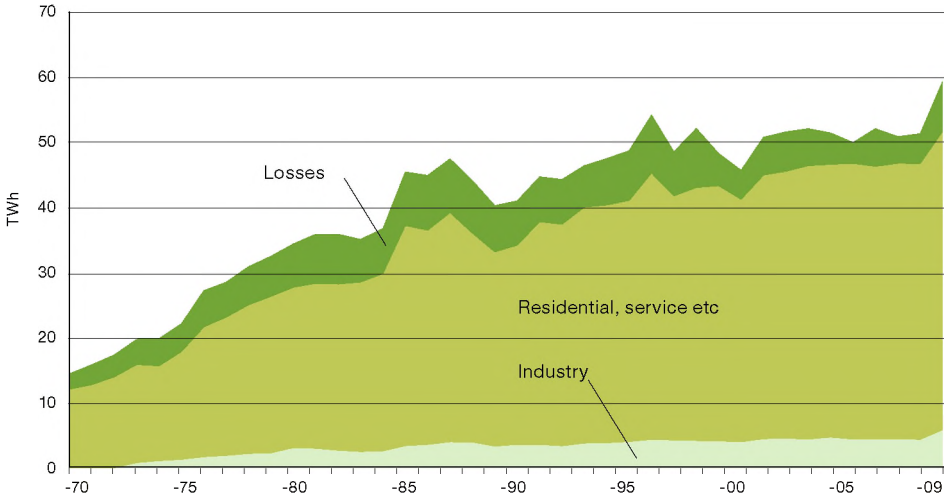


Source: Statistics Sweden, Bank of Sweden, Nordpool.
Note: The prices of electricity for domestic users and for industry have been weighted in proportion to the respective sector proportions.

5.2 District heating and district cooling

District heating has been used in Sweden since the 1950s, but district cooling did not appear until the 1990s. District heating supplies residential buildings, commercial premises and industries with heat for space heating and domestic hot water production, while district cooling, on the other hand, finds a market mainly in the commercial sector for air conditioning of shops and offices, and also for process cooling in industry and for cooling large computer centres. Figure 29 shows the growth in the use of district heating since 1970.

Figure 29 Use of district heating, 1970–2009



Source: Statistics Sweden and the Swedish Energy Agency

Increasing proportion of renewable energy for district heating production

One of district heating's advantages is its flexibility in respect of choice of fuel. Since 1970, there has been a move away from oil to renewable energy sources, mainly in the form of biofuels. The proportion of waste used as a fuel has increased steadily over the last ten years. The increase can be credited partly to low costs for waste and to the policy measures[76] introduced to reduce disposal of waste in landfill, in combination with increased imports of waste. The use of electricity in the district heating sector, particularly for supplies to electric boilers, and also for large heat pumps[77], has declined since deregulation of the electricity market.

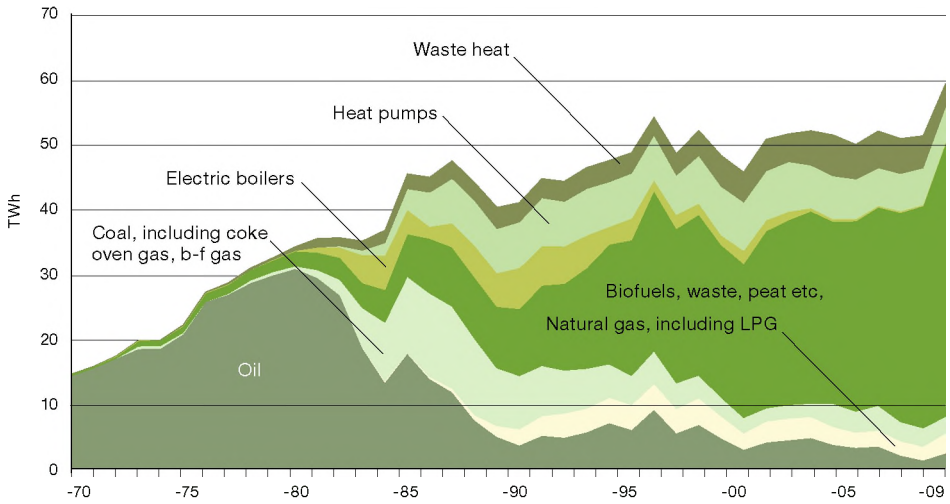
76 The ban on landfill disposal of unsorted potentially combustible waste came into force in 2002, and that on organic waste in 2005.
77 i.e. as used for supplying heat to district heating systems etc. - not small domestic heat pumps.

Losses from district heating distribution systems have fallen as a result of improved technology, higher load factors and a greater proportion of packaged heat. In 2009, distribution and conversion losses amounted to slightly less than 13 % of the total district heating input, as against almost 20 % in the 1980s. Figure 30 shows the energy input to district heating production since 1970.

The changing district heating market

In January 2009, the Government appointed a commission to investigate the ways in which third parties might be given legal right to access district heating distribution systems. The commission is due to report by not later than the end of 2010. One of the ideas that have been investigated is that of splitting the district heating market up into a production side and distribution side, in a similar way to the present-day electricity market. This would make it easier for heat-producing companies to reach end-users, and also make it easier to use industrial waste heat. At the same time, it would also improve competition on the district heating market.

Figure 30 Energy input for district heating, 1970–2009



Source: Statistics Sweden and the Swedish Energy Agency

The District Heating Act controls the market

Since 2008, the district heating market in Sweden has been governed by a special District Heating Act. District cooling, however, is not covered by the legislation. The Energy Market Inspectorate is the surveillance authority responsible for ensuring that the requirements of the legislation are followed.

The law is intended to strengthen the position of district heating customers. It includes a requirement, for example, 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 organisational 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.

There are significant price differences in district heating between areas[78]. 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[79] that set out companies' liability to provide pricing information, and how such information must be provided. The new regulations came into force at the beginning of October 2009.

Most district heating companies nowadays are run as local authority-owned limited companies. Deregulation of the electricity market was followed by progressive ownership concentration in the sector, with the larger energy groups buying up local authority energy companies, including their district heating operations. Today, about 130 companies account for 98 % of the country's district heating production.

The electricity legislation provides for greater market transparency

Electricity legislation 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. However, the Energy Market Inspectorate's 2009 investigation[80] indicates that the requirements for separate accounting are not sufficient to address the risks of cross-subsidisation. The focus should instead be on tackling the risk of overcharging that applies on the district heating market. One way of doing this is through information to district heating customers: for this reason, the Inspectorate has, for the first time, collected information on prices, business conditions and operating conditions from district heating companies in 2010.

78 Heating in Sweden 2009, the Energy Market inspectorate's annual survey
79 EIFS 2009:2
80 Special report on district heating activities, EIR 2009:11

New legislation on guarantees of origin

Interest in district heating, based primarily on bioenergy, has again increased in recent years in Sweden, due partly to the effects of higher carbon dioxide tax, changes in CHP taxation and the green electricity certificate system. A new act concerning guarantees of origin came into force in 2006. Under it, producers of electricity and district heating by high-efficiency CHP[81], or from renewable energy sources, can obtain a guarantee of origin from Svenska Kraftnät.

The idea is that this guarantee can be used for marketing purposes. At the same time, the requirement for obtaining a concession in order to lay district heating pipes was removed. This, in combination with changes to CHP taxation, has made the market for district heating more favourable for heat producers.

District cooling for cooling of commercial premises and industrial processes

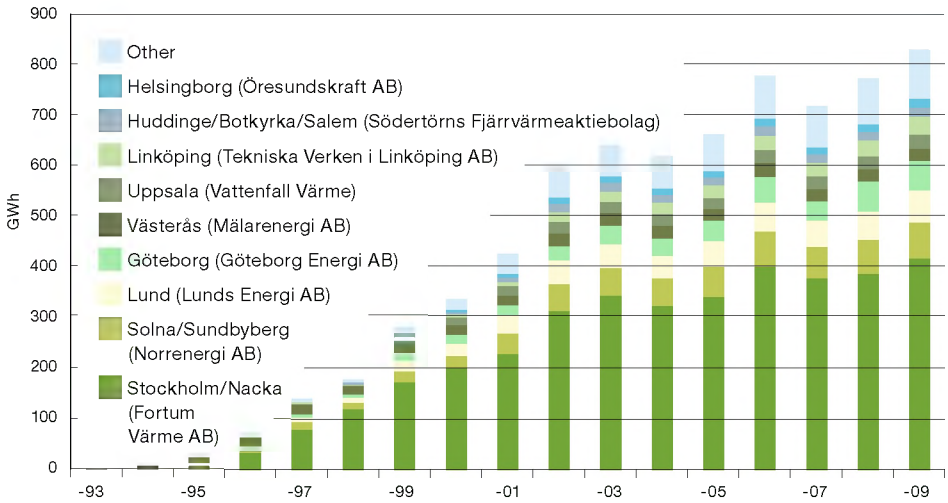
District cooling is used mainly in offices and commercial premises, as well as for cooling various industrial processes. Its principle is similar to that of district heating: cooled water is produced in a large central plant and distributed through pipes to customers. The statistics provide data only 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.

The market for district cooling has expanded strongly since the first system was started up 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. In 2009, there were 29 commercial district cooling suppliers, some operating more than one system. 829 GWh of district cooling were supplied, which is an increase of 7 % relative to 2008.

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

Figure 31 Supply of district cooling, 1993–2009



Source: Swedish District Heating Association.

5.3 Energy gases are more than just natural gas

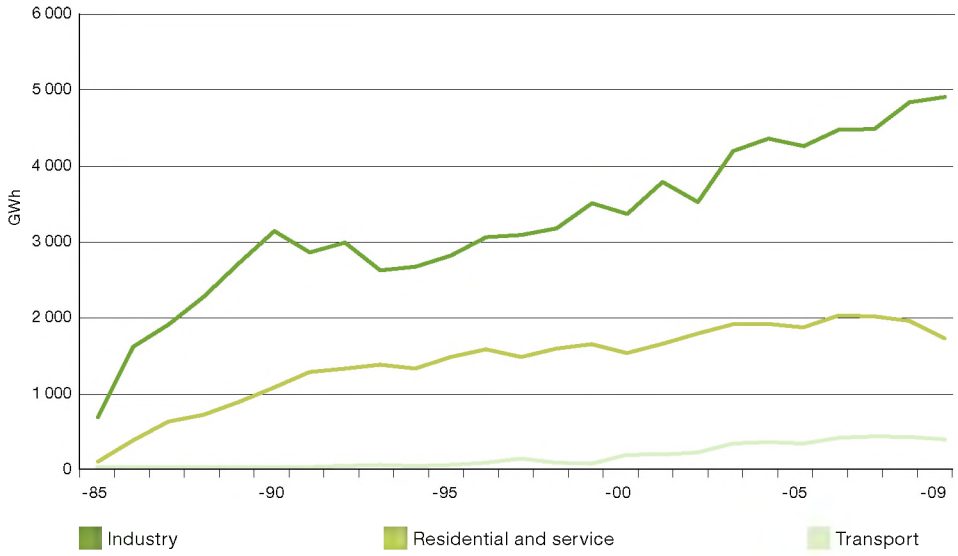
Energy gases is an umbrella name for natural gas, LPG, biogas, town gas and hydrogen. Natural gas is by far the most widely used energy gas, meeting about a quarter of the world's energy use. Sweden uses relatively small quantities of gas in comparison with many other European countries, although it 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 over 40 % since the beginning of the 1990s.

Natural gas on the rise 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 2009, Sweden imported 12.8 TWh of natural gas.

The natural gas network today extends from Trelleborg in the south to Gothenburg, with a number of branches, such as to Gnosjö in Småland and Stenungsund, north of Gothenburg. Natural gas can also be transported in liquid form (known as LNG) after being sufficiently cooled. However, due to the high costs of the necessary cooling, LNG has not previously been able to offer any serious competition to piped natural gas, although the costs for production and transport of LNG have started to fall. An LNG terminal in Nynäshamn is expected to be ready in 2011.

Figure 32 Final use of natural gas in Sweden, 1985–2009, by user sector



Source: Statistics Sweden and the Swedish Energy Agency.

The energy sector is expected to make greater use of natural gas due to construction of gas-fired CHP plants. The Öresund power station in Malmö was restarted in the autumn of 2009 after conversion to gas firing, and is expected to use over 5 TWh of natural gas per year when in full operation.

The Swedish natural gas market has gone from being a local monopoly to a competitive market. 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 in Sweden and around the world has been to create the right conditions for effective utilisation of resources, and thus keep down gas prices. Several structural regulatory changes have been introduced in order to ensure a properly operating market. Some of the more important of these are unbundling and third-party access.

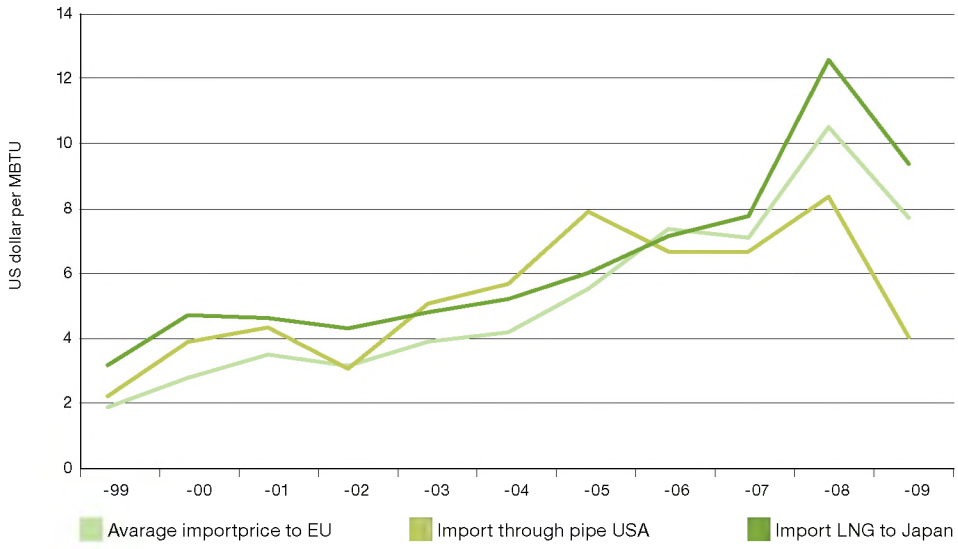
Unbundling means that transport and sale of the gas must be run as separate business entities and can be operated at different levels. The purpose of this is to ensure correct apportionment of the costs for the two different activities, and thus prevent cross-subsidisation. Cross-subsidisation is the 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.

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. It 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 the year, reaching a peak in March 2009.

Svenska Kraftnät has system responsibility for the Swedish natural gas market. 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.

Figure 33 Import price of natural gas, 1999-2009



Source: IEA Energy Prices & Taxes, Quarterly Statistics, Second Quarter 2010.

Local production of biogas

Biogas is produced today primarily from indigenous raw materials such as waste or sewage sludge. A certain amount of waste is also digested together with plant material. However, in response to increased demand, other raw materials for anaerobic digestion, such as straw or waste, can be imported. 227 biogas production plants were in operation in 2008[82], producing a total of 1.4 TWh during the year.

The raw materials are first digested to produce a crude gas, the quality of which must be upgraded before it can be used as motor fuel gas or for admixture with natural gas. Biogas is at present upgraded to natural gas quality in about 30 plants throughout the country.

Biogas is sold today both as pure biogas and in admixtures with natural gas. The existing natural gas network in southern Sweden offers users the option to purchase pure biogas. This requires careful metering and reporting of delivered and consumed quantities of biogas to the system. The methane molecules can obviously not be physically separated from each other, so it is the quantities that are accounted for and set off against each other, thus guaranteeing the consumer that a corresponding quantity of biogas has been delivered to the system.

Recently, distribution of upgraded biogas has increasingly been provided by parties other than the producers. Gas can be distributed either by road tanker or by pipe. In many case, biogas pumps at petrol stations are owned by the producer or distributor of the gas. Today, Sweden has 107 public outlets for motor fuel gas[83]. However, there are substantial differences between the density of the network in different parts of the country, with most of the gas refuelling stations being in the south of the country and in the major urban areas.

LPG and town gas complement natural gas

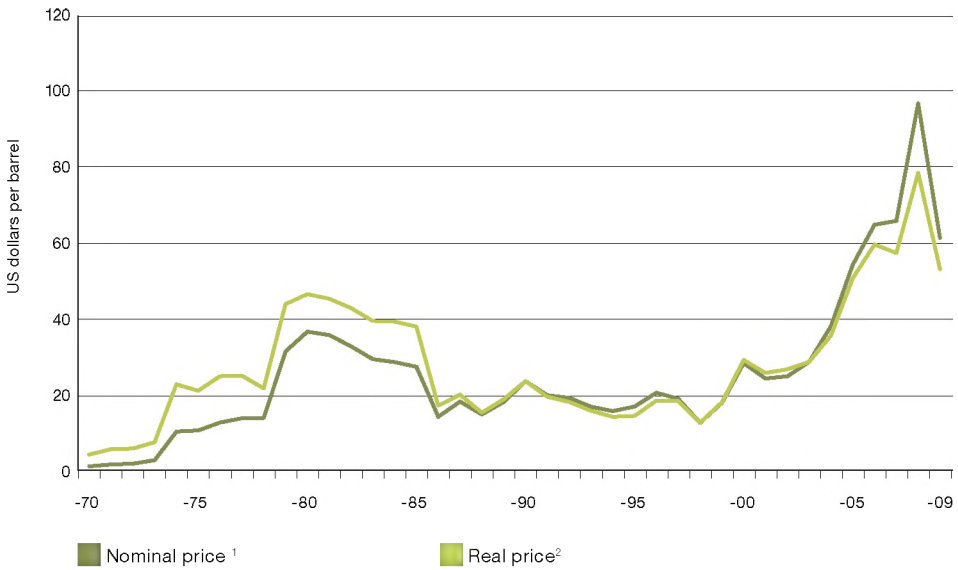
LPG is a petroleum product, having environmental characteristics very similar to those of natural gas. It is used mainly in industry, as well as in the restaurant trade and in horticulture. As LPG and oil and also, to some extent, biofuels are interchangeable fuels in these applications, the use of LPG is sensitive to changes in energy taxation or fuel prices. In 2009, 3.6 TWh of LPG were used in industry, 0.7 TWh in the residential and services sector, and 0.1 TWh for electricity and district heating production.

82 Read more in the Agency's report "Production and Use of Biogas in 2008", ES 2010:01. The report can be downloaded from www.energimyndigheten.se.

83 SPI, www.spi.se

Town gas (gasworks gas) was previously produced by cracking naphtha. The town gas used in Malmö and Gothenburg and, with effect from 2010, also in Stockholm, nowadays consists of natural gas or of natural gas mixed with a small proportion of air. Town gas is used for heating detached houses, larger properties and industries, as well as for cooking in homes and restaurants. 0.23 TWh of town gas were used in 2009.

Figure 34 Nominal and real prices of light crude oil, 1970–2009



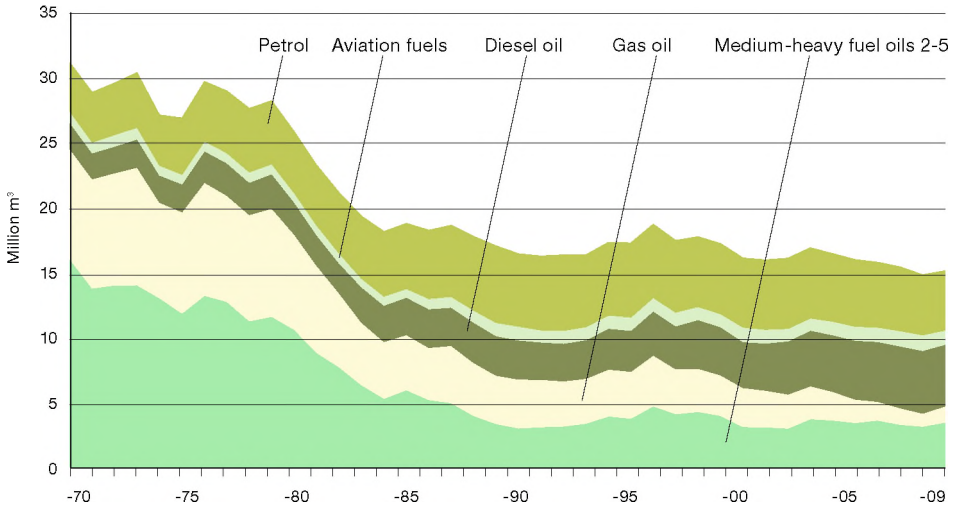
1) Due to revision of statistics at Bp the timeseries has been revised back to 1984.
2) Global real prices deflated with MUV-index from The World Bank.

Source: www.bp.com and the World Bank.

5.4 Substantial price swings on the oil market

2009 was an eventful year, with substantial fluctuations on the oil market. At the start of 2009, after the steep price crash at the end of 2008, the price of oil was USD 35 per barrel, but then stabilised through a fall in production. The price gradually recovered during the spring, so that by the end of 2009 it had reached USD 75 per barrel.

Figure 35 Use of oil products in Sweden, including international transport, 1970–2009



Source: Statistics Sweden and the Swedish Energy Agency.

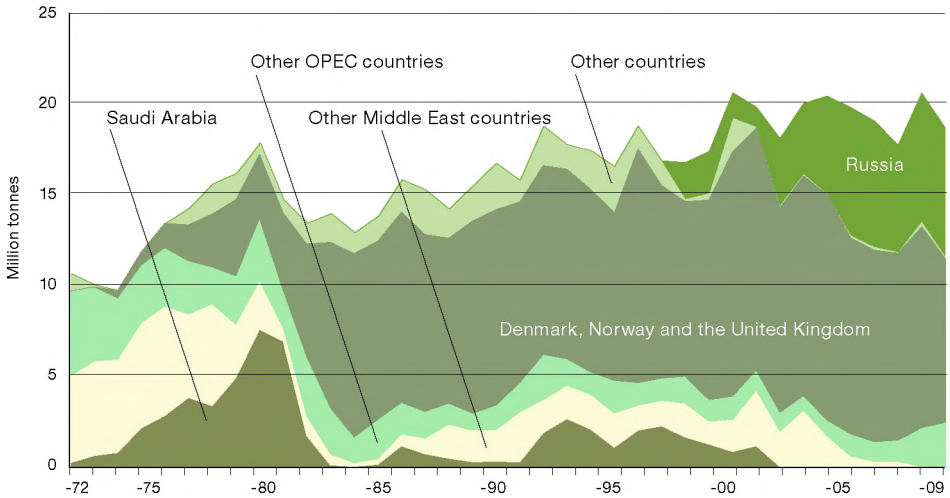
The use of oil in the Swedish energy system has been reduced by half since 1970. It is particularly the use of fuel oils that has been reduced in recent years (and especially in the detached house sector), as can be seen in Figure 35. Another important change is the fact that Sweden nowadays exports, rather than imports, refined oil products. An increase in refinery capacity has been an im-portant means of helping to protect the Swedish economy against excessive price rises.

Sweden imported almost 19 million tonnes of crude oil in 2009, and net-exported 4.4 million tonnes of refinery products: see Figure 36. Over 50 % of Sweden's total crude oil imports come from the North Sea – mainly from Denmark and Norway. Over the last decade, there has been a substantial increase in the proportion of Sweden's oil imported from Russia, amounting to 38 % in 2009[84].

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[85] 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

84 Additional data and statistics on the oil sector can be found in SPI Branschfakta 2010 [SPI Branch Facts], www.spi.se.
85 International Energy Agency.

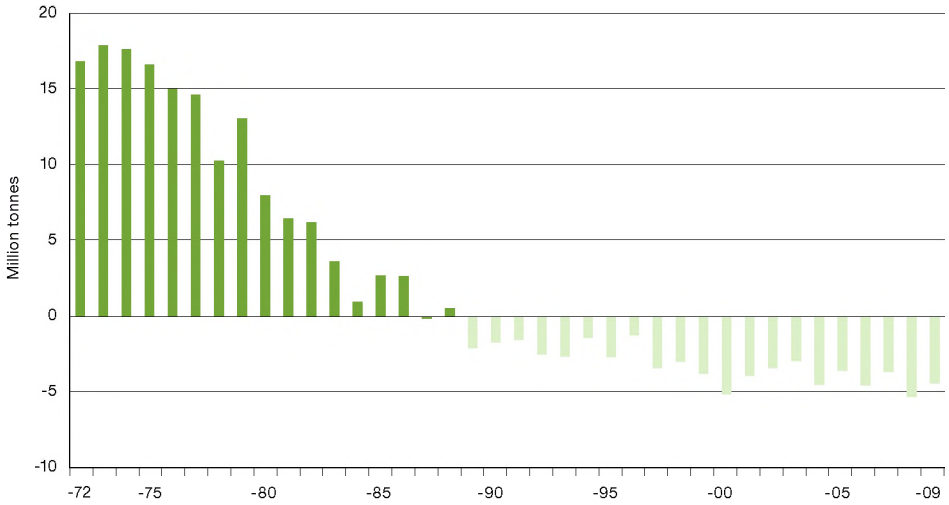
Figure 36 Swedish net imports of crude oil and oil products, by country of origin, 1972–2009



Source: Statistics Sweden and the Swedish Energy Agency.
Note: Until and including 1997, imports from Russia is included in the category other countries.

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 that had been presented in 2008. The Directive requires all member states to maintain strategic stocks of oil equivalent to 90 days' net import, and must be implemented by the end of December 2012. Sweden's total strategic stores of crude oil and oil products already amount to an average of about 145 days' net import. Implementation of the new directive will mean that the present Swedish Oil Storage Act and Ordinance will have to be rewritten.

Figure 37 Net imports (+) and exports (-) of refinery products, 1972–2009



Source: Statistics Sweden and the Swedish Energy Agency.

5.5 Coal producers are also major coal users

Considerable quantities of coal are used in the countries in which coal is produced, and only small amounts are exported, which means that only a small proportion of world production enters international trade streams. It is also relatively difficult to set prices for coal, as its quality varies from one coalfield to another. Coal is traded via bilateral contracts, and there is no spot market for it in the same way as there is for oil.

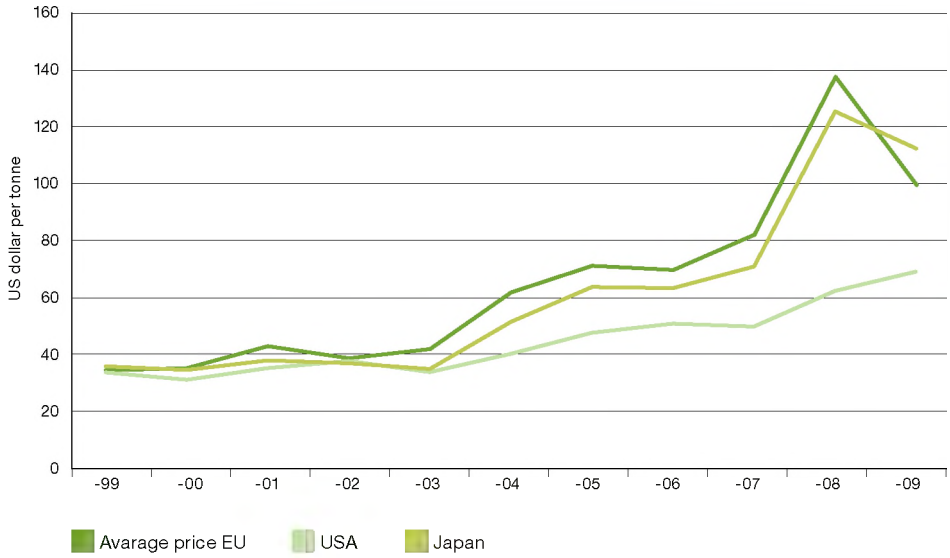
In July 2008, the price of coal reached a record level of USD 220 per tonne. From this peak, the price fell very considerably, down to USD 60 per tonne in the middle of 2009. In May 2010, the price of energy coal had recovered to about USD 90 per tonne. If production continues at the present rate, proven and economically recoverable world resources would last for 146 years.[86]

86 IEA, Coal Information 2009.

FACTS - 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 (energy content). This division is not particularly precise, as no two coalfields produce coal with exactly the same properties. 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.

Figure 38 Coal prices in the EU, USA and Japan, 1999-2009



Source: IEA Energy Prices & Taxes, Quarterly Statistics, Second Quarter 2010.

The use of coal in industry

Industry uses energy coal, metallurgical coal, coke and smaller quantities of other coal products, such as graphite and pitch. Coke is essentially pure carbon, produced from metallurgical coal in coking plants. The country's two coking plants (at steelworks)

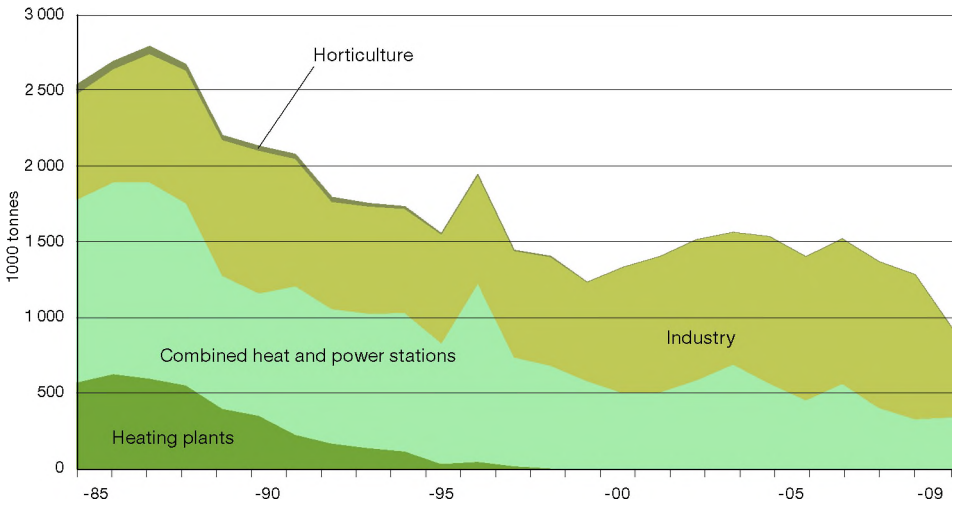
also produce coke oven gas as a result of the process.

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[87] of iron ore in the blast furnaces, and also provides an energy input to the process. Some of the energy content of the coke is converted to blast furnace gas, which is used in the same way as the coke oven gas. Energy coal is used in industry for cement manufacture. 1.5 million tonnes of coking coal were used in industry in 2009, together with 0.6 million tonnes of energy coal, to provide a total energy input of 4.5 TWh.

Substantial reduction in the use of coal for district heating

The use of coal in the Swedish district heating sector has fallen substantially during the 1990s since the introduction of the carbon dioxide and sulphur taxes. Coal has been replaced by biofuels. CHP plants, however, 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. In 2009, the district heating sector used 0.3 million tonnes of energy coal (2.6 TWh) and 1.6 TWh of coke oven and blast furnace gas for electricity and heat production.

Figure 39 Use of energy coal in Sweden, 1985–2009



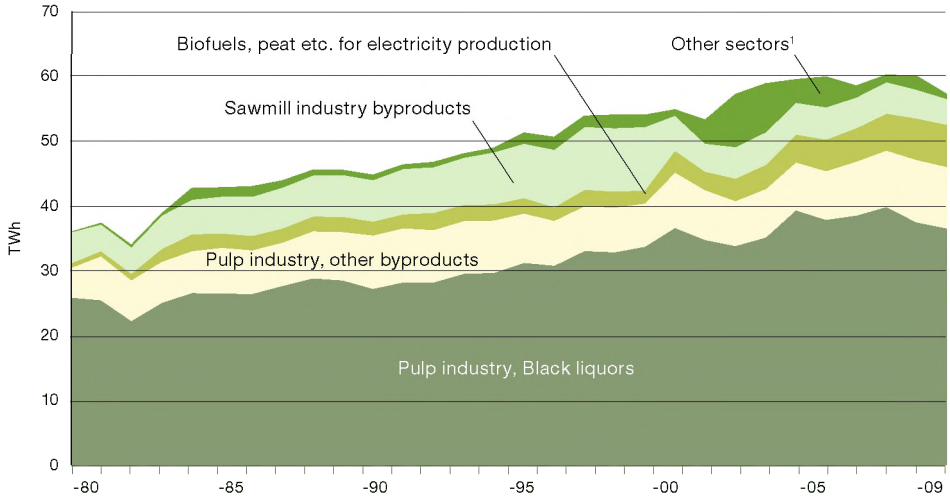
Source: Statistics Sweden and the Swedish Energy Agency.

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

5.6 Supply of biofuels, peat and waste has doubled

The use of biofuels, peat and waste in the Swedish energy system has increased over the years, from a little over 10 % of total energy supply in the 1980s to over 22 % (127 TWh) in 2009. They are used mainly in the forest products industry, in district heating plants, for electricity production and for heating of residential buildings. Most of the increase in the use of bioenergy has occurred in industry and for district heating, although use is also increasing in the residential and transport sectors.

Figure 40 Use of biofuels, peat etc. in industry, 1980–2009



Source: Statistics Sweden and the Swedish Energy Agency

Note: 1. The short term statistics for other sectors is continously underestimated. Other sector includes food, chemical and manufacturing (engineering) industry among others

FACTS - BIOFUELS

Most of the biofuels, peat and waste used in the Swedish energy system consist of:

- Wood fuels; not upgraded (logging residues, bark, chips, recycled wood, and biomass from short-rotation plantations), and upgraded (pellets, briquettes and powder).
- Black liquors and tall oil pitch (intermediate and by-products in chemical pulp production).
- 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.

Waste products from the forest products industry

The forest products 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 transportation.

The forest products industry uses the by-products and waste from various manufacturing processes, together with raw materials that do not meet quality standards, for the production of heat and electricity. Both the pulp industry and sawmills use sawdust and bark as fuel 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 the wood.

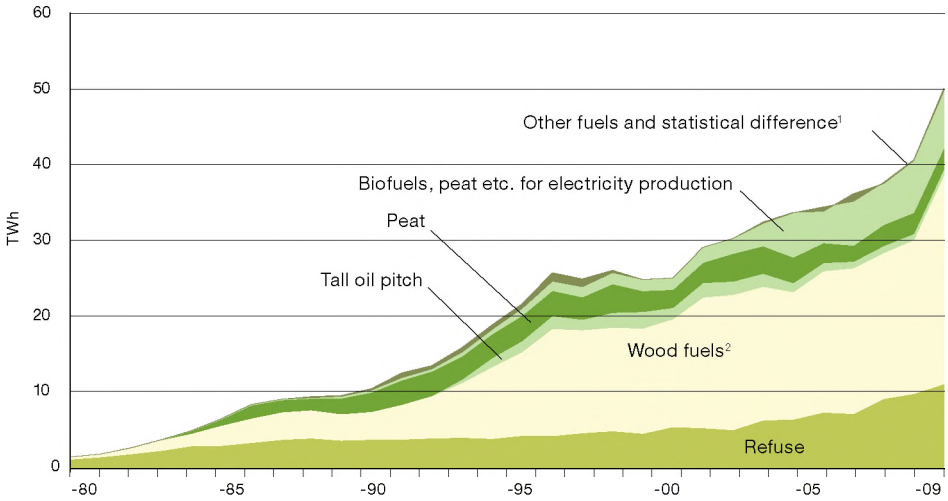
One of the by-products from chemicals recovery is raw tall oil. Raw tall oil and refined tall oil can be used as fuels, but are taxed as fuel oils and are therefore used primarily as industrial raw materials. Tall pitch oil, however, is treated as an untaxed biofuel, and is therefore being increasingly used as a fuel. Energy from the use of black liquors as fuel is used internally within the pulp industry: in 2009, it amounted to 36.7 TWh, excluding electricity production.

Use in district heating plants

42.2 TWh of biofuels, peat and waste were used for heat production (i.e. excluding electricity production) in district heating plants in 2009. Of this, wood fuels supplied 27.7 TWh, black liquors and tall oil pitch 0.8 TWh, waste 11.3 TWh and peat 2.8 TWh. The use of biofuels in the district heating sector has increased by more than fivefold since 1990, as shown in Figure 41. The main biofuels are logging residues including 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 2009, the quantity increased from 4 TWh to 11.3 TWh. This increase has been due mainly to the fact that, since 2002, there has been a ban on disposal of unsorted combustible waste in landfill, and since 2005 it has been forbidden to dispose other organic waste in landfills.

Figure 41 Use of biofuels, peat etc. in district heating plants, 1980–2009



Source: Statistics Sweden and the Swedish Energy Agency
Notes: 1. The difference is due to two different statistical sources. 2. The short-term statistics is continuously overestimated.

Increasing use of biofuels for electricity production

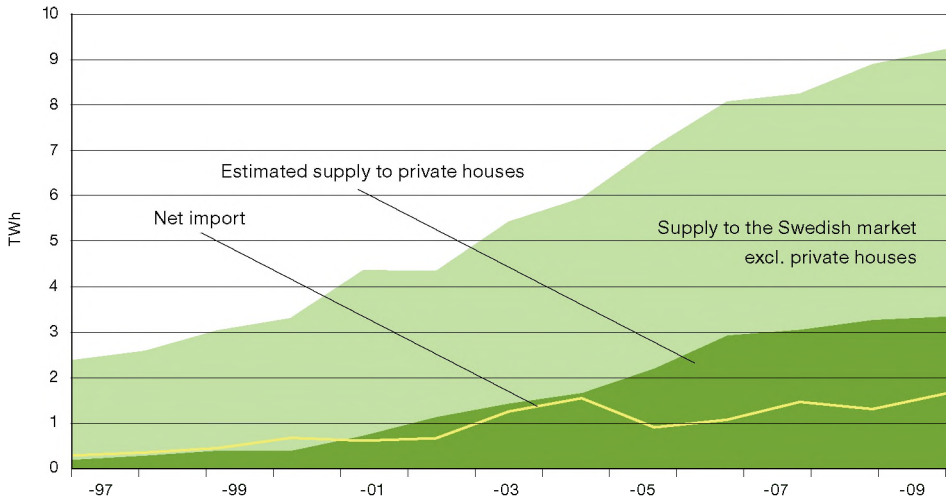
14.4 TWh of biofuels, peat and waste were used for electricity production in 2009. 7.9 TWh of this were used in CHP plants, and 6.5 TWh in industrial back-pressure plants.

Most imported biofuels are used for district heating production

Although most of the biofuels used in Sweden are of indigenous origin, there is also an extensive import of biofuels, such as ethanol, wood pellets and peat. It is estimated that almost a fifth of the quantity of wood pellets used in the country consists of net imports. In total about 430 000 tonnes is being imported and about 88 000 tonnes exported. Peat imports amounted to 435 000 tonnes in 2009. Unfortunately, no reliable satisfactorily comprehensive import or export statistics for biofuels are at present collected, and so it is difficult to estimate quantities. However, imports are included in the country's energy balance as indigenously produced, based on the statistics of use. Investigations that have been carried out into the import quantities of biofuels indicate a figure in the range of 5–9 TWh, which means that the import represents a significant contribution. Most of the imported material is used for the production 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.

Figure 42 Supply of pellets to the Swedish market, 1997–2009



Source: Swedish Association of Pellet Producers

5.7 What makes up energy prices?

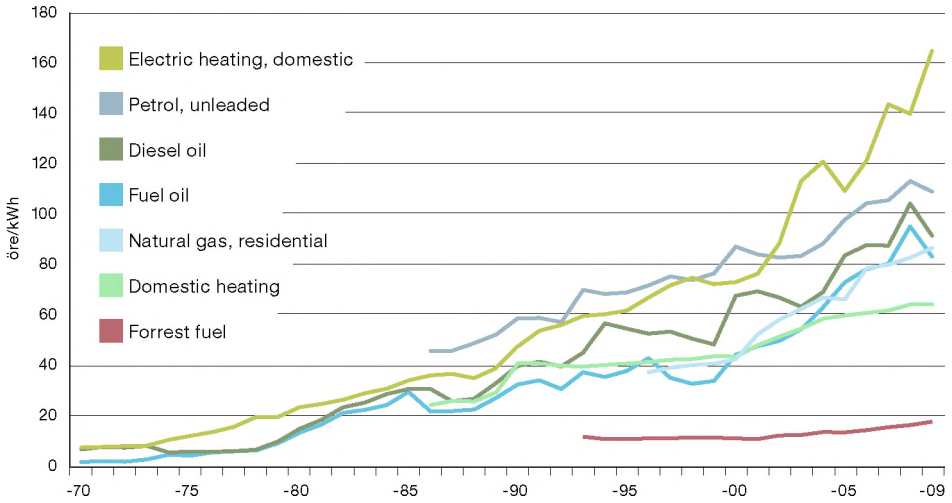
Commercial energy prices consist of several elements, such as the price of the fuel, operating and maintenance costs, capital costs, taxes and VAT. Taxes and charges can vary, depending on how and where the fuel is used. Using real prices allows for inflation: the prices are shown in 2009 levels. Figure 43 shows actual commercial energy prices.

Steep rise in real prices

The price of an average kWh of energy rose nominally between 2008 and 2009, from SEK 1:00/kWh to SEK 1:13/kWh. This price is the weighted price of all purchased energy, including applicable taxes. Bearing in mind that the trading prices of oil and electricity both fell during the year this is a substantial real price rise. However, the falls in the prices of oil and electricity were less than the increases in the mark-ups of the prices to end-users. Most of the increase occurred in the domestic sector: the real price in the transport sector was about 1 %, and that in industry was less than 2 %. As with previous years, it was the prices of district heating and electricity that accounted for most of the increases experienced in the domestic sector.

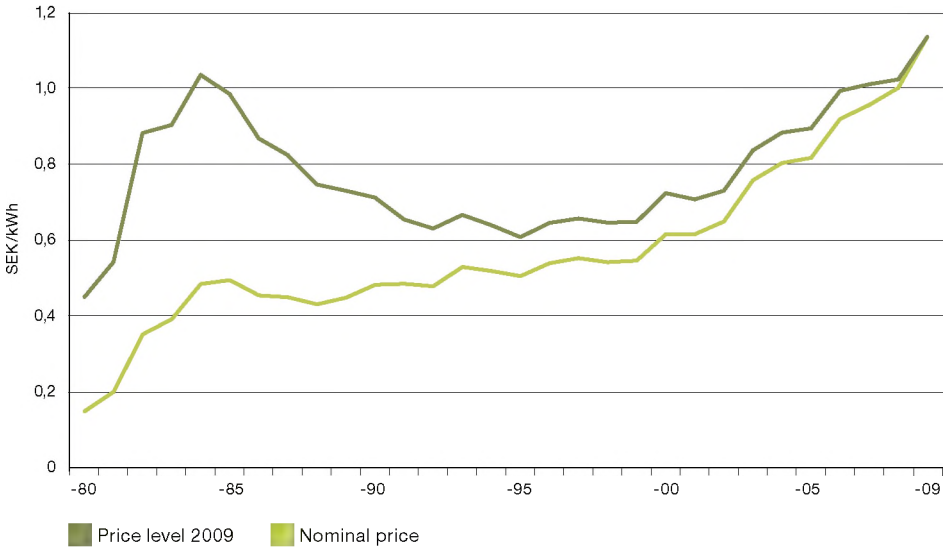
The import prices for energy fell for all forms of energy sources during 2009, with the greatest fall in the price of gas oil, which determines the price level for diesel fuel and domestic gas oil. The oil industry took the opportunity of increasing its mark-ups, which meant that end-user prices, excluding tax, were essentially unchanged.

Figure 43 Actual commercial energy prices in Sweden, including tax, 1970-2009



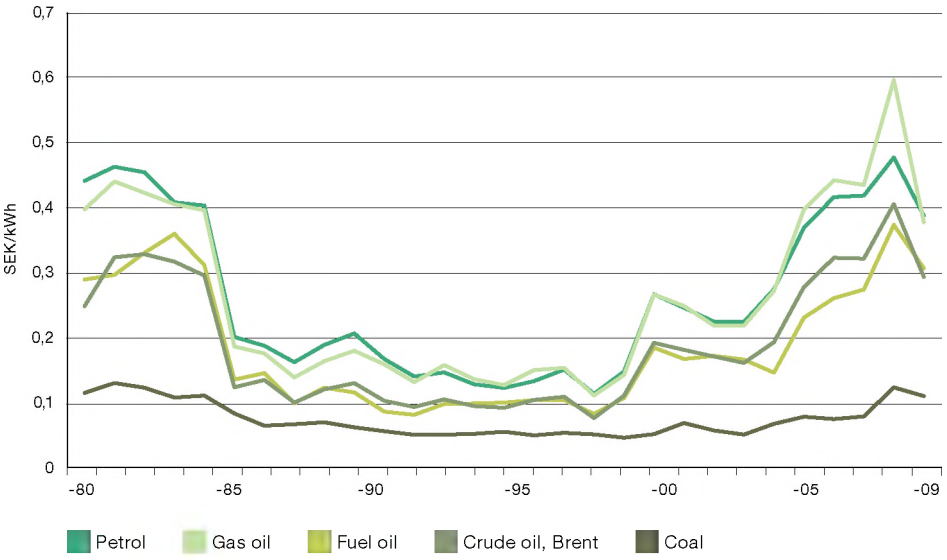
Source: Swedish Petroleum Institute, Statistics Sweden, Swedish Energy Agency and Eurostat.
Note: Unless outherwise stated, prices and taxes for 1993 are for supplies for non-industrial use. VAT is included in district heating, domestic electric heating and natural gas for domestic use.

Figure 44 Price of purchased energy (relative to 2009 price level)



Source: Statistics Sweden, Bank of Sweden and IEA Energy Prices and Taxes.

Figure 45 Import price trends 1980-2009 (relative to 2009 price level)



Source: Statistics Sweden, Bank of Sweden and IEA Energy Prices and Taxes

Summary

Deregulation has resulted in major changes to both the Swedish electricity market and the Swedish gas market. The electricity market was deregulated as long ago as 1996, and has steadily become more and more integrated with the markets in the rest of the Nordic countries and the EU.

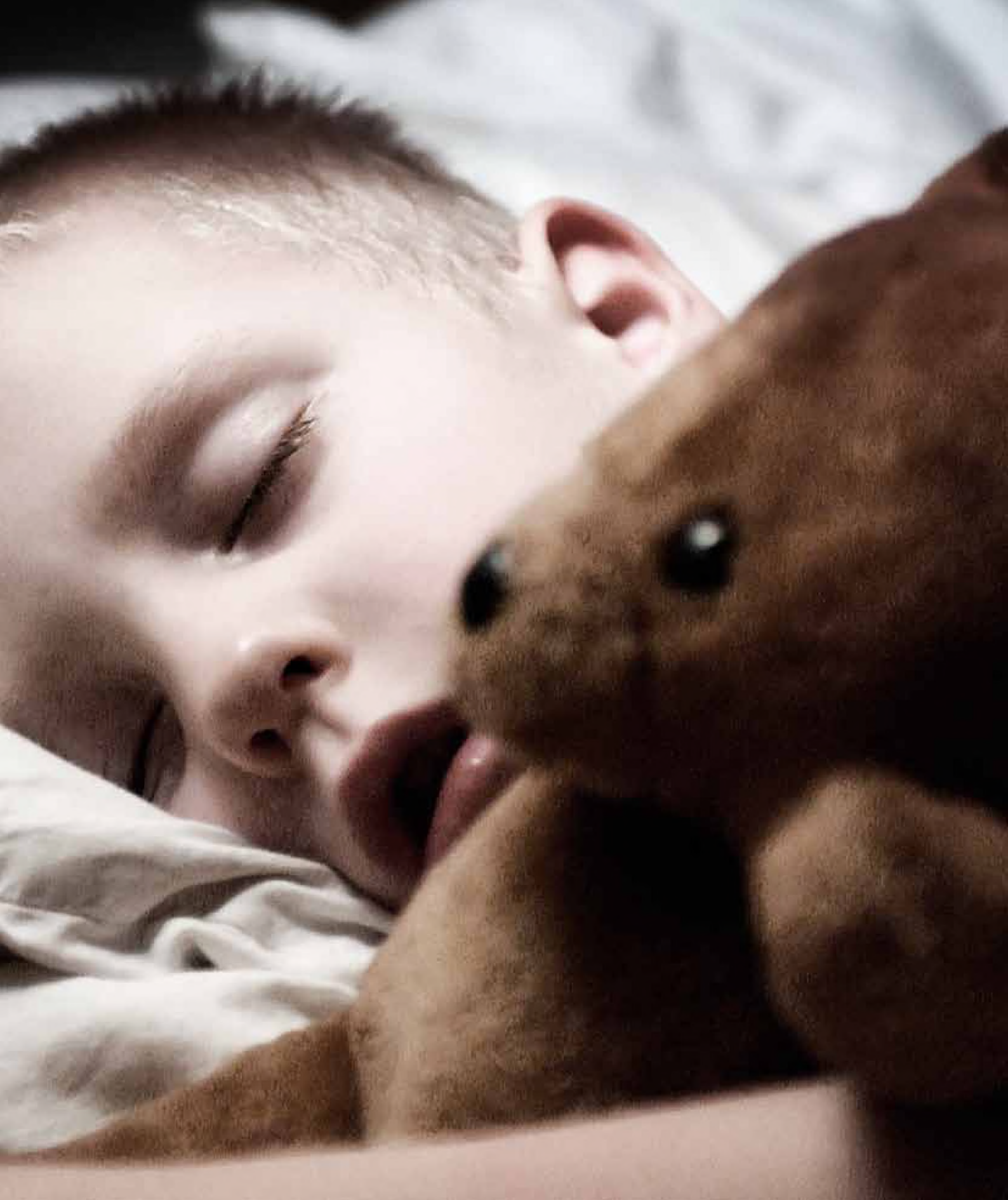
In 1970, most of Sweden's electricity was produced by hydro power and oil-fired cold condensing production. In 2009, nuclear power provided 37 %, hydro power 49 %, and wind power almost 2 % of electricity production. The remaining 12 %, bringing total production to 134 TWh, was provided by fossil-fuelled and bio-fuelled production.

District heating has existed in Sweden since the 1950s, and has expanded substantially in recent decades, so that it is now the commonest form of heating for apartment buildings and commercial premises. One of district heating's advantages is its flexibility in terms of fuel sources.

In 1980, biofuels, waste and peat provided 10 % of the country's energy input. By 2009, their contribution had risen to 22 %. Biofuels are used primarily within the forest products industry, in district heating plants, for electricity production and for residential heating.

6 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 it is sometimes necessary to have access to one form of energy in order to be able utilise another form. Users vary in their awareness of the vulnerability of the energy system. They vary, too, in terms of their needs, their wants and their economic ability to take steps to improve their situation. All told, they naturally have different views on how robust the energy system needs to be. Now and then, energy supplies are interrupted for some reason or other: by bad weather, by accidents or by sabotage. Long interruptions test the ability of individuals, organisations and society as a whole to deal with serious problems of energy supply.



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

Interruptions to the supply of energy occur to greater or lesser degrees every year. Achieving the necessary level of security involves not only preventive work in the technical infrastructure, in organisations and by individuals, but also appropriate preparations in order to tackle problems suffered by producers, suppliers or users[88]. All this must, in turn, be balanced against the wish for a low-pollution and cost-effective 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 of energy supply. All those concerned with energy matters, or who use energy in any form, have to make these judgements.

Electricity suppliers are liable to pay compensation to their customers if interruptions to supply last for longer than twelve hours. This does not replace customers' existing right to claim compensation for damage or injury. In addition, with effect from 2011, unplanned supply failures must not last for more than 24 hours. This is the basic level of security of supply that has been determined by Parliament. Electricity users requiring a higher level of protection of security of supply should consider additional solutions, such as purchasing their own stand-by power generation equipment.

6.2 High electricity prices resulting from shut-down reactors

Interruptions to energy supply can result in energy shortages, power shortages or damage to distribution systems. The resulting problems for users can essentially be summarised by high prices, limited availability of energy, or interruptions in its supply. High prices occur if there is an insufficient supply of energy and demand is high, or as a result of market uncertainties which result in high speculative prices. Limited availability of energy can be a result of a long-term shortage, to which the response is to reduce use or to introduce rationing. The third result, of interruption to supply, can be due to physical damage to electricity networks or access routes, or be the result of disconnection in the event of insufficient production capacity.

Most incidents and events in the energy system result in only brief interruptions to supply, although they can affect many users. However, some events are more serious and can affect large parts of - or even the entire - country. A number of

88 The Agency has produced information material with concrete advice and descriptive examples for various target groups describing how to prevent or reduce the effects of interruptions to electricity or heat supplies. See www.energimyndigheten.se/tryggenergi.

events occurred in 2009, of which some could have resulted in serious consequences if conditions had been different. The following list is of examples of some larger incidents.

- February: 20 000 customers in Umeå were without electricity for up to five hours or more, and district heating production was interrupted.
- June: Over 100 000 customers in north Stockholm were without electricity for four hours.
- June: A leak in the district heating system in Örebro drained the system of water, affecting 4 000 customers to varying extents.
- October: Two major electricity failures in Karlstad, a week apart, caused serious problems for health care centres, hospitals, dairies, shops etc. Several nuclear power reactors remained shut down as a result of delays in their ongoing uprating programmes, causing Svenska Kraftnät to publish a warning of potential power shortage. At times, hourly spot prices on the electricity exchange were very high during late autumn 2009 and the winter of 2009/2010.
- December: Electricity customers, mainly in Dalsland, suffered from a long power failure after heavy snowfalls over Christmas. Some were without power for several days.

6.3 Almost all energy supplies depend on electricity

Electricity is a prerequisite for almost all other forms of energy supply, and is therefore a particularly important element of the entire energy system. Electricity is often necessary for other physical systems to operate.

Electricity must be used in the same instant as it is produced, which means that a shortage can occur at any time, depending on how the particular production and transmission capacities relate to use at the particular time and place. Sweden's electricity system is linked to those in neighbouring countries, which is important for security of supply, as electricity can be imported or exported depending on where it is needed. However, when demand for electricity is at its highest in Sweden, which occurs during very cold winter weather over the entire country, it is likely that neighbouring countries are also experiencing high demand. In such a situation, it may be difficult to import sufficient quantities of electricity. In the worst case Svenska Kraftnät, which is responsible for maintaining the country's power supply, 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 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 reactor 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.

6.4 The energy system is dependent on transport

The transport sector is very dependent on petrol and diesel fuel, although other motor fuels may replace or significantly reduce the use of fossil-based fuels. The biggest threat to security of supply of oil-based fuels and natural gas are those connected to geopolitical actions and factors that are difficult to influence.

Several other parts of the energy system depend on road transport. In the event of a severe crisis in the supply of oil, there would be consequential effects on the use of all types of fuels. The use of biofuels in district heating plants, for example, requires transport from forest to fuel processing plant and then to the district heating plant. The distribution of motor fuels is also dependent on a reliable supply of electricity: for example, to power the pumps at petrol stations.

Summary

Interruptions to energy supply can affect a large part of society and the population. It is technically and economically impossible for the overall energy system to meet the reliability requirements of every single user. Electricity occupies a special position in the energy system, as it is a prerequisite for virtually all other forms of energy supply. Through Parliament, society has placed a duty on the electricity network companies that, with effect from 2011, power failures must not last for more than 24 hours. In practice, this means that 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 resulting from loss of power supply.

7 An international perspective

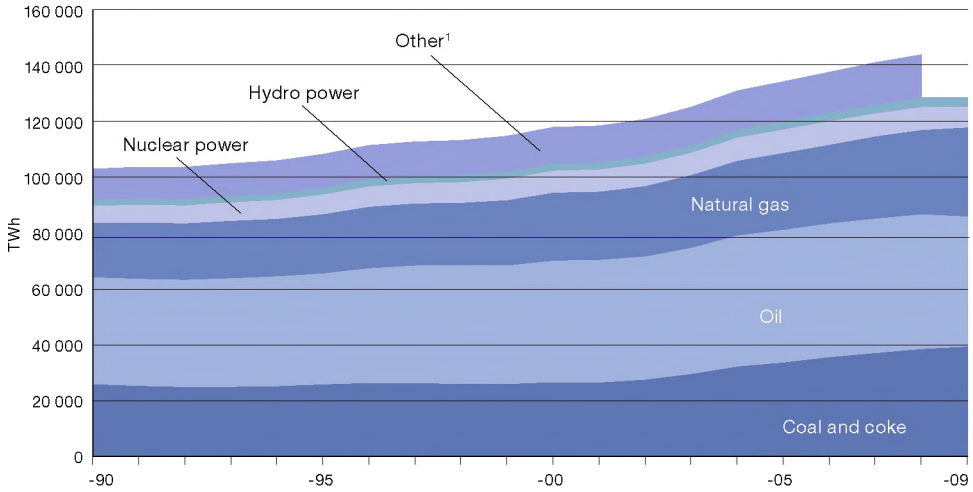
World energy supply is still dominated by fossil fuels, but there are major differences in the use of energy between regions, both in terms of per-capita use and of the forms of energy supply. These differences are due to countries' different circumstances in terms of availability of energy, economic 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.

7.1 The economic crisis and energy use

2009 was marked by the financial crisis and the world-wide global downturn that occurred in the second half of 2008. The OECD countries were the countries most severely affected by the economic crisis, and it was in them that use of energy declined the most. Non-OECD countries are thought to account for 90 % of the increase in energy use during 2009. The economic crisis affected energy use to the extent that it probably fell for the first time since 1982.

Figure 46 shows the growth of global energy supply since 1990. In 2008, fossil fuels accounted for over 81 % of energy supply: the greatest contribution is from oil, with 33 % of supply, followed by coal (27 %) and natural gas (21 %). Including hydro power, the proportion of energy supply from renewable sources during the last ten years has amounted to 13 %. Nuclear power accounts for the remaining 6 % of energy supply.

Figure 46 Total world energy supply, 1990-2009



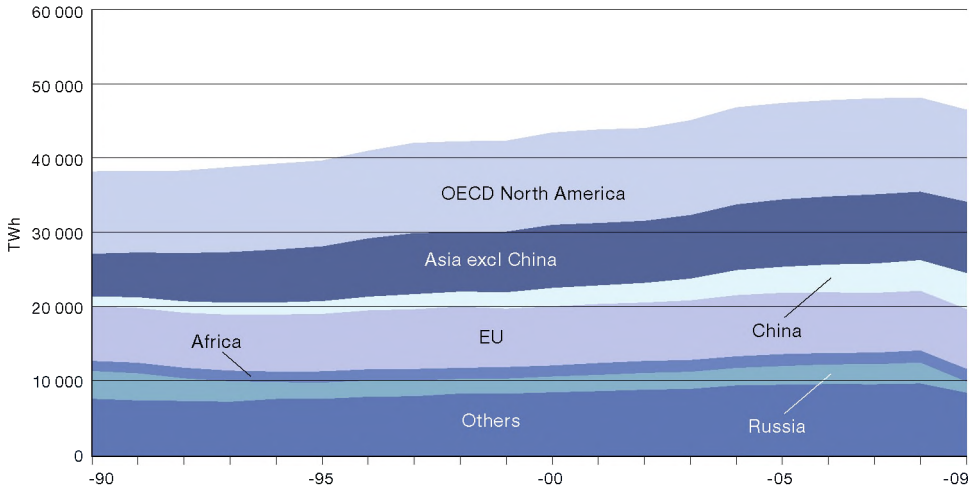
Source: IEA Energy Balances of Non-OECD Countries, 2010 och BP Statistical Review of World Energy, 2010.
Note: 1. There is no statistics for renewable fuels year 2009.

7.2 The use of oil continued to fall during 2009

The use of oil declined by 3 % in 2009 in comparison with 2008. The single greatest decline occurred in Russia, although it also continued to fall in the EU. Although the use of oil fell in total, China and Asia increased their consumption during the year.

In the oil segment, the use of petrol has largely remained constant over the last ten years, accounting for about 32 % of oil use. The proportion of heavy fuel oils continues to fall, and is now down to less than 11 %. On the other hand, this decline is offset by an increase in the use of intermediate distillates – i.e. mainly diesel oil – the proportion of which has increased from 34 % to 36 % over a ten-year period[89].

Figure 47 Global supply of oil 1990-2009



Sources: Energy Balances of Non-OECD Countries 2010, Energy Balances of OECD Countries 2010 and BP Statistical Review of World Energy, 2010.

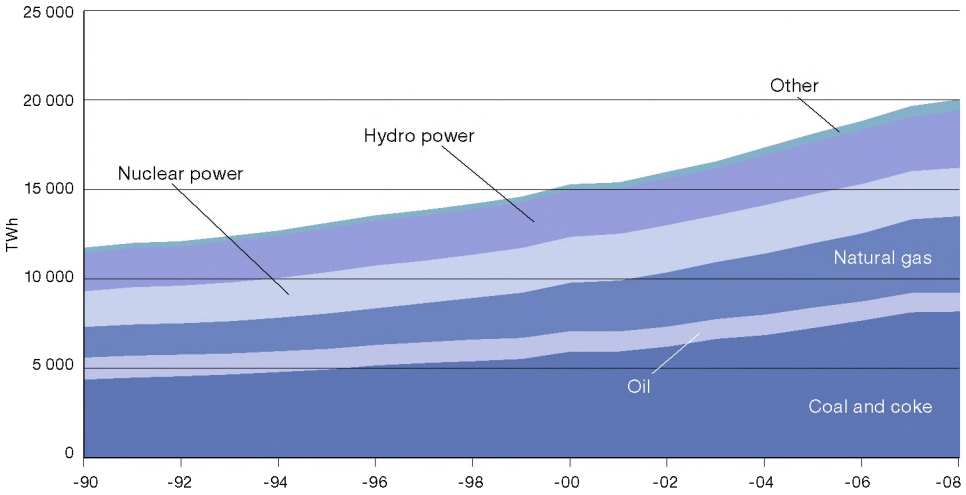
89 BP Statistical Review of World Energy.

7.3 Fossil fuels dominate electricity production

World electricity production amounted to over 20 000 TWh in 2008, which is an increase of 71 % from 1990. In 2008, fossil fuels provided the energy source for 68 % of electricity production: see Figure 48.

Final statistics for electricity production are not yet available for 2009, although preliminary figures show that the year may be marked by a trend break: for the first time since the 1940s, electricity use may have declined in 2009.

Figure 48 World power generation by energy resource, 1990-2008

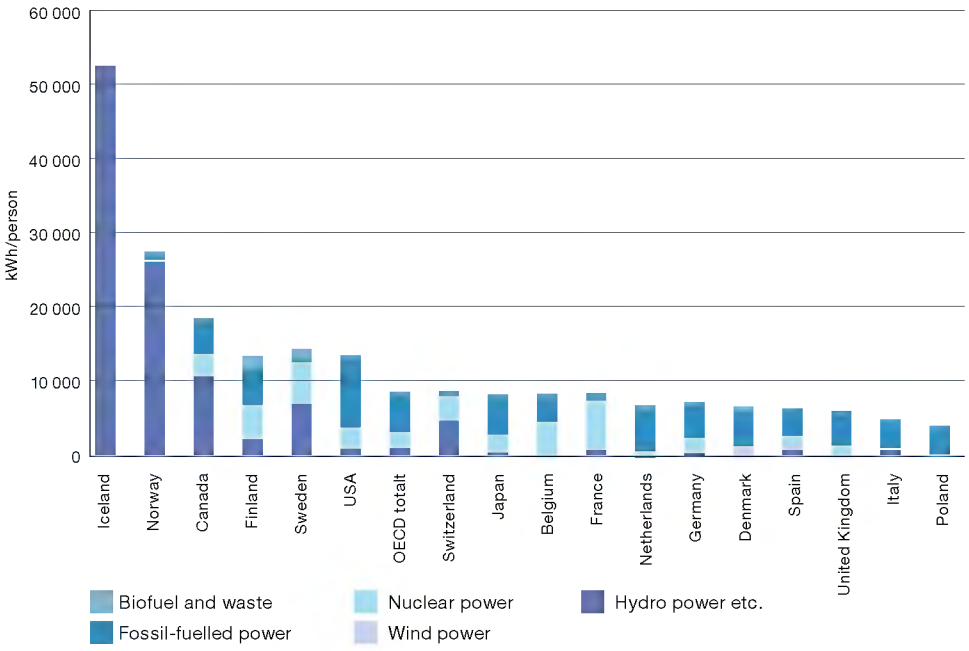


Source: IEA Energy Balances of Non-OECD Countries 2010.

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 2009, 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.

Per-capita electricity production in Sweden amounted to somewhat over 14 000 kWh in 2009. Only Iceland, Norway, Canada and Finland have higher per-capita production 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 54 % lower than that in Sweden.

Figure 49 Specific electricity production per inhabitant by power source, 2009

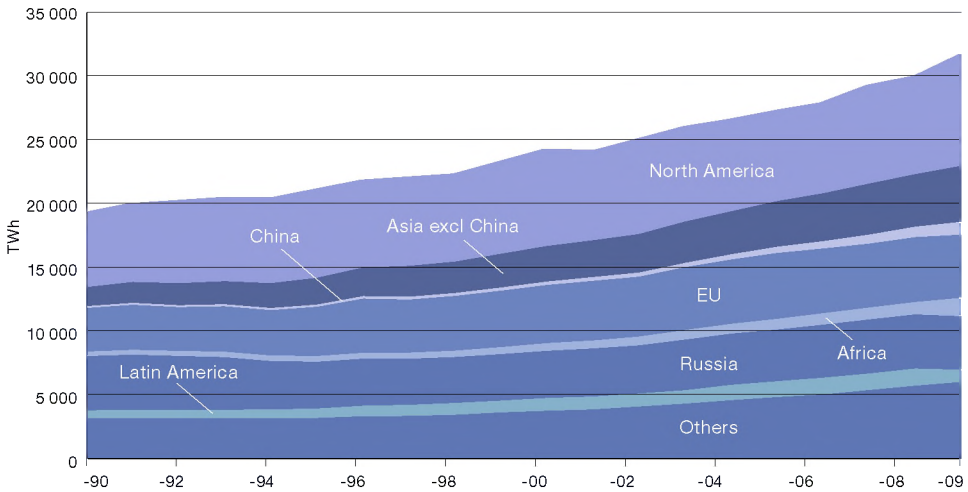


Source: Electricity information 2010 IEA/OECD.

7.4 Natural gas production fell in 2009

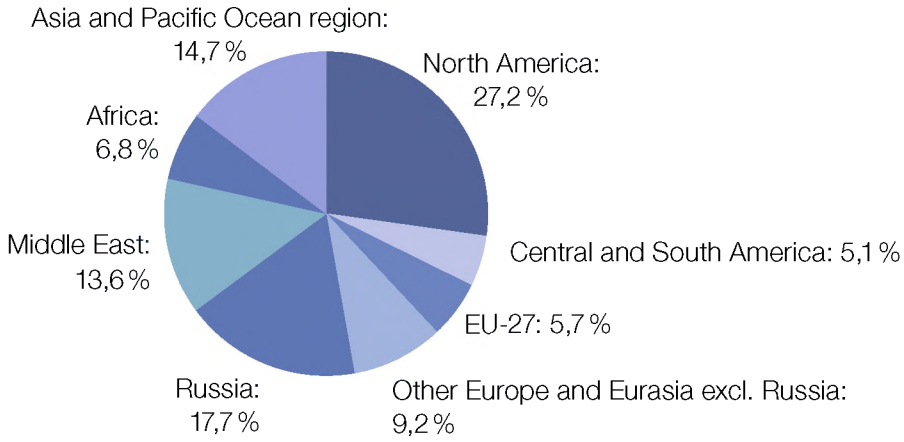
Natural gas production fell in 2009, although its use increased by over 5.5 % during the year. It provides about a quarter of the world's total energy use, and reserves are substantial. At the end of 2009, commercially recoverable reserves amounted to 187 000 x 10^9 cubic metres, which would last for 63 years at the present rate of use, with present-day technologies and prices. Most of the reserves are in the former Soviet republics (31 %) and in the Middle East (41 %). Most of the gas imported to the EU comes from Russia, Norway and Algeria. The largest present-day producer countries are the USA, Russia and Canada. The proportion of global energy supply provided by natural gas has grown rapidly over the last decade. Over the last 20 years, the use of natural gas by the world as a whole has increased by 50 %. Consumption of natural gas is highest in the USA and Russia. In the EU, natural gas has a part to play in the work of reducing environmentally hazardous emissions, primarily by replacing coal and oil.

Figure 50 Global supply of gas 1990-2009



Sources: IEA Energy Balances of Non-OECD Countries, 2010, IEA Energy Balances of OECD Countries, 2010. For 2009, BP Statistical Review of World Energy, 2010.

Figure 51 World production of natural gas, 2009



Source: The BP Statistical Review of World Energy 2010, www.bp.com

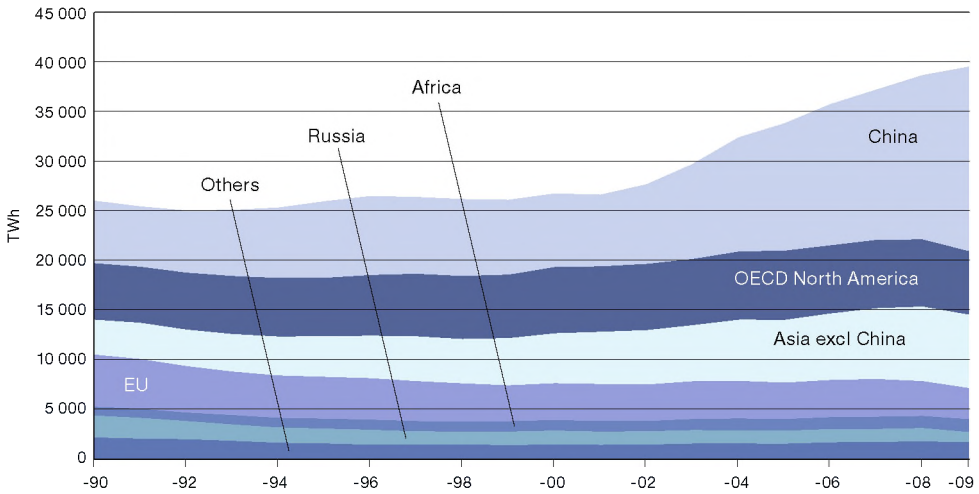
7.5 The use of coal increased in 2009

The use of coal in Europe and North America fell substantially in 2009, while China continued to increase its use. As a result of the increase in use in China, the Middle East and Latin America, overall world use of coal increased by over 2 %, despite the substantial reduction in use in the OECD countries. Coal provides a quarter of the world's energy supply, and is the next largest source of energy after oil[90].

World production and consumption of coal have increased considerably in recent years. China, the USA and India are the countries that use the most coal: the largest producers of hard coal are China and the USA. In Europe, indigenous production of hard coal is declining, and imports now exceed production. If annual world production continued at the present rate, proven and economically viable reserves would last for 146 years[91].

90 IEA, World Energy Outlook, 2009.
91 IEA, Coal Information, 2009.

Figure 52 Global supply of coal 1990-2009

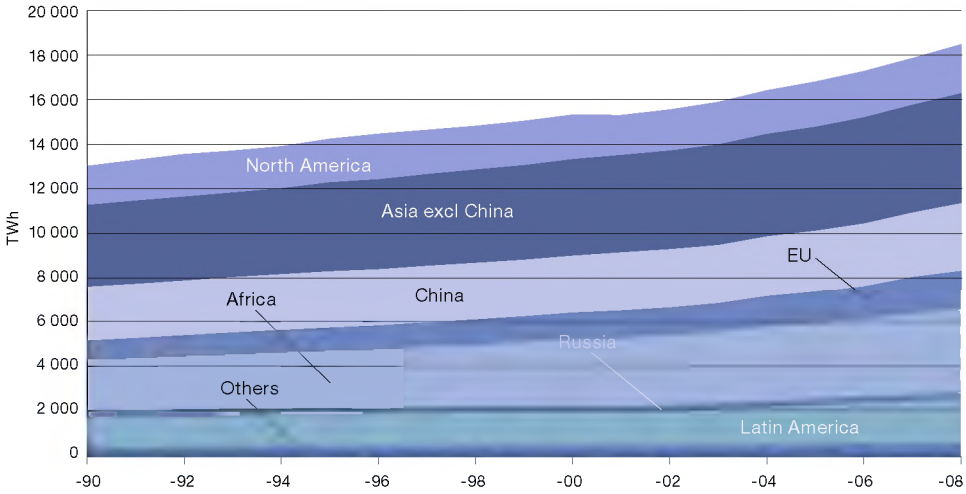


Source: IEA Energy Balances of Non-OECD Countries, 2010. IEA Energy Balances of OECD countries, 2010. For 2009, BP Statistical Review of World Energy, 2010.
Note: Revised figures relative to those shown in previous ediдtion.

7.6 The use of renewable energy continues to increase

Comprehensive statistics of the total supply of renewable energy are not yet available for 2009. Nevertheless, despite the economic crisis, preliminary figures show that the quantity of renewable energy delivered continues to increase. During 2008, the supply of renewable energy increased by 3 % in comparison with 2007.

Figure 53 Global supply of renewable energy 1990-2008



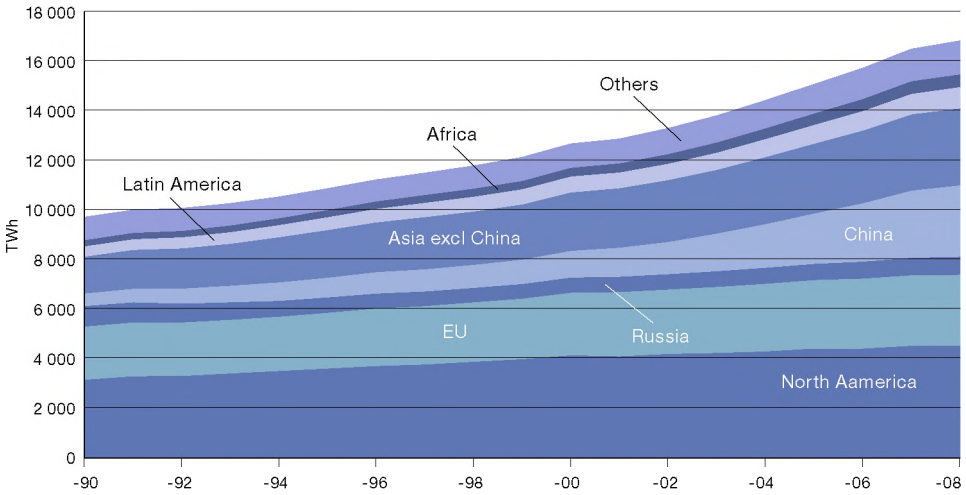
Source: IEA Energy Balances of Non-OECD Countries, 2010. IEA Energy Balances of OECD Countries, 2010.

7.7 Energy use in China increasing rapidly

China uses 47 % of the world's coal supply, and this use is increasing rapidly. The country's use of oil is also rising rapidly. Together with the Middle East and India, China increased the amount of oil that it uses by almost 5 %, or about 900 TWh, while global use of oil fell by the equivalent of 1 200 TWh.

In 2008, China was also responsible for half of the world's total increase in electricity use. The substantial rise in China's increase in its use of electricity in recent years resulted in the country overtaking the EU in 2008 in terms of electricity use: Figure 54.

Figure 54 World power use by region 1990-2008

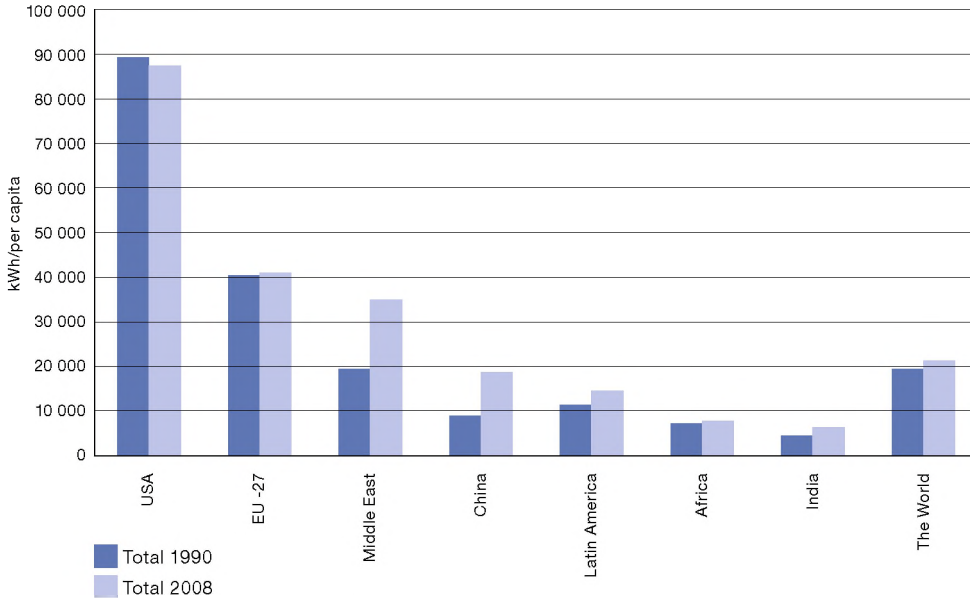


Sources: IEA Energy Balances of Non OECD Countries 2010, IEA Enegy Balances of OECD Countries 2010.

The rate of increase in the use of oil in OECD countries is slowing, as are the rates of increase in the use of coal and natural gas. Preliminary figures for 2009 indicate a strong decline in the use of all energy carriers by the OECD countries.

The USA still has a significantly higher per-capita use of energy than any other country or region: see Figure 55. China, on the other hand, is the country with the highest percentage rate of per-capita increase since 1990. These figures should be treated with caution, as historical values of statistics are revised each year as more data becomes available.

Figure 55 Regional energy use for 1990 and 2008



Sources: IEA Energy balances of Non OECD Countries 2010, IEA Energy Balances of OECD Countries 2010.
Note: Figures for all years have been revised relative to those shown in previous edition.

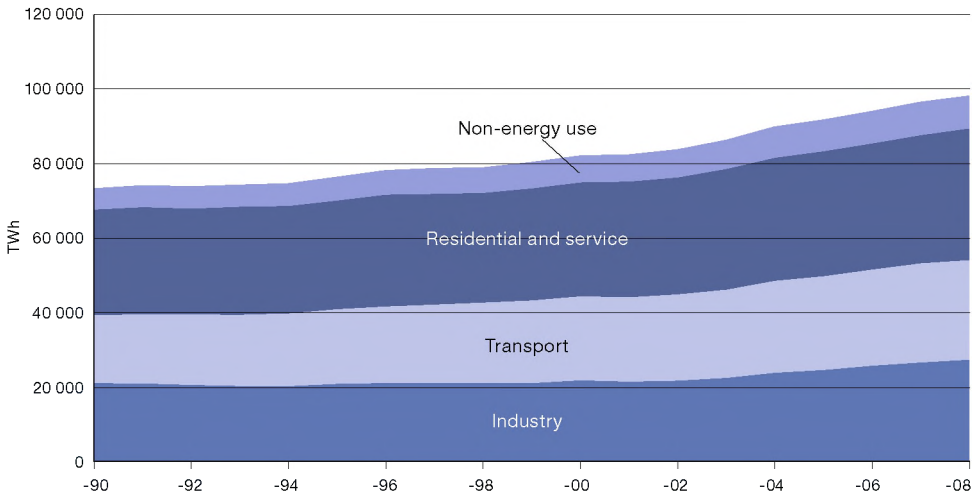
7.8 Overall energy use rising moderately or remaining constant

In recent years, the proportion of energy used by the industrial sector has increased only modestly, despite the fact that the sector is that which has increased the most in comparison with the other sectors. This increase is due particularly to rising industrial production in Asia, with China at the fore.

Although the transport sector is often maligned as being the most rapidly growing sector, its energy use has in fact remained relatively constant at about 27.5 % throughout the decade. In comparison with the industrial and residential sectors, its energy in 2008 was actually that which increased the least: see Figure 56.

In previous years, the proportion of energy used by the domestic sector has fallen substantially. However, in 2008, it increased, bringing it back to 36 % of total energy use.

Figure 56 Total world energy use per sector 1990-2008



Source: IEA Energy Balances of Non-OECD Countries 2010, IEA Energy Balances of OECD countries 2010.

Summary

2009 was dominated by the economic crisis, which affected the use of energy to the extent that it actually fell for the first time since 1982. The OECD countries were most affected by the crisis, and were also those in which the greatest falls occurred in energy use.

Preliminary statistics for 2009 indicate a reduction in the use of oil of over 3 % in comparison with 2008. Although the use of coal fell substantially in Europe and North America, its overall use increased by over 2 % as a result of its considerable increase in China, the Middle East and Latin America. The use of renewable energy in 2008 increased by 3 % over 2007.

China is the country with the greatest rise in total energy use. Of the total world increase in the use of coal, China alone was responsible for 96 %. China was also responsible for over half of the total increase in world electricity use.

8 The environmental situation

All recovery, conversion and use of energy or energy materials has some kind of environmental impact. The most significant direct environmental effects are those relating 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 some apparently less harmful energy sources can reduce some environmental problems, they may have some other adverse environmental impact. Hydro power production, for example, generates no atmospheric emissions, but can prevent upstream migration of fish in rivers.

8.1 Active environmental work in Sweden

Sweden has a long history of active and successful consideration of the environment. It has, for example, succeeded in reducing its greenhouse gas emissions while at the same time increasing its economic growth. Since 1990, emissions have declined by over 12 % while GDP has increased by over 50 % between 1990 and 2008[92]. Environmental problems such as climate change affect the entire world population, and therefore require an international response.

8.2 Environmental targets contribute to achieving sustainable development

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 targets in Sweden must have been achieved 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, county administrative boards, local authorities and other parties, to contribute to the common cause. The Swedish Environmental Objectives Council[93] 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.

92 A Greener Sweden, Environmental Policy 2006-2010, The Government Offices and the Ministries, Article no. 2010.16

93 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.

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. Read more about them at www.miljomal.se They are:

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

Reviewing environmental targets

On 1st January 2008, the Government appointed a commission to investigate the structure, organisation and allocation of powers and duties in the environmental targets system. The commission presented the results of its work in 2009[94], and Parliament considered Bill No. 2009/10:155, Swedish Environmental Targets – For more Effective Environmental Work on 22nd June 2010. The decision involved changes to the target structure, to assessment of target achievement and to the organisation of the work.

Environmental work will continue to have a generation objective that describes the necessary changes to society in order to achieve the environmental quality targets within a generation. The 16 national environmental objectives are retained, setting out the conditions to which the work is intended to lead[95]. Stage targets, replacing the partial targets that had been specified under the environmental quality targets, will be set in priority areas in order to facilitate and give concrete form to the work.

The basis for assessing the degree of fulfilment of the 16 environmental objectives has been changed. Instead of assessing the state of the environment, it is the progress of the work towards achieving the objective that will be assessed, thus making allowance for the fact that it takes a long time for nature to recover. The assessments will say whether fulfilment of the objectives requires international cooperation.

The Environmental Protection Agency will be responsible for coordinating, monitoring and reporting of achievement of the environmental objectives. The Swedish Environmental Objectives Council will be phased out. Each year, the Agency will assess the progress towards achieving the stage and final objectives, complemented by an in-depth evaluation at least once each mandate period. The reports will be prepared in conjunction with the other relevant public authorities concerned.

94 SOU 2009:83

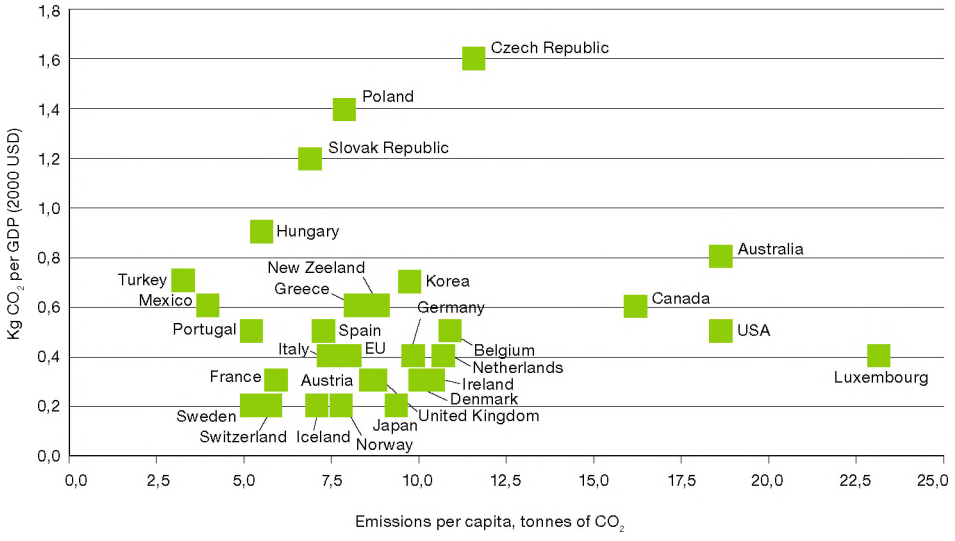
95 The decision includes a number of smaller changes to three environmental quality objectives - "Natural acidification only", "A non-toxic environment" and "A safe radiation environment" – together with elimination of one of the partial targets on the way to the "Reduced climate impact" objective and its replacement by a stage target with the same content.

A Parliamentary Standing Committee will be appointed, with a duty of advising the Government on how the environmental quality objectives can be achieved. Working in conjunction with other public authorities engaged in the environmental quality system, the standing committee will prepare proposals for stage targets, policy measures and necessary actions in priority areas. The new stage targets and strategies replace the three action strategies of more efficient use and transport, non-toxic and low-resource recycling, and conservation and stewardship of ground and water.

Reduced climate impact will be difficult to achieve despite actions

The reduced climate impact target is for stabilisation of greenhouse gases in the atmosphere in accordance with the UN Framework Convention for Climate Change. Sweden's emissions are low in per-capita and per-GDP terms in comparison with those of most other industrialised countries, but are considerably higher than corresponding emissions in the developing countries: see Figure 57. According to the latest forecast from the Swedish Environmental Objectives Council, this objective will be very difficult or impossible to achieve, even if more improvement actions are implemented[96].

Figure 57 Emissions of carbon dioxide in total, per capita and per GDP in EU and OECD countries, 2007



Source: OECD in figures - 2009 edition.

96 Find the forecast in the Environmental Objectives Council's report on progress towards achievement of Sweden's environmental objectives (de Facto 2010).

The trend towards cleaner air has stalled

The target for clean air is that the air should be so clean that it poses no risk to human health, animals, plants or cultural assets. Elevated concentrations of nitrogen oxides, particles and volatile organic compounds (VOCs) in the air are caused by emissions from traffic, industry and residential heating systems. However, much air pollution is caused by long-distance transportation of air pollutants.

There are many air pollutants that are detrimental to human health. 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 oxides and sulphur contribute to eutrophication of water bodies and acidification.

The Swedish Environmental Objectives Council's forecast until 2020 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. If the objective is to be achieved, emissions from traffic, wood firing and the energy sector must be reduced.

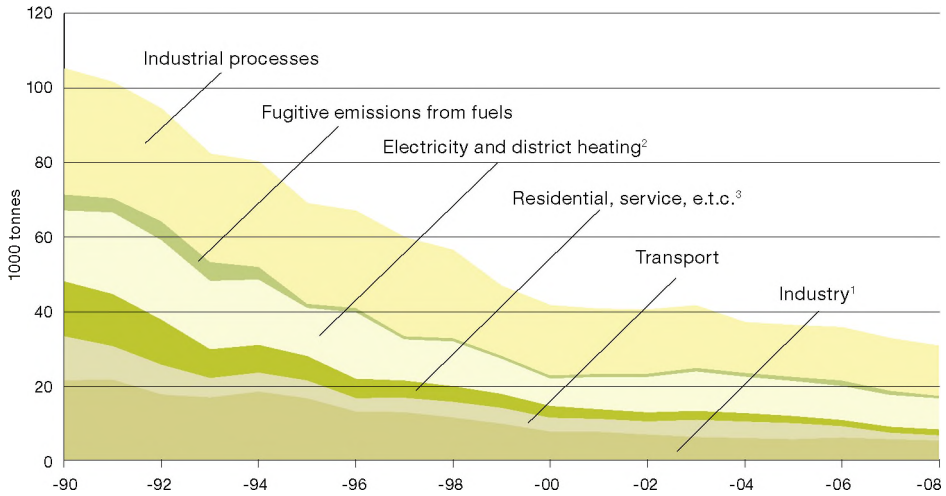
International cooperation must continue if the reduced acidification target is to be achieved

The target for natural acidification only is that 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 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. The main source of sulphur dioxide emissions is combustion of fossil fuels, although emissions have been reduced as a result of flue gas cleaning and sulphur removal from fuels before use. Figures 58 and 59 show sulphur dioxide and nitrogen oxides emissions from 1990 to 2008.

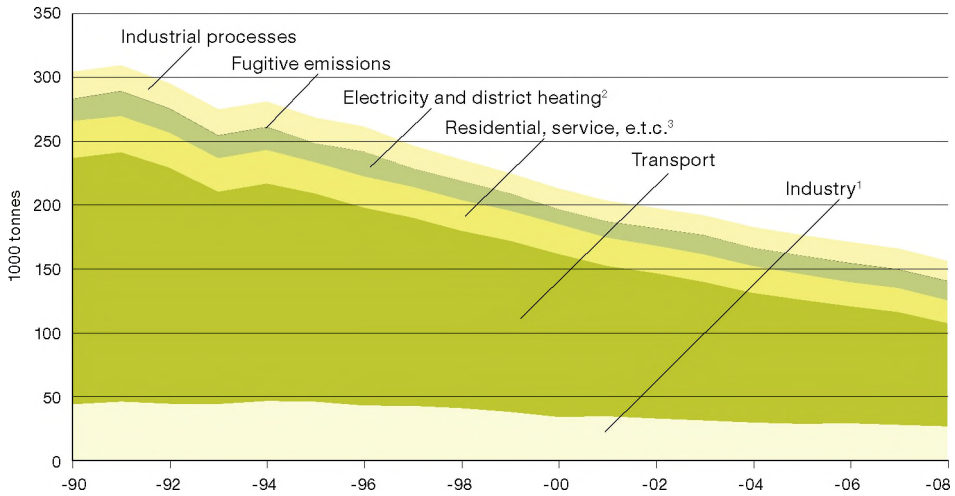
The forecast until 2020 shows that this objective will be very difficult or impossible to achieve, even if additional actions are applied. However, the general trend in environmental conditions is favourable, with sulphur and nitrogen oxides emissions from countries in Europe declining, but further reductions are needed if the target objective is to be achieved. Reducing sulphur dioxide emissions requires continued international cooperation. In order to assist nature in countering wet precipitation, many lakes and watercourses in Sweden have been limed for many years.

Figure 58 Emissions of sulphur dioxide (SO_2) in Sweden 1990–2008



Source: Swedens reporting to the UN CLRTAP, Swedish Environmental Agency 2010, Processed by the Swedish Energy Agency.
Note. Details are revised compared to earlier editions. 1. Including electricity production from industry and hazardous waste incineration. 2. Including coke-oven plants and and refineries. 3. Including agriculture, forestry and fishing.

Figure 59 Emissions of nitrogen oxides in Sweden 1990–2008



Source: Swedens report to the UN CLRTAP, Swedish Environmental Protection Agency 2010, Data processed by the Swedish Energy Agency. Note: Details are revised compared to earlier editions.
1. Including electricity production from industry and hazardous waste incineration. 2. Including coke-oven plants and refineries. 3 Inlcuding agriculture, forestry and fishing.

A good built environment can be partly achieved if several actions are taken

One of the elements of the objective of a good built environment is that the built environment must provide a good, healthy living environment and contribute to a good regional and global environment. The parts of the target that primarily concern the energy sector are those aimed at reducing the environmental impact of energy use in residential buildings and commercial and public premises. This is to be achieved through improvements in the efficiency of energy use to reduce the need for energy input, and by increasing the proportion of energy provided from renewable sources.

The forecast until 2020 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 performed.

Hydro power needs to change in order to maintain flourishing lakes and watercourses

One of the requirements of the objective of achieving flourishing lakes and watercourses is that the lakes and watercourses must be ecologically sustainable and their variety of habitats must be preserved. 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. 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. This is often difficult, as the migration of fish is a local problem, while energy and climate are of global importance.

The forecast until 2020 shows that this objective could be achieved if several actions are performed. The Swedish Energy Agency has been running the 'Hydro Power and the Environment' research project, with the aim of ensuring that the environmental impact of hydro power production is as little as possible. As part of the work of the public water authorities, the National Judicial Board for Public Lands and Funds has been instructed to consult the Environmental Protection Agency, the National Board of Fisheries and the county councils to prepare decision-making material and strategies to deal with obstacles to fish migration, water level regulations, water conservation measures and other physical obstacles that affect watercourses and systems to prevent them from achieving, or risk preventing them from achieving, good ecological status or good ecological potential.

Expansion of wind power should not adversely affect the magnificence of Sweden's uplands

The objective of a magnificent mountain landscape involves combining work on biological diversity, recreational value, and natural and cultural assets, while at the same time supporting work towards sustainable development.

In recent years, municipalities and energy companies have shown increasing interest in establishing wind farms in upland areas. Some Sami communities have also considered the feasibility of constructing wind power farms. Such installations should be sited 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 viable populations of sea eagles and golden eagles.

The forecast until 2020 shows that this objective could be achieved if additional actions are performed. The Environmental Protection Agency's National parks plan from 2008 proposes that nature reservations should be upclassified to national parks. This would provide them with greater protection against exploitation such as the construction of wind power plants.

Summary

Environmental effects occur on many levels: local, regional and global. There are no clear boundaries between the levels, as this depends on the type of effect and how the pollution is spread.

Since 1999, Sweden has used environmental objectives as a way of structuring efforts for a better environment. Assessment has shown that actions are resulting in an improvement, but that more needs to be done if the objectives are to be achieved. The work has been evaluated, and decisions on changes to the structure of the objectives, assessment of their achievement and the organisation of the work have been made in order to improve the effectiveness of the work.

9 Energy units and conversion factors

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.

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

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

Table 7 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 8 Prefixes used before energy units

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

Table 9 Calorific values in MWh and GJ per physical quantity

Fuel	Physical quantity	MWh	GJ
Wood chips	1 tonne	2,00-4,00	7,20-14,4
Peat	1 tonne	2,50-3,00	9,00-11,0
Pellets, briquettes	1 tonne	4,50-5,00	16,0-18,0
Coal	1 tonne	7,56	27,2
Coke	1 tonne	7,79	28,1
Nuclear fuel	1 tonne	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
Virgin naphtha	1 m^3	9,08	32,7
Light virgin naphtha	1 tonne	8,74	31,5
Petroleum naphtha	1 m^3	9,34	33,6
Aviation paraffin and other intermediate distillates	1 tonne	9,58	34,5
Other paraffin	1 m^3	9,54	34,3
Diesel fuel and gas oil	1 m^3	9,96	35,9
Heavy fuel oils	1 m^3	10,6	38,1
Propane and butane	1 tonne	12,8	46,1
Town gas, gaswork gas	1 000 m^3	4,65	16,7
Natural gas[1]	1 000 m^3	11,0	39,7
Blast furnace gas	1 000 m^3	0,93	3,35
Ethanol	1 m^3	5,90	21,2
Biogas	1 000 m^3	9,70	34,9
FAME	1 m^3	9,17	33,0

Note: The table expressed conversion factors to three significant figures. Calculations used a greater number of significant figures.

1. The value for natural gas is for the 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 provide more in-depth information. They can be ordered or downloaded from our web site www.energimyndigheten.se – webbshop.

Energiläget 2010 – printed
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Energiläget i siffror 2010 – PDF
Energiläget i siffror 2010 – Excel
Energy in Sweden 2010 – printed
Energy in Sweden 2010 – PDF
OH-pictures (Swedish) – 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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