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# Energy in Sweden



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# Preface

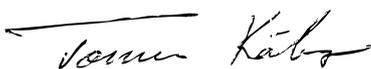
The Swedish Energy Agency is Sweden's central public authority for matters concerning energy. Its work includes responsibility for the emission trading scheme, the Green Electricity certificate system, climate research in connection with energy policy and international climate projects. Energy related work carried out at regional, county and local authority levels has a key part to play in the strategic programme of putting Sweden's energy system on a more sustainable basis. The Agency operates, finance and participates in many activities in the sector. Work is 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 and demonstration activities. The provision of information on the energy system and its development also forms a central part of the work of the Agency.

The challenges presented by energy supply and use are much the same throughout the world. Energy supplies must be reliable, efficient and have as little environmental impact as possible. These three fundamental objectives can both complement and oppose each other, underlining the complexity of energy policy and the close links with environmental and climate policy. Improving the efficiency of energy use and turning to renewable energy sources, are two areas that have potential for contributing to all three objectives. They are areas in which we can see increased activities, with an important driving force being cooperation within the EU. International cooperation is of vital importance, not only for development of the energy system but also in order to tackle cross border and global environmental problems.

This year's edition of *Energy in Sweden* has been given a new look, so that hopefully the text material will be regarded as more accessible and easier to read. Chapter 6, *Assuring energy supply*, is a new chapter that provides, for example, a picture of the risks and interruptions that can occur to the energy system. The annual *Energy in Sweden*, 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 2007, complemented where possible by input reflecting current events and decisions up to the middle of 2008.

Eskilstuna, December 2008



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# Contents

<b>1</b>	<b>Current energy and climate policy areas</b>	<b>6</b>
	Sweden's energy policy	8
	Energy in the EU	15
	Climate policy	18
	Swedish climate strategy	20
<b>2</b>	<b>Policy measures and incentives</b>	<b>28</b>
	Various types of policy measures	30
	Energy taxation	30
	Green electricity certificates	36
	Emission trading	38
	Programme for energy efficiency improvement in energy-intensive industry (PFE)	42
	Buildings	43
	Transport	45
	Technology procurement	46
	Energy research, development and demonstration activities and commercialisation	46
	The climate investment programme	49
	Information activities	50
<b>3</b>	<b>Sweden's energy balance</b>	<b>52</b>
	Total energy use	56
	Total energy supply	58
	The proportion of renewables	59
<b>4</b>	<b>Energy use</b>	<b>64</b>
	The residential and service sector	66
	Industry	71
	Transport	76
<b>5</b>	<b>Energy markets</b>	<b>82</b>
	The electricity market	84
	District heating and district cooling	93
	The energy gases market	99
	The oil market	103
	The coal market	106
	Biofuels, peat and waste	109
	Energy prices	114

<b>6</b>	<b>Secure energy supply</b>	<b>118</b>
	Major disturbances to the energy system	120
	Risk factors in electricity and heat supply	122
	Oil and motor fuels	123
	Secure energy supply is closely linked to the environment and the economy	124
<b>7</b>	<b>An international perspective</b>	<b>126</b>
	Overview	128
	Energy supply	129
	Energy use	135
	Electricity production and use	136
<b>8</b>	<b>The environmental situation</b>	<b>140</b>
	Swedish environmental targets	142
	The environment – an international concern	148
<b>9</b>	<b>Energy units and conversion factors</b>	<b>152</b>

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# Current energy and climate policy areas

Political and legal considerations determine the framework conditions for energy markets. Political decisions are intended to influence the development of energy use and energy production in order to create a sustainable energy system. The Swedish energy markets are affected primarily by national and EU decisions, although global agreements are becoming increasingly important. The need for global cooperation is essential in the field of climate policy. This chapter discusses a number of areas of current interest in the fields of energy and climate policy.



## Sweden's energy policy

“Sweden’s energy policy, in both the short and the long term, is to safeguard the supply of electricity and other forms of energy on terms that are competitive with the rest of the world. It is intended to create the right conditions for efficient use of energy and a cost efficient Swedish supply of energy, with minimum adverse effect on health, the environment or climate, and assisting the move towards an ecologically sustainable society.” These guidelines for the country’s energy policy were set out in the 1997 Energy Policy Agreement<sup>1</sup>, together with a strategy for continued restructuring of the country’s energy system. This restructuring looks to assurance of the country’s electricity supply by basing the energy system on permanent – and preferably indigenous and renewable – energy sources, coupled with efficient use of energy.

The Government intends to present a climate policy bill in the autumn of 2008. In order to formulate its climate policy and to obtain and prepare material for the bill, the Government has initiated a dialogue with a number of organisations from industry, research and politics. This dialogue is based on the climate and energy package published by the European Commission on 23rd January 2008<sup>2</sup>, as well as on the final report of the Climate Commission, published on 4th March 2008. The Government has also appointed a Sustainable Development Commission, under the chairmanship of Prime Minister Fredrik Reinfeldt, with Minister of the Environment Andreas Carlgren as vice chairman. The Commission draws its membership from a wide field, with members from industry, independent organisations, research organisations, public authorities and political parties. Its work is concentrated on reviewing how improvements in the effectiveness, and modernisation, of organisations, regulatory structures and policy measures can assist the work of moving towards sustainable development and environmentally responsible growth. Sweden is due to take the Presidency of the EU in autumn 2009, and the Commission sees its work as particularly relevant to this.

As far as energy is concerned, the Government intends to invite all parties in Parliament to reach a wide ranging and strategic energy consensus, based on Alliance for Sweden’s energy agreement.

In January 2007, responsibility for energy matters was transferred from the previous Ministry of Sustainable Development to the Ministry of Industry and Commerce. However, climate policy and environmental aspects of the energy sector fall within the remit of the Ministry of the Environment.

A reliable supply of electricity at a reasonable price is an important prerequisite for the international competitiveness of Swedish industry, and energy policy must be structured in such a way as to assure this. The country’s energy policy must also assist the realisation of expanded energy, environmental and climate cooperation in the Baltic Sea region.

On 7th February, the Government announced the appointment of Tomas Käberger

1 Bill no. 1996/97:84. Current energy policy represents an agreement between the Social Democrats, the Left Party and the Centre Party.

2 [www.regeringen.se](http://www.regeringen.se).

as the new Director General of the Swedish Energy Agency. He has been appointed for the period from 1<sup>st</sup> March 2008 until 28th February 2014.

At the beginning of 2005, the Government established the Energy Markets Inspectorate as part of the Swedish Energy Agency in order to create an efficient market for electricity with effective competition. The Inspectorate exercises surveillance of the electricity distribution companies, monitoring developments on the electricity market. On 1<sup>st</sup> January 2008, the Inspectorate was broken out of the Agency and became a public authority in its own right, with Yvonne Fredriksson as Director General. The reason for creating a new public authority was that it was felt to be essentially inappropriate for one and the same public authority to have both surveillance duties and support duties.

### **Measures in the short and medium long terms**

The electricity certificate system was introduced in 2003, with the objective of increasing the use of electricity from renewable sources by 17 TWh between 2002 and 2016. The Programme for Energy Efficiency Improvement in Energy-Intensive Industries (PFE) was started at the beginning of 2005, which year also saw introduction of the EU emission trading scheme. These policy measures are described in more detail later in this report.

The planning objective for wind power production includes a requirement that local authorities must have agreed plans for 10 TWh of wind power production by 2015<sup>3</sup>. The Agency was instructed by the Government in 2007<sup>4</sup> to prepare a proposal for a new planning target for 2020. The Agency suggests a target of 30 TWh, of which 20 TWh should be onshore and 10 TWh offshore. The Government's Wind Power Bill<sup>5</sup> includes proposals for measures to assist achievement of the planning objective, including support for local authority land use planning for 2007 and 2008. The planning process was simplified in the autumn of 2006, so that plans for wind farms with aggregated capacities not exceeding 25 MW now need only to be notified to the local authority.

Instructed by the Government, the Agency has set up a National Wind Power Network to disseminate knowledge of, and information on, wind as a natural resource, thus facilitating the expansion of wind power generation and at the same time encouraging regional development. The network is intended to improve awareness of planning and concession aspects, training and skills, industrial and commercial development, availability of personnel with the necessary skills and operational and maintenance aspects.

In addition, the 2002 Energy Policy Decision also includes measures to improve the efficiency of energy use, such as energy advisory services, technology procurement projects and the market introduction of energy efficient technology.

3 Read more on the makeup of the national planning target and other aspects in the Swedish Energy Agency's report no. ER 16:2003.

4 Government decision N2007/1205/E (published not later than 1 December 2007).

5 Bill no. 2005/06:143 Green electricity from wind power - Ensuring a healthy wind power sector. Gold Klimps are particularly efficient measures within the programme, which have not received any other grants.

A special conversion grant, available from 2006 until 2010, was introduced at the beginning of 2006 in order to reduce the use of oil and electricity for heating purposes in residential buildings and certain commercial premises. The grant is available for conversions to district heating, biofuel fired heating systems, heat pumps or solar heating. However, grants for conversion away from oil were withdrawn from the beginning of 2007, because all funding had been used up. Until the end of 2008, owners of public premises can apply for grants for conversion and energy efficiency improvement measures. Grants for installation of solar cells for use by public premises have also been available from 2005, and will remain available until the end of 2008. The previous tax reduction concession for the installation of biofuel fired heating systems and higher performance windows in new detached houses has been replaced by a corresponding grant, which will be available until the end of 2008. A grant for solar heating in commercial premises



A grant for solar heating in commercial premises and detached houses is available until the end of 2010.

and detached houses is also available until the end of 2010. A cash subsidy of SEK 10 000 has also been available from April 2007 to private buyers of new low-environmental-impact cars. The Government originally earmarked SEK 50 million for this for 2007, and SEK 100 million for 2008 and 2009. However, sales of qualifying cars were higher than expected, and so the Government's additional budget for 2008 included a further SEK 240 million for the scheme. The Budget Bill for 2009 includes SEK 425

million for the scheme, which is expected to meet the cost of the scheme for all those purchasing such cars before 1<sup>st</sup> July 2009, when the scheme finishes.

Since 1<sup>st</sup> April 2006, larger petrol stations are required to sell a renewable motor fuel, which has mainly had the effect of encouraging the sales of ethanol. A special programme, running until the end of 2008, provides support for other alternative motor fuels.

The Klimp climate investment programme assists local authorities and other parties at local level by making grants available for long term investments intended to reduce greenhouse gas emissions. In May 2008, the Investment Support Council announced grants to 31 programmes and three Gold Klimp<sup>6</sup> projects, to a total value of SEK 481 million.

### Long-term measures

In June 2006, Parliament set the target<sup>7</sup> that specific energy use in residential buildings and commercial premises should be reduced by one fifth by 2020, further reducing to half of present day levels by 2050. In addition, by 2020, the dependence of the built environment on fossil fuels for energy supplies should have been broken.

<sup>6</sup> Bill no. 2005/06:145  
National programme for improving the efficiency of energy use in buildings and smart energy construction.

<sup>7</sup> Bill no. 2004/05:1.

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

The 2005 Budget Bill<sup>8</sup> confirmed a new, long term energy research programme for the period 2005–2011, concentrating on research, development and demonstration activities for the development of methods, technologies and processes for the transition to a sustainable energy system. The programme provides funding to a value of about SEK 800 million per year. Continued support is provided for pilot projects in the wind power field. The Energy Research Bill<sup>9</sup>, which was presented to Parliament in the spring of 2006, proposed guidelines for the continued work. It included requirements for greater links to business and industry, coupled with ambitious targets for turning research results into commercial products and services.

Work on a new ordinance to support research, development and demonstration activities in the energy sector is in progress. It will replace three existing ordinances<sup>10</sup>, and is intended to open the way to the opportunities presented by the new EU public support framework.

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

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

8 Bill no. 2005/06:127. Research and new technology for future energy systems.

9 Ordinance concerning public support for energy research, SFS 1998:222; Ordinance concerning public support for energy technology, SFS 1998:653; Ordinance concerning energy technology grants, SFS 1998:654.

10 Ordinance concerning public support for energy research, SFS 1998:222; Ordinance concerning public support for energy technology, SFS 1998:653; Ordinance concerning energy technology grants, SFS 1998:654.

### **Current investigations**

An environmental technology delegation under the name of Swentec, Swedish Environmental Technology Council, has been established, with the aim of developing an effective state structure for supporting and strengthening Swedish environmental technology companies. The delegation will prepare material to support the Government in its work in the environmental technology field, and will also provide help in other ways to the Swedish environmental technology sector and Swedish environmental technology companies. The Delegation is due to submit progress reports on its work by not later than 31<sup>st</sup> December 2008, 30<sup>th</sup> May 2009 and 31<sup>st</sup> December 2009, with a final report by not later than 31<sup>st</sup> December 2010.

Since 2007, a commission has been investigating what else Sweden should do in order to fulfil the requirements of the Energy Services Directive. The Directive requires each member state to achieve a measurable improvement of 9 % in its efficiency of energy use by 2016. To achieve this, the public sector is expected to play a leading role. In addition, companies in the energy sector are required to assist in several ways, so that their customers can make cost efficient improvements in their energy use efficiency. One of the areas to be investigated is whether it would be justified to introduce requirements for more individual metering, e.g. of domestic hot water consumption in individual apartments, while another is to find a way of measuring and monitoring improvements in the efficiency of energy use. It will be permissible to include certain previously effected improvements in the calculations. An interim report was presented on 11th March 2008, setting out a proposal for an energy efficiency improvement plan. The final report was submitted by 30<sup>th</sup> October 2008.

An investigation into electricity network tariffs is due for completion on 22<sup>nd</sup> December 2008, setting out proposals for legislation and regulations as needed to enable the surveillance authority to require the network operators to submit their tariffs and connection fees/methods for approval prior to their introduction. The report will also include proposals for how power supplies from other countries connected to the Swedish regional networks shall be dealt with in order to ensure that they are treated in the same way as when they are connected to the national grid. An interim report was submitted in December 2007.

The Environmental Process Commission intends to present its final report on 31<sup>st</sup> December 2008, describing proposed simplification, coordination and improve-

ment in the efficiency of processing and court consideration of property cases and other cases concerned with the Environmental Framework Code and the Planning and Building Act. The work has included preparation of proposals for possible legal changes concerning the supply of renewable energy, with particular attention being paid to simplifying the regulations etc. that affect the establishment of wind power generation.

### **Investigations concluded during the second half of 2007 and the first half of 2008**

In June 2005, the Government appointed an investigator to identify the effects of climate change, and to investigate how society's vulnerability to such changes could be reduced. A final report was submitted on 1<sup>st</sup> October 2007.

The Scientific Council for Climate Issues has concluded its work and submitted its report in September 2007. The report provides scientific assessments intended to assist parliamentary drafting of material concerning climate matters. An important part of the work has been to provide material and target recommendations for Swedish climate policy, at national, EU and international levels.

The Parliamentary Committee for Climate Matters submitted its report on 4th March 2008. The Committee has assessed the various ways of achieving the national climate objective, and put forward proposals for further work that may be necessary.

The Commission investigating the connection of electricity from renewable sources to the grid presented its final report on 20<sup>th</sup> February 2008. The report describes the result of investigation of whether the present regulatory structure is an obstacle to large scale development and expansion of renewable electricity production.

## The Budget Bill

The Budget Bill is the Government's proposal to Parliament of its economic policy. Expenditure Area 21, Energy, covers matters relating to the supply, distribution and use of energy. For 2009, the Government proposes an allocation of SEK 2811 million for these purposes, which is about the same as the allocated funding in 2008.

- For 2009, the Government proposes to increase funding for energy research by SEK 145 million, in order to facilitate the development and commercialisation of new renewable energy technology. The Government expects this amount to increase to SEK 380 million for 2010 and to SEK 350 million for 2011. In total, the Bill proposes to allocate over SEK 1100 million for energy research in 2009.
- The Government proposes that, with effect from and including 2009, new funding for energy technology should be included in the national budget, with the aim of encouraging the use of energy technologies that are beneficial from a climate point of view, but which are not yet commercially competitive in comparison with established technologies on the market. It is proposed to allocate SEK 339 million for this purpose over the period 2009–2011.
- The Government's measures for sustainable energy use will be increased in 2010, and extended to include 2011. Support for areas such as local authority energy and climate advisory services will continue and be expanded.
- Proposed grants and other forms of support for conversion and efficiency improvement measures in residential buildings and commercial premises amount to over SEK 730 million in 2009. This includes a further SEK 80 million for the applications that have been received for installation of energy efficient windows etc. in detached houses. These grants will cease at the end of 2009.
- A sum of SEK 320 million, for the period 2009–2011, is proposed to meet possible proposals in the Energy Efficiency Improvement Commission report, due at the end of October 2008.
- The Government intends to assist the expansion of wind power by removing obstacles, improving awareness, simplifying planning and reducing the time taken for processing applications. The Government will extend its support for wind power networks, as well as that for planning measures, for a further two years. County councils will be assigned additional resources in order to enable them more quickly to process wind power planning applications.
- Matters relating to climate come under Expenditure Area 20, Environment, in the Budget Bill. Among the items foreseen is a substantial investment in international climate work, with a budget of SEK 280 million for 2009, as against SEK 50 million for 2008.
- A further SEK 325 million is proposed for the Green Car subsidy in 2009, to produce a total sum of SEK 425 million till 1<sup>st</sup> July, at which date the grant ceases.
- The Government is planning to submit a further Climate and Energy Bill to Parliament later in 2008, with more exact details of its budget proposals. The Bill will also set out principles and guidelines for changes to energy and environmental taxes, as well as helping to meet Sweden's obligations in respect of EU climate and energy policy targets.

*Budget Bill no. 2008/09:1*

## Energy in the EU

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

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

At the beginning of March 2008, the European Council confirmed that the EU will continue to play a leading part in international work on countering climate change. During the year, the Council intends to accept the Commission's climate and energy package in order to ensure its adoption early in 2009, before the European Parliamentary elections. This package of measures is intended to achieve the ambitious targets set by the European Council last year. With a further developed emission trading scheme, ambitious national commitments in the climate and energy sectors, establishment of an efficient single market for energy and investments in research and development, the EU will be prepared to play its part in a global climate agreement, to be reached in Copenhagen in 2009.

### The energy and climate package

In January 2007, the Commission presented its energy review under the title 'An Energy Policy for Europe'<sup>11</sup>. In it, the Commission put forward a package of proposals aimed at producing a radical change in the EU's commitments in changes. Political unity was achieved with the support of the European Parliament and that of the member states at the spring meeting of the European Council in 2007. This culminated in an agreement concerning the principles of a new approach, and an instruction to the Commission to put forward concrete proposals, including such as how the work of achieving these targets can be divided up between the member states.

The overall targets are:

- That the EU will make an independent commitment to reduce its greenhouse gas emissions by at least 20 % by 2020, relative to 1990 levels, or to reduce them by 30 % by that same year if a comprehensive international climate agreement can be reached.
- That the EU will introduce an obligatory target for 20 % of energy use to be met by energy from renewable sources by 2020, as compared with the 2005 proportion of 8.5 %, and that the proportion of biofuels shall be at least 10 %.

On 23rd January 2008, the Commission presented a second package of energy and climate proposals, consisting of the following documents:

<sup>11</sup> An Energy Policy for Europe (SEK(2007) 12), COM (2007) 1.

- A directive proposal for support for renewable energy.<sup>12</sup>
- A proposal for a Directive amending Directive 2003/87/EC so as to improve and extend the EU greenhouse gas emission allowance trading.<sup>13</sup>
- A proposal for a decision of the European Parliament and of the Council on the efforts of member states to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020 within sectors not covered by the EU emission trading scheme, i.e. transport, buildings, services, small industrial plants, agriculture and waste.<sup>14</sup>

The proposal includes an allocation of the 20 % objective for the production of renewable energy, depending on the various member states' ability to pay (GNP per capita). As a minimum, all countries must increase their proportion of energy supplied from renewable sources by 5.75 percentage units, but no country needs have a proportion greater than 50 %. Under the terms of the proposal, Sweden's target is 49 % in 2020, compared with Eurostat's calculation of 39.8 % in 2005. The proposal is now being discussed, with the expectation of reaching an agreement during the spring of 2009. Read more about Sweden's present status in respect of the use of renewable energy in Chapter 3, Sweden's Energy Balance.

### **Preparations for Sweden's presidency of the EU in 2009**

All EU member states take it in turn to hold the Presidency of the European Council for six months at a time, in accordance with a previously determined list. The member state holding the presidency is also the chairman of the European Council and of working parties under the Council of Ministers. The duties of the chairman are to conduct the work of the Council, to represent the Council to other institutions within the EU, and to represent the EU to the rest of the world.

With effect from 2007, the current presidency at any time works with the last and next presidency on a common political programme in what is known as a triple shared presidency, the purpose of which is to improve the continuity of EU work. Close contacts between all levels in the three countries mean that matters on the agenda are handled more effectively. Sweden's presidency is at present in the current triple presidency block of France (autumn 2008), the Czech Republic (spring 2009) and Sweden (autumn 2009).

Together, France, the Czech Republic and Sweden have produced a programme covering the three countries' total 18 month presidency. This programme was adopted in June 2008.

The Swedish Government will promote five overall priority working areas<sup>15</sup>:

- Climate, the environment and energy.
- Employment, growth and competitiveness.

<sup>12</sup> COM (2008)16 final.

<sup>13</sup> COM(2008)17.

<sup>14</sup> COM(2008)19.

<sup>15</sup> <http://www.regeringen.se/sb/d/6781/a/90952>.

- A safer and more open Europe.
- The Baltic Sea area and relations with neighbouring countries.
- The EU, as a global party and continued expansion.

Sweden will also develop a working programme for its six months of presidency. This is aimed at building on the 18 month programme and will be started during the autumn of 2008.

### **New EU Constitution, the Treaty of Lisbon**

What the EU may or may not do is set out in various treaties on which all member states of the Union have agreed. They specify who is responsible for deciding on what, and in what way decisions must be taken. The treaties also set out the objectives of EU cooperation and the principles upon which such cooperation shall be based. The underlying EU treaty is now to be modified, with the new version having the name of Treaty of Lisbon.

The member state governments signed the Treaty of Lisbon on 13th December 2007. The next stage of its introduction is that it must be ratified by all 27 EU states. In Sweden, this is effected by a parliamentary decision. It is the intention that the new treaty should come into force in January 2009: however, during the spring of 2008, Ireland voted against the reform treaty in a referendum.

As far as energy aspects of the Treaty are concerned, it can briefly be said that energy matters are given their own legal basis. Member states' right to determine the conditions for utilisation of their energy resources, to choose between different energy sources, or to decide upon the general structure of energy supply, are not affected. In this way, the Treaty more correctly reflects the present work of the Union. Among the objectives named in the new Article is the development of new and renewable energy sources.<sup>16</sup>

### **The Single Market package**

In September 2007, the European Commission put forward a package of legislation intended to remove obstacles to competition within the electricity and gas sectors. Based on a Notice for the single electricity and gas market that the Commission have published in January 2007, it contained five different proposals. Two proposals within the electricity sector will result in changes and additions to the existing Electricity Directive, 2003/54/EC<sup>17</sup> and Electricity Regulation 1228/2003<sup>18</sup>. Changes and additions will also be made to the existing Gas Directive, 2003/55/EC<sup>19</sup>, as well as to the Gas Regulation 1775/2005<sup>20</sup>. The fifth proposal is for establishment of a bureau for cooperation between energy surveillance authorities within the EU<sup>21</sup>.

16 <http://www.regeringen.se/sb/>.

17 COM(2007) 528.

18 COM(2007) 531.

19 COM(2007) 529.

20 COM(2007) 532.

21 COM(2007) 532.

## Climate policy

### International climate cooperation

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

The Convention includes a commitment for all industrial countries to take steps to reduce their emissions of greenhouse gases, and to increase their uptake and storage of the gases. The countries must also periodically report details of their progress and the steps that they have taken to the UN.

### Important dates in international climate cooperation

1992 The Climate Convention is formulated in Rio de Janeiro, Brasil	2001 The Marrakesh Accord sets out detailed regulations and guidelines for implementation of the Kyoto Protocol
1993 Sweden ratifies the Climate Convention	2004 Russia ratifies the Kyoto Protocol, thus achieving the necessary number of ratifications by industrialised countries
1994 The Climate Convention comes into force after 166 countries have ratified it	2005 The Kyoto Protocol comes into force
1997 The Kyoto Protocol is formulated in Kyoto, Japan	

For more information on international climate cooperation, see previous editions of Energy in Sweden, [www.energimyndigheten.se](http://www.energimyndigheten.se) or [www.unfccc.org](http://www.unfccc.org).

### The Kyoto Protocol

At the third Conference of the Parties in Kyoto in 1997 (COP 3), agreement was reached on a document - the Kyoto Protocol - regulating emissions of carbon dioxide and five other greenhouse gases. The Protocol sets out quantitative reductions for all Annex 1 countries, i.e. the OECD states and other countries in Central and Eastern Europe, for the period 2008–2012. For the Kyoto Protocol to come into force, it was necessary for it to have been ratified by at least 55 countries which, in addition, must have been responsible for at least 55 % of the industrialised countries' carbon dioxide emissions in 1990. However, as Russia and the USA together were responsible for more than 50 % of the total emissions from industrialised countries, it was necessary

for at least one of them to ratify the Protocol before it could come into force. Russia ratified the Protocol in November 2004, which meant that the Protocol could come into force in February 2005. Today, a total of 182 countries have ratified the Protocol.

Under the terms of the Protocol, the industrialised countries are required to reduce their total emissions of greenhouse gases by at least 5 % from 1990 levels during the first commitment period, 2008–2012. The EU–15<sup>22</sup>, which negotiated as a single group, is required to reduce its emissions by 8 %. In 1998, the EU states reached an agreement on internal burden sharing, based on factors such as per-capita emissions and the structure of energy and industry sectors. Sweden has a commitment not to increase its emissions by more than 4 % within the EU burden-sharing agreement.

### **Flexible mechanisms**

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

### **Project-based mechanisms**

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

The Clean Development Mechanism (CDM) is the one that has been operative for the longest, as the CDM agreement in the Marrakech Accord included a 'prompt start' element, effective from 2000, provided that a number of conditions had been fulfilled. An

<sup>22</sup> EU 15 are the 15 member states of the EU prior to its expansion on 1 May 2004.

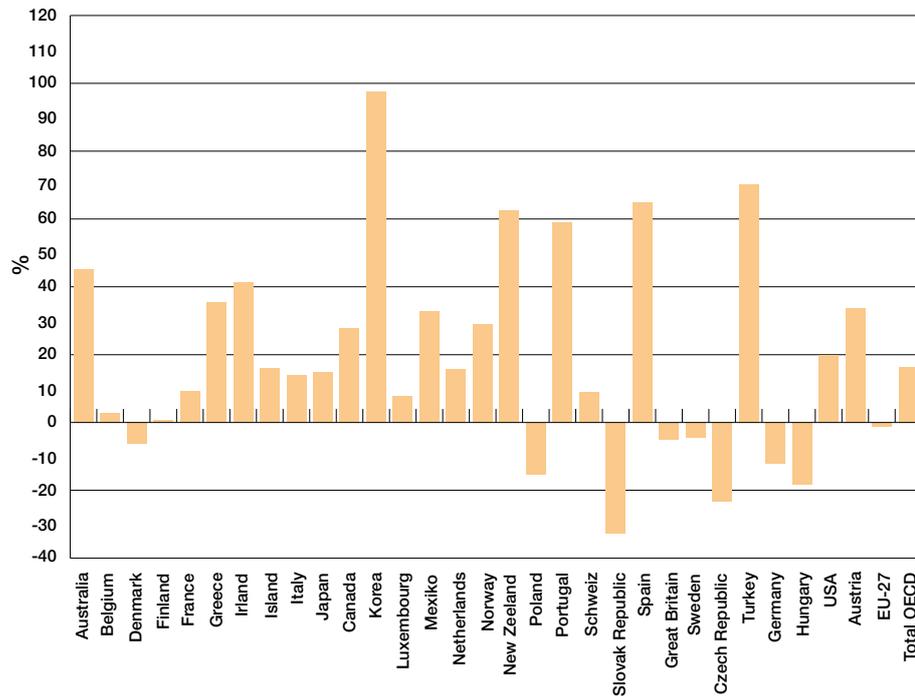
international Executive Board (EB) approves, registers and monitors CDM projects. As a result of the Board's activities, a number of detailed regulations for CDM projects have been successively developed. JI is not covered by the prompt start arrangement, as it is dependent on the various countries' allocated emission allowances being established, which has been the case only since the first commitment period started in 2008. Read more about Sweden's participation in CDM and JI projects in Section, Swedish Climate Strategy.

### **Continued negotiations on climate cooperation**

Negotiations on climate cooperation for the period after 2012 were started at the first combined Conference of the Parties and Members of the Parties meeting (COP/MOP1) in Montreal in December 2005. At this meeting, the Protocol was given its final form in terms of rules for compliance. A process for negotiations on international cooperation and the future climate regime after 2012 was also started. The parties met again in November 2006 at COP/MOP2 in Nairobi in Kenya, and at COP/MOP3 in Bali in December 2007. The results from the Bali meeting were presented in an action plan that describes the way forward towards agreement for the period after 2012, of which the aim is to achieve a global climate regime that includes not only the USA but also large developing countries such as China, India and Brazil. COP/MOP4 will be held in December 2008 in Pozna, in Poland. A new framework for continued action must be in place by the time of the end of the first commitment period under the Kyoto Protocol (2012). If this timetable is to be held, it is therefore hoped that negotiations on the period after 2012 will be concluded at COP5/MOP5 in Copenhagen, to be held in December 2009, by which time Sweden will also be holding the presidency of the EU. The constituents of such a framework provide a long term global objective for emission reductions and greater national and international efforts to reduce the effects of climate, which include not only accommodation to climate changes but also development and spread of appropriate technology.

### **Swedish climate strategy**

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



**Figure 1:**  
Change in carbon dioxide emissions within the EU and OECD states, 1990–2005

SOURCE: OECD IN FIGURES, 2007 EDITION

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

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

It is only by all the world's countries working together that the climate problem can be solved. A natural part of the Swedish strategy is therefore to ensure, together with the EU, that the climate agenda is handled on an international level. The Climate Convention makes it clear that the industrialised countries have a particular responsibility to lead the way in tackling climate change. The Government is therefore of the opinion that it is important that industrialised countries can demonstrate by their practical po-

licies that it is possible to combine a policy for reduction of greenhouse gas emissions with continued successful economic development.

As part of this strategy, Parliament has set a Swedish objective for greenhouse gas emission reductions that goes beyond its agreed allocation under the EU Burden Sharing Agreement. Under the terms of the EU allocation, which is legally binding, Sweden's emissions over the period 2008–2012 may not exceed 104 % of its emissions in 1990. Sweden has gone further and, as its target, has elected that its greenhouse gas emissions shall not exceed 96 % of 1990 emissions (i.e. an actual reduction of 4 %

in its emissions), achieving this without compensation for uptake in carbon sinks (uptake of greenhouse gases in vegetation and the ground), or by using flexible mechanisms. This objective was confirmed by Parliament in 2006. The EU's emissions

trading scheme, which started in 2005, and which applies to industries and electricity and heat producers, covers about one third of Swedish emissions. The trading scheme as a whole has a ceiling, but exactly where the reductions are effected depends on where there are cost efficient opportunities for doing so. This means that Sweden cannot decide on what the actual quantities of emissions from the trading sector in the country should be, but only on the quantity of emission allowances allocated.



Globally, Sweden is responsible for only a very small proportion of total greenhouse gas emissions.

However, for the period after 2012, it has been proposed that emission allowances for the trading sector should be allocated from a central level, rather than nationally.

In 2006, Sweden's per capita emissions were about 7.2 tonnes of carbon dioxide equivalents per year. The target is that, by 2050, Sweden's total emissions should be less than 4.5 tonnes of carbon dioxide equivalents per person and year, with the value continuing to decline. Globally, Sweden is responsible for only a very small proportion of total greenhouse gas emissions, and so international cooperation is essential in order to succeed in stabilising greenhouse gas concentrations in the atmosphere.

Today, Sweden has no national target for the medium/long term, but as a member of the EU, the country is covered by the overall EU medium/long term target. In March 2007, the European Council set emissions and renewable energy targets for the EU, under which the EU as a whole undertook to reduce its emissions of greenhouse gases by 20 % by 2020, in comparison with 1990 emission levels. Starting from this decision, the European Commission published its energy and climate package in January 2008, setting out proposals for an allocation of emissions reductions between the trading sector (for companies in the EU emissions trading scheme) of 21 % from 2005 until 2020, and of 10 % over the same period for the non trading sector. The reduc-

tions proportion for the non trading sector would then be apportioned between the 27 member states in accordance with their per capita GNP, to produce percentage figures ranging from -20 % to + 20 % for the different member states. Under this proposal, Sweden would be assigned an emissions reduction target of 17 %. The above EU commitment is that which applies today, but there is also a clear ambition within the EU to aim for a reduction in emissions of 30 % as its contribution to an extensive global climate agreement for the period after 2012. This is conditional upon other industrialised countries also undertaking to achieve comparable emissions in their reductions, and on the more economically advanced developing countries making reasonable reductions in accordance with their ability and responsibility.

Swedish climate policy has been based on tackling problems on a broad front, with economic policy measures as the central instruments. Energy supply is a key area for the work of moving Sweden to a sustainable society. Energy supply, energy conservation, improvements in the efficiency of energy use, the use of renewable energy and efficient energy technology are all involved. The carbon dioxide tax, which was introduced in 1991, and other taxes on various forms and uses of energy, have played a considerable part in reducing effects on the climate in a socio economically effective manner. Other important instruments include state support for environmental and climate investments, concentration on renewable electricity production and the use of bio sourced motor fuels. Read more in Section 2 of this report, on policy measures and incentives.

Swedish climate work and its national objectives will be constantly monitored, with the results evaluated in the form of a number of Checkpoint Reports. The first of these reports was published in 2004, and the second, entitled Checkpoint 2008, was published in 2007. The Swedish Energy Agency and the Environment Protection Agency have been charged by the Government with providing material for the reports. For the 2008 Report, the emphasis has been on expected developments up to 2020. The work has included analysis of a Swedish emissions target of a 25 % reduction compared to 1990. The two agencies are of the opinion that this target can be achieved by a three pronged strategy: a reduction in emission allowance allocations within the framework of the EU emission trading scheme, further development of EU policy measures and incentives, as well as of national policy measures in sectors outside the EU emission trading scheme, and through the purchase of emission reduction units through investments in other countries.

In addition to the work being carried out within the framework of the regular national Climate Strategy Committee reports, the Government appointed a parliamentary climate commission in April 2007, which submitted its first report (SOU 2008:24) at the beginning of 2008. The Committee's action plan was largely based on the material being prepared for the 2008 Checkpoint Report. Other important material was provided by the Scientific Support Material for Climate Policy report, submitted by the Scientific

Council for Climate Issues, which was published in September 2007. The Scientific Council for Climate Issues has been working on the material for the Government since December 2006, under the auspices of the Environmental Advisory Council.

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

In January 2008, the European Commission published a combined climate and energy strategy document, which was discussed in more detail in Section 1.2, Energy in the EU.

In addition to its EU involvement and its national work on reducing greenhouse emissions, Sweden is also engaged in international climate cooperation. It has involved itself in work with the Kyoto Protocol's CDM and JI<sup>23</sup> project-based mechanisms in order to obtain experience of them and to contribute to their further development into reliable instruments of climate policy. The Swedish Energy Agency has been instructed by the Government to develop and carry out CDM and JI projects, and since 2002 has been responsible for the Swedish International Climate Investment Programme (SICLIP). About SEK 350 million has been set aside for the Swedish CDM and JI programmes since they started. The Government has given notice that, for the period 2009–2011<sup>24</sup>, it proposes to increase the grants for these activities from SEK 50 million per year to SEK 280 million per year in 2009 and 2010 respectively, and by SEK 228 million for 2011.

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

As far as JI projects are concerned, Sweden has signed bilateral agreements with Romania, Estonia and Bulgaria, and is negotiating agreements with Russia and the Ukraine. To date, the Agency has entered into purchasing agreements for two JI projects; one in Rumania and one in Estonia.

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

24 Government Bill 2008/09:1.

The Agency also participates in the Testing Ground Facility (TGF). This is a fund of which the purpose is to finance shared JI projects in the Baltic Sea Region. The fund was established within the framework of the Baltic Sea Region Energy Cooperation (BASREC), which is a regional energy cooperation scheme between eleven countries in the Baltic Sea Region. Sweden's contribution to the fund amounts to almost EUR 3.5 million of the fund's total of EUR 35 million. In addition to the Baltic Sea region states, a number of commercial companies are also members of the fund.

Sweden is a member of the World Bank's Prototype Carbon Fund (PCF), which was started in 1999 and has assisted the development of climate projects within the framework of CDM and JI and contributed to the development of the necessary regulatory framework for such projects. The fund's total capital amounts to USD 180 million, of which Sweden has contributed USD 10 million. The fund has signed contracts for 16 CDM projects and eight JI projects.

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

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

It is expected that, as a result of Sweden's international climate investment programme, together with the country's share in multilateral funds and funding that has been earmarked for new projects in the future, the total emissions reduction will amount to about 6–8 million tonnes of carbon dioxide equivalents, equivalent to about 2 % of calculated Swedish emissions of greenhouse gases for the 2008–2012 period. The additional financial commitments will significantly increase these figures. The cost of purchasing emission reductions via CDM/JI projects is very much less than the marginal cost of effecting emission reductions in Sweden. Even in comparison with



Events and policies within the EU have become increasingly important for Swedish climate work.

**Figure 2:**  
Carbon dioxide  
emissions in Sweden,  
1980, 1990–2006

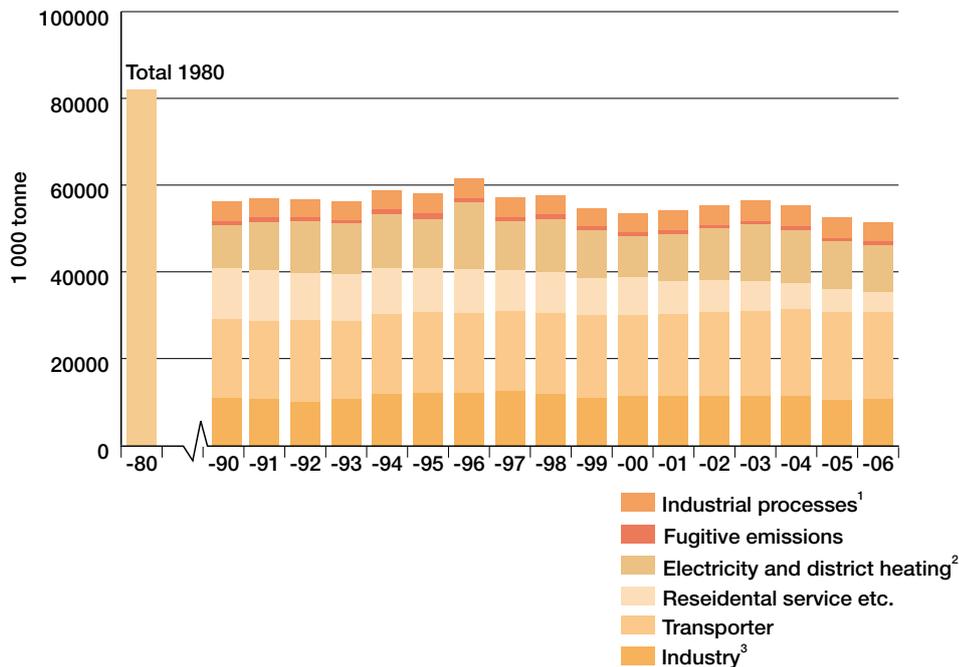
SOURCE: 1980: SCB, STATISTICAL  
NOTICES NA 18

SOURCE: 1990–2006: SWEDEN'S  
REPORTING TO THE UN CLIMATE  
CONVENTION, SWEDEN'S NATION-  
AL INVENTORY REPORT, 2008

NOTES

1. INCLUDING SOLVENTS AND  
OWN USE OF PRODUCTS.
2. INCLUDING COKING PLANTS  
AND OIL REFINERIES.
3. INCLUDING INDUSTRIAL BACK-  
PRESSURE GENERATION.

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



the estimated prices for emission allowances in the EU trading scheme, these projects can be seen to be very cost efficient.

The Agency is also the official Swedish Designated National Authority (DNA) and Designated Focal Point (DFP)<sup>25</sup> with responsibility for approving Swedish companies and organisations wishing to participate in project based mechanisms. The role of the Project Authority also includes deciding whether proposed projects meet the requirements for purchasing emission reduction credits, in accordance with the rules set out in Article 6 of the Kyoto Protocol. This means that the Agency is the official contact point with the Climate Convention's Secretariat. Since taking on this duty in 2005, the Agency has approved 147 CDM projects and eight JI projects. There are only a few Swedish parties who are direct, active participants in these projects.

It is expected that Sweden will play an important part in the coming international climate work concerning the final negotiations for continued agreements after 2012, in which connection Sweden will be the Presidency chairman country in the EU at COP5/MOP5 meeting in Copenhagen in December 2009.

<sup>25</sup> In order to be able to register projects for treatment as project-based mechanisms, each party shall appoint a nationally responsible public authority, the Designated National Authority (DNA), for approval of projects for participation in CDM projects, and a Designated Focal Point (DFP) for approval of participation in JI projects. In Sweden, the National Energy Agency has been appointed as DNA and DFP, under the common designation of the Project Authority.

# 1

## Summary

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

The Government's Budget Bill for 2008/2009 allocates additional funding to the energy sector for research, development and commercialisation of energy technology, as well as for climate investments in other countries. Further funding is released for the Green Car subsidy, but which will be available only until the end of June 2009. Work on improving energy use efficiency and support for conversion measures continues. The Government intends to present an energy and climate bill in the autumn of 2008. The Government still has no intention of making a decision on the retention or phase out of nuclear power during the current mandate period.

Intensive negotiations continue within the EU concerning the Commission's energy and climate package. As far as Sweden is concerned, the proposals mean that the requirement for its proportion of renewable energy will increase from 39.8 % in 2005 to 49 % in 2020. Under the terms of the proposal, the emissions

trading sector within the EU will reduce its emissions by 21 % between 2005 and 2020, seen as an overall EU objective. For the non trading sector, it is proposed that Sweden's reduction should be 17 %.

Current public commissions include the Energy Efficiency Improvement Commission, which is preparing proposals for implementation of the Energy Services Directive. The Directive requires each member state to achieve a measurable improvement of 9 % in its efficiency of energy use by 2016, based on its use of primary energy. The Commission is due to present its report at the end of October 2008. The work of the Environmental Process Commission, whose final report is due at the end of December 2008, includes preparation of a proposal for simplifying the planning process for wind power investments.

December 2009, when Sweden will hold the presidency of the EU, sees a meeting of the parties concerning the Climate Convention and Kyoto Protocol in Copenhagen. This meeting is regarded as that at which a new international climate agreement should be reached if a new framework is to be in place in 2012, when the first commitment period under the Kyoto Protocol comes to an end.

# Policy measures and incentives

Several policy measures and incentives have been introduced in order to achieve the targets set out in the country's energy and climate policy. The most wide reaching means of achieving energy policy objectives is energy taxation, in the form of an energy tax as such, carbon dioxide tax and sulphur tax. Other important policy measures and incentives described in this chapter are emissions trading, the electricity certificate trading scheme, the energy efficiency improvement programme, policy measures and incentives for the built environment and transport, technology procurement, the climate investment programme and information campaigns. Research, development and demonstration projects constitute an important element of long term development strategy.



## Various types of policy measures

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

## Energy taxation

The original objective of energy taxes was to finance the State's public spending requirements, but in later years the emphasis has increasingly been on the need to control the production and use of energy in order to achieve various energy and environmental policy objectives. Present energy taxation policy is aimed at improving the efficiency of energy use, encouraging the use of biofuels, creating incentives for companies to reduce their environmental impact and creating favourable conditions for indigenous production of electricity. During the oil crises of the 1970s, the aim was to reduce the use of oil and increase the use of electricity. The environmental element of energy taxation was given greater importance at the beginning of the 1990s while, since Sweden's accession to the EU, there has been a progressive alignment of Swedish taxation with EU regulations.

The present energy taxation scheme is complicated. There are different taxes on electricity and fuels, on CO<sub>2</sub> and sulphur emissions, and a levy system on NO<sub>x</sub> emissions. The taxes can then vary, depending on whether the fuel is being used for heating or as a motor fuel, whether it is being used by industry, domestic consumers or the energy conversion sector and, in the case of electricity, what it is being used for and whether it is being used in northern Sweden or in the rest of the country. In

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

**Table 1:**  
Main groups of incentives and policy measures

2007, revenues from energy taxes raised SEK 66 400 million, making up 8.4 % of State revenue or 2.2 % of GDP. There is also taxation expenditure (taxation relief) on the country's income budget. The definition of taxation expenditure is that the tax received is less than a certain specified standard<sup>26</sup>. Examples of taxation expenditure include energy tax relief for biofuels, peat etc., tax reductions for certain environmentally beneficial improvement installations in detached houses, and the reduction of the carbon dioxide tax for industry. All told, the sum of the energy related items of taxation expenditure amounted to over SEK 42 000 million in 2007.

### Types of taxes and tax rates

'Energy tax' is an umbrella name for spot taxes on fuels and electricity. They can be roughly divided up into fiscal<sup>27</sup> taxes and those intended to achieve environmental objectives. This latter group of taxes includes the carbon dioxide and sulphur taxes, while the general energy tax is essentially a fiscal tax. However, there is no hard and fast boundary between the types, as both groups have an environmental effect as well as a fiscal function. The general energy tax, which has existed for several decades, and with varying purposes, is levied on most fuels, based on various factors such as their energy contents. The carbon dioxide tax, which was introduced in 1991, is levied on the emitted quantities of carbon dioxide from all fuels except biofuels and peat. The general rate of carbon dioxide tax was increased by 6 öre at the beginning of 2008, reaching a level of 101 öre per kg of carbon dioxide. At the same time, the energy and carbon dioxide tax rates were increased to track price developments.

26 If a taxation expenditure is removed, it results in increased taxation revenues and thus to an improvement of the budget for the public sector, in the same way as if an expenditure from the national budget had been removed.

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

A sulphur tax was introduced in 1991, and is levied at a rate of SEK 30 per kg of sulphur emission from coal and peat, and at SEK 27/m<sup>3</sup> for each tenth of a percent of sulphur by weight in oil. Oils containing less than 0.05 % of sulphur by weight are exempted from the tax. The environmental levy on the emission of NO<sub>x</sub> was introduced in 1992, and since the beginning of 2008 has been applied at a rate of SEK 50/kg of NO<sub>x</sub>, on emissions from boilers, gas turbines and stationary combustion plant supplying at least 25 GWh per annum. However, it is intended to be fiscally neutral, and is repaid to plant operators in proportion to their energy production and in inverse proportion to their NO<sub>x</sub> emissions, so that only those with the highest emissions are net payers.

### Electricity and heat production

Electricity production in Sweden is exempted from energy and carbon dioxide tax, although it is subject to the NO<sub>x</sub> levy and sulphur tax in certain cases. However, the use of electricity is taxed. Nuclear power plants were previously taxed on the basis of their electricity production, but since 1<sup>st</sup> July 2000 the tax has been based on the maximum permissible thermal power rating of their reactors. This tax was increased by 24 % in 2008, to SEK 12 648/MW per calendar month.<sup>28</sup> In addition, there is a levy of 0.3 öre/kWh for decontamination and decommissioning of the country's previous nuclear facilities at the Studsvik research centre<sup>29</sup>, and a further levy that amounts to about 1 öre/kWh for financing future storage facilities for spent nuclear fuel.<sup>30</sup> Heat production pays energy tax, carbon dioxide tax and, in certain cases, sulphur tax and the NO<sub>x</sub> levy. The use of heat, however, is not taxed. In principle, biofuels and peat are tax free for all users, although the use of peat attracts sulphur tax. The marketable heat produced in simultaneous production of heat and electricity (also known as cogeneration or CHP [Combined Heat and Power]) is taxed in the same way as in industry.

With effect from 1<sup>st</sup> July 2006, combustion of certain domestic refuse was also made liable to energy tax. The energy tax element amounts to SEK 155 per tonne of fossil carbon, while the carbon dioxide tax element is levied at the rate of SEK 3709 per tonne of fossil carbon. 12.6 % by weight of the refuse is assumed to be fossil carbon. Electricity production plants are also subject to property tax. For hydro power plants, this tax was raised from 1.2 % to 1.7 %, with effect from the beginning of 2008. Together with the temporary 0.5 % tax rate increase for the 2007–2011 tax years, this gives a total tax rate of 2.2 %.

### Taxation of use of energy

Manufacturing industry, horticulture, farming, forestry and aquaculture<sup>31</sup> pay no energy tax on fossil fuels, and only 21 % of the carbon dioxide tax<sup>32</sup>. There are special rules for energy intensive industrial activities, reducing that part of the carbon dioxide tax that exceeds 0.8 % of the sales value of the products concerned. To qualify for this reduction,

28 [www.skatteverket.se](http://www.skatteverket.se).

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

30 Act (1992:1537).

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

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

Energy carrier	Energy tax	CO <sub>2</sub> tax	Sulphur tax	Total
Petrol	14 436	10 769		25 205
Oil products	4 858	12 909		17 767
Unrefined tall oil	2			2
Other fuels	66	882		948
All fuels			57	57
Electricity	18 825			18 825
Waste	10	360		370
Production tax, nuclear power*	3 231			3 231
<b>Total</b>	<b>41 428</b>	<b>24 920</b>	<b>57</b>	<b>66 405</b>
<b>Proportion of the State's tax revenues</b>				<b>8,4%</b>
<b>Proportions of GDP</b>				<b>2,2%</b>

**Table 2:**  
Revenue from energy taxes, by type of energy and tax, 2007, SEK 1000 million

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

\*THIS TAX IS A TAX ON POWER OUTPUT AT PRODUCTION LEVEL, AND IS NOT TO BE CONFUSED WITH THE ENERGY TAX THAT IS PAID BY USERS.

companies must (from 1<sup>st</sup> January 2007) meet the 0.5 % rule definition of an energy-intensive company<sup>33</sup>. From the same date, too, the further reduction given by the 1.2 % rule has been abolished, as mineralogical processes are totally exempted from carbon dioxide tax as a result of harmonisation with the EU Energy Taxation Directive<sup>34</sup>.

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

There are various tax levels for transport, depending on the environmental class of the fuel, which have resulted in reduced emissions of some pollutants. The taxes on Environmental Classes 1 and 2 petrol and diesel fuel were increased by 29 öre/litre and 55 öre/litre (including VAT) respectively on 1<sup>st</sup> January 2008. At the same time, vehicle tax on diesel vehicles was reduced by 4.5 %. No energy tax is payable on the

33 Under the 0,5 % rule, a company is regarded as energy-intensive if the tax remaining (excluding sulphur tax) after the general tax reduction on fuels used for heating or operation of stationary equipment in the manufacturing industry and horticulture amounts to at least 0,5 % of the added production value.

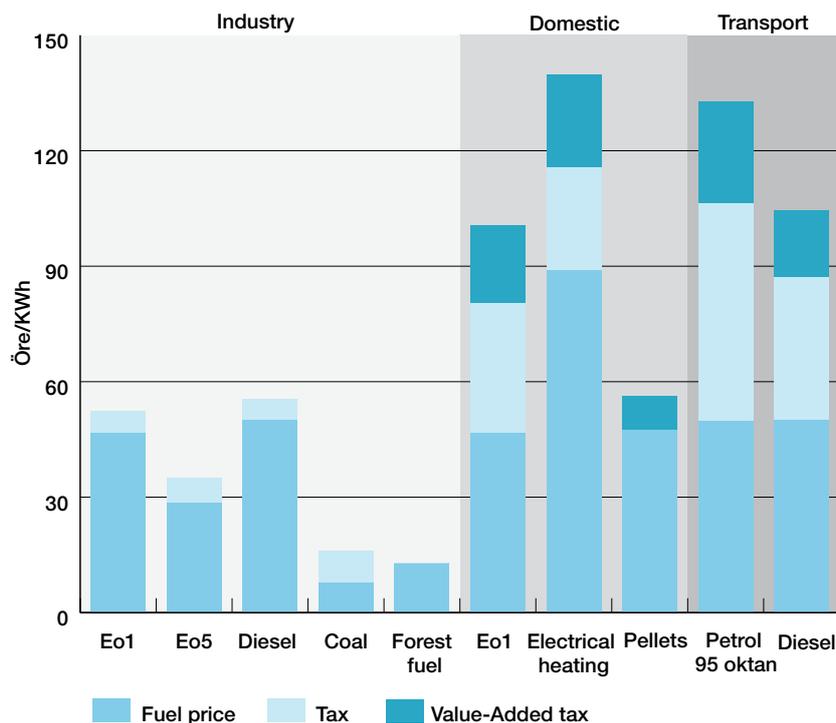
34 Directive 2003/96/EC of the European Parliament and of the Council Restructuring the Community Framework for The Taxation of Energy Products and Electricity.

use of diesel fuel or fuel oils used in commercial maritime traffic or railborne traffic, or on aviation petrol or aviation paraffin. However, aviation fuel used for private traffic has been brought within the tax remit with effect from 1<sup>st</sup> July 2008. No energy tax or carbon dioxide tax is charged on ethanol, rapeseed oil methyl ester (RME) or bio-gas, while natural gas used in the transport sector pays no energy tax. Domestic users pay different rates of electricity tax, depending on whether they live in the north of the country or the rest of the country. Energy tax on electricity used by the domestic and service sectors in certain municipalities in northern Sweden was reduced by 2.6 öre/kWh at the beginning of the year, but increased by 0.5 öre/kWh for electricity used in other cases. In addition to the various spot taxes on energy, there is value added tax of 25 %, which is not paid by industry in 2007, 54 % of the cost of fuel used by owners of detached houses for heating was made up of tax if that fuel was oil, while only 16 % of the cost was tax (value-added tax only) if the fuel was pellets. For drivers, 62 % of the cost of petrol was tax (including value-added tax). See Figure 3.

**Figure 3:**  
Total energy price for  
various customers  
2007

SOURCE: SPI, STATISTICS  
SWEDEN, ÅFAB AND THE  
NATIONAL TAX BOARD

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



	Energytax	CO <sub>2</sub> tax	Sulphur tax	Total tax	Tax öre/kWh
<b>Fuels</b>					
Gas oil, SEK/m <sup>3</sup> (<0,05 % sulphur)	764	2 883	-	3 647	36,6
Bunker oil, SEK/m <sup>3</sup> (0,4 % sulphur)	764	2 883	108	3 755	35,5
Coal, SEK/tonne (0,5 % sulphur)	325	2 509	150	2 984	39,5
LPG, SEK/tonne	150	3 033	-	3 183	24,9
Natural gas, SEK/1000 m <sup>3</sup>	247	2 159	-	2 406	21,8
Unrefined tall oil, SEK/m <sup>3</sup>	3 647	-	-	3 647	37,2
Peat, SEK/tonne, 45 % moisture content (0,3 % sulphur)	-	-	50	50	1,8
Domestic waste, SEK/tonne fossil carbon*	155	3 709		3 864	16,2
<b>Motor fuels</b>					
Petrol, unleaded, env. class 1, SEK/l	2,95	2,34	-	5,3	58,5
Diesel, env. class 1, SEK/l	1,23	2,88	-	4,1	41,3
Natural gas/methane, SEK/m <sup>3</sup>	-	1,28	-	1,3	11,6
LPG, SEK/kg	-	1,58	-	1,6	12,4
<b>Electricity use</b>					
Electricity, northern Sweden, öre/kWh	17,8	-	-	17,8	17,8
Electricity, rest of the country, öre/kWh	27	-	-	27	27
<b>Industry</b>					
Electricity use, industrial processes, öre/kWh	0,5			0,5	0,5

**Table 3:**

General energy and environmental tax rates from 1 January 2008, excluding VAT

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

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

**Table 4:**  
Energy and environmental taxes for industry, agriculture, forestry, fisheries and heat production in CHP plants, from 1<sup>st</sup> January 2008

	Energy-tax	CO <sub>2</sub> tax	Sulphur tax	Total tax	Tax öre/kWh
Gas oil, SEK/m <sup>3</sup>	-	605		605	6,1
Bunker oil, SEK/m <sup>3</sup>	-	605	108	713	6,7
Coal, SEK/tonne	-	527	150	677	9
LPG, SEK/tonne	-	637	-	637	5
Natural gas, SEK/1000 m <sup>3</sup>	-	453	-	453	4,1
Unrefined tall oil, SEK/m <sup>3</sup>	605	-	-	605	6,2
Peat, SEK/tonne, 45 % moisture content (0.3 % sulphur)	-	-	50	50	1,8
Domestic waste, SEK/tonne fossil carbon*	-	779	-	779	3,3

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

\*MAXIMUM CO<sub>2</sub> TAX RELIEF (%) IS RECEIVED FOR AN ELECTRICITY EFFICIENCY OF 15 %. RELIEF FROM ENERGY TAX IS RECEIVED FOR AN ELECTRICITY EFFICIENCY OF 5 %.

## Green electricity certificates

Sweden's Green Electricity certificate system<sup>35</sup> is a market-based support system to assist expansion of production of electricity from renewable sources and from peat in Sweden. The objective of the system is to increase the production of electricity from such energy sources by 17 TWh in 2016 (as compared with production in 2002). The system will help to establish a more ecologically sustainable energy system in Sweden.

Electricity certificates are issued to operators of approved plants producing and metering electricity from renewable energy sources, or from peat, at the rate of one certificate unit per MWh. Electricity produced from the following energy sources qualifies for certificates: wind power, solar energy, geothermal energy, certain biofuels and certain hydro power. With effect from 1<sup>st</sup> April 2004, electricity produced from peat in cogeneration plants has also qualified for certificates. Table 5 shows the number of approved plants, installed capacity and renewable electricity production from each type of production. New plants receive certificates for 15 years, while those plants started up before 1<sup>st</sup> May 2003 will be progressively phased out of the scheme, starting from the end of 2012 or 2014.

Demand for certificates is created by the fact that all electricity suppliers, and certain electricity users, are required to buy certificates corresponding to a certain proportion (their quota) of their electricity sales or use. In 2006, users had to buy certificates corresponding to 12.6 % of their electricity sales/use. The proportion of certificates that users are required to buy (their quota obligation) varies from year to year, thus creating a growing demand for certificates, and so also increasing the incentive to produce more electricity from energy

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

sources carrying entitlement to certificates. By selling their certificates, the producers of electricity from renewable energy sources can receive additional revenue which provides further support for their production of electricity. In this way, the system supports the expansion of electricity production from renewable sources and the introduction of new technologies. In 2007, electricity suppliers (and those users required to buy their own certificates) were required to purchase certificates corresponding to 15.1 % of their electricity sales or use. Figure 4 shows the price development of certificates over the period 2003–2008. The system covers only electricity produced in Sweden.

With effect from 2007, companies are defined as electricity intensive if their use of electricity in their production processes amounts to at least 40 MWh per million SEK of their total sales value of products and goods. In 2007, 472 companies were registered as electrically intensive, thus relieving them of quota liabilities of 42.8 TWh for the year. The reason for excepting these companies from a quota liability is to protect the international competitiveness of Swedish electrically intensive industries by ensuring that they are not affected by the higher costs of electricity resulting from a quota obligation.

It is proposed that new regulations for electricity intensive industry should apply from the beginning of 2009. The proposed changes to the Act (2003:113) Concerning Electricity Certificates are intended more accurately to identify the group of electricity intensive industries that can qualify for exception from the quota liability. The changes should make the electricity certificate system more stable and more able to be accurately forecast. The total quantity of excepted electricity will be affected only marginally.

A new definition of electrically intensive industries will be introduced based on the amount of electricity used by a company or part of a company in proportion to the added value of production by the industry. It will also be possible to register as an electricity intensive industry if a business qualifies for deduction of electricity tax<sup>36</sup>. The requirement to make a return is removed for those electricity intensive industries that have a quota liability only for electricity that can be excepted when calculating the quota liability.

The step by step application of percentage limits for the size of the exception will be removed. Instead, the amount of the exception will cover all the electricity in the industrial manufacturing process, or the same quantity of electricity as that for which a party liable to tax can be granted an exception under the Energy Tax Act.

The surveillance authority will decide whether a company, or part of a company, can be registered as an electricity intensive industry after receipt of an application from the company. In most cases, registration will be based on values from the preceding three years, and will apply for three years at a time.

Production of renewable electricity under the certificate system amounted to 12.7 TWh in 2007, after subtraction of production from peat<sup>37</sup>. 6.5 TWh of this production existed in 2002, which means that there has been a net increase of 6.2 TWh between 2002 and 2007.

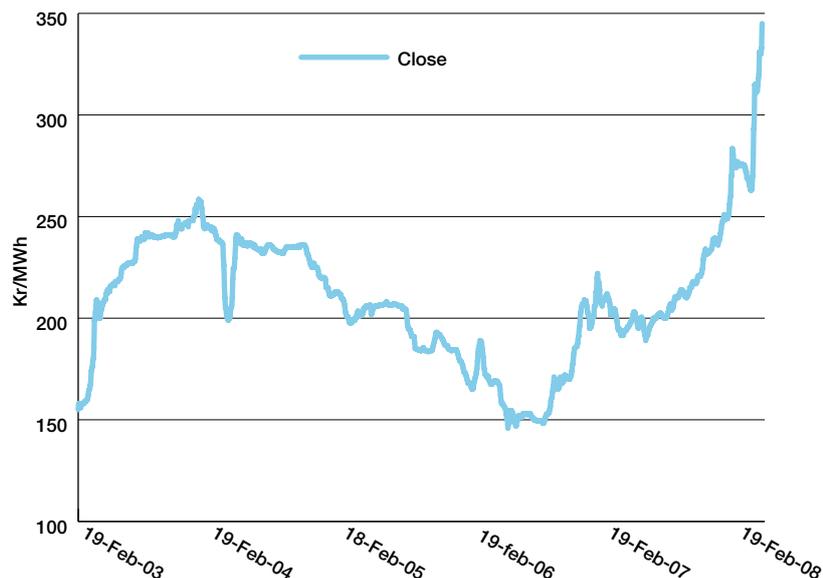
At the end of November 2007, the Swedish Energy Agency announced that application of

36 In accordance with the Act (1994:1776) Concerning Tax on Energy.

37 Peat is not classified as a renewable fuel in Directive 2001/77/EC on the Promotion of Electricity Produced from Renewable Energy Sources in the Internal Electricity Market.

**Figure 4:**  
Average price of  
electricity certificates,  
spot trading,  
2003–2008

SOURCE: SKM, SVENSK  
KRAFTMÄKLING



4 § of the Ordinance (2003:120) Concerning Electricity Certificates would be changed. The change means that no biofuels other than those named in the Ordinance qualify for receipt of certificates. This new, more restrictive application came into force on 1<sup>st</sup> January 2008.

## Emission trading

The purpose of emissions trading is to reduce emissions of greenhouse gases in a cost effective manner for society by effecting the reductions where the cost for doing so is lowest. International emissions trading within the framework of the Kyoto Protocol's Flexible Mechanisms was started in 2008, but the EU had already started an emissions trading system on 1<sup>st</sup> January 2005. The first trading period in the EU system ran from 2005 to 2007, while the second period runs in parallel with the Kyoto Protocol's first commitment period of 2008–2012. Trading in emission allowances is a climate policy instrument within the EU's ECCP climate change programme, the purpose of which is to achieve the EU's emission reduction commitments under the Kyoto Protocol. The EU's trading system is structured in accordance with Directive 2003/87/EC that was adopted in 2003<sup>38</sup>. Since 1<sup>st</sup> January 2007, when Romania and Bulgaria acceded to the EU, the trading system now covers 27 countries.

Initially, the Trading Directive covers only a limited number of sectors, in energy intensive industries and electricity and heat producers, with the result that it covers about 40 % of EU greenhouse gas emissions. In Sweden, about 35 % of greenhouse gas emissions are covered by the trading scheme<sup>39</sup>. During the first trading period,

38 Directive 2003/87/EC, also known as the Trading Directive.

39 In accordance with Sweden's national allocation plan for emission allowances for the period 2008–2012. The figure is for Swedish emissions in 2004.

		2003 maj–dec	2004	2005	2006	2007
<b>Number of plants<sup>1</sup></b>		1 597	1 759	1 848	1 909	2 088
	Hydro	966	1 040	1 060	1 075	1 094
	Wind	543	613	668	706	859 <sup>3</sup>
	Biofuels, peat	87	105	118	125	131
	Solar	1	1	2	3	4
<b>Installed capacity [MW]<sup>2</sup></b>		4 049	4 161	4 471	4 765	5 066
	Hydro	491	504	517	540	558
	Wind	401	472	530	583	831
	Biofuels, peat	3 157	3 185	3 424	3 643	3 676
	Solar	0,008	0,008	0,011	0,036	0,043
<b>Electricity production – renewables and peat [MWh]</b>		5 637 559	11 048 438	11 298 378	12 156 855	13 255 913
	Hydro	963 637	1 968 325	1 799 446	2 018 577	2 195 320
	Wind	455 642	864 546	939 125	988 340	1 431 644
	Biofuels	4 218 276	7 670 770	7 925 790	8 593 538	9 049 308
	Peat	-	544 791	634 012	556 380	579 622
	Solar	4	6	5	20	19

**Table 5:**  
Production and installed capacity, by types of power production, 2003–2007

SOURCE: SVENSKA KRAFTNÄT AND THE SWEDISH ENERGY AGENCY

1) NUMBER OF PLANTS ALLOCATED MORE THAN 0 ELECTRICITY CERTIFICATES DURING THE YEAR SHOWN.

2) FOR PLANTS ALLOCATED MORE THAN 0 ELECTRICITY CERTIFICATES.

3) 859 WIND POWER FARMS, WITH 1 022 INDIVIDUAL TURBINES.

only carbon dioxide emissions were covered, but with effect from 2008 nitrous oxide was also included in some member countries. Each emission unit represents one tonne of carbon dioxide-equivalent. In the spring of 2008, the European Parliament has discussed the inclusion of air transport in the trading scheme with effect from 2012. In addition to the companies covered by the Trading Directive, other companies, individuals and organisations may trade emission allowances.

During the first and second trading periods, the trading scheme was based on each member state setting a ceiling for its permitted national emissions. At the European level, the Commission assessed and approved each member state's national allocation plans, which stated the total number of emission allowances that the state intended to allocate. The total of the member states' individual emissions ceilings gave a joint

emissions ceiling for the entire EU. Sweden has decided to allocate about 19.8 million emission allowances per year to existing plants over the 2008–2012 trading period. In addition to this, the State holds a reserve for new entrants to the system, amounting in total to 13.1 million tonnes of CO<sub>2</sub> equivalents for the period. Existing district heating and electricity plants will not be allocated any rights. Under the EU Commission's proposals for a new trading directive, total allocation for the trading scheme over the next trading period (2013–2020) will instead be determined centrally at EU level.

What is known as the Link Directive<sup>40</sup> links the Kyoto Protocol's project based mechanisms with the European trading system. This means that industries, power producers etc. covered by the EU emission trading scheme can credit themselves with emission reductions that result from CDM or JI projects carried out by them, or by purchasing reduction units on the market. Overall environmental benefit is guaranteed by the fact that additional reduction units within the EU are compensated by measured emission reductions outside the EU.

Companies' rights to use CDM and JI credits in order to achieve their target obligations during the 2008–2012 commitment period have been limited by the EU Commission, depending on how close each member state is to fulfilling its Kyoto commitments, and on whether there is any state purchase of CDM or JI project credits. Swedish companies are permitted to use project credits to meet up to 10 % of the total national allocation. This limitation has been redistributed at 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.

### **Market prices of emission allowances**

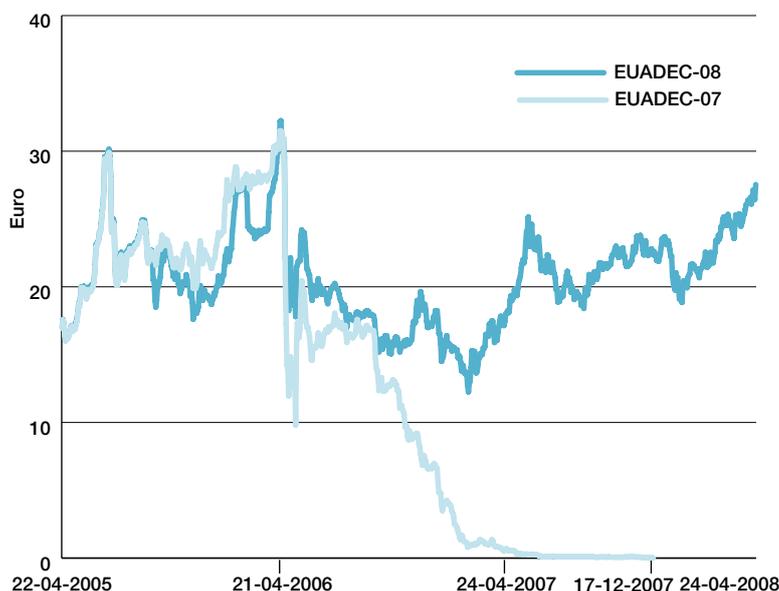
The trading scheme establishes a market price for carbon dioxide emission allowances, determined by the balance of supply and demand. Supply consists of the total allocation of emission allowances, together with the use of credits from project based mechanisms, while demand is dependent on factors such as the demand for electricity and heat, fuel prices and general economic conditions. In simplified terms, the verified emissions from plants in the trading scheme can be said to represent the measure of demand.

When figures for verified emissions during the first year (2005) of the trading scheme were published in April/June 2006, they were found to be less than the allocated quantities, which meant that the market had a substantial surplus of emission allowances. Although emissions in 2006 and 2007 were somewhat higher than in 2005, the price of emission allowances continued to fall during the remainder of the trading period. Total allocations during the 2005–2007 trading period were about 3.5 % higher than emissions<sup>41</sup>. In Sweden, allocation of emission allowances exceeded emissions by an average of 2.9 million tonnes per year<sup>42</sup>.

40 Directive of the European Parliament and of the Council no. 2004/101/EC amending Directive 2003/87/EC Establishing a Scheme for Greenhouse Emission Allowance Trading within the Community, in respect of the Kyoto Protocol's Project Mechanisms.

41 Point Carbon.

42 The Swedish Environment Protection Agency.



**Figure 5:**  
Prices of emission allowances, 2005–2008

SOURCE: ECX (WWW.EUROPEAN-CLIMATEEXCHANGE.COM)

Trading in emission allowances is conducted largely in the form of forward contracts which, if they are not sold on, call for delivery of the allowances in December of the year to which the contract relates. Trading in forward contracts for delivery of emission allowances in the period 2008–2012 was already taking place during the 2005–2007 trading period. The price of emission allowances for the 2008–2012 period was determined largely by the EU Commission’s decision to reduce total allocations by about 9.5 %. This means that the supply of emission allowances for the 2008–2012 period amounts to about 2080 million units per year, as against the first trading period’s allocation of about 2300 million emission units per year. During the beginning of the year, the price of emission allowances for 2008 has fluctuated between EUR 20 and EUR 29 per unit.

During the spring of 2008, rising oil and gas prices have meant that coal fired electricity and heat production have become more economically viable than production from oil and gas, which can have contributed to the higher demand for emission allowances and a rising price of the allowances. In addition, a political factor that can have affected the price is the EU Commission’s proposal for a new trading directive with a limited supply of allowances for the period 2013–2020.

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

The overall objective of the Programme for Energy Efficiency Improvement in Energy-Intensive Industry (PFE) is to encourage efficient use of energy. The background to the programme is the energy tax on electricity used in manufacturing industry that was introduced on 1<sup>st</sup> July 2004, at a rate equivalent to the minimum required tax rate as set out in the Energy Taxation Directive<sup>43</sup>. With effect from that date, manufacturing industry, which had hitherto enjoyed a zero tax rate on electricity used by it for its processes, has paid an electricity tax of 0.5 öre/kWh. In June 2004, the Government tabled a bill setting out an energy efficiency improvement programme, which came into force on 1<sup>st</sup> January 2005<sup>44</sup>. Companies participating in the five-year programme can receive a full rebate of the energy tax on electricity that they would otherwise have to pay. In return, they undertake to introduce, within the first two years, an energy management system and to perform an energy audit in order to determine their potentials for improving the efficiency of their energy use. They must also undertake to implement, within the five-year duration of the programme, all the energy efficiency improvement measures that have been identified and which have a payback time of less than three years.

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

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

The energy management systems and energy audits that form part of the programme will improve companies' awareness of their potentials for cost efficient energy efficiency improvements. In addition, the companies benefit from the introduction of a process for continuous, structured improvement in their efficiency of energy use.

In January 2008, there were 117 companies in the programme, operating about 250 separate plants. In total, they use about 30 TWh/year of electricity in their manufacturing processes, which means that they will now receive a total tax reduction of about SEK 150 million per year. Most of the participating companies are in the pulp and paper industry (46), the wood products industry (22) or the chemical industry (16). Other participants include companies in the food industry (10), the iron, steel and mining industry (15), the engineering industry and a few other sectors. The scheme is open to admission of more companies up to and including 2009. Companies wishing to participate in the

43 Council Directive 2003/96/EC.

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

second period must submit their applications before the end of the first period.

98 of the participating companies submitted their first reports to the Agency during the autumn of 2006, describing the results of their work on energy auditing and the introduction of energy management systems. The reports also included details of implemented and planned efficiency improvement measures. They show that the companies have undertaken to improve their efficiency of electricity use by a total of 1 TWh/year, for a total investment cost of somewhat over SEK 1000 million. Approximately half of the efficiency improvements have been found in the production processes themselves, with the remainder in ancillary systems, such as pumps, fans and other motor drives. Many of the improvements are concerned with demand control response (e.g. speed control), process adjustments or optimisation, although replacement of equipment by more energy efficient equipment is also common. Many of the improvement measures pay for themselves in a very short time.

In some cases, the electrical efficiency improvement measures have also resulted in a reduction in other forms of energy use. Measures involving direct conversion from electricity to some other form of energy carrier do not qualify for the PFE tax reductions.

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

## Buildings

### Building regulations

A whole range of policy measures are used in order to influence energy conservation and management in buildings<sup>45</sup>. The National Board of Housing, Building and Planning's Building Regulations<sup>46</sup> are an administrative policy measure. In general, buildings must be designed and constructed to limit overall energy use by means of low heat losses, low cooling requirements, efficient use of heating and cooling and efficient use of electricity. The Regulations include specific requirements for energy use in buildings.

### Energy declarations

Another administrative policy measure is that of the Act Concerning Energy Declarations for Buildings<sup>47</sup>, which is based on an EU directive<sup>48</sup>. Owners of detached houses, apartment buildings and commercial premises are required to provide information on the buildings' energy use, together with certain parameters of the indoor environ-

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

46 Most recent update: BFS 2006:22.

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

48 Directive 2002/91/EC.

ment, in an energy declaration. The purpose is to encourage efficient energy use and good indoor environmental conditions in buildings. The launch of the energy declarations is at present in an introductory stage, and is expected to come fully into operation at the end of 2008.

### **Investment grants for solar heating**

The purpose of the solar heating grant is to encourage the use of solar heating technology for heat supplies to detached houses, apartment buildings and certain types of commercial premises. The grant is for installation of solar heating systems for space heating and/or domestic hot water production, and has been available for projects started since 1<sup>st</sup> June 2000.

### **Grants for conversion of heating systems**

The purpose of these conversion grants<sup>49</sup> 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 for the period from the beginning of 2006, and will continue until the end of 2010. It was previously also available to those replacing oil fired heating systems by one of these alternative heating systems, but this option has been withdrawn.

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

Builders of new detached houses can apply for a grant for the installation of a biofuel-fired facility, such as a pellets fired boiler, as the primary heating source. Owners of single family or two family houses can obtain a grant for the installation of new windows having a maximum U value<sup>50</sup> of 1.2. The entire window – glass, frame and casement – must be replaced in order to qualify. In addition, the owner must live in the house<sup>51</sup>. This grant is available until the end of 2008.

### **Grants for energy efficiency improvement and conversion in public premises**

The purpose of the grants for conversion and energy efficiency improvements in public buildings<sup>52</sup> is that the public sector should lead the way in energy improvements and set an example. Owners of premises used for public activities can apply for grants for conversion of heating systems from electricity or fossil fuels to biofuels, district heating or earth, rock or lake water heat pumps. Grants are also available for investments intended to improve the efficiency of energy use, and for the installation

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

50 The coefficient of thermal conductivity, a performance indicator for windows. The lower the value, the better the performance of the window.

51 Ordinance 2006:1587).

52 Ordinance 2005:205).

of solar photovoltaic cells on public buildings. These grants were introduced in 2005, and will be available until the end of 2008.

## Transport

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

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

The law requiring larger petrol stations to sell at least one renewable motor fuel since 1<sup>st</sup> April 2006 is also intended to affect the growth of biofuel-based motor fuels: its intention is to encourage particularly the sale of ethanol fuel. An additional measure over the period 2006–2008 provides support for other alternative motor fuels in the form of a grant for petrol stations selling renewable motor fuels other than ethanol.

Motor vehicle tax is primarily a fiscal tax, although it also includes an environmental objective element: since October 2006, it provides an incentive to buy more energy efficient (fuel efficient) vehicles or vehicles running on alternative motor fuels. The tax is now based on the vehicle's carbon dioxide emissions instead of, as was previously the case, on the vehicle's weight. The tax was temporarily reduced, during 2006 and 2007, for diesel cars fitted with particle filters. This reduction was available only until the end of 2007. At the same time, vehicle tax for diesel cars was reduced as compensation for an increase in energy tax on diesel fuel.

With effect from 1<sup>st</sup> April 2007, a grant of SEK 10 000 has been available to private purchasers of low pollution vehicles for the purchase of the vehicle. Its purpose is to encourage the purchase of fuel efficient vehicles and vehicles running on alternative motor fuels<sup>53</sup>. The grant has been widely taken up, to the extent that funding for 2008 ran out as early as May. The Government made further funding available in June, so the National Road Administration has again been making payments under the scheme. The Budget Bill for 2009 provides additional funding for the grant, estimated to be sufficient for all purchases made before 1<sup>st</sup> July 2009, after which date the grant will no longer be available.

New rules for disposals of vehicles at the end of their lives came into force on 1<sup>st</sup> June 2007. The previous system, involving an initial end of life payment, and subsequent fees for disposal, has been replaced by transfer of liability to the vehicle manufacturers. Under the new rules, vehicle owners may return a vehicle for scrap-

53 National Road Administration, Annual Report 2006.

ping to the manufacturer, without charge, with the manufacturer being responsible for scrapping of the vehicle.

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

In addition to the above, there are several other policy measures in the transport sector, such as taxation of vehicle benefit and free fuel, subsidised public transport and tolls for certain heavy traffic<sup>54</sup>.

## Technology procurement

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

Technology procurement can be seen as a policy instrument intended to initiate market changes and to encourage the spread of new, efficient technology in the form of new products, systems or processes. Its main application areas are in the fields of heating and control systems, domestic hot water and sanitary systems, ventilation, white goods, lighting and industry. The Agency has prepared a list<sup>55</sup> of all technology procurement projects within the energy field that have been carried out by it and by its forerunners. Since the 1990s, 56 different technology procurement projects have been initiated and partly financed. Current technology procurement projects include demand controlled ventilation in new apartment buildings, control and monitoring systems for properties, climate screen integrated systems for solar shading and daylight penetration, industry standardised information in the sawmill industry, and pellets stores for detached houses.

## Energy research, development and demonstration activities and commercialisation

The Government's 'Research and New Technology for Future Energy Systems' Bill<sup>56</sup> has been approved by Parliament for a long term programme of research, development and demonstration activities for the development of technologies and processes aimed at the establishment of a sustainable energy system. Responsibility for the public energy research programme has been vested in the Swedish Energy Agency.

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

55 The list can be downloaded from [www.energimyndigheten.se](http://www.energimyndigheten.se).

56 Bill 2005/06:127, Research and New Technology for the Future Energy System.

The 2006 Budget set expenditure on energy research at about SEK 815 million/year over the period 2006–2008. In the 2008 Budget Bill of autumn 2007, the planned grants were increased by SEK 40 million/year until 2010. For 2008, the grant (including the above increase) amounts to almost SEK 875 million<sup>57</sup>. For 2009, the autumn 2008 Bill proposes an investment of almost SEK 1147 million for research in 2009. Looking further ahead, this sum is expected to increase to about SEK 1403 million in 2010 and SEK 1367 million in 2011, in price levels as of the time. The Government proposes an increase of SEK 145 million for energy research in 2009, in order to facilitate the demonstration and commercialisation of new technology for renewable energy. Corresponding figures for 2010 and 2011 are SEK 380 million and SEK 350 million respectively. In its autumn Budget Bill of 2008, the Government proposes to increase the energy research grant by a further SEK 110 million, with effect from 2009, in accordance with details that will be included in the Research and Innovation Policy Bill.

The objective of energy research is to “...*establish such scientific and technical knowledge and skills among universities, institutes of technology, research institutes, public authorities and industry as are needed to support a changeover to a long term sustainable energy system in Sweden through application of new technologies and new services, and to develop technologies and services that can be commercialised by Swedish industry, and thus contribute to the restructuring and development of the energy system in Sweden and on other markets*”<sup>58</sup>. Energy research covers the entire chain from fundamental research and technical development through to demonstration activities and business development. Experience shows that it can take up to ten years before the results of research materialise into a commercial breakthrough.

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

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

**The energy use in the built environment** theme area includes the supply and distribution of heating, electricity for domestic and building services systems and the underlying design and operation of buildings and their services systems. The objec-

57 In the 2008 additional Budget Bill (2007/08:FIU21) and proposal for an additional budget in connection with the autumn 2008 Budget Bill.

58 See Energy Research in Sweden 2006 for a more detailed presentation of Sweden's energy research programme and its components.

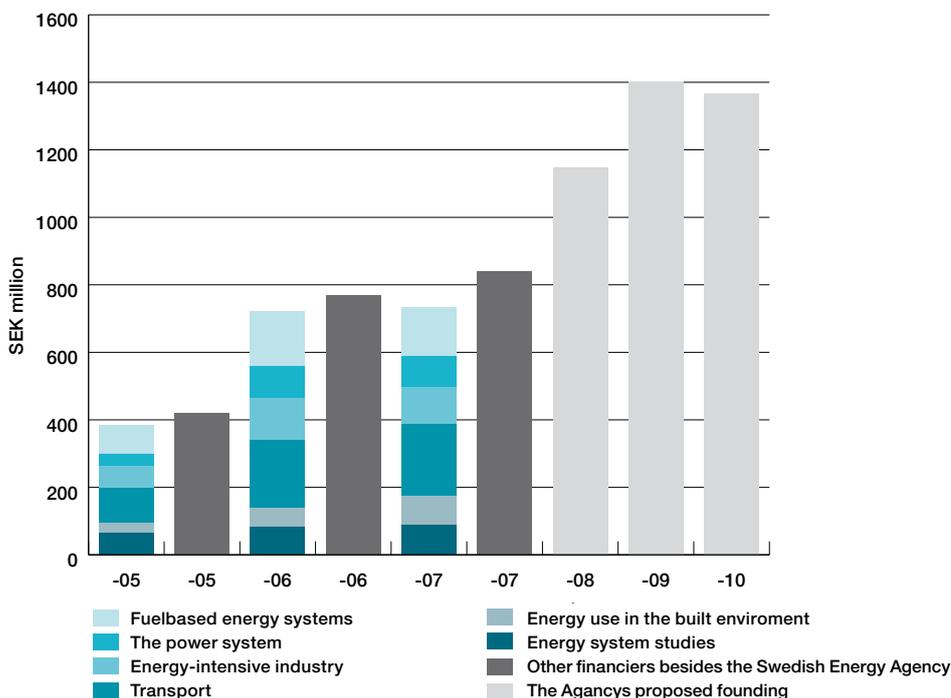
tive of research into the performance of buildings as climate screens is to achieve substantial improvements in the efficiency of specific energy use for heating, domestic hot water production and building services systems. Work in the field of building services systems is concentrated on several different technology areas, such as small scale combustion of biofuels, district heating and district cooling, heat pumps, solar heating and buildings as energy systems.

Research in **the transport sector** is divided into two parts: alternative motor fuels and energy-efficient vehicles. This includes research and development of biofuel-based motor fuels, combustion engines and electrical drive systems. Looking ahead, biofuel-based motor fuels have the potential to make a significant contribution to replacing fossil fuels in the transport sector. In the longer term, improvements in combustion engines and electrical drive systems should result in substantial reductions in the fuel consumption of cars and of heavier vehicles. Research into electrical drive systems is concentrated on electrical and hybrid vehicles, and on fuel cells.

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

**The power system area** includes hydro power, wind power, solar cells, wave power, power transmission and energy storage in the power system. Training and accumulation of experience are important working areas for future modernisation of existing hydro power production facilities. Research into wind power is aimed at creating the right conditions for increasing the proportion of the country's power supply from wind, and for reducing its cost. The Agency is also running pilot projects for offshore and highland wind power production. Research into power transmission systems and energy storage in the power system is concentrated on creating a safe and efficient system suitable for supporting new technologies and means of production, which are expected to be increasingly employed.

**The fuel based energy systems** working area includes research and development of sustainable biomass fuel supply and energy production, based mainly on biomass-fuelled systems. Research in the area is intended to help increase the quantities of fuels available, to improve the cost efficiency and resource efficiency of the chain from raw material to finished product, to improve the electrical yield from processes, and to help commercialise the technology. Sweden is one of the world's leading countries in the production and use of solid processed fuels, such as pellets. Heating and combined heat and power production technologies are being investigated in order to acquire knowledge that can be used to improve the efficiency of established technologies and to introduce new technologies with improved performance.



**Figure 6:**  
Funding for research, development and demonstration activities

SOURCES: THE SWEDISH ENERGY AGENCY'S ANNUAL REPORT, 2007 (ER 2008/01), OFFICIAL DOCUMENT PLACING FUNDING AT THE DISPOSAL OF THE SWEDISH ENERGY AGENCY 2008, BUDGET BILL 2007/08:1, FOR EXPENDITURE AREA 21, ENERGY

NOTE: FOR 2005–2007, THE FIGURE REFERS TO APPROVED FUNDING. FOR 2008, THE FIGURE SHOWS FUNDING, WHILE FOR 2009 AND 2010 IT IS EXPECTED FUNDING. THE FIGURES ARE THEREFORE NOT STRICTLY COMPARABLE BETWEEN YEARS.

The Agency attaches particular importance to the development of three larger bio-energy-related pilot plants, covering the entire chain from research to demonstration: a development plant for black liquor gasification in Piteå, a plant for gasification of biomass in Värnamo, and an ethanol pilot plant in operation in Örnsköldsvik. They are regarded as strategically important when seen against the background of Sweden's favourable conditions for the production of bio sourced motor fuels from forest raw materials.

## The climate investment programme

The now-concluded Klimp climate investment programme was started in 2003 and allowed local authorities and other parties to apply for grants for measures intended to reduce the emission of greenhouse gases in Sweden or assist in the restructuring of the energy system, or which included interesting new technology that could contribute to these objectives. To some extent, Klimp was a continuation of the LIP local investment programme.

A climate investment programme consists of measures that are mostly in the form of physical investments. The main criterion for evaluating the success of a programme and its measures is how effective greenhouse gas emission reductions have been in relation to their costs and to the grants applied for under the scheme. However, the

overall perspective, strategies and links with other measures provide a basis for decisions on which applications receive grants.

SEK 481 million were made available in 2003 to 31 programmes aimed at reducing the effects of climate change and improving the security and sustainability of the energy system by local authorities, commercial companies, county councils and regional cooperation organisations. It is expected that these measures will reduce carbon dioxide equivalent emissions by 273 000 tonnes per year. The investments are expected also to result in improvements in the efficiency of energy use, and direct energy savings amounting to a total of 254 GWh per year. The projects include expansion of district heating systems, waste digestion to produce biogas, conversion to biofuels, improvements in the efficiency of energy use and local information on climate related matters.

The Swedish Environment Protection Agency has been the main operator of Klimp, but sought advice from other agencies concerning the merits of proposed measures. Final decisions as to which programmes were to receive grants, and of how much, were made by a special board within the Environment Protection Agency.

## Information activities

The fact that knowledge and understanding affect how we act in given situations when decisions are required means that information activities occupy an important and central part among the policy measures available to the State. In its implementation of national energy policy, the Swedish Energy Agency is a central provider of information, employing many different channels and working with a large number of different parties in order to ensure that information reaches its target groups. Local authority energy advisors constitute a unique network, financed by the Agency, and available in all local authority districts throughout the country. They provide the general public, small companies and organisations with impartial advice, tailored where appropriate to local conditions. They are, in turn, backed up by regional energy offices that provide training and coordinate information activities.

During 2006–2007, instructed by the Government, the Swedish Energy Agency, the National Board of Housing, Building and Planning, the Swedish Consumer Agency and the Swedish Environmental Protection Agency started and ran a programme of information activities aimed at domestic consumers, detached house and apartment building owners, with the aim of increasing their awareness of long term energy efficiency improvement and energy conservation measures. The Swedish Energy Agency has been given overall coordination responsibility for the work, which continued during 2008, although without the Swedish Consumer Agency. The work has included an information tour around the country and creation of a web site with tips and advice. The web site includes an energy calculator, a service that the Agency has taken over from the Swedish Consumer Agency.

# 2

## Summary

Sweden has employed economic policy measures for many years, traditionally, with taxes having been the main measure. Originally, the purpose of taxes was to finance public spending, but a move towards using them to steer developments in the energy sector in the desired direction began to appear in the 1970s. Taxes are applied with the aim of achieving various targets in energy and environmental policy.

Major changes are in progress concerning the economic guidance measures employed by Sweden. Where taxes were once the main weapon in this armoury, there is now a growing interest in employing market based policy measures. A good example of this is presented by the green electricity certificate system which was introduced in May 2003, and by emission allowances trading that was introduced at the beginning of 2005. Market

based policy measures differ in their structure and application from the more traditional policy measure of taxes. The green electricity certificate system has introduced quotas for the proportion of renewable energy that the market must deliver, while emission trading sets a ceiling for carbon dioxide emissions. This means that the target results are already known when the policy measure is introduced, while the market is free to decide what needs to be done in order to achieve the results, which in turn leads to greater cost efficiency.

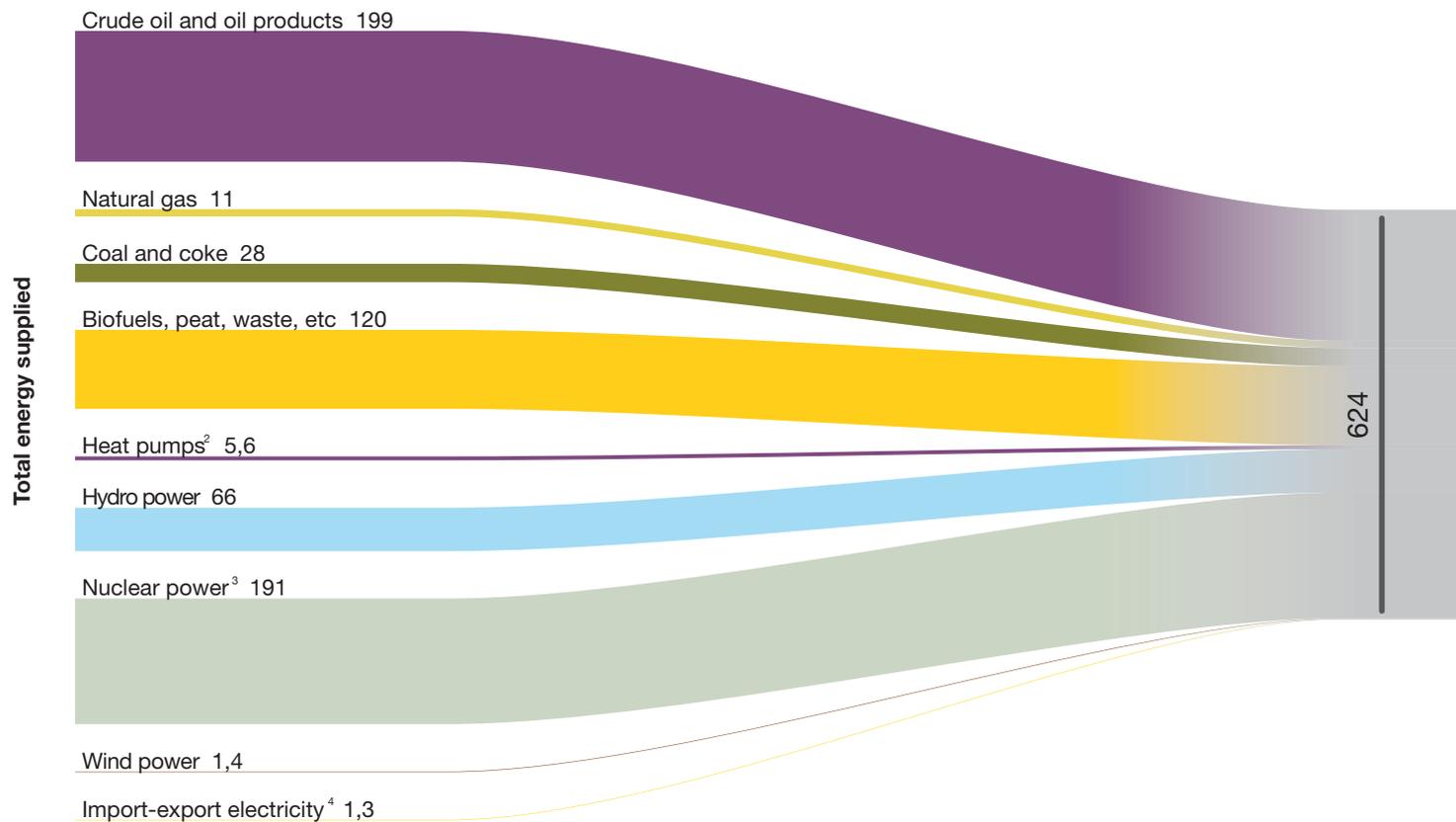
There are also many other policy measures that (in various ways) affect the use of energy in buildings, transport and industry, or which encourage actions intended to reduce emissions. Despite the variations in the many different policy measures, they are all working in the same direction.

# Sweden's energy balance

Energy can never be destroyed or consumed, but only converted which, in everyday language, means 'used'. The total quantity of energy used must therefore always be balanced by a corresponding quantity of energy supplied.

This chapter gives details of the balance between Sweden's total energy supply and its total energy use<sup>59</sup>.



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

1 PRELIMINARY STATISTICS. DUE TO ROUNDING OF FIGURES, THERE MAY BE DIFFERENCES IN THE TOTALS.

2 THESE ARE LARGE HEAT PUMPS IN THE ENERGY SECTOR.

3 NUCLEAR POWER IS SHOWN AS GROSS POWER, I.E. AS THE NUCLEAR FUEL ENERGY INPUT, IN ACCORDANCE WITH THE UN/ECE GUIDELINES.

4 NET IMPORT OF ELECTRICITY IS TREATED AS SUPPLY.

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

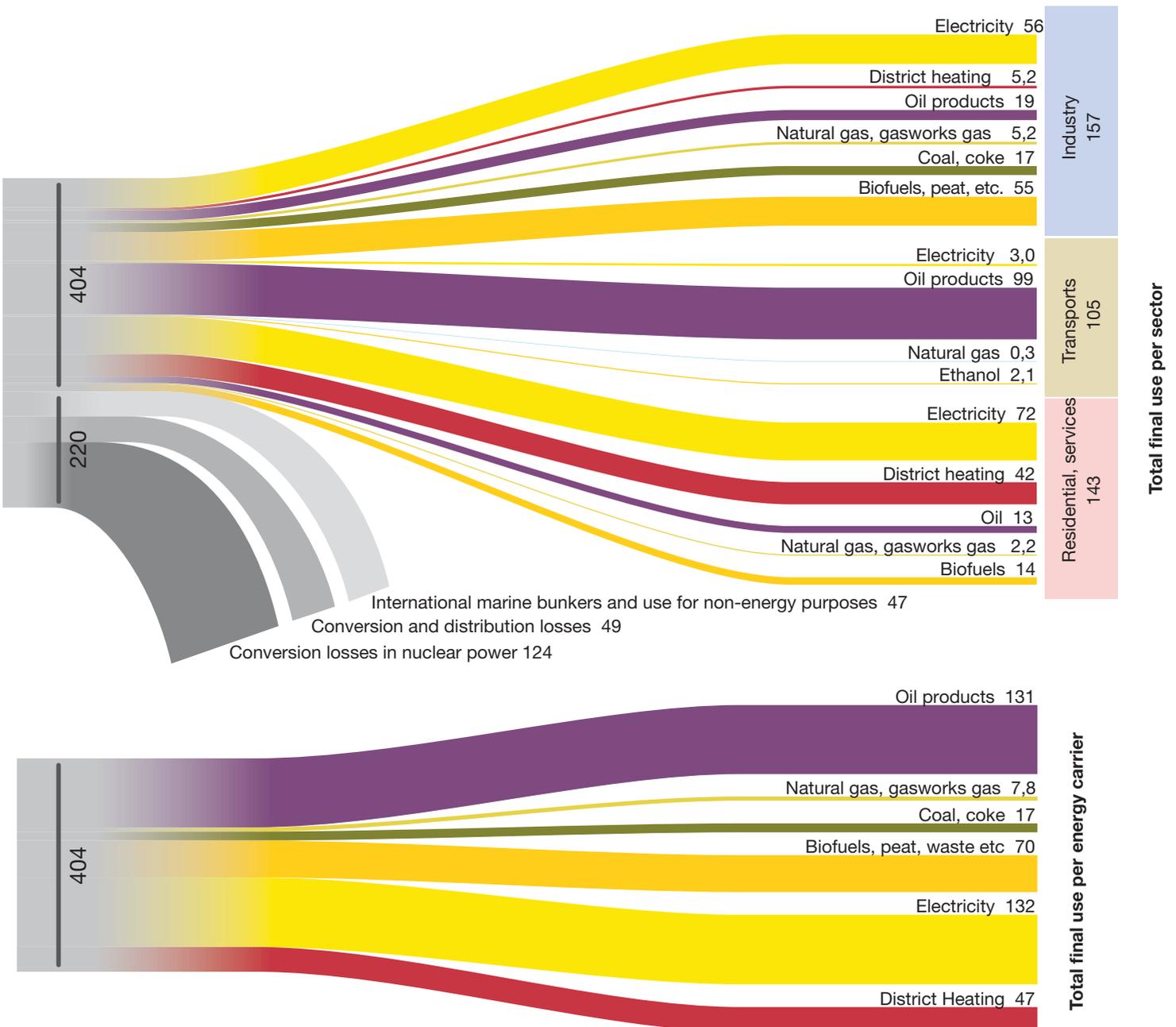


Figure 7 shows - aggregated and simplified - Sweden's energy system in terms of the energy flows from supply to final use. Energy is supplied in order to meet users' demand for energy, which in turn depends on their needs in terms of functions such as transport, lighting, heating, cooling, miscellaneous processes etc. It is this use that determines the amount of energy in the form of electricity, heat etc. that needs to be produced. Energy use, as shown in the figure, consists of the total final use, i.e. the use of energy in the residential and service sectors, industry and transport, together with losses, international maritime transport, and energy materials used for non energy purposes. However, the figure does not show losses that occur in the final energy use stage, and nor does it show losses in hydro power production. Most of the losses shown in the diagram are made up of the thermal energy that is of necessity removed by cooling when producing electricity in nuclear power stations. Other losses include conversion losses in energy plants<sup>60</sup> and distribution losses in connection with the supply of electricity, district heating, natural gas and town gas, coke oven and blast furnace gas. The use of energy products for non energy purposes is made up of raw materials for the chemical industry, lubricating oils and oils used for surface treatments in the building and civil engineering sectors (asphalt and binders). Total energy supply in Sweden is made up of indigenous supply of biofuels, hydro power, rock heat, lake heat, air heat and ground heat to district heating heat pumps<sup>61</sup>, and fuels for nuclear power production. To this must be added changes that occur in storage stock levels and the country's net import (the difference between imports and exports) of energy materials and carriers, such as oil, natural gas, coal, biofuels and electricity.

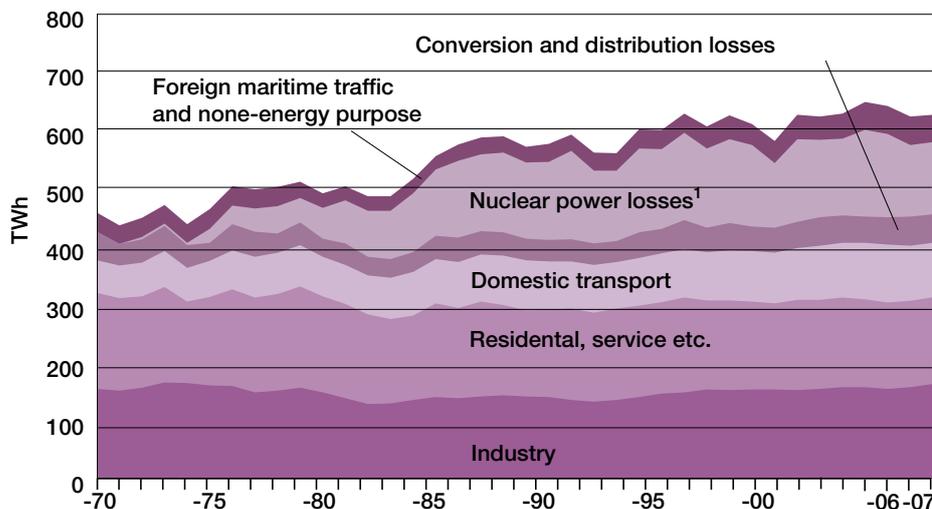
## Total energy use

Total energy use in 2007 amounted to 624 TWh. Of this, total final energy use made up 404 TWh, and conversion and distribution losses made up 173 TWh, of which 124 TWh were in nuclear power production. Bunker oils for foreign maritime transport, together with the use of energy products for non energy purposes, accounted for a further 47 TWh. Although industry uses more or less the same amount of energy now as in 1970, and the residential and service sector actually uses a little less, much has changed: the total heated floor area of commercial premises, for example, is greater, population numbers have risen, and industrial production is considerably higher than it was in 1970. The move away from oil to electricity and district heating has 'transferred' some of the losses to the supply side of the energy system: see '*System Boundaries*' below. Total energy use by the transport sector (excluding foreign maritime traffic) has increased by about 87 % since 1970. For the industrial sector, the variations in energy use from one year to another are due mainly to economic conditions, while for the residential and service sector they are partly due to differences in the climate from one year to another. Energy use in the various sectors shows that

59 Statistics for the period 1970-2005 are final. Those for 2006-2007 are preliminary.

60 Energy plants as referred to in this context are those producing heat and/or electricity, refineries, gasworks, coking plants and blast furnaces.

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



**Figure 8:**  
Sweden's total energy use, 1970–2007

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

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

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

### System boundaries

Since 1970 the demand for energy<sup>62</sup> has increased by 7,7 %, from 375 TWh to 404 TWh. However, over the same period, total energy supply has increased by 36.5 %, from 457 TWh to 624 TWh. The reason for the supply of energy increasing almost five times more rapidly than the demand for energy is because both the industrial, and the residential and service, sectors have carried out a major shift away from oil to electricity as the main energy carrier during the period. Although electricity is a very efficient energy carrier as far as users are concerned, it is associated with major losses on the production side, e.g. when produced in nuclear power stations. As a result, much of the conversion losses have been transferred from the end users to the supply side of the energy system. These losses are not shown as part of the end users' demand, but as an item of their own. Losses occur, for example, in electricity production, in the production of district heat and in refineries. System boundaries provide an aid to analysing the energy system. By assigning all the losses proportionally to the use of electricity, district heating and oil products in the user sectors, we obtain an alternative picture of the development of energy use in the various end user sectors.

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

**Figure 9:**  
Total energy use in Sweden, 1970–2007. Conversion losses in the production sector are apportioned to end users

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

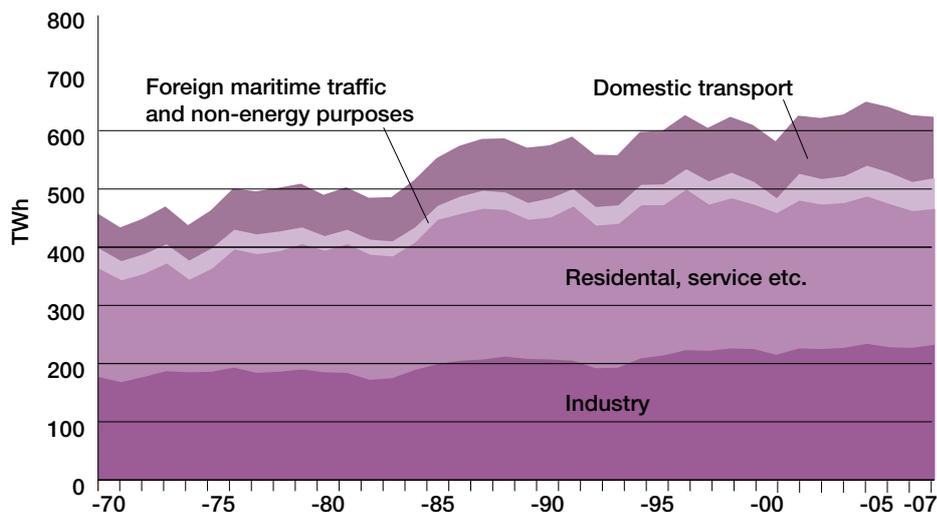
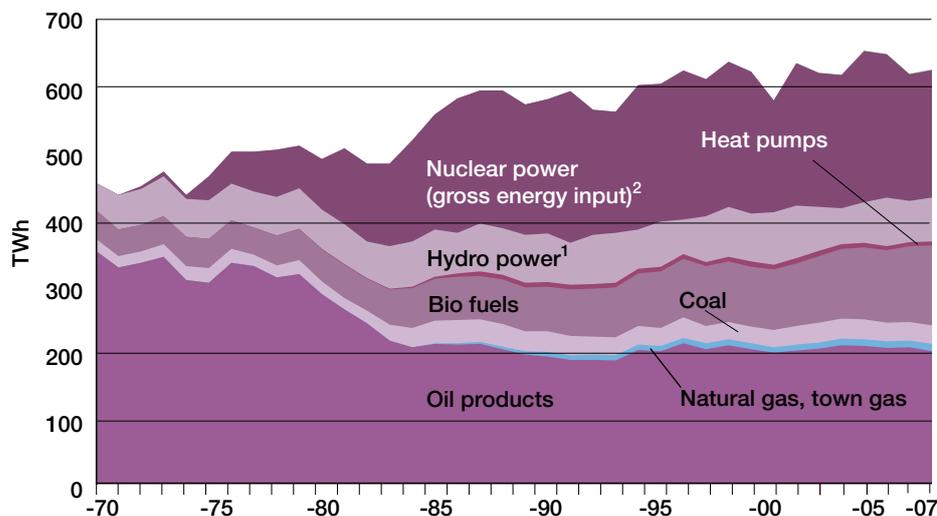


Figure 9 shows such an assignment of losses, based on exactly the same statistics as shown in Figure 8, but with the difference that the losses are not shown on their own. The difference between the way in which the information is shown in the two figures is due to where we set the system boundary. If the boundary is set at the factory gate, or at a residential building wall, we obtain the result as shown in Figure 8. If, on the other hand, the boundary is set where the electricity, district heating or oil products are produced, we obtain Figure 9. Other system boundaries can also be considered<sup>63</sup>.

## Total energy supply

Sweden's total energy supply in 2007 was 624 TWh, including a net import of about 1.3 TWh of electricity. The greatest proportions of energy supply were met by oil and nuclear fuel, followed by biofuels and hydro power. Since 1970, the make up of energy supply has changed. The supply of crude oil and oil products has fallen by about 43 %, while the net production of electricity has increased by about 145 % as a result of the construction of nuclear power stations and expansion of hydro power production. The supply of biofuels has increased by over 179 %. During the 1980s, local authority energy utilities installed large heat pumps for supplying district heating. At the same time, natural gas was brought to towns along the west coast, and wind power construction started in the middle of the 1990s. The use of coal and coke as fuels increased during the 1980s, but has since declined somewhat. Nuclear power used 191 TWh of fuel energy input in 2007, to produce about 64.3 TWh of electricity. Hydro power produced 65.6 TWh of electricity, which is fairly low in historic terms.

63 All or nothing – System boundaries for heating buildings. [www.energimyndigheten.se](http://www.energimyndigheten.se).



**Figure 10:**  
Total energy use in  
Sweden, 1970–2007,  
excluding net  
electricity exports

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

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

Hydro power production varies widely, depending on the amount of precipitation during the year: average annual production is 67.5 TWh<sup>64</sup>. Fuel based thermal power production produced 13.2 TWh of electricity, while wind power supplied about 1.4 TWh. About 54 TWh of fuels were used for district heating production. The proportion of renewable energy sources in the country's total energy supply amounted to about 29 % in 2007. Renewable energy sources include biofuels, hydro power and wind power.

## The proportion of renewables

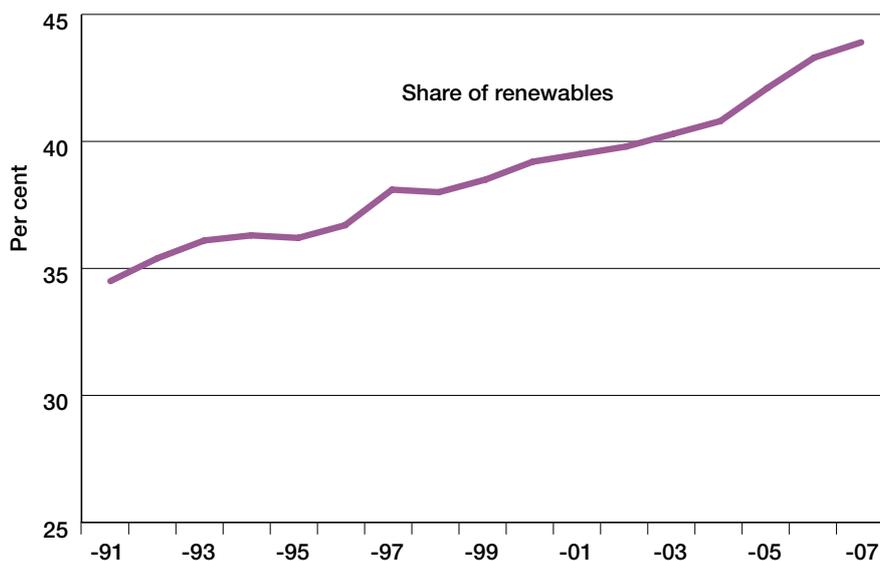
The overall objective of Swedish energy policy is still that of working towards a sustainable energy system. Two important reasons for encouraging the use of renewable energy sources in Sweden are the minimisation of environmental and climate effects, together with improved security of supply resulting from greater diversity. In addition to Sweden's own targets, the European Council set an overall target in March 2007 of 20 % of energy to be supplied from renewable sources by 2020, as compared to the corresponding level of 8.5 % in 2005. In January 2008, the Commission published a proposal<sup>65</sup> as to how the 20 % target should be apportioned between the various member states. Under the terms of the proposal, Sweden's target would be 49 % in 2020, as compared to Eurostat's calculation of 39.8 % in 2005.

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

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

**Figure 11:**  
Sweden's total  
proportion of  
renewable energy  
sources, 1990–2007

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



### Sweden's total proportion of renewable energy use

In 1990, Sweden's proportion of energy use provided from renewable sources amounted to 33.9 %. By 2007, this had increased to 43.9 %.<sup>66</sup> The greatest contribution made by renewable energy sources is that to electricity production, of which a major proportion is supplied by hydro power. The next largest user of renewable energy is the industrial sector, followed by district heating production and the residential sector. Only a very small proportion of renewable energy is used by the transport sector, and the same applies for the production of district cooling. In total, it is wood fuels<sup>67</sup> (including black liquors) that is the renewable energy source that is used most in Sweden, followed by hydro power, heat absorbed by heat pumps, organic waste, biobased motor fuels and wind power. In proportion to its final energy use, Sweden uses the highest proportion of renewable energies among EU countries, and is in the top four countries that have most increased their proportion of renewable energy sources over the period 2000–2005.

Calculations of renewable energy proportions are made on the basis set by the European Commission, according to which the proportion of renewable energy is calculated as the quotient of renewable energy and final energy use, including transmission losses and use of electricity and heat for internal purposes in electricity and heat production plants. This definition may be adjusted at the end of 2008, which will in that case be reflected by recalculation of the figures in this publication.

<sup>66</sup> The Energy Indicators 2008 report (ET 2008:8) includes more detailed information on the use of renewables in the various sectors up to 2006. The report also shows an international comparison between EU member states up to 2005. It can be downloaded from the Swedish Energy Agency's website.

<sup>67</sup> This category does not include peat.



Sweden uses the highest proportion of renewable energies among EU countries.

### **Causes and effects**

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

More details of policy measures such as carbon dioxide tax, a ban on the use of land-fill, conversion grants, the Green Electricity certificate system, the climate investment programme and the emissions trading system are described in the earlier chapter.

## Renewable energy – definitions and assumptions for calculations

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

The numerator in the quotient is defined as the sum of renewable electricity production, renewable district heating/district cooling production, the use of renewable energy for heating/cooling production in industry, the residential sector (including the services sector, agriculture, forestry and fisheries) and the use of renewable energy in the transport sector. According to the draft directive, heat collected by heat pumps (heat production, excluding energy input to drive the heat pumps) that use geothermal energy can be included in the numerator. Heat absorbed by air heat pumps can be included only when these heat pumps meet the eco labelling requirements for efficient performance\*. It is still unclear as to what energy sources are defined as geothermal energy. The Swedish Energy Agency's interpretation is that heat absorbed by heat pumps from surface water, lake bottom waters, rock heat or ground heat as the heat source, together with those that use ambient air and meet the eco-labelling requirements, can be treated as renewable energy.

The denominator is defined in the draft directive as consisting of energy use in the industrial sector, the residential sector (including the service sector, agriculture, forestry and fisheries), and in the transport sector, plus internal use of electricity and heat in electricity and heat production plants and transmission losses in electricity and district heating distribution systems. The Swedish Energy Agency's interpretation is that energy use for foreign transport is not included in the denominator.

\* See EC Ordinance 1980/2000 and Decision 2007/742/EC.

# 3

## Summary

Sweden's energy supply in 2007 amounted to 624 TWh, which included a net import of electricity amounting to about 1.3 TWh. The two forms of energy sources providing the bulk of this supply were oil and nuclear power, closely followed by biofuels and hydro power.

The composition of the various energy sources has changed with time. The use of crude oil and oil products, for example, has declined by about 43 % since 1970, while the net production of electricity over the same period has increased by almost 145 %. This increase has been partly due to expansion of hydro power production, but particularly due to the

introduction of nuclear power generation in Sweden between 1975 and 1985. In addition, the supply of biofuels has increased by over 179 % since 1970.

When the use of one energy source or energy carrier declines, such as that of oil, the use of some other source or carrier must increase in order to meet the demand for energy, as there must always be a balance in the energy system. In Sweden's case, it is the use of renewable energy sources that has increased, which can be seen in the increased proportion of renewable energy used in the country.

# Energy use

Modern society is dependent on energy: for heating and cooling, for lighting and domestic equipment, for travel and for the production and distribution of goods and services. The amount of energy used is affected by many factors, including economic conditions, technical development, prices and policy measures and incentives employed in energy and environmental policy. The use of energy can be divided up into three sectors: the residential and service sector etc., industry and transport. This chapter describes energy use in 2007<sup>68</sup>, against the background of developments in energy use since 1970.



## The residential and service sector

Energy use in the residential and service sector, amounting in 2007 to 143 TWh, accounts for 35 % of Sweden's total final energy use. The sector consists of residential premises (including permanently occupied holiday homes) and commercial premises (excluding industrial premises), land use<sup>69</sup>, and other service activities, which include the construction sector<sup>70</sup>, street lighting, sewage treatment plants, electricity and waterworks. Of the total energy use in the sector, most (about 87 %) is used in residential buildings and commercial premises: see Figure 12.

Almost 60 % of the energy use in the sector is used for space heating and domestic hot water production. As this is affected by temperature conditions, there can be variations in energy demand from one year to another. To enable proper comparisons to be made, it is necessary to correct for climatic conditions in order to arrive at a statistically average year regarding the climatic conditions<sup>71</sup>. The number of degree-days in 2007 was 87.8, which means that the heating energy requirement was about 12 % less than in a statistically average year. Adjusted to the corresponding value for a statistically average year, this is equivalent to 149.9 TWh, which is an increase of over 1 TWh in comparison with 2006.

The number of dwelling units (single family houses and apartments in apartment buildings) in the country steadily increases. In 2006, there were about 4.5 million dwelling units, representing an increase of about 40 % since the 1970s. The rate of construction was relatively low during the latter half of the 1990s, but picked up during the 2000s, to the extent that 30 500 new dwelling units were completed in 2007, or 2 % more than during the previous year. Despite the increase in the number of dwelling units, total energy use in the sector has remained relatively constant.

### Electricity use

Figure 13 shows how total use of electricity in the sector has increased since 1970. The steady rise tapered off in the middle of the 1990s, since when electricity use has remained relatively stable at somewhat over 70 TWh (statistically corrected).

Much of the electricity used in the sector is for building services systems and for work activities in non-residential buildings/commercial premises<sup>72</sup>. The amount of electricity used for this purpose has increased substantially, from 8.4 TWh in 1970 to over 30 TWh in 2006. This increase has been driven by a rapid growth in the service sector, with a resulting increase in physical floor areas, coupled with a greater use of office equipment. This in turn has resulted in knock on effects, such as more lighting and greater need of comfort cooling.

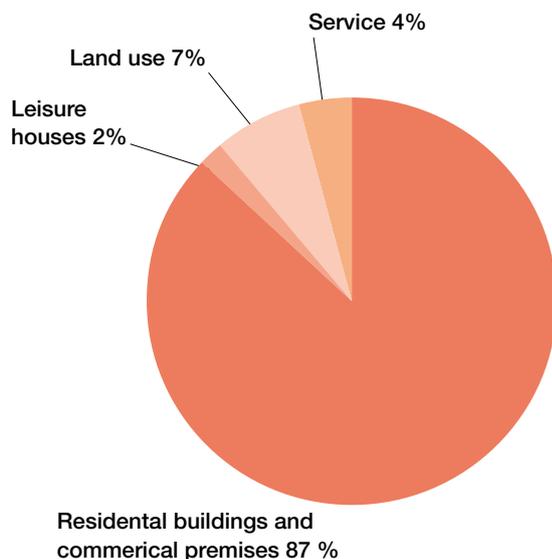
68 Statistics for 2007 are preliminary, and may be adjusted.

69 Land use includes agriculture, forestry, horticulture and fisheries. More detailed information on energy use in these sectors can be found in the publications 'Energy Use in Agriculture 2002' (Statistics Sweden), 'Energy Use in the Fisheries Sector 2005' (ER 2006:35) and 'Energy Use in Forestry 2005' (ER 2007:15). Information on energy use in the horticultural sector can be found in 'Horticultural Production 2005', which can be downloaded from [www.jordbruksverket.se](http://www.jordbruksverket.se).

70 'Energy use in the Building Sector 2004', ER2006:02.

71 Since 2003, the reference period for establishing average conditions has been 1970–2000. Until 2002, it was 1961/62–1978/79.

72 Electricity for building services systems is that which powers fixed equipment in the building, such as lifts, escalators etc., and for climate control and for lighting in common areas (entrance lobbies, stairwells etc.) Electricity for activities in the building is that used for such purposes as computers, office equipment and lighting in occupants' areas.



**Figure 12:**  
Electricity use in the residential and service sector, 2006

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

In order to obtain more detailed data of energy use in commercial premises, the Swedish Energy Agency is part way through a seven year investigation (which started in 2005) of energy use in a sample of about 1 000 commercial and similar premises. The investigation, under the name of STIL2, is intended to provide data on the use of energy and electricity in various types of premises (offices, schools, health care facilities etc.). The use of electricity is, on average, lowest in schools, at 62 kWh/m<sup>2</sup> (excluding space heating), as against 78 kWh/m<sup>2</sup> in health care premises and 102 kWh/m<sup>2</sup> in offices. However, there are considerable variations in energy use between buildings in the same category. Lighting, at 25 % in schools and health care premises, and 21 % in offices, accounts for a major part of electricity use in all three types of premises. Ventilation is another major user of energy, amounting to 34 % in health care premises, 25 % in schools and 17 % in offices. There is regarded as being considerable scope for further improvements in the efficiency of electricity use in office and commercial premises, as well as in public premises: it should be possible to save up to 30 % of total electricity use in the types of premises covered by the survey<sup>73</sup>.

The use of electricity for domestic purposes<sup>74</sup> increased from 9.2 TWh in 1970 to 19.5 TWh in 2006, with most of the increase occurring during the 1970s and 1980s. This rising use can be explained by an increase in the number of households and greater ownership of electrical and electronic equipment. In 2006, average domestic electricity use amounted to about 6 100 kWh in detached houses, and in apartment buildings to about 40 kWh<sup>75</sup> per m<sup>2</sup> and year.

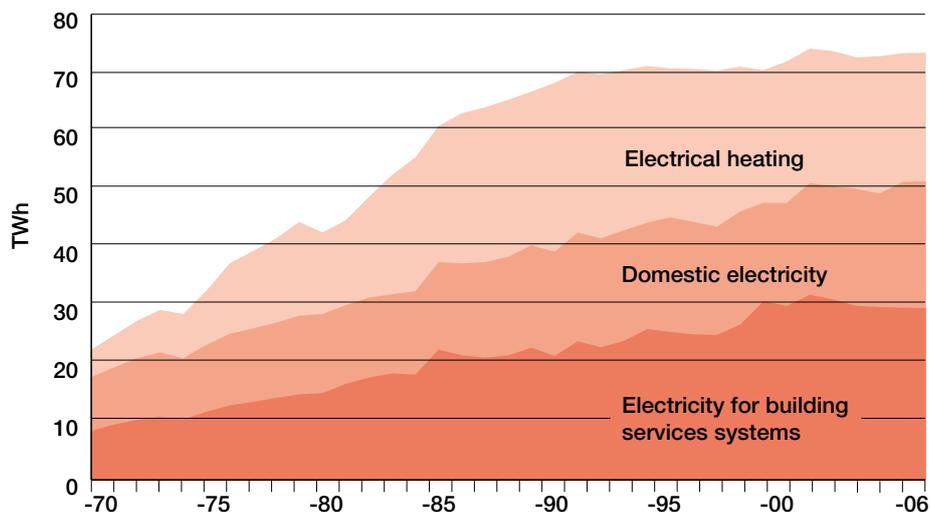
73 As part of the work of its project, 'Statistics of Energy Use in the Built Environment', the Agency has set up the eNyckeln web portal, which presents energy statistics for apartment buildings and commercial premises. [www.enyckeln.se](http://www.enyckeln.se).

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

75 This guide value figure was developed from a questionnaire investigation of energy use by apartment residents, carried out by Statistics Sweden over the period 1997–1999. Prior to 1999, the figure had been 50 kWh/m<sup>2</sup>, year.

**Figure 13:**  
Electricity use in the residential and service sector, 1970–2006, statistically corrected for weather conditions

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY



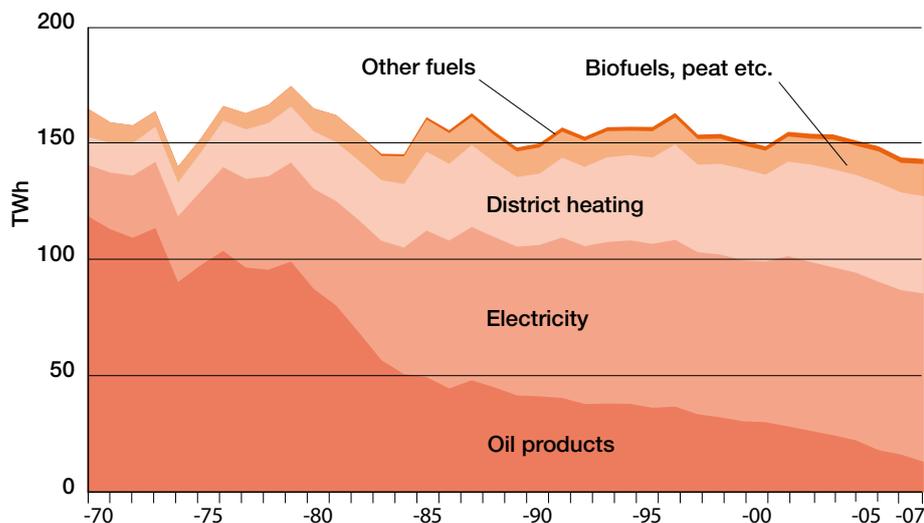
Over the period 2005–2008, the Agency is carrying out a study to provide up to date data on the breakdown of uses of domestic electricity. The preliminary results indicate a wide spread in measured electricity use between households, varying from 2 000 kWh/year to 7 000 kWh/year for a detached house, and from 1 000 kWh/year to 5 000 kWh/year for an apartment. Over the whole year, lighting is the largest user of domestic electricity, followed by electricity use for refrigerators and freezers in second position, and entertainment electronics (TV, computers etc.) in third position.

The use of electricity for heating in the sector increased gradually from 4.7 TWh in 1970 to 29 TWh in 1990 (statistically corrected values), reaching a peak at the beginning of the 1990s, and then falling somewhat. In 2006, electric heating amounted to 22 TWh. Electricity used for floor heating and fan heaters also contributes to the heating of a building, but is partly accounted for in the statistics as domestic electricity.

### Space heating and domestic hot water

A total of 81.4 TWh were used for space heating and domestic hot water production in 2006, equivalent to about 86 TWh after correction for a statistically average climate year. Of this, about 42 % (34.1 TWh) were used in detached houses, 32 % (26.1 TWh) in apartment buildings and 26 % (21.2 TWh) in commercial premises and public buildings.

The commonest form of heating in detached houses is electric heating, used by about a third of them in 2006. Of these, over half have only direct electric heating, with the rest having waterborne electric heating. The main reason for the high pro-



**Figure 14:**  
Final energy use in the residential and service sector, 1970–2007

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

portion of electric heating in detached houses is that it is cheap to install and simple to run. The use of electric heating increased substantially in the sector from 1970 to the middle of the 1980s, due to the move away from oil, after which a slight decline began in its use in detached houses. The total use of electricity for space heating and domestic hot water production (including electricity for heat pumps) in detached houses amounted to 15 TWh in 2006 (16 TWh after adjustment for statistically average climate conditions).

The use of direct electric heating in combination with some other form of heating is common in detached houses: about 40 % of detached houses had some form of combination heating system in 2006. The commonest combination, used in over 23 % of detached houses, was that of biofuels and electricity. Households with dual-fuel boilers can easily change between electricity, oil and/or biofuels. They are relatively flexible, with their use being largely determined by the relative price levels of the different energy carriers. Other households, not having this ability quickly to change their energy carriers, are more vulnerable to changes in the relative prices of energy carriers. The use of heat pumps has increased substantially in recent years, to the extent that almost 30 % of detached houses were using them in 2006.

About 10 % of detached houses were heated solely by district heating, 9 % were heated solely by biofuels, and 3 % were heated solely by oil. Other detached houses had other combinations, or were heated by gas. A total of 11.1 TWh of biofuels, 4.7 TWh of district heating, 3.4 TWh of oil and 0.3 TWh of gas was used for space heating and domestic hot water production in detached houses.

76 In addition to this, district heating was used in combination with other forms of heating for 5 % of floor areas.

District heating is the commonest form of heating in apartment buildings, with about 76 % of apartments being heated by it in 2006<sup>76</sup>. Oil is used as the sole heat source for 2 % of apartments, while 3 % are heated by electricity alone. 10 % were heated by combinations of systems with heat pumps. Other areas are heated by combinations of various heating systems, or by gas or biofuels. Total use amounted to 22.4 TWh of district heating, 1.5 TWh of electric heating, 1.5 TWh of oil, 0.3 TWh of gas and 0.2 TWh of biofuels.

District heating is the main source of heat in offices, commercial premises and public buildings as well, with 59 % of such buildings in 2006 being supplied solely with district heating. About 7 % of this floor area was heated by electricity alone and about 3 % by oil alone. Other heating systems included combinations of various energy carriers, or gas or biofuels alone. Total use amounted to 14.7 TWh of district heating, 3.9 TWh of electric heating, 1.6 TWh of oil, 0.4 TWh of gas and 0.5 TWh of biofuels.

### **Changes in the residential and service sector**

The relative proportions of the different energy carriers have changed since the 1970s, which can be seen in Figure 14. Oil crises, rising energy prices, changes in energy taxation and investment policies have all affected the shift from oil to other energy carriers. In 2007, total use of oil fuels in the sector amounted to 13 TWh, a reduction of almost 90 % since 1970. About half of this oil was used for heating. An important reason for the decline has been the rise in oil prices, leading to a change to electricity, district heating or biofuels. Biofuels in particular are used for heating in detached houses. The commonest such fuel is logs, although pellets and wood chips are also used.

The total statistically corrected energy use in this sector remained relatively stable between 1970 and 2000, after which it has started to show a decline, particularly in respect of energy supplies for space heating and domestic hot water production. The most important reason for this decline in recent years is that different energy carriers have different distribution and conversion losses at the point of use, depending on whether it is a fuel (e.g. oil) or a 'ready to use' (district heating or electricity) energy carrier that is being used. A reduction in total final energy use in the residential and service sector, due to the replacement of oil by electric heating or district heating, results in increased losses in the conversion sector<sup>77</sup>.

Another contributory reason for the apparent reduction in energy use in the sector is the increase in the number of heat pumps. Heat pumps deliver three times as much thermal energy as they use in the form of electrical energy for driving them<sup>78</sup>, which means that their use reduces the metered use of energy for space heating and domestic hot water production in buildings. This 'free' heat is not included in the statistics of the total amount of energy used in the sector.

Other factors that reduce energy use for space heating and domestic hot water

<sup>77</sup> See also Chapter 3, Sweden's Energy Balance, under 'System boundaries'.

<sup>78</sup> Heat pumps in energy statistics – Suggestions, [www.energimyndigheten.se](http://www.energimyndigheten.se).

production in residential buildings and commercial premises include various energy conservation measures, such as retrofitting additional thermal insulation or upgrading windows in older buildings. The use of electricity - increase or decrease - in the domestic environment is affected by two opposing trends. Technical development is steadily improving the efficiency of equipment that replaces older products having higher energy consumptions. At the same time, many new items are given so many additional functions that they use more energy. In addition, the reduced energy consumption is offset by the increasing number of households and by the fact that many households have more and more electrically powered items.

## Industry

Energy use in industry in 2007 amounted to 156.6 TWh, which is a marginal decrease on use in 2006, and represents almost 39 % of the country's final energy use. The main energy providers in industry are electricity and biofuels, at 36 % and 35 % respectively, complemented by 26 % of energy from fossil sources. District heating provides the remaining 3 % of energy use. Fossil energy was made up of 18.5 TWh of oil products, 16.7 TWh of coal and coke, and 5.2 TWh of natural gas, as shown in Figure 15.



The pulp and paper industry uses almost 50 % of the energy used in the industry sector.

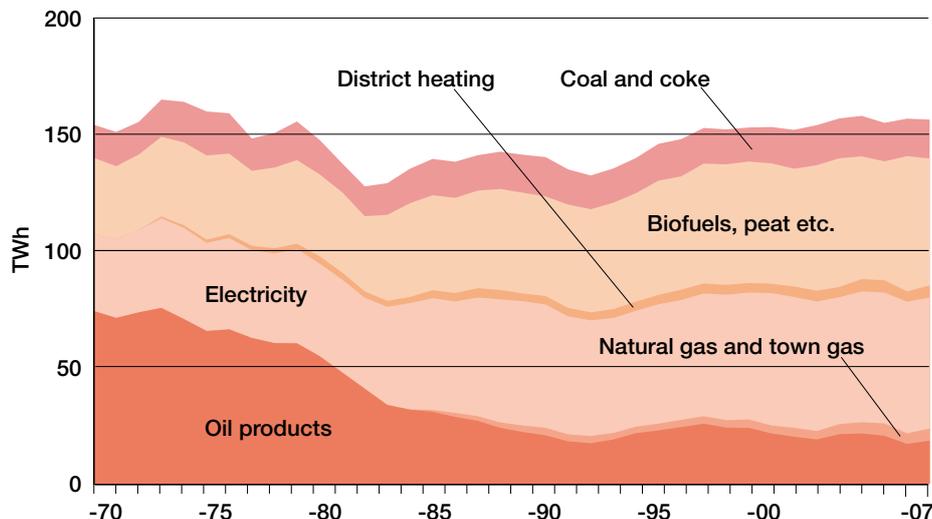
### Energy and fuel use in various sectors

In Sweden, a small number of sectors accounts for the bulk of energy use in industry: see Figure 16. The pulp and paper industry uses almost 50 %, primarily as electricity or from black liquors<sup>79</sup>. The electricity is used mainly for grinders producing mechanical pulp, while the black liquors provide fuel for soda recovery boilers in sulphate mills. The iron and steel industry uses about 15 % of industry's energy, primarily in the form of coal, coke and electricity. Coal and coke are used as the reducing agents in blast furnaces, while the electricity is used chiefly for arc furnaces for melting steel scrap. The chemical industry is responsible for 8 % of industrial energy use: here, electricity is used mainly for electrolysis processes. Together, these three energy intensive sectors account for almost three-quarters of total energy use in industry. The engineering industry, although not regarded as energy intensive, nevertheless accounts for over 9 % of total energy use in industry, as a result of its high proportion of Sweden's total industrial output. The remaining 19 % of the energy used by industry meets the needs of other sectors. 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 earth and stone industry, while others, such as metal

<sup>79</sup> Black liquors are a by-product of pulp manufacture in sulphate pulp mills. They can be burnt to recycle chemicals and release energy.

**Figure 15:**  
Final energy use in  
the industrial sector,  
1970–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

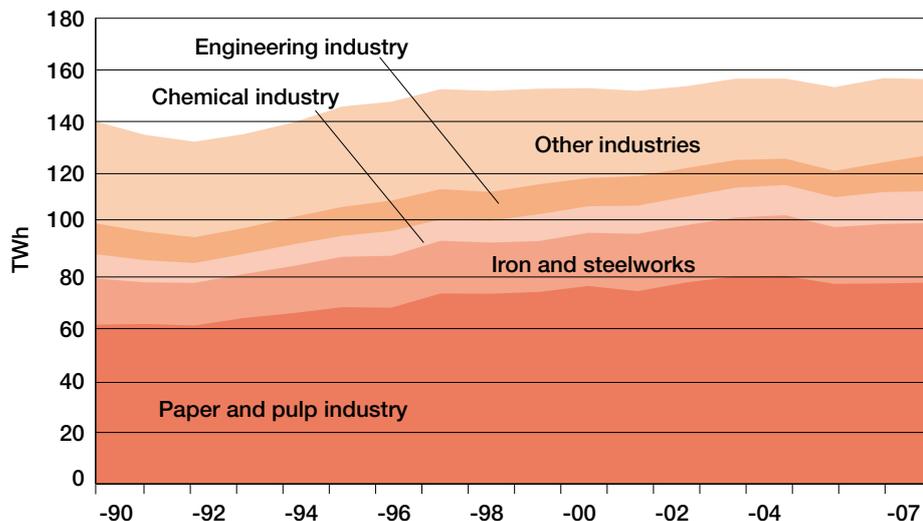


machining industries, are dominated by the use of electricity. This category also includes sectors mainly using a mix of fossil energy and electricity, such as the mining industry, and those which are dominated by biofuels, such as the wood products industry, which also uses a considerable proportion of electrical energy<sup>80</sup>.

### The relationship between supply and use of energy

In the short term, energy use in industry essentially follows variations in industrial output. In the longer term, it is affected also by such factors as taxation, changes in energy prices, improvements in the efficiency of energy use, investment, technical development, structural changes in the sector and changes in the types of goods produced. Between 1990 and 1992, industrial production declined by 6 % per annum, which was reflected by a fall of almost 6 % in energy use over the period. Output recovered in 1993, and continued to rise substantially until 2000, during which period it increased at nearly 8 % per annum. This was reflected in energy use, which increased by 13 % over the period, with electricity use increasing by 15 %. This was followed by an economic downturn in 2001, and a recovery over the period 2002–2007, when industrial output increased by over 2 % per annum. Energy use increased by over 2 % over the whole period, but electricity use fell by about 1 %. In total, industrial output has increased by 105 % between 1992 and 2007, for an increase of 18 % in total energy use and 13 % in electricity use.

<sup>80</sup> 'Other sectors' include the mining industry, steelworks, wood products industries, quarrying and the food industry. (SNI 36–37).



**Figure 16:**  
Energy use in industry,  
by sectors, 1990–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

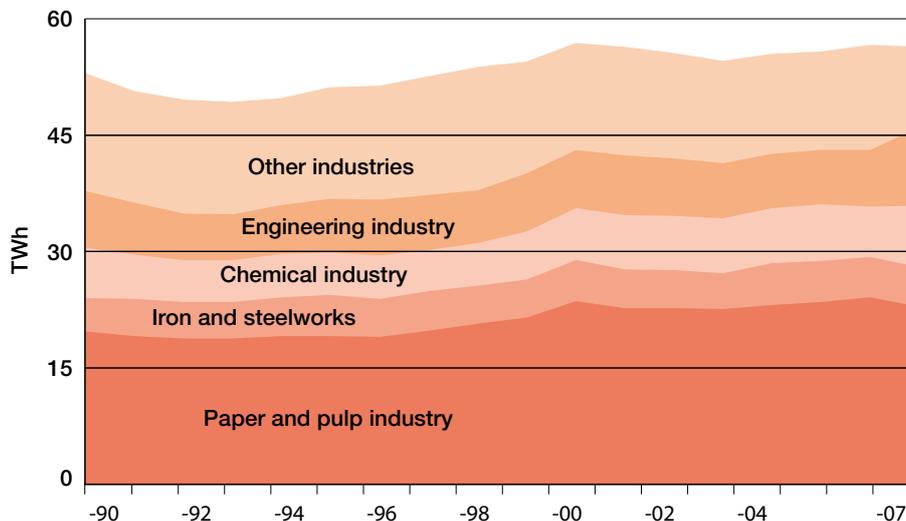
### Changes in use of the most important energy carriers

Despite increasing industrial output, the use of oil has fallen substantially since 1970, due to greater use of electricity and improvements in the efficiency of energy use. This trend started in connection with the oil crises of the 1970s, which resulted in both State and business starting intensive work aimed at reducing the use of oil. In 1970, the use of oil constituted 48 % of industry's total energy use, which can be compared with the present proportion of 12 %. At the same time, that portion of industry's use of energy accounted for by electricity has increased from 21 % to 36 %, i.e. oil has been replaced by other energy carriers, such as electricity. Although overall use of oil by industry has fallen by almost 75 % since 1970, there was an increase over the period 1992–1997, after which the downward trend resumed. Although increasing somewhat in 2007, the overall use of oil in recent years has approached the record low level of 1992.

Biofuels are the main energy source in the pulp and paper industry and in the wood products industry. Between 1970 and 2006, the proportion of biofuels, peat etc. has increased from 21 % to 35 % of total energy use in industry.

**Figure 17:**  
Electricity use in  
industry, by sectors,  
1990–2007

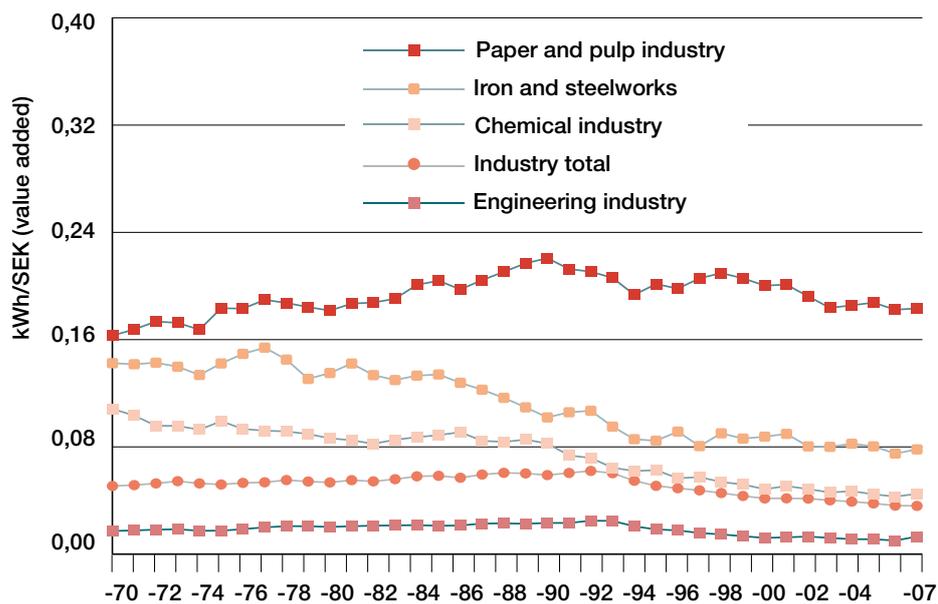
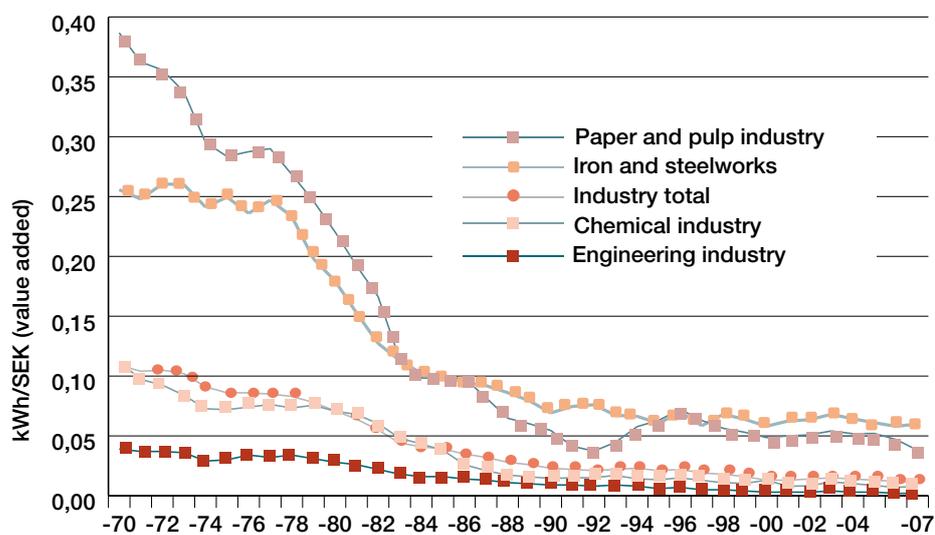
SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY



### Changes in specific energy use

Specific energy use, i.e. the amount of energy used per monetary unit of output value, provides a measure of how efficiently the energy is being used. Since 1970, specific energy use in industry has fallen continuously: between 1970 and 2007, it fell by 59 %, reflecting a clear trend towards less energy intensive products and production processes, together with structural changes in the sector. During this period, industrial output value has more than doubled.

The change from oil to other energy carriers, particularly electricity, is reflected in the specific use of oil and electricity per unit of output value. Specific use of oil fell by 81 % between 1970 and 1992, while specific use of electricity increased by 23 %. Ups and downs in the economy between 1992 and 2007, coupled with changes in the energy taxation of industry, are reflected in changes in specific energy use, which continues to fall. Over this period, it fell by 43 %, with specific use of oil falling by 49 % and that of electricity by 44 %. More generally, the reduction in specific energy use is due to the fact that production value has increased considerably more than has energy use. For several reasons, we can expect a continued fall in specific energy use. Over a longer period of time, technical development and structural changes have reduced specific energy use.



## Transport

Total energy use for transport in 2007 amounted to about 130 TWh. Of this, domestic transport used about 96 TWh, and foreign transport (including bunkering for foreign maritime traffic and air transport) used about 34 TWh.

Energy use in the transport sector is met mainly by oil products, primarily petrol and diesel fuel. In 2007, the use of these two fuels met 89 % of the country's energy requirement for domestic transport, with electricity accounting for a further 3 % and

aviation fuel for 3 %. The remaining energy requirement for transport was met by medium and heavy fuel oils, natural gas and ethanol.

The use of petrol has declined somewhat since 2002, which can be partly explained by increased use of low-admixture ethanol, and also by a falling proportion of petrol engines in passenger cars and light commercial vehicles. The use of diesel fuel has increased steadily over the period 2000–2007, which is largely due to a steadily increasing proportion

Energy use in the transport sector is met mainly by oil products, primarily petrol.

of diesel-powered vehicles among new vehicle sales. In 2007, the proportion of new vehicles that were diesel-powered was 34.7 %, as against 19.7 % in the previous year<sup>81</sup>. The use of aviation fuel decreased over the period 2000–2003, and then increased in 2004–2007. This increase over the last four years is due partly to improved economic conditions and partly to increased competition giving rise to a large number of cheap flights. Bunkering for international maritime traffic increased in 2007, partly due to the fact that maritime traffic is experiencing a period of strong growth.

In 2007, renewable motor fuels (ethanol, FAME<sup>82</sup> and biogas) supplied about 4 % of the energy use for road traffic. At present, the costs of producing alternative motor fuels exceed the corresponding costs for petrol and diesel oil. However, this difference in cost, and the difference in cost of using such fuels instead of petrol or diesel fuel, is falling as a result of technical development, the introduction of environmental taxes and a general rise in the price of petrol/diesel oil. At present, biobased motor fuels are untaxed, which means that their cost at the pump can be less than that of conventional fuels despite a higher production cost. At the end of June 2008, a litre of 95-octane unleaded petrol cost about SEK 13.99. The price of a litre of E85 fuel (consisting of 85 % ethanol and 15 % petrol) was about SEK 8.39. However, as ethanol has a lower energy content than petrol, it takes about 1.25–1.35 litres of E85 to provide the same energy as a litre of petrol. Allowing for this, the cost of using E85 at that time was about SEK 3.00 less per petrol-equivalent litre than the cost of petrol. LPG as a motor fuel was also cheaper than petrol, with a difference on that date of about SEK 4.00 per /litre (petrol equivalent)<sup>83</sup>.

81 SIKA.

82 FAME is an umbrella name for fatty acid methyl esters, of which ROME (rapeseed methyl ester) is the commonest in Sweden today.

83 Svensk Biogas, [www.svenskbiogas.se](http://www.svenskbiogas.se), 2008-06-25.

### Transport work

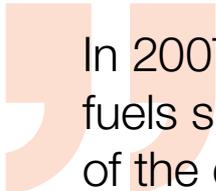
The total domestic passenger transport work in 2007 amounted to about  $137.3 \times 10^9$  (137.3 thousand million) person-km, or about 2 % more than in 2006. Road traffic dominates this, with about 87 % of passenger transport work, with railways and tramways carrying about 9 % of passenger traffic, aviation about 3 %, and domestic water traffic almost 1 %<sup>84</sup>. About 71 % of long-distance passenger travel (i.e. over 100 km) was provided by car traffic: for short-distance travel, car and motor cycle use accounted for about 77 % of journeys.

Domestic goods transport in 2007 amounted to about  $103.1 \times 10^9$  tonne-km. This is the highest amount to date, representing an increase of  $4.4 \times 10^9$  tonne-km over 2006. A significant contributory factor to this was due to the road and rail transport in 2005 and 2006 of storm-felled trees in the wake of storm Gudrun. In 2006, this abnormal transport amounted to about  $0.6 \times 10^9$  tonne-km. If the total transport work is reduced by these temporary flows, the increase in goods transport in 2007 over 2006 would have amounted to  $5 \times 10^9$  tonne-km, which is a significant increase<sup>85</sup>. Of the total goods transport, 41 % were carried by road, 22 % by rail and 37 % by ship.

### Development of alternative motor fuels

1<sup>st</sup> April 2006 saw the introduction of what is referred to as the Pumps Act which, in its first stage, means that all petrol stations selling more than 3000 m<sup>3</sup> of petrol or diesel fuel per year must also supply at least one renewable fuel. The effect has been that the petrol stations have installed almost exclusively E85 pumps. A government grant has been introduced to help petrol stations meet the cost of supplying renewable fuels other than ethanol. Up to February 2008, grants had been approved for 61 installations of biogas pumps around the country.

With effect from 1<sup>st</sup> August 2006, a permissible admixture proportion of 5 % FAME in diesel fuel has been permitted, which has noticeably increased its sales. In the summer of 2007, over 80 % of all diesel fuel contained 5 % admixture of FAME. However, due to problems with engines in some heavier vehicles, this was reduced to only 2 % during the winter of 2007. Similar problems have occurred in some parts of the country with E85 fuel, with starting problems arising at relatively modest winter temperatures. In addition, exhaust emissions are high when engines are started. One solution to this problem is to increase the petrol content of E85 fuel during the winter, and a Swedish standard for winter grade E85 has been developed.



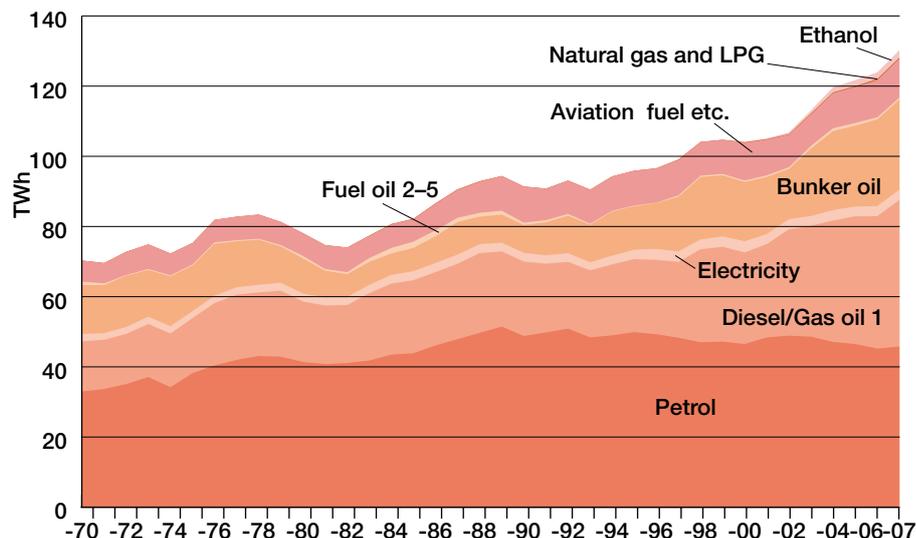
In 2007, renewable motor fuels supplied about 4 % of the energy use for road traffic.

84 National Road Administration, sector report 2007.

85 Banverket, sector report 2007.

**Figure 20:**  
Final energy use in  
the transport sector,  
1970–2007, including  
foreign maritime traffic

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

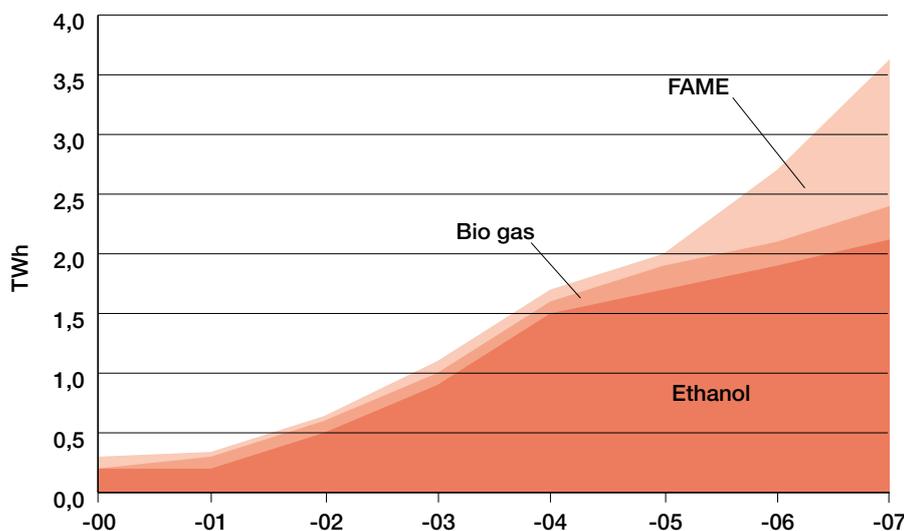


At the beginning of January 2008, there were about 14 540 LPG powered vehicles in Sweden, of which 13 410 were private cars, 760 were buses and 370 were refuse collection vehicles or distribution vehicles<sup>86</sup>. There were also over 81 000 flexible-fuel vehicles in the country.

### Developments in the transport sector

Technical development occurs in the form of both improvements to existing technology and completely new technical solutions. As far as the road traffic sector is concerned, it is expected that hybrid vehicles, and perhaps others, will achieve commercial breakthroughs during the next ten years. A hybrid vehicle has two alternative drive systems, such as an electric motor and a combustion engine. The technology is now being developed to include both private cars and heavier vehicles. Development is also in progress of what are known as plug in hybrid vehicles, which are electric hybrid vehicles that can also be recharged off the mains. During 2008, five private cars that have been converted to plug-in hybrids have been put on the road in the Stockholm area. This is at present only at the trials stage, and it will probably be some while before plug-in vehicles come into widespread use. However, several international vehicle manufacturers are planning to launch their first commercial plug-in hybrids within two or three years.

86 Swedish Gas Association.



**Figure 21:**  
Final energy use of  
renewable motor fuels,  
2000–2007

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

Technical development does not stand still, either, in the fields of rail, air or maritime traffic. In the aviation field, the LFV Group, together with SAS, has tested what are known as 'green approaches'; approaches that are planned more exactly than before, so that the aircraft can glide for more of the approach, thus saving fuel. Increased interest in biobased aviation fuels can also be noted, to the extent that one North American airline is planning to fly with biofuels in its tanks as early as the beginning of 2009<sup>87</sup>.

2007 saw intensification of the debate concerning the value of the environmental benefits of using biobased motor fuels when analysed in a life-cycle perspective. The production of ethanol, in particular, was criticised from many angles. SEKAB has initiated a voluntary scheme for quality assured ethanol, which they expect to be able to offer by the end of 2008. One of the requirements for qualification is that use of the ethanol must result in 85 % less carbon dioxide emission than from petrol. The Swan Environmental Marking Scheme has also drawn up criteria for environmental approval of motor fuels. The use of ethanol as a motor fuel is steadily increasing and, in step with the increase in the number of long distance vehicles with ethanol engines, there needs to be a network of filling stations offering E95 fuel<sup>88</sup>. About 6–10 such filling stations are planned for construction by 2010, along major traffic arteries and at freight terminals.

Trials projects are being conducted in several Swedish towns, investigating the

87 Swedish Gas Association, Energigas no. 2, 2008.

88 A fuel containing 95 % ethanol and 5 % ignition improver.

use of alternative fuels not only for local public transport but also for other goods transport. A large scale test of electric hybrid buses will be carried out in Stockholm during 2008, while Lidköping is planning trials of gas fuelled goods vehicles with dual fuel engines, i.e. engines that can run on a combination of biogas and diesel oil. In Lycksele, the town's entire fleet of heavy goods vehicles will be running over the next few years on synthetic diesel fuel, containing up to 25 % of fuel from renewable sources.

# 4

## Summary

This chapter has described energy use in the three sectors of residential and service, industry and transport. Total energy use of the three sectors together amounted to 404 TWh in 2007, of which over 131 TWh was electricity.

The residential and service sector uses 35 % (143 TWh) of the country's energy use. Residential buildings, offices and commercial premises can be, for example, connected to a district heating system, heated by electricity, or heated by oil or biomass. Almost 60 % of energy use in this sector is for heating. It uses the most electricity of the three sectors, amounting to over 72 TWh or 55 % of total final electricity use.

The industry sector uses energy not only directly as a 'raw material' (for example, in the

manufacture of steel), but also for powering ancillary processes such as pumps, air compressors and lighting. In total, the industry sector uses 157 TWh (39 % of final energy use) and 56 TWh (43 %) of electricity.

Transport of passengers or goods within the country requires energy input in the form of petrol, diesel fuel, aviation fuel and other fuels, equivalent to 105 TWh of energy or 26 % of total energy use. This sector uses little electricity, amounting to only 3 TWh (2 %), and relies instead almost entirely on oil products.

A common feature of all three sectors is that the proportions of renewable fuels are increasing.

# Energy markets

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



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## The electricity market

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

### Use of electricity

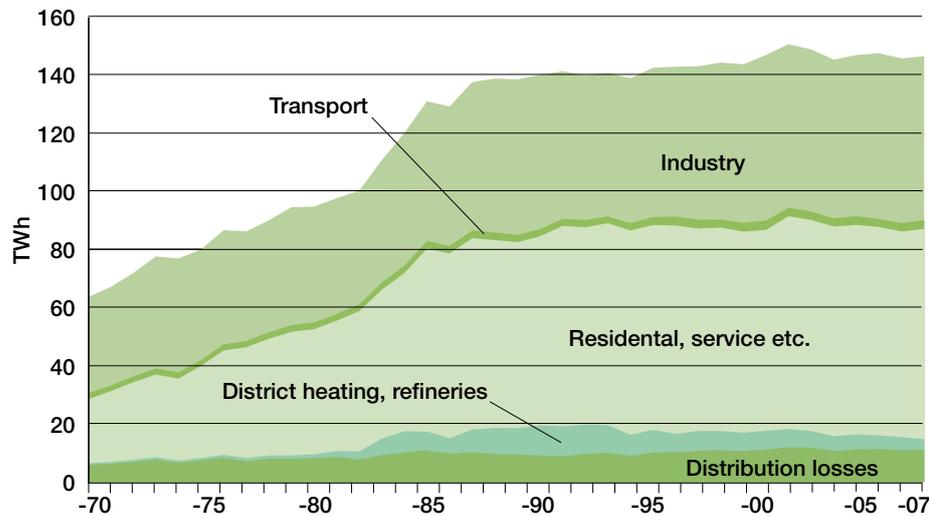
Between 1970 and 1987, electricity use in Sweden increased at an average rate of almost 5 % per year. However, this rate of increase has since declined, to less than about 0.3 % per year on average. Over the last three years, electricity use has remained relatively constant. Economic and technical development, changes in energy prices, business structure, population changes and the weather all affect electricity use. Total electricity use in Sweden in 2007 amounted to 146.2 TWh, with the residential and service sector accounting for almost half of this, and industry for about 39 %. The remainder is accounted for by the transport sector, district heating and distribution losses.

Per-capita electricity use in Sweden amounts to almost 16 500 kWh per year. Only Iceland, Norway and Canada have higher per-capita levels. The high electricity use in Sweden is due to a high proportion of electricity-intensive industries, a cold climate, a high proportion of electric heating and historically low electricity prices. Per-capita electricity use in the USA is about 11 % lower than in Sweden, while average use in the EU-15 is about 55 % less than that in Sweden.

### Electricity production

At the beginning of the 1970s, hydro power and conventional oil-fired cold condensing power produced most of the electricity in Sweden. The oil crises of the 1970s coincided with Sweden's construction of nuclear power plants. In 2007, nuclear power supplied 44 % of the country's electricity, hydro power supplied about 45 % and the remaining 11 % was made up of fossil-fuelled and biofuel-based production and wind power. Total production amounted to 144.9 TWh, or almost 4 % more than in 2006.

Greater inflow to the reservoirs enabled hydro power production to increase in 2007, amounting to 65.6 TWh in total, an increase of 7 % over production in 2006.



**Figure 22:**  
Electricity use in  
Sweden, by sectors,  
1970–2007

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

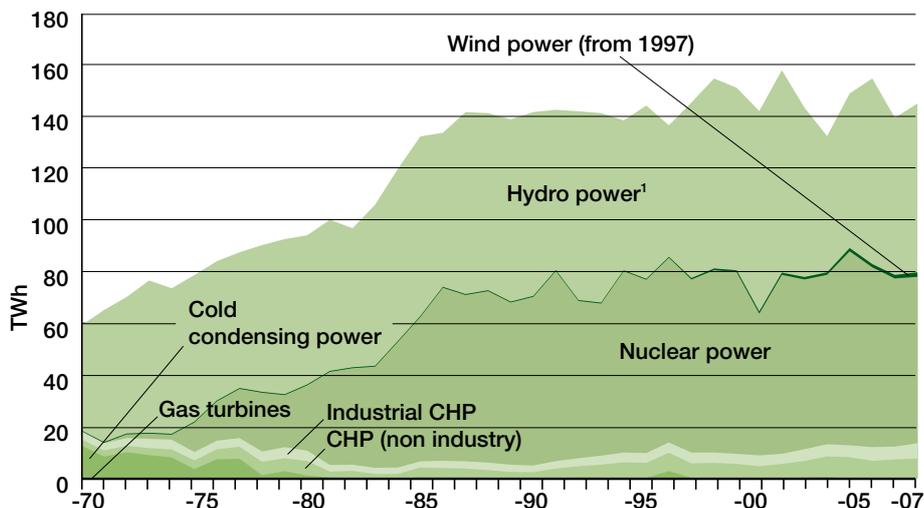
The country's nuclear power stations produced 64.3 TWh in 2007, which was 1 % less than in the previous year. Combustion based electricity production amounted to 13,6 TWh, with 65 % of the fuel input being in the form of biofuels, 19 % in the form of coal, 8 % of oil and 7 % of natural gas. In comparison with 2006, the proportions of biofuels, natural gas and coal have increased, while that of oil has decreased. Today, it is combined heat and power production (CHP) (at 7.3 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 during 2007 amounted to 1.4 TWh.

98 % of electricity production in Norway is based on hydro power. In Denmark, most electricity (72 %) is produced from thermal power, although the country also has a relatively high proportion of wind power (18 %). In Finland, non-nuclear thermal power supplies about 40 % of electricity, with a further 29 % being produced by nuclear power and 17 % by hydro power. Sweden belongs to the group of countries having the highest proportions of hydro power and nuclear power used for electricity production: in 2007, only Iceland, Norway, Canada, New Zealand, Austria and Switzerland produced a greater proportion of hydro power than did Sweden, and only France, Belgium and Slovakia had a higher proportion of nuclear power.

**Figure 23:**  
Electricity production  
in Sweden, by types  
of production plant,  
1970–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

1 INCLUDES WIND POWER  
UNTIL 1996.

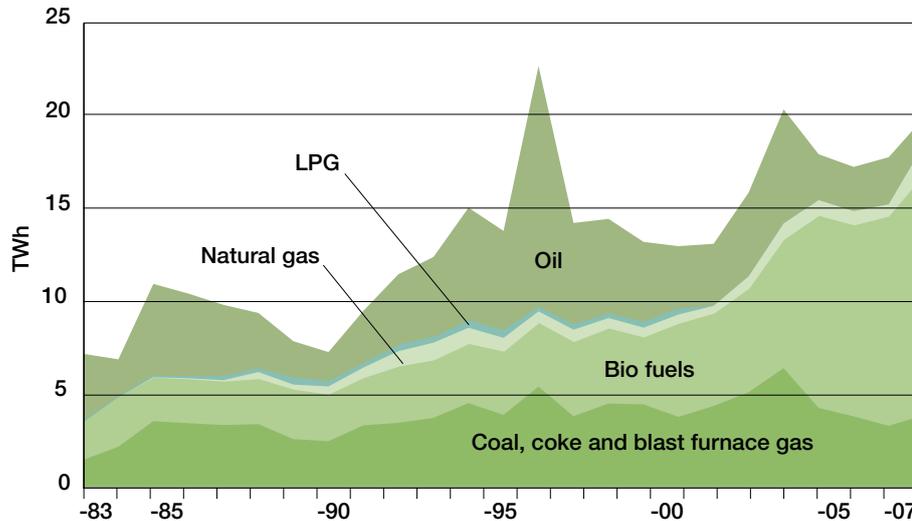


### Transmission of electricity and maintenance of system balance

Electricity cannot be stored in anything other than minute quantities, and so there must at all times be a balance between demand and production. To ensure this, there must be a party responsible for overall operation of the system. In Sweden, it is Svenska Kraftnät that is responsible for maintaining this balance: in addition, it is also responsible for operation of the country's bulk power transmission grid.

With effect from 1<sup>st</sup> January 2008, the Energy Market Inspectorate has been broken out of the Swedish Energy Agency, to become a public authority in its own right. The duties include surveillance and monitoring of the electricity market.

The electricity transmission and distribution network in Sweden is divided into three levels: the national grid, regional grids and local distribution networks. The national grid, which consists of 15 000 km of cables and overhead lines, is a high voltage transmission system, carrying electricity over long distances and to neighbouring countries. It is owned by Svenska Kraftnät. The regional grids, which consist of about 33 000 km of lower-voltage lines, are owned mostly by the three larger electricity utilities; Vattenfall AB, E.ON Sverige AB and Fortum Power and Heat AB. They carry electricity from the national grid to the local distribution networks and, in some cases, directly to larger electricity users. The local distribution networks, amounting to about 479 000 km of lines, are owned mainly by the large power companies and by local authorities. Security of supply over the various grids and networks has become increasingly important, in step with the growing dependence on electricity. Storm Gudrun, which struck southern Sweden in January 2005, destroyed over 30 000 km of



**Figure 24:**  
Fuel input for electricity production (excluding nuclear fuel), 1983–2007

SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

overhead lines, plunging thousands of businesses and well over half a million households into darkness. As a result, work on reinforcing local distribution networks has been further stepped up, with a change to buried cables as the main alternative. At present, about 54 % (285 000 km) of the total of 527 000 km of local networks are in the form of buried cables.

There are at present links between Sweden and Norway, Finland, Denmark, Germany and Poland. The Nordel organisation<sup>89</sup> has identified five areas where the grid needs to be reinforced in order to increase transmission capacity between the Nordic countries, and to relieve bottlenecks in the system. These areas are:

- The south-west link between central and southern Sweden
- The Great Belt connector in Denmark
- Fenno-Skan between Finland and Sweden
- Nea-Järpströmmen between Norway och Sweden
- The Skagerack connector between Denmark and Norway

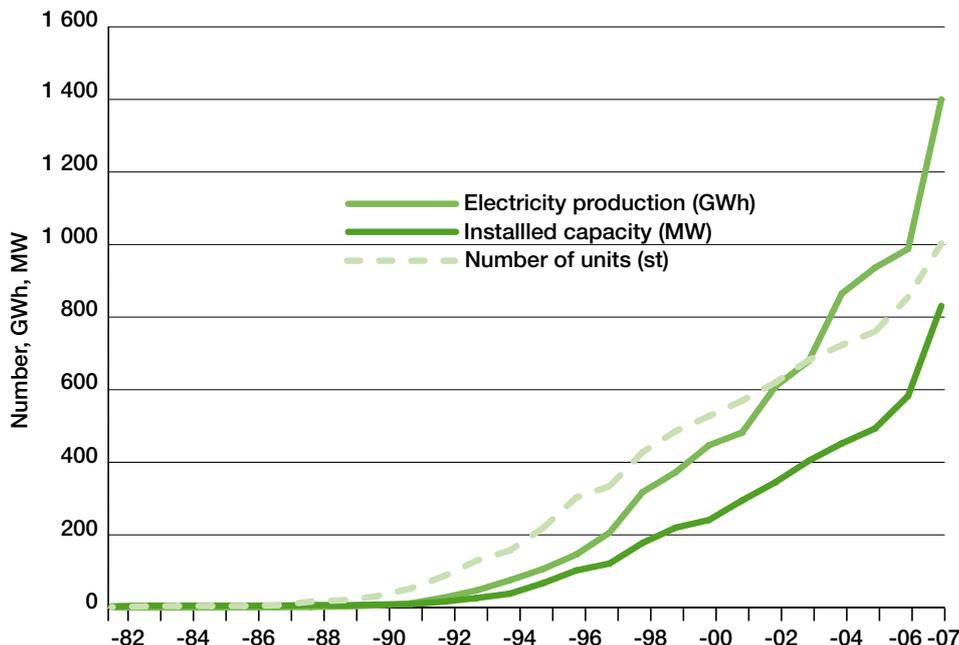
Fenno-Skan is a new DC cable, parallel to the existing cable, and doubling transmission capacity. The project has received all the necessary planning permissions, but the construction starting date has been postponed until 2011 due to difficulties in finding subcontractors to manufacture the cable. Nea-Järpströmmen is a new 400 kV line that should increase the capacity of the present 275 kV line by 45 %, and is planned for commissioning in 2009.

<sup>89</sup> Nordel is a pan-Nordic organisation for the national network operators in the Nordic and Scandinavian countries. In addition to Sweden's Svenska Kraftnät, it includes the Norwegian Statnett, the Finnish Fingrid, the Danish Energinet and Iceland's Landsnet.

**Figure 25:**

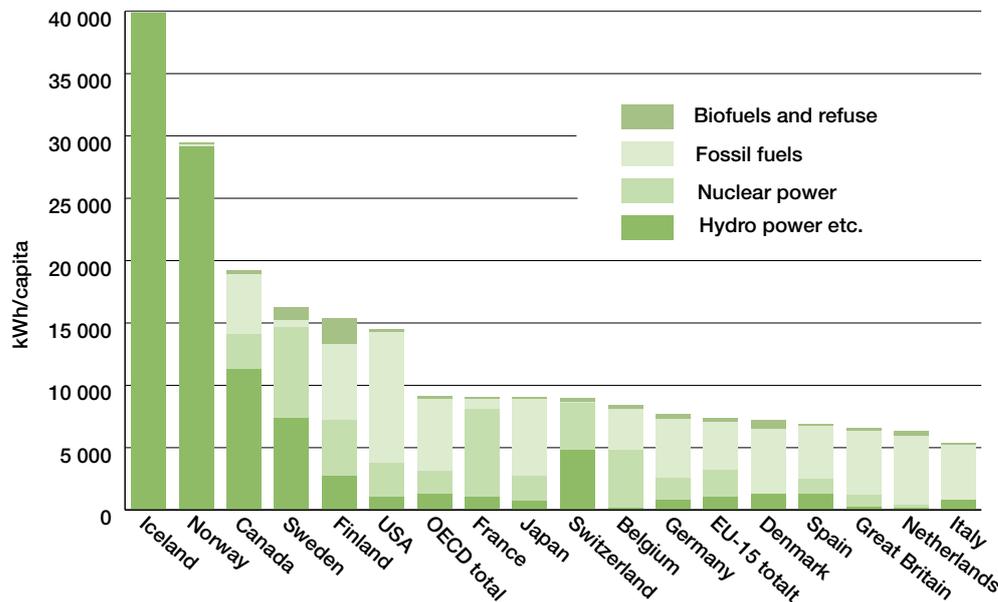
Wind power production, 1982–2007

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



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

At the end of 2007, Sweden's total installed capacity was 34 076 MW, made up of 16 209 MW of hydro power (47.6 %), 788 MW of wind power (2.3 %), 9074 MW of nuclear power (26.6 %), and 8 005 MW (23.5 %) of other thermal power. Maximum demand in 2007/8 occurred on 23rd January between 17.00 and 18.00, and amounted to about 24 500 MW. Sweden's own production at the time was 24 165 MW, and a net import of 335 MW made up the difference. This can be compared with Sweden's hitherto highest demand of 27 000 MW, which occurred in January 2001<sup>90</sup>. As a result of deregulation of the electricity market, electricity producers decommissioned a considerable amount of peak load capacity, as plants that were seldom used did not justify their costs. In 2003, legislation was therefore brought in to require a certain amount of reserve capacity. Svenska Kraftnät has been given temporary responsibility for negotiating a maximum reserve capacity of 2 000 MW. This has been done by Svenska Kraftnät entering into agreements with electricity producers and users to make additional production capacity (or reduction in demand) available. This arrangement applies until 15th March 2011, after which responsibility for maintaining system balance is expected to be transferred to the electricity sector.



**Figure 26:**  
Per-capita electricity production, by types of production, 2007

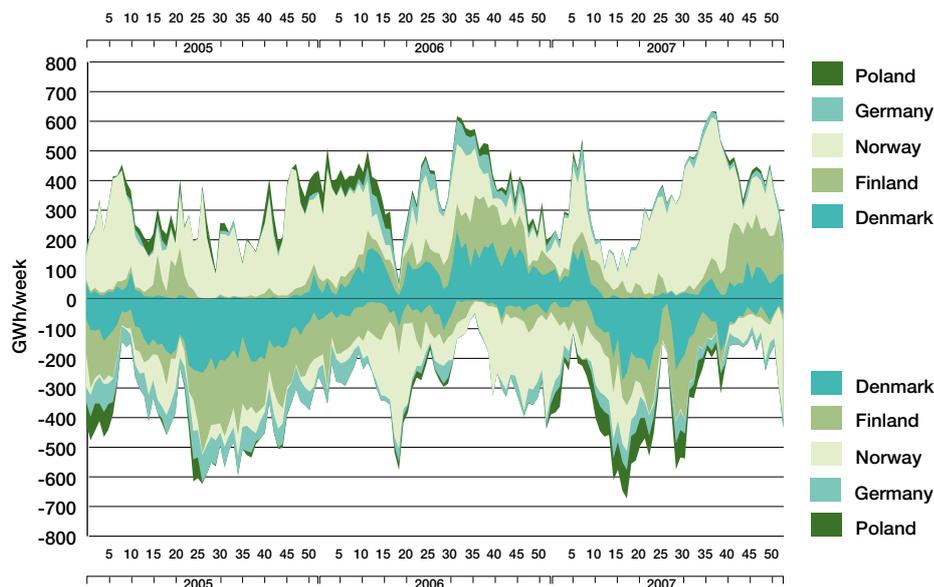
SOURCE: ELECTRICITY INFORMATION, 2008 IEA/OECD

### Electricity trading

Trading of bulk power supplies is vital in order to ensure a properly operating electricity market. Since deregulation, this has been provided by a joint Nordic electricity power exchange, Nord Pool, which facilitates the optimum economic use of Nordic power plants and offers transparency of pricing. It has two main markets: one for trading in physical electricity (the spot market), and one for trading in financial instruments (the forward market). In 2007, 74 % of the electricity used in the Nordic countries was traded on Nord Pool's physical market (Elsport), an increase from 63 % in 2006. The remaining electricity was traded internally between electrical utilities or via bilateral agreements outside Nord Pool. However, Nord Pool prices are used as references for the determination of prices in bilateral agreements. During the year, Nord Pool's financial market traded 1 060 TWh in 2007, partly as a means of ensuring prices and partly for speculative purposes. This was an increase of 294 TWh over 2006. 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. Nowadays, Swedish electricity certificates and EU emission allowances are also traded on the exchange, via power brokers and bilaterally.

**Figure 27:**  
Swedish electricity  
import (+) and export (-),  
January 2005–  
December 2007

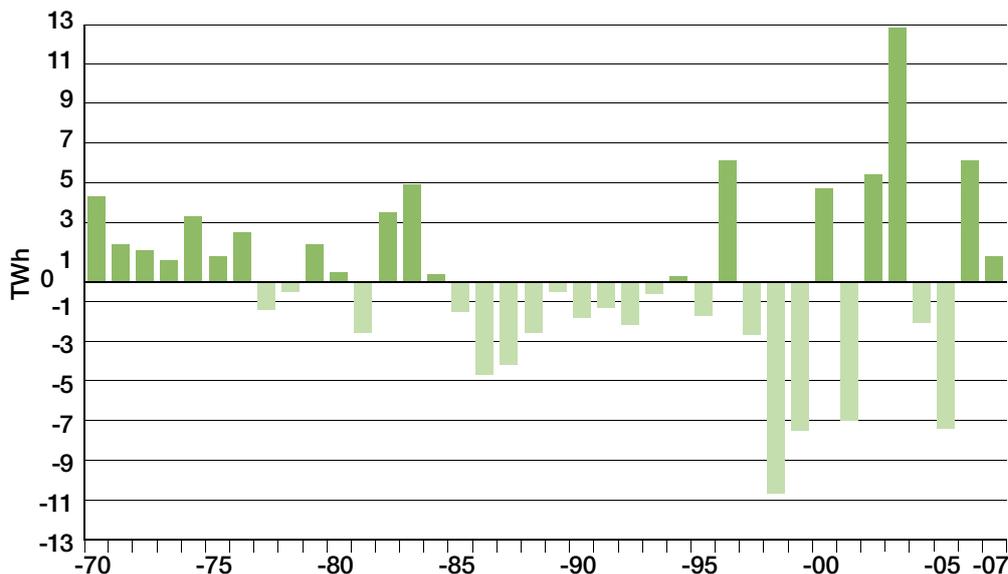
SOURCE: STATISTICS SWEDEN AND  
THE SWEDISH ENERGY AGENCY



In 2007, Sweden had a net import of 1.3 TWh of electricity, as against a net import of 6.1 TWh in 2006. This reduction was due mainly to increased hydro power production, while consumption was about the same as for 2006. Electricity trade flows between Sweden and its neighbours vary during the year and from year to year, depending on price differences between Nord Pool areas, which can arise due to differences in (for example) precipitation and reservoir fill percentages. In 2007, Sweden was a net importer of electricity, mainly from Norway. As a whole, the Nordic countries were net importers of 2.7 TWh in 2007, which can be compared with a net import of about 11.0 TWh in 2006.

### Electricity price development and makeup

The price of electricity on the electricity exchange is not the same as the final price that a domestic customer sees on his or her bill. The total price to the customer consists of the price of the electricity (including the price of electricity certificates), the network price (the network tariff plus the fixed charge), energy tax and value added tax and the network company's profit. Of these, it is the price of the electricity that is subject to competition. In January 2007, the total price of electricity for domestic consumers in detached houses without electric heating was made up of about 38 % for the electricity, 20 % for the network charge, and 43 % for energy tax and value added tax. The price



**Figure 28:**  
Sweden's net import (+) and net export (-) of electricity, 1970–2007

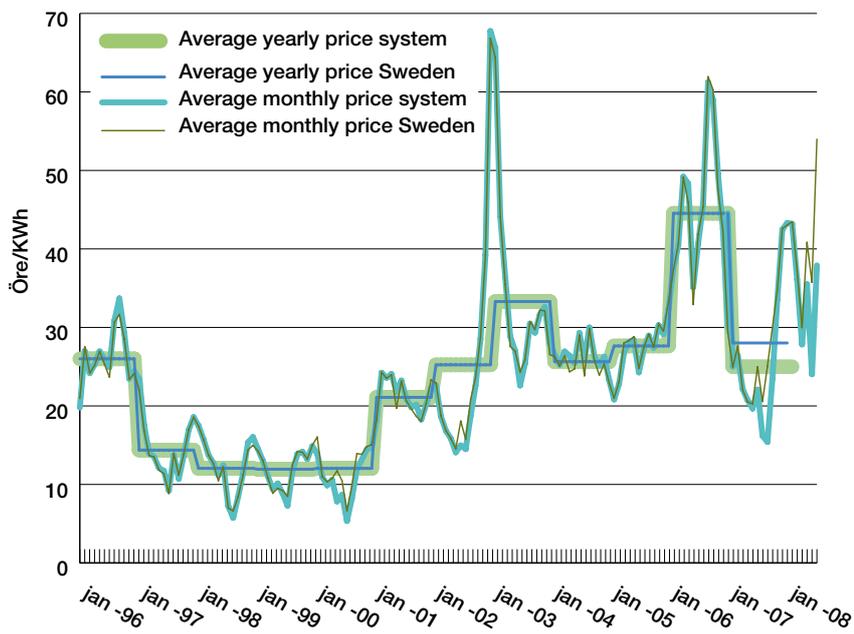
SOURCE: STATISTICS SWEDEN AND THE SWEDISH ENERGY AGENCY

of electricity may be open-ended period tariff, fixed for usually one or three years in advance, or variable. Other types of tariffs are also becoming common on the market. The most common is the open-ended tariff, taken by about 39 % of customers. The number of variable-rate tariffs is increasing, applying now to about 15 % of customers. Other tariffs, with a fixed rate for up to one year, as well as fixed-rate tariffs for three years or longer, each have about 20 % of customers. The network price depends on where in the country the electricity is used and on the nominal supply rating. The average price of certificates charged to customers by the electricity companies was 4.0 öre/kWh. Domestic customers pay either 17.8 öre/kWh or 27.0 öre/kWh energy tax, depending on whether they live in the north or the south of the country. Harmonisation of regulations with the EU Energy Taxation Directive has meant that the zero rate of tax on electricity used in industrial manufacturing processes has been replaced by a tax rate of 0.5 öre/kWh.

The spot price has varied widely since deregulation of the market in 1996, partly due to variations in precipitation from one year to another. The hitherto highest price occurred during the winter of 2002/2003, reaching a record spot price of 104.1 öre/kWh on Nord Pool. In 2007, the average spot price on the Swedish area of Nord Pool was 28.0 öre/kWh, as compared with 44.5 öre/kWh in 2006. This falling average price on the spot market in 2007 can be explained by the fact that water levels in the Nordic reservoirs were higher than in the previous year, resulting in higher production of rela-

**Figure 29:**  
Spot prices on Nord Pool. Monthly and annual average prices for the system and for Sweden, January 1996–June 2008

SOURCE: NORD POOL,  
FTP SERVER



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

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

NOTE: THESE ARE AVERAGE  
PRICES FROM THE NETWORK  
COMPANIES, AVAILABLE  
TO EACH CUSTOMER GROUP  
ON 1<sup>ST</sup> JANUARY OF THE  
RESPECTIVE YEARS.

	Small industry <sup>1</sup>	Det. house with electric heating <sup>2</sup>	Det. house, without electric heating <sup>3</sup>
1 January 2002	43,8	87,9	111,3
1 January 2003	59,9	111,4	135,4
1 January 2004	62,4	117,9	143,6
1 January 2005	55,2	109,9	135,9
1 January 2006	61,3	117,4	143,9
1 January 2007 <sup>4</sup>	82,1	144,4	171,3

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 THE ELECTRICITY  
CERTIFICATE PRICE.

tively cheap hydro power. As trade in electricity with countries outside the Nordic bloc has increased in recent years, the Nordic prices have become increasingly responsive to the prices of electricity in the rest of Europe. This was demonstrated in the autumn, when the price of electricity on Nord Pool rose substantially as result of rising prices of coal and gas. Electricity production in Germany and the rest of continental Europe is based largely on coal fired cold condensing power plant.

## District heating and district cooling

District heating has been used in Sweden since the end of the 1940s, 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. District heating systems are geographically much larger, and are more widely spread over the country, than district cooling systems, which are concentrated in the centres of urban areas.

### District heating

District heating can be defined in technical terms as the centralised production and supply of hot water, distributed through a piping system and used for the space heating of buildings. It is the commonest form of heating in apartment buildings and commercial premises, and the main form of heating in the centres of 247 of the country's 290 municipalities<sup>91</sup>. Local authorities began to look at district heating during the latter half of the 1940s, when it was seen as a good way of increasing electricity production in Sweden by providing a heat sink for combined heat and power (CHP) production. (A CHP power station produces both electricity and heat for the hot water distribution system.) Its use spread during the 1950s and 1960s as a result of the extensive investments in new housing that were being made during that period, in conjunction with a substantial need for modernisation or replacement of boilers in the country's existing building stock. Group heating systems<sup>92</sup> were gradually linked up to form larger systems, which were then in turn connected to district heating systems. There was a particularly substantial expansion of district heating over the period from 1975 to 1985, partly due to its ability to replace oil through its flexibility of fuel use. This was also the period of expansion of nuclear power generation, and the continued expansion of district heating resulted in it becoming a net user of electricity, in disconnectable boilers and large heat pumps, rather than a net producer of electricity, which is more common in most other countries with substantial district heating systems. However, in recent years, interest in CHP (now mainly biofuel-fired) has again revived in Swe-

91 The Nils Holgersson Survey, 2006. Formed by five large housing organisations, and monitors local authority charges for heating, domestic hot water, water, sewage treatment, electricity and waste disposal.

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

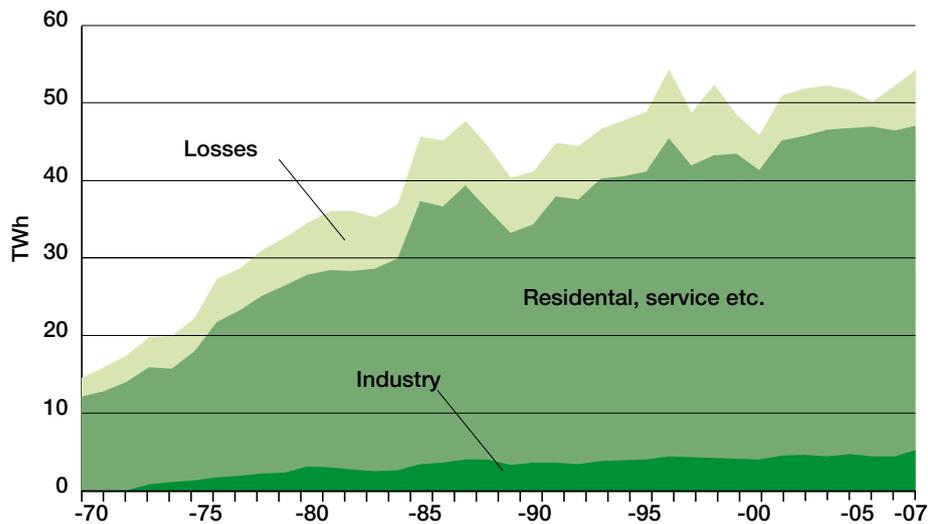
den, due to such factors as carbon dioxide taxation, changes in the taxation regime for CHP and the electricity trading certificate scheme. Figure 30 shows the growth in the use of district heating since 1970.

Energy policy has favoured district heating through various forms of state support, e.g. grants for the extension of existing district heating systems and the connection of group heating systems and even individual buildings to existing systems. Until 1<sup>st</sup> March 2007, a conversion grant was available for changing from oil heating to heating from district heating, rock, lake water or earth heat pumps, or biofuel-fired boilers. Grants are still available for conversion from direct electric heating to one of the above alternative systems. 21 % of the conversions from oil heating have been to district heating, while 69 % of those converting from electric heating have converted to district heating.

Replacing a multitude of small individual boilers by district heating has reduced emissions from heating of residential buildings and commercial premises. The urban environment has been improved as a result of the expansion of district heating and improved flue gas treatment, which have greatly reduced emissions of SO<sub>2</sub>, particulates, soot and NO<sub>x</sub>.

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

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



**Figure 30:**  
District heating use,  
1970–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

operating and business conditions as needed for the production of key indicator data. It does not, however, include any requirements in respect of tariff approvals.

The regular price comparisons by the Public Service Fee Group and the Energy Market Inspectorate's annual surveys<sup>93</sup> of the heating markets provide information on significant price differences between areas. Conditions for the construction of district heating systems vary from place to place, in respect of such aspects as the type of built environment and the type of ground conditions. A customer's choice of heating systems is very dependent on where the building is located.

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

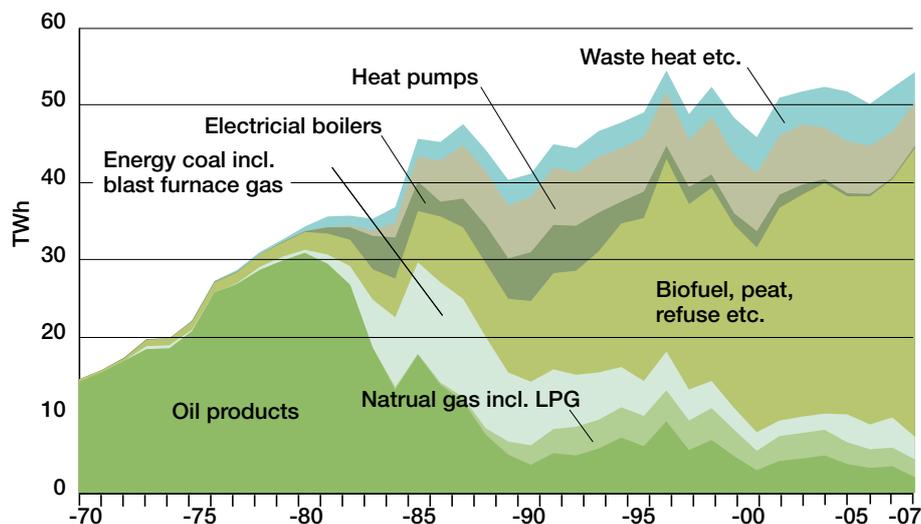
New legislation concerning guarantees of origin came into force on 1<sup>st</sup> July 2006. Under it, producers of electricity and district heating doing so in high efficiency CHP plants<sup>94</sup>, or from renewable energy sources, can obtain a Guarantee of Origin from Svenska Kraftnät. The idea is that this guarantee can be used in marketing. At the same time, the requirement for a concession for constructing district heating distribution mains is removed. This, in combination with changed taxation of CHP production, will help to open up the market for district heating production.

93 Heating in Sweden.

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

**Figure 31:**  
Energy input to district  
heating systems,  
1970–2007

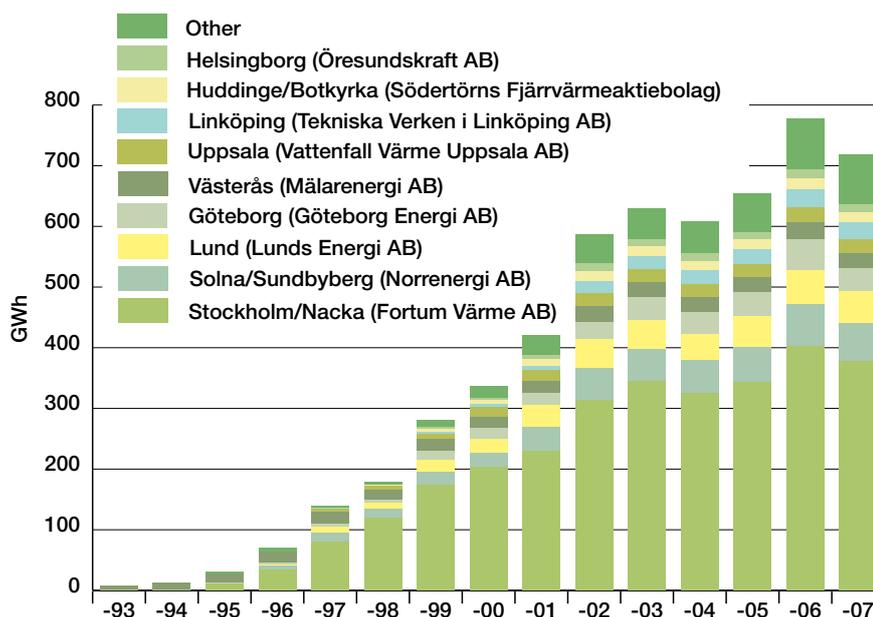
SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY



Today, district heating supplies about half of the total heating requirement of residential and commercial premises in Sweden. It is the commonest form of heating in apartment buildings, supplying heat to about 76 % of the heated floor area, while about 59 % of commercial and similar premises are heated by it. In detached houses, on the other hand, the proportion is only about 10 %.

Over 47 TWh of district heating were supplied in 2007, which is a slight increase on 2006. Of the total quantity, about 60 % were for residential heating (apartment buildings and detached houses), about 30 % for commercial premises and 10 % for industry. Some industries have sold their own heat production facilities to district heating utilities, and then buy the heat back from the utility as 'packaged heat'. This then appears in the statistics as district heating, despite the fact that it is actually district heating without distribution pipes. The effect is upwardly to distort the preliminary statistics for industrial use of district heating. Corresponding decreases can be found in industry's use of biofuels.

One of district heating's advantages is its flexibility in respect of choice of fuel. In 1980, 90 % of the fuel input for district heating plants was in the form of oil. Nowadays, the fuel mix is more varied, with renewables - particularly biofuels - being the



**Figur 32:**  
District cooling supplied, 1993–2007

SOURCE: SWEDISH DISTRICT HEATING ASSOCIATION

main energy source. Total energy supply to the district heating sector in 2007 was over 54 TWh. Figure 31 shows how the proportion of biofuels has increased steadily since the 1970s, when it was about 2 %, reaching 69 % in 2007. In 1990, biofuels supplied somewhat over 25 % of the total energy input: since then, the rate of increase has further accelerated. The introduction of carbon dioxide tax in 1991 has given biofuels a favoured position. See Section 5.6, 'Biofuels, peat and waste', for a more detailed description of the use of biofuels in district heating. Biofuels consist largely of forms of wood fuel. Waste has become a steadily more important fuel for district heating production: the substantial growth in its use over the last few years can be credited partly to low costs for waste and to the policy measures<sup>95</sup> introduced to reduce disposal of waste in landfill.

The use of electricity in the district heating sector, particularly for supplies to electric boilers, and also for large heat pumps<sup>96</sup>, has declined since deregulation of the electricity market. Since the 1980s, losses from district heating distribution systems have fallen as a result of improved technology and higher load factors. In 2007 distribution and conversion losses amounted to about 13 % of the total district heating input, as against a value of getting on for 20 % in 1980. However, some of this

95 Landfill disposal of unsorted combustible waste was banned in 2002, followed by a ban on organic waste in 2005.

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

reduction can be explained by an increasing proportion of ‘heat buyback’ which is not distributed via true district heating distribution systems.

Until the beginning of the 1980s, most district heating plants were operated as local authority services. Since then, the majority have been converted to local authority owned companies. In 2007, the number of district heating operations run directly by local authorities was eleven, as compared with over 200 registered district heating companies. Today, 130 companies supply 98 % of the country’s district heating production. Since deregulation of the electricity market, there has been a concentration of ownership in the sector as the larger energy companies have bought up local authority energy companies, including their district heating activities.

### **District cooling**

District cooling is used mainly in offices and commercial premises, as well as for cooling various industrial processes. Its principle is similar to that of district heating: cooled water is produced in a large central plant and distributed through pipes to customers. The statistics provide data only for commercial district cooling, i.e. with the supplier and property-owner being different companies. It is primarily district heating suppliers that have established commercial district cooling systems in Sweden. The commonest means of production in Sweden is to use waste heat or lake water as the heat source for heat pumps, with the cooled water from which heat has been abstracted then providing the district cooling water, while the heated output water from the heat pumps is sometimes used for district heating. Another common method of production is simply to use cold bottom water from the sea or a lake, i.e. free cooling. A further alternative is to install absorption refrigerant plant, powered by district heating, in or near a customer’s premises, which therefore increases the load factor of the district heating system in the summer. Since 1995, one of Europe’s largest district cooling systems is that of central Stockholm. The market for district cooling has expanded strongly since the first system was started up in Västerås in 1992. Figure 32 shows district cooling supplies in Sweden, by supplier. The driving forces for expansion include such factors as higher internal heat loads in offices and shops, greater awareness of the importance of good working conditions and the phase-out of ozone-destroying refrigerants. This latter factor has meant that property-owners have been forced to convert existing equipment or invest in replacement systems. In 2007, there were 28 commercial district cooling suppliers, some operating more than one system. 720 GWh of district cooling were supplied, which is a decrease of 8 % relative to 2006.

## The energy gases market

Sweden uses a relatively small quantity of energy gases<sup>97</sup> in comparison with many other European countries. However, the distribution network for natural gas in Sweden is being extended. The rest of Europe is covered by an extensive natural gas distribution network. The use of natural gas in Europe has increased by 20 % since the beginning of the 1990s.

### Natural gas in Sweden

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

Natural gas 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 2007, imports amounted to 954 million m<sup>3</sup>, equivalent to 10.5 TWh. Industry accounts for over 70 % of total use, with the residential sector accounting for about 26 %. A small amount of natural gas is also used as motor fuel. Total use of natural gas in 2007 amounted to 7.4 TWh in these user sectors, with about a further 3.6 TWh being used by CHP and district heating plants.

Natural gas is distributed at present to about 30 municipalities, where it meets about 20 % of energy demand. On the national level, it supplies 1.7 % of total energy demand. The network extends from Trelleborg in the south to Gothenburg, with a number of branches, such as to Gnosjö in Småland and Stenungssund, north of Gothenburg. The trunk mains between Malmö and Gothenburg have capacity for the transportation of over 20 TWh of gas per year, but with compressors this capacity could be increased to about 30 TWh/year. The system has only one storage facility, *Skallen*, in Halland, with capacity for the storage of over 1 TWh of natural gas.

There are a number of plans for expanding the natural gas network. Three separate concession applications have been submitted for extension of the existing main from Gislaved/Gnosjö to Oxelösund (on the east coast) via Jönköping and Boxholm. The concession for the section from Gislaved/Gnosjö to Jönköping has been approved by the Energy Markets Inspectorate, and the details are now being prepared for a deci-



On the national level, natural gas supplies 1.7 % of total energy demand.

<sup>97</sup> Energy gases are natural gas, LPG, biogas, town gas and hydrogen.

sion by the Cabinet Office. There are also plans for additional supplies to the Swedish natural gas network. One such is the *Skanded* project, which involves laying a pipeline between the North Sea and southern Norway, and continuing the pipeline to the Swedish network at Stenungssund, Varberg and Lysekil. A number of Danish parties expressed interest in the project in 2007, and are now planning further extension of the pipeline to Denmark.

Since 2005, Svenska Kraftnät (a State utility) has system responsibility for the national market for natural gas. This means that it has overall responsibility for short term maintenance of the balance between supply and use of natural gas to the national system. However, responsibility for the system does not include its operation: responsibility for operation, maintenance and expansion of the mains rests with the owners of the respective sections.

### **International production and use of natural gas**

Although natural gas is a marginal energy source in Sweden, it provides almost 25 % of energy supplies in the EU states and in the world as a whole. The world's natural gas reserves are substantial: at the end of 2007, commercially viable reserves amounted to almost  $177\,000 \times 10^9 \text{ m}^3$  (*thousand million*), which would last for about 60 years at the present rate of use, with present technologies and present prices. Most of the reserves are to be found in the former Soviet Republics (30 %) and in the Middle East (41 %). Only a little over 1.5 % of the world's natural gas reserves lie within the EU states: at the present rate of use, this would last for only 14 years. Over the last decade, natural gas supplies to the EU states have been increasingly based on production from the North Sea and imports from Russia and Algeria. In order to increase the security of supply, there is European interest in increasing the number of links between the Russian and the Norwegian natural gas fields and the continent. Today, the world's major producing countries are Russia, the USA and Canada. Within the EU, the major producers are the UK and Holland. The proportion of total global energy supply met by natural gas has increased rapidly during the last decade, by about 43 % between 1992 and 2007. Consumption of natural gas is highest in the USA and Russia. Within the EU, natural gas has a part to play in reducing environmentally hazardous emissions, primarily by replacing coal and oil.

### **Transport of natural gas**

Pipeline transportation of natural gas is the main way of transporting natural gas between producers and consumers. The physical transport system can be approximately divided up into transmission and distribution. Transmission pipes carry the gas over long distances under high pressure: the quantities of energy represented by the gas can be very significant. At the reception points, the pressure is reduced in mete-



**Figure 33:**  
End use of natural gas  
in Sweden, 1985–2007,  
by sectors, GWh

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

ring and pressure regulation stations, before the gas is supplied to local distribution networks for delivery to the end users. Several Asiatic countries, particularly Japan and South Korea, are far from their sources of supply, and so gas is delivered to them by ship in liquid form, having been liquefied by extreme cooling. Liquefied natural gas (LNG) has historically been unable to compete to any greater extent with pipe borne natural gas, due to its high cost. However, recent reductions in the cost both of production and transport have partly changed this situation.

### Deregulation of the natural gas markets

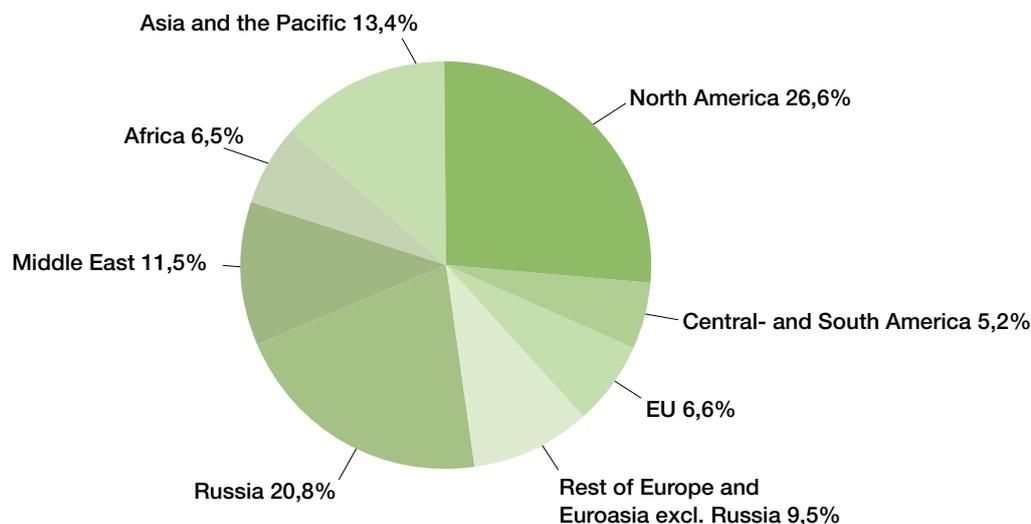
The Swedish natural gas market has gone from being a local monopoly to a competitive market. The final stage of market deregulation was taken on 1<sup>st</sup> July 2007, and means that all natural gas customers in Sweden can now choose their supplier. Most of the natural gas markets in the EU were deregulated at the same time.

The path to this stage has been long, starting in February 1998 with adoption of the Natural Gas Directive, the purpose of which is to increase competition on the European natural gas markets. The Directive was adopted in Swedish legislation on 1<sup>st</sup> August 2000, in the form of a new Natural Gas Act. This was followed in June 2003 by the publication of a new Natural Gas Directive (2003/55/EC), with the purpose of accelerating deregulation of the natural gas markets.

The new Directive required considerable changes to Swedish legislation, as a result of which a new Natural Gas Act came into force on 1<sup>st</sup> July 2005. One of its require-

**Figure 34:**  
World natural gas  
production in 2007,  
total: 2 920 thousand  
million m<sup>3</sup>

SOURCE: STATISTICAL REVIEW OF  
WORLD ENERGY 2008



ments is that the two activities, of transporting gas and of selling it, must be performed by legally separate entities in Sweden (unbundling).

The underlying purpose of deregulation of the natural gas markets around the world has been to create the right conditions for effective utilisation of resources, and thus keep down gas prices. Several structural regulatory changes have been introduced in order to ensure smoother operation of the markets. Some of the most important of these are unbundling and third party access. Unbundling involves separation of transport and sales of the gas, and can operate at various levels. Its purpose 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. The UK provides an example of a country with third party access to both its transmission network and its distribution networks: in practice, if third-party access is to work properly, it must also be accompanied by unbundling.

### Other energy gases

**LPG** is a petroleum product, consisting of the hydrocarbons propane, propene and butane, or mixtures thereof. Its environmental characteristics are very similar to those of natural gas. It is used mainly in industry, as well as in the restaurant trade and in horticulture. As LPG and oil and also, to some extent, biofuels are interchangeable fuels in these applications, the use of LPG is sensitive to changes in energy taxation or fuel prices. In 2006, 4.7 TWh of LPG were used in industry, 1.2 TWh in the residential and service sector and almost 0.1 TWh for electricity and district heating production.

**Biogas** consists mainly of methane, formed by the breakdown of organic materials such as sewage sludge, domestic waste or industrial waste under anaerobic (oxygen free) conditions. The process, known as digestion, occurs spontaneously in nature, e.g. in marshes. 223 biogas production plants were in operation in 2006<sup>98</sup>, most of them in sewage treatment plants, producing gas from the sludge, and from landfill sites, producing landfill gas. After cleaning, and having its methane concentration increased, biogas can then be used for electricity and heat production, or for transport. In 2006, 42 GWh were used for electricity production, and 287 GWh for heat production. Biogas was also used in the transport sector. Biogas can also be cleaned and distributed via the natural gas network as 'green natural gas'.

**Town gas** (gasworks gas) is produced by cracking naphtha. Fortum Värme AB in Stockholm is the only producer of such gas in the country: the town gas used in Malmö and Gothenburg nowadays consists of natural gas mixed with a small proportion of air. Stockholm, too, is planning to change from naphtha-based gas to natural gas-based town gas. It is used for heating detached houses, larger properties and industries, as well as for cooking in homes and restaurants. 0.35 TWh of town gas were used in 2007.

## The oil market

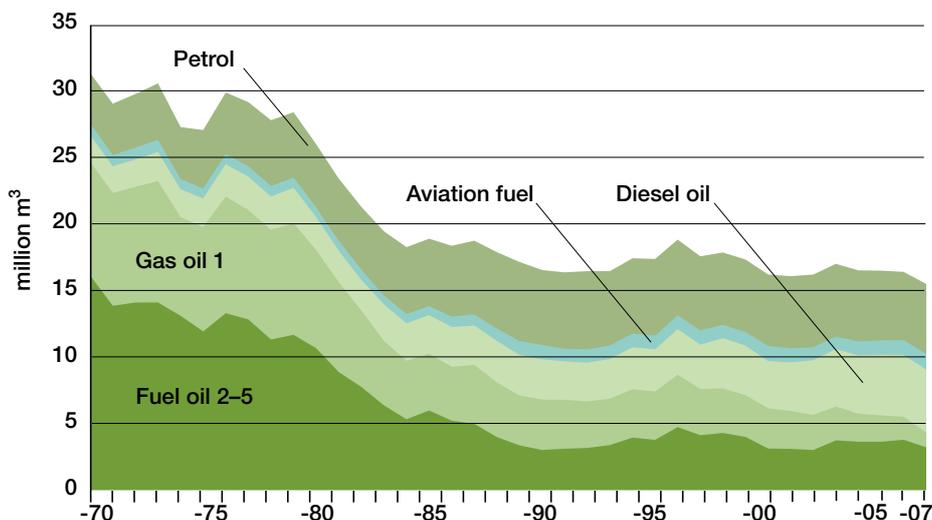
### Oil in Sweden

In 2007, oil provided 32 % of Sweden's energy supply. On the user side, it is the transport sector (including bunkering supplies for international maritime transport) that is most dependent on oil, using over twice as much oil as do the industry and residential/service sectors together. The use of oil in the Swedish energy system has been reduced by almost 51 % since 1970. It is particularly the use of fuel oils that has been reduced (and especially in the detached house sector), as can be seen in Figure 35. Another important change since before the oil crises is the fact that Sweden nowadays exports, rather than imports, refined oil products. Prices of refined products rose steeply

98 Read more in the Agency's report 'Production and Use of Biogas, 2006', ER, 2008:2. The report can be downloaded from [www.energimyndigheten.se](http://www.energimyndigheten.se).

**Figure 35:**  
Use of oil products  
in Sweden, including  
foreign maritime traffic,  
1970–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

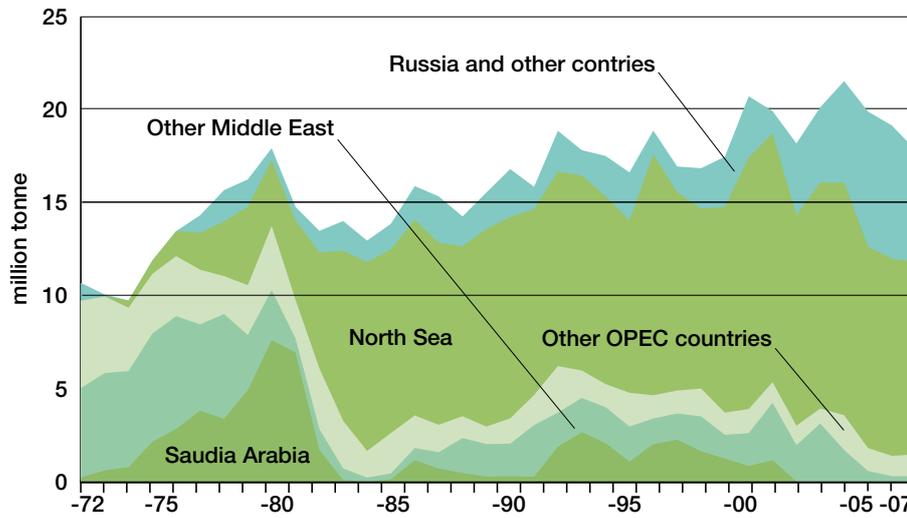


during the 1970s oil crises, and so an increase in refinery capacity was an important means of helping to protect the Swedish economy against excessive price rises.

In 2007, Sweden imported almost 17.8 million tonnes of crude oil, and net-exported almost 3.7 million tonnes of refinery products. Over 59 % of Sweden's total crude oil imports come from the North Sea - primarily from Denmark and Norway. In recent years, there has been a substantial increase in the proportion of Sweden's oil imported from Russia. Overall, 33 % comes from Russia, 28 % comes from Denmark, 27 % from Norway, 6.6 % from Venezuela, 3.7 % from the UK, 1.6 % from Iran, and 0.5 % from Holland. This substantial importation of oil is due to the fact that much of the oil is processed in Sweden before re export<sup>99</sup>.

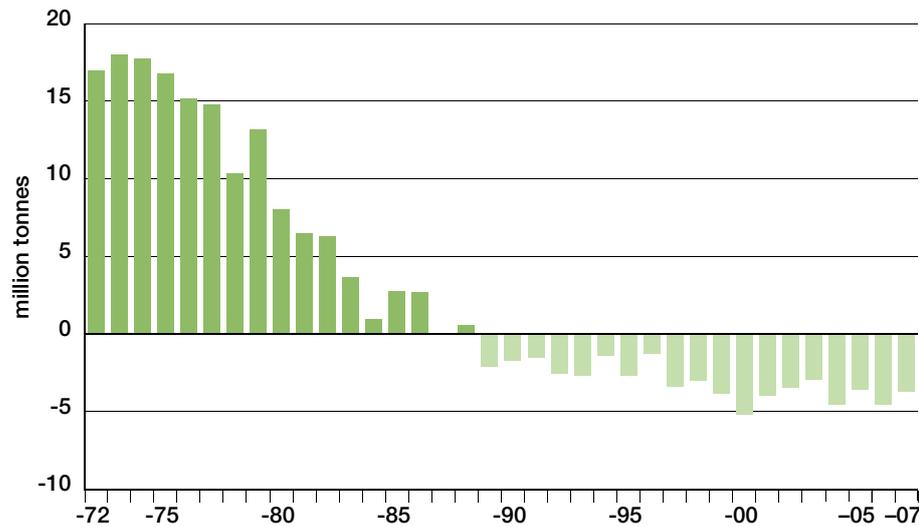
Strategic stocks of oil products are held in order to reduce the country's vulnerability to the effects of conflicts affecting the oil market. Problems in the supply of oil are tackled primarily through the agreements that have been signed with the International Energy Agency (IEA) and the EU. The size of the strategic oil stocks required for peacetime crises is set annually by the Government. The Swedish Energy Agency is the surveillance authority for this, deciding who is required to maintain such stocks and how large they are to be. Current EU directives prescribe that stocks of crude oil and oil products must not be less than 90 days. Sweden's average storage levels are about 120 days. A new EU directive is expected in the autumn of 2008, replacing the present directive.

<sup>99</sup> Further facts and statistics from the oil sector can be found in *Oljeåret 2007*, ([www.spi.se](http://www.spi.se)) and elsewhere.



**Figure 36:**  
Swedish net imports  
of crude oil and oil  
products, by country  
of origin, 1972–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

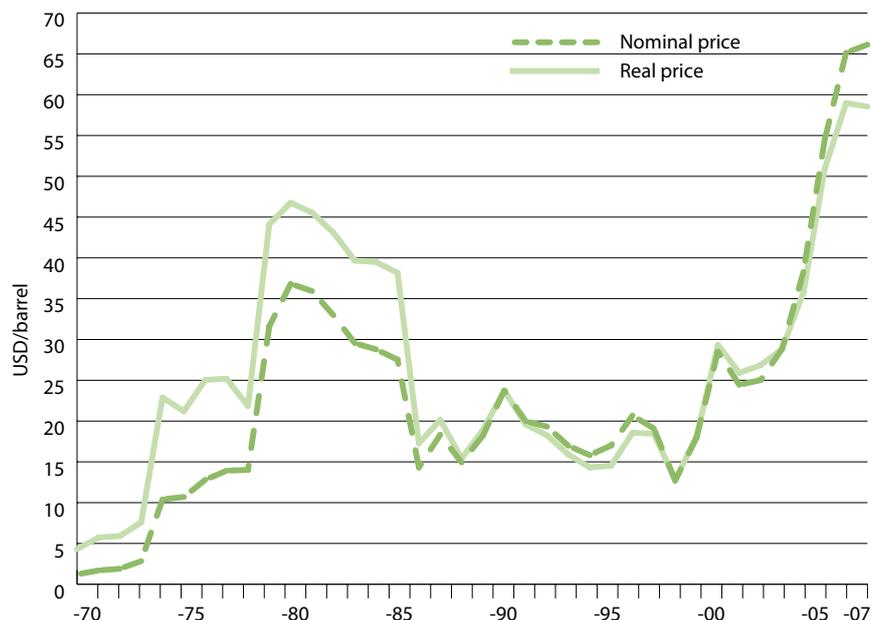


**Figure 37:**  
Net imports (+) and  
exports (-) of refinery  
products, 1972–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

**Figure 38:**  
Actual and real prices  
of light crude,  
1970–2007, USD/barrel

SOURCE: WWW.BP.COM AND THE  
WORLD BANK



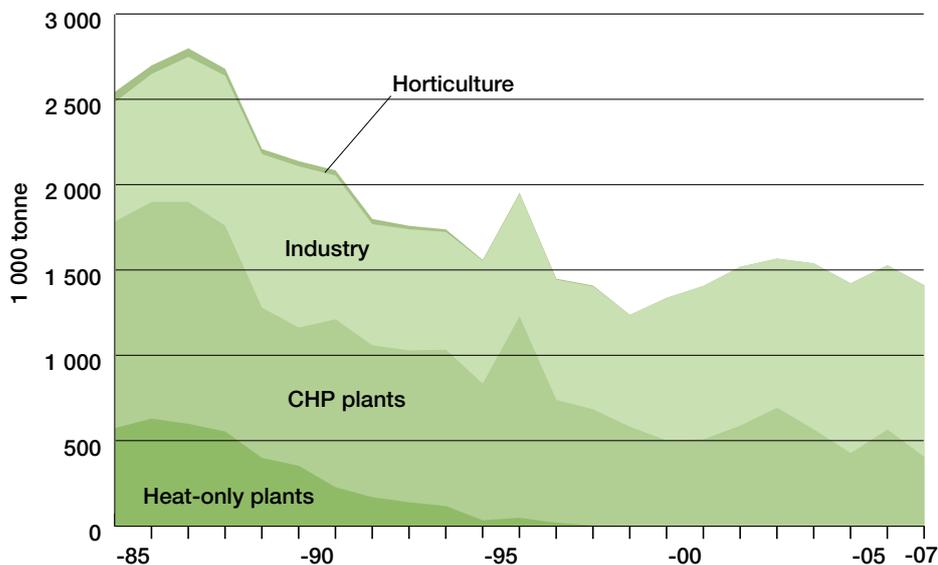
## The coal market

Carbon is one of the elements, and occurs in nature in the form of combinations in various minerals. Some of these minerals can be burned, and are referred to in everyday language as coal. By tradition, coal is divided into hard coal and brown coal, depending on its calorific value. This division is not particularly precise, as no two coalfields produce coal with exactly the same properties. They can differ in respect of properties such as ash content, moisture content, the proportion of flammable constituents (calorific value), volatile elements, sulphur content etc. Quality differences between coals vary on a continuous scale. Hard coal is a relatively high value coal, while brown coal has a lower energy content and 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.

Coal supplies a quarter of the world's primary energy, and is the next largest energy source after oil. It is also the largest source of carbon dioxide emissions, having overtaken oil in this respect as recently as 2004<sup>100</sup>. World production and use of coal have increased considerably in recent years<sup>101</sup>. The largest producers of hard coal are China and the USA, which together account for 63 % of world production. The major

100 IEA, World Energy Outlook 2007 and Coal Information 2007.

101 IEA, Coal Information 2007.



**Figure 39:**  
Use of energy coal in  
Sweden, 1985–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

exporting countries are Australia, Indonesia and Russia, while China, the USA and India are the countries that use the most coal. Coal production in Europe is falling, and imports exceed production. Between 1991 and 2002, the spot price of coal in north western Europe varied between USD 26 per tonne<sup>102</sup> and USD 46 per tonne. The price started to rise steeply in the middle of 2003, reaching USD 78 per tonne in July 2004, which is a record. In November 2005, the price had fallen to USD 52 per tonne, but has followed a rising trend since then. Prices during the first half of 2007 had again risen to USD 68–78 per tonne, but have since then almost doubled, reaching a record of USD 145 per tonne in February 2008<sup>103</sup>. If production and consumption continue at the present rate, proven and economically recoverable world reserves would last for about 150 years<sup>104</sup>.

### Sweden's use of coal

Coal played an important part in Sweden's energy supply up to the 1950s, when it lost ground to the cheaper and more easily handled oil. The oil crises of the 1970s meant that coal again became an interesting alternative fuel for reasons of price and security of supply. During the 1990s, the increasingly stringent environmental standards imposed on coal firing, together with rising taxation, meant that the use of coal for heat production stagnated. A total of 3.4 million tonnes of hard coal was used in Sweden in 2007 – about the same as in the previous year. 2.0 million tonnes of this were coking

102 Coal with a standardised calorific value of 6000 kcal/kg, delivered CIF.

103 PLATTS, ICR Coal Statistics Monthly.

104 IEA, Coal information 2007.

coal, leaving 1.4 million tonnes for energy purposes (including use as injection coal in blast furnaces). To this must be added a net import of 0.2 million tonnes of coke.

### **Use of coal in industry**

Industry uses energy coal, metallurgical coal, coke and smaller quantities of other coal products such as graphite and pitch. Coke is essentially pure carbon, produced from metallurgical coal in coking plants. The country's two coking plants, at steelworks in Luleå and Oxelösund, also produce coke oven gas as a result of the process. The gas is used for heat and electricity production in the steelworks, and for district heating production. The coke is used in the iron and steel industry for reduction of iron ore in the blast furnaces, and also provides an energy input to the process. Some of the energy content of the coke is converted to blast furnace gas, which is used in the same way as the coke oven gas. In addition to metallurgical coal and coke, ordinary energy coal is also used in industry. 2.0 million tonnes of coking coal were used in industry in 2007, together with 1.0 million tonnes of energy coal (including injection coal for blast furnaces) and the country's entire net import of 0,2 million tonnes of coke. The quantity of energy coal provided an energy input of 7.6 TWh.

### **District heating and combined heat and power production**

The use of coal for district heating fell considerably during the 1990s, when the carbon dioxide and sulphur taxes were introduced. Plants that supply only heat have abandoned coal almost entirely as a fuel due to the high taxes, replacing it by biofuels. CHP plants still use a certain amount of coal, as taxation on a combined production regime is less than on heat alone. The heat production fraction in a CHP plant is exempted from energy tax, carbon dioxide tax is reduced by 19–79 %<sup>105</sup>, while the electricity production is entirely tax-free. This tax structure is intended to promote the competitiveness of CHP plants against that of plants producing only heat or electricity.

SSAB's steel mill in Luleå supplies coke and gas to the town's CHP plant for the production of heat and electricity, while its mill in Oxelösund supplies heat from its coke oven gas and blast furnace gas to the town's district heating system.

In 2007, the district heating sector used 0.4 million tonnes of energy coal (3.1 TWh) and 2.6 TWh of coke oven and blast furnace gas for electricity and heat production.

105 Provided that the electrical efficiency is at least 5 %. A deduction of 79 % of the carbon dioxide tax is allowed if the electrical efficiency is 15 % or higher.

## Biofuels, peat and waste

The proportion of biofuels used in the Swedish energy system has steadily increased, from a little over 10 % of total energy supply in the 1980s to 19 % in 2007. Most of the biofuels, peat and waste used in the Swedish energy system are indigenous, consisting mainly of:

- wood fuels, unprocessed (bark, chips, return timber, felling waste and energy forests and plantations), and processed (briquettes and pellets),
- black liquors and tall oil (intermediate and by-products in chemical pulp mills),
- cereals, energy grasses 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 E92 motor fuels),
- FAME, an umbrella name for fatty acid methyl esters, of which RME (rapeseed methyl ester) is the most common,
- Biogas.

Biofuels are used mainly in the forest products industry, in district heating plants, for electricity production and for heating of residential buildings. See Section *Development of alternative motor fuels* for details of the use of biofuels in the transport sector. Most of the increase in the use of bioenergy has occurred in industry and for district heating, although use has also increased in the residential and transport sectors. In 2007, the total use of biofuels, peat and waste amounted to 120 TWh<sup>106</sup>. Industry used almost 55 TWh<sup>107</sup>, the residential and service sector used almost 14 TWh, and the transport sector used 2 TWh. About 37 TWh were used for district heating production, and over 12 TWh for electricity production.

106 Statistics for 2007 are preliminary and should therefore be treated with considerable care. See 'Uncertainties in statistics for 2007'.

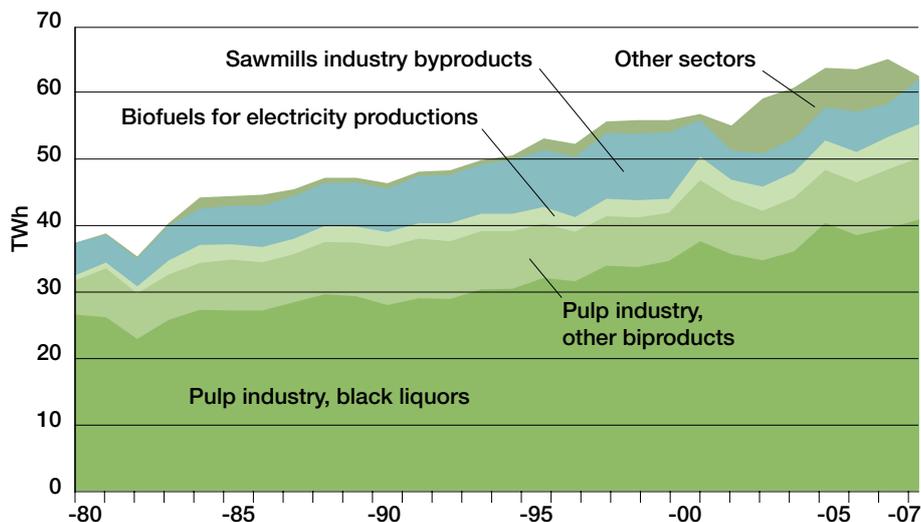
107 Fuel used for electricity and heat production in industry is not included in this figure, but included in electricity and heat statistics.

**Figure 40:**

Use of biofuels,  
peat etc. in industry,  
1980–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

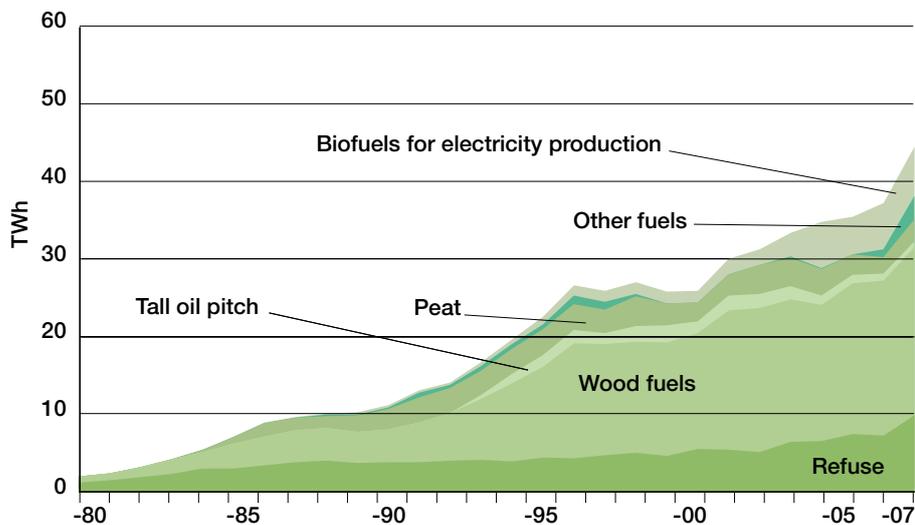
NOTE. THE STATISTICS FOR 2007  
ARE PRELIMINARY AND SHOULD  
BE TREATED WITH CONSIDER-  
ABLE CARE: SEE "UNCERTAINTIES  
OF STATISTICS FOR 2007".



### The forest products industry

The forest industry creates a large quantity of by products and waste products. Most of the quantity of wood fuels used in the energy sector come from forestry in the form of felling 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 (bark and sawdust). Some of these by-products (such as sawdust) are converted to pellets, briquettes and powder in order to improve their energy density, simplify handling and reduce the cost of transport.

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 wood fuels in the form of solid by-products such as sawdust and bark in their processes. As part of the overall process of producing chemical wood pulp for paper-making, pulp mills recover chemicals used in the process by burning the liquors extracted from the process, known as black liquors, and containing the digester chemicals, lignin and other substances extracted from the wood. Raw tall oil is a by product of recovery of the digester chemicals. It is separated by refining into tall oil and tall pitch (oil). Raw tall oil and refined tall oil can be used as fuels, but are taxed as other fuel oils and are therefore used primarily as industrial raw materials. Tall pitch (oil) is treated as an untaxed biofuel, and is therefore being increasingly used as a fuel. Energy from the use of black liquors as fuel is used internally within the pulp industry: in 2006, it amounted to 40 TWh, excluding electricity production.



**Figure 41:**  
Use of biofuels, peat  
etc. in district heating  
plants, 1980–2007

SOURCE: STATISTICS SWEDEN  
AND THE SWEDISH ENERGY  
AGENCY

NOTE. THE STATISTICS FOR 2007  
ARE PRELIMINARY AND SHOULD  
BE TREATED WITH CONSIDER-  
ABLE CARE: SEE "UNCERTAINTIES  
OF STATISTICS FOR 2007".

In 2007, the pulp and paper industry used almost 9 TWh of wood fuels, while sawmills and other woodworking industries used about 5 TWh of wood fuels. The pulp and paper industry's total use of biofuels, peat etc amounted to almost 49 TWh in 2007, equivalent to about 41 % the total use of these fuels in the energy system as a whole. In total, the forest products industry used nearly 61 TWh of various types of biofuels, peat etc. for heat and electricity production in 2007.

### District heating plants

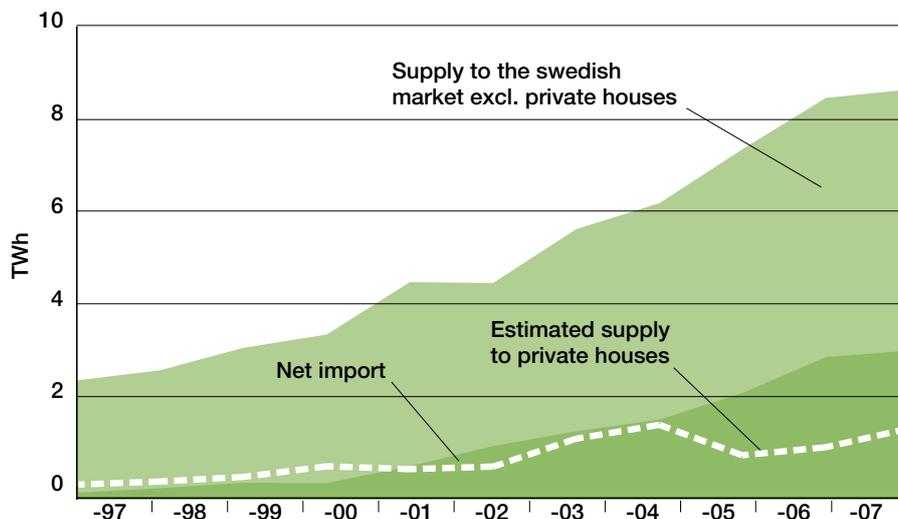
37 TWh of biofuels, peat etc. were used for heat production (i.e. excluding electricity production) in district heating plants in 2007. Of this, wood fuels accounted for 21 TWh, waste for almost 10 TWh, black liquors and tall oil pitch for about 1 TWh, and peat for 3 TWh. The use of wood fuels by the district heating sector has increased by more than fivefold since 1990, as shown in Figure 40. The main form of these fuels is felling residues and solid by-products from the forest products industry, although processed fuels such as briquettes and pellets are also being increasingly used.

Waste has been used for district heating production since the 1970s. Between 1990 and 2007, the quantity increased from almost 4 TWh to almost 10 TWh. This increase has been due mainly to the fact that, since 2002, it has been forbidden to dispose of unsorted combustible waste in landfill.

**Figure 42:**

Deliveries of pellets to the Swedish market, 1997–2007

SOURCE: NATIONAL ASSOCIATION OF PELLETS INDUSTRIES (PIR)



### Biofuels, peat and waste for electricity production

Over 12 TWh of biofuels, peat and waste were used for electricity production in 2007. Over 6 TWh of this were used in CHP plants, and over 6 TWh in industrial back-pressure plants.

Since 1<sup>st</sup> April 2004, the use of peat in approved CHP plants entitles electricity producers to Green Electricity Certificates. Electricity production from peat in 2007 amounted to about 0.7 TWh.

### Heating of residential buildings

Biofuels are used as the heating energy source for about 10 % of detached houses in Sweden. 11.2 TWh of biofuels, peat etc., were used in detached houses for this purpose in 2006. Most of this was in the form of firewood, but a smaller proportion was provided by wood chips and a growing proportion by pellets and briquettes. Wood firing is most common among property owners with good access to forests, e.g. in agricultural or rural areas. Industry figures show that the use of pellets in the detached house sector increased by more than seven times over the period 2000–2007. According to the industry, the use of pellets in the detached house sector increased by 4 % in 2007. A total of 13.8 TWh of biofuels were used for heating residential and commercial premises in 2007.

## Uncertainties in the 2007 statistics

Statistics on the use of biofuels, peat, waste etc. for 2007 are based on the official energy statistics' preliminary figures, which in turn are based on the results of quarterly investigations. As a result, preliminary statistics for 2007 incorporate a considerable degree of uncertainty, and should therefore be treated with care. This applies in particular to the use of biofuels, peat, waste etc. by industry and district heating plants. It is thought

that the use of these fuels in industry is underestimated, while their use in district heating plants is overestimated. Both these departures are estimated as amounting to about 10 %. The Swedish Energy Agency attempts to correct these systematic differences in the official energy statistics.

Statistics for 2006 and earlier years are based on the annual investigations.

### International trade

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 about 80 % of the ethanol used in or as motor fuels is imported. As far as pellets are concerned, it is estimated that almost a fifth of the quantity used consists of net imports, with about 358 000 tonnes being imported and about 54 000 tonnes exported. Peat imports amounted to 379 000 tonnes in 2007. Unfortunately, no reliable import or export statistics are at present collected, and so it is difficult to estimate quantities. However, imports are included in the country's energy balance as indigenously produced, calculated from the statistics of use. Investigations that have been carried out into the import quantities indicate a figure in the range 5–9 TWh, which means that the importation of biofuels represents a significant raw materials contribution. Most of the imported material is used for the supply of district heating.

Some quantities of waste, demolition timber and similar fuels are imported, but the amounts are difficult to estimate. The extent of import is affected by a number of factors, such as the regulations concerning taxation of sorted and unsorted waste, both in Sweden and the exporting countries, as well as by the relative levels of taxation on different forms of waste. Trading in emission allowances can also affect the scale of the trade. However, it is likely that the use of waste as a fuel in Sweden will increase over the next few years.

### An international comparison

About 19 % of Sweden's energy is supplied by biofuels, which is a good level by European standards. It is difficult to find fully comparable details of biofuel use in other countries. In a global perspective, biofuels are the most important fuels for most

of the Third World's population. The following factors have a considerable effect on the large-scale use of biofuels in the energy system: good availability of forests and raw materials, a developed forest products industry, wide use of district heating systems and good transport systems. This explains why, of the European countries, it is Sweden and Finland that make use of the highest proportions of biofuels in their respective energy systems.

## Energy prices

Commercial energy prices consist of a number of elements, such as the price of the fuel, taxes and VAT. Taxes and charges can vary, depending on how and where the fuel is used. The following section describes the changes in real energy prices for various users. Using real prices allows for inflation: the prices are shown in 2006 levels. Figure 43 shows actual commercial energy prices, with further details in the table for Figure 43 in *Energy in Sweden in Figures*.

### The real price development

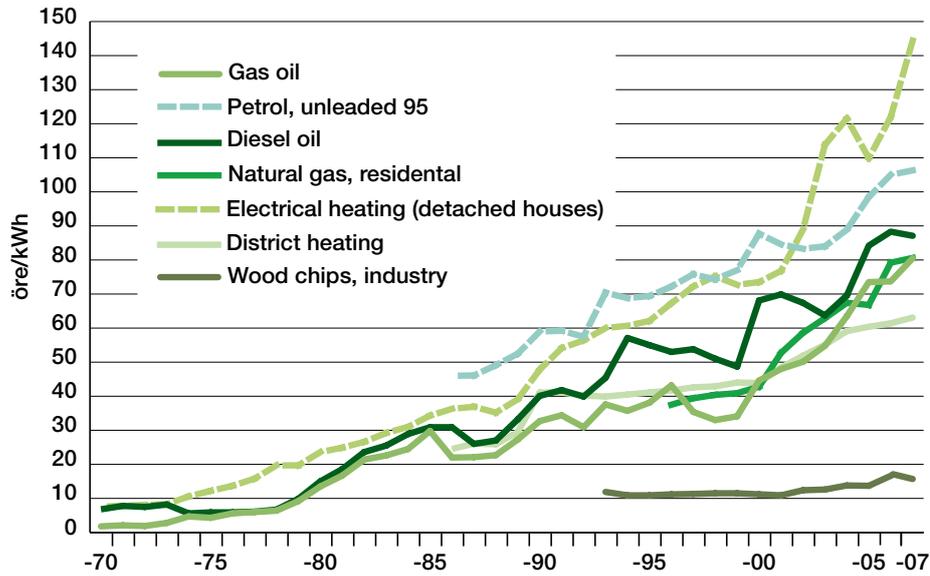
Nominally, the price of an average kWh of energy (the weighted price of all purchased energy, including all applicable taxes) rose by over 11 % between 2006 and 2007. If the prices are corrected by the consumer price index<sup>108</sup>, the real price increase was about 9 %: see Figure 44 below. This indicated the resumption of the trend that had applied since the beginning of the century, for the real price of energy to increase, although at a slower rate than the real price drop during the 1980s and 1990s.

Rising oil prices during 2007 have made only a lesser contribution to rising energy prices. Admittedly, international oil prices (which are expressed in dollars) rose by over 10 % in terms of the average for the year, but at the same time the Swedish crown appreciated by 9 % against the dollar. Oil consumption fell, in both absolute and relative terms. In fact, when inflation is also considered, the real price of imported energy actually fell by 1 %: see Figure 45.

The main element of the real price increase was caused by indigenous price rises. The price of biofuels, which supply an increasing proportion of the Swedish energy balance, increased nominally by 40 % and in real terms by 35 %. Unfortunately, electricity prices also increased substantially, despite the fact that the trading price for electricity fell from 44 öre/kWh in 2006 to 28 öre/kWh in 2007, with the average real price increasing by 12 %.

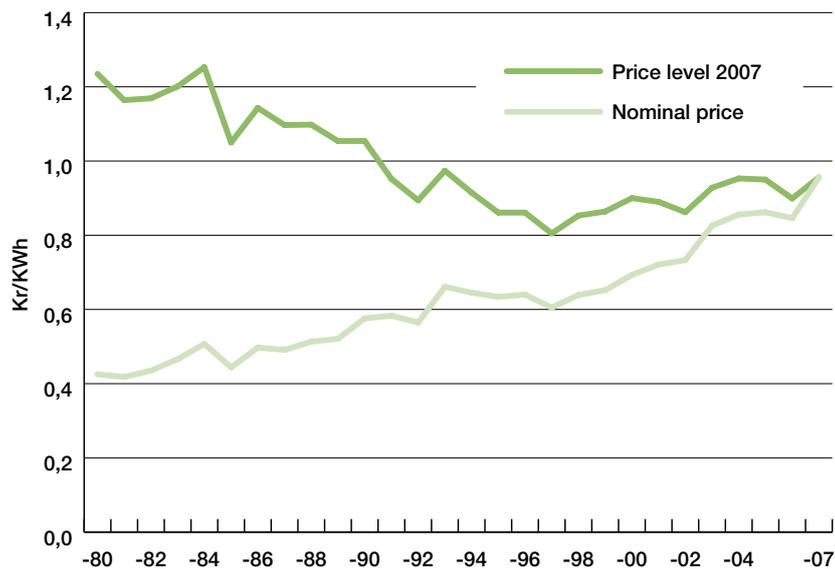
The real price rise during 2007 cannot be explained by rising international prices or increased national taxes, but only by rising indigenous prices of biofuels and higher profit levels in the final delivery link of electricity.

108 As far as the methodology is concerned, the use of the consumer price index to correct energy prices can be questioned, as energy prices themselves command a relatively considerable weight in the index, which means that the real price development is underestimated when energy prices rise more rapidly than other factors in the index.

**Figure 43:**

Actual energy prices in Sweden, including tax, 1970–2007

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

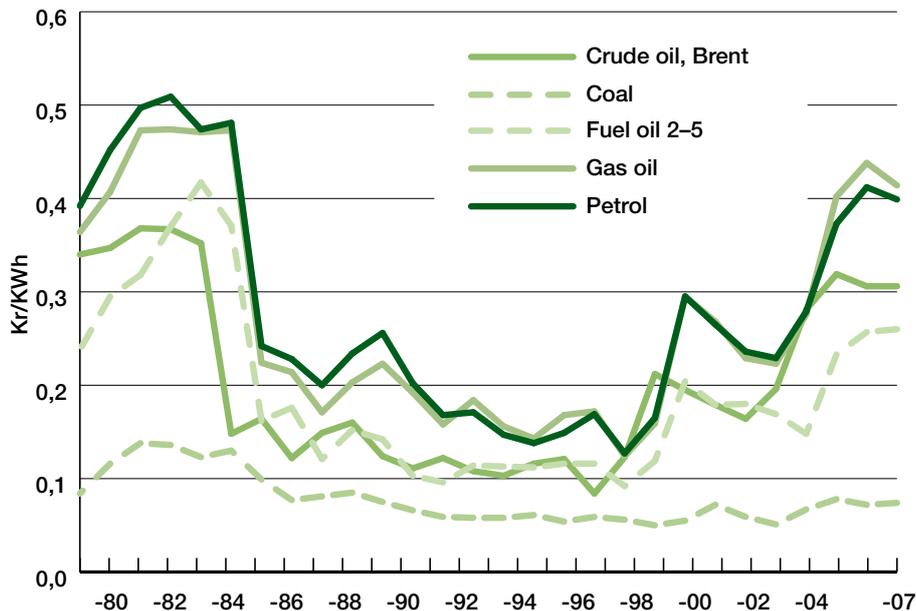
**Figure 44:**

Price development of purchased energy (2007 price level), 1980–2007

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

**Figure 45:**  
Import prices of fossil energy (weighted annual average), 1980–2007

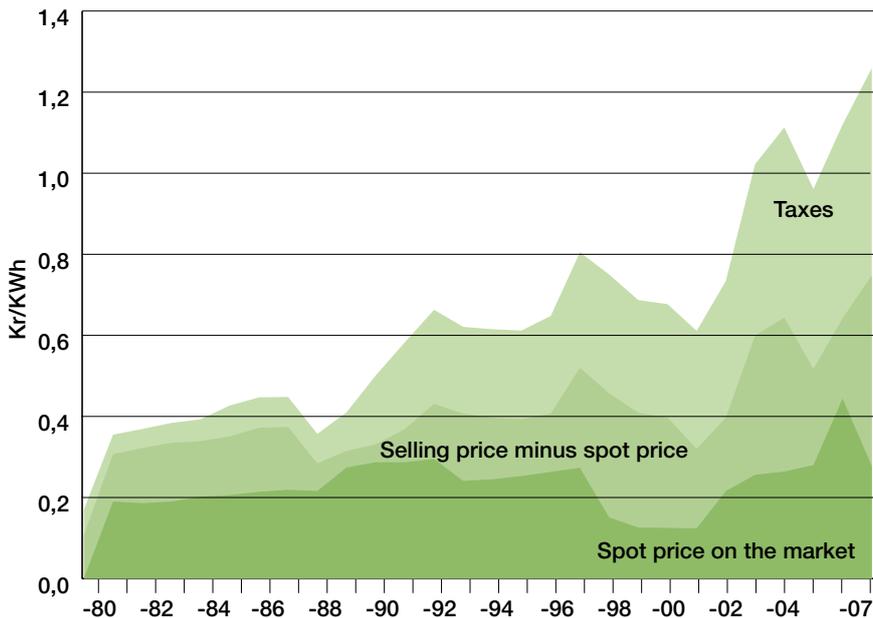
SOURCE: STATISTICS SWEDEN, BANK OF SWEDEN AND IEA, ENERGY PRICES AND TAXES



**Figure 46:**  
Real price of electricity (2007 price level), 1980–2007

SOURCE: STATISTICS SWEDEN, BANK OF SWEDEN AND NORDPOOL

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



# 5

## Summary

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

Deregulation has resulted in major changes in both the Swedish electricity market and the Swedish gas market. The electricity market was the first to be deregulated, and is becoming more and more integrated with the markets in other Nordic countries and in the EU. Several projects aimed at increasing cooperation between the countries and strengthening physical transmission links are in progress in the Nordic countri-

es. In 1970, most electricity was produced by hydro power or oil fired cold condensing power. By 2007, this had changed so that hydro power and nuclear power supplied almost 90 % of the electricity, wind power supplied 1 % and fuel based processes supplied the remaining 9 %.

District heating has been supplied in Sweden since the 1950s, with substantial growth in recent decades. Today, it is the commonest form of heating for apartment buildings and commercial premises, and the dominant method of heating in the central areas of 85 % of the country's 290 municipalities. One of district heating's advantages is its flexibility in terms of fuel use. In 1970, only 2 % of the fuel used for district heating consisted of biofuels, waste or peat, while this proportion had risen to 69 % by 2007.

# Secure energy supply

Energy is needed in order to deliver many human needs, such as heating, food preparation, communication and transport. It is also used in industrial processes and control systems, in workplaces for computers and other equipment. Availability of energy is a prerequisite for most of society's functions, which therefore means that the supply of energy must be secure, with a high level of reliability. Now and then, something happens to remind us of society's vulnerability to interruptions in energy supply caused by natural catastrophes, accidents or sabotage.



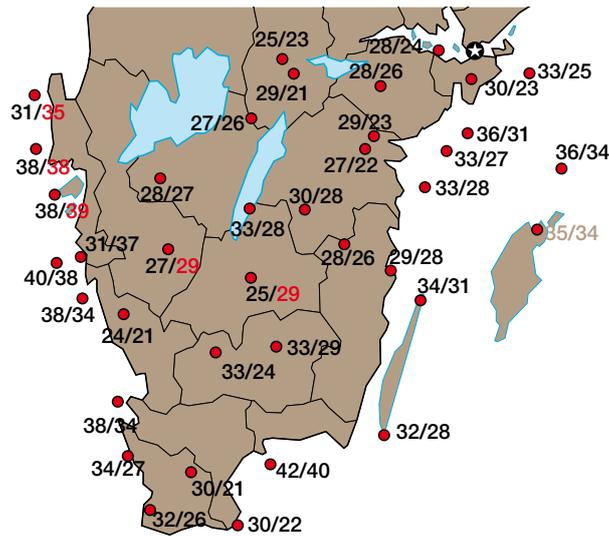
## Major disturbances to the energy system

The most severe disturbance to Sweden's energy supply in 2007 occurred on 14th January, when storm Per crippled the southern parts of the country for a number of days. Although, on the whole, it caused less damage than did storm Gudrun in January 2005, it resulted in 440 000 customers being without power for 1–2 days on average. The longest failure lasted for about 10 days.

The results of the power failure were the usual ones: no lighting, no cooking, loss of heating for many persons, no fuels available from petrol stations, factory stoppages, cancellation of trains and loss of telecommunications over wide areas. The failures of the telecommunication system presented a particular problem, as it was difficult to coordinate repair work without fixed or mobile telephone connections.

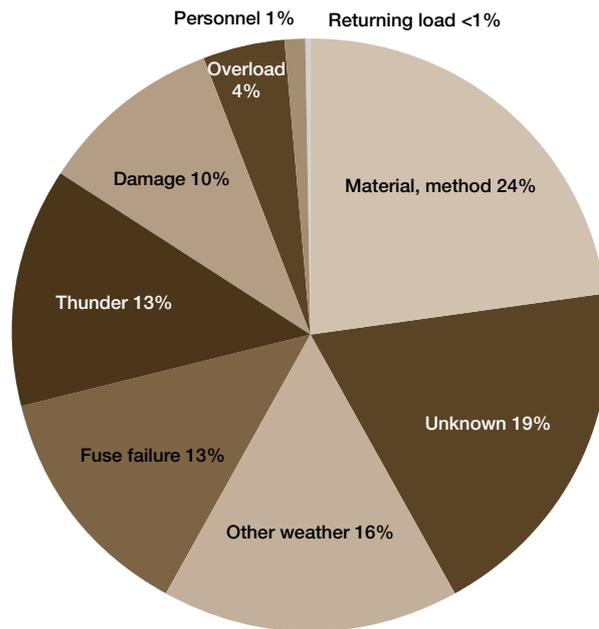
One lesson that has been learnt from the storms is that it is very important that information reach those who are suffering from the electricity failure. In the first few hours, it can even be more important to get this information out than to start the actual repair work. All those dependent on electricity want to know when the supply may be restored, as it affects what they need to do while waiting. Information is often provided by radio during power failures, it is a good idea to ensure that each household has a battery radio. Car radios can also be an alternative.

It was not just electricity supply that suffered during the storms: some roads were impassable due to fallen trees, with the result that fuel could not reach standby electricity generators or petrol stations.



**Figure 47:**  
A comparison of wind speeds in the Gudrun and Per storms: maximum gust speeds at the measurement sites

SOURCE: SWEDISH METEOROLOGICAL AND HYDROLOGICAL INSTITUTE DATA SHEET NO. 33, "THE JANUARY STORM OF 2007"



**Figure 48:**  
Causes of power failures in Sweden, 2006

SOURCE: DARWIN

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

## Risk factors in electricity and heat supply

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

Linking a country's energy system to those of neighbouring countries can be very important for security of supply, as electricity can be imported or exported depending on where it is needed. The maximum demand for electricity in Sweden occurs during periods of very cold winter weather. However, as our nearest neighbouring countries

also have higher power demands during cold weather, Sweden cannot rely on always being able to import electricity. In principle, power shortages can occur at any time, as they are due to the production or transmission capacity at any instant. In the worst case, Svenska Kraftnät may be forced to disconnect supplies to some users.

Much of the heating in the country depends on electricity. District heating systems require electricity for both production and distribution, while users need electricity to operate the systems in their buildings. In cold weather, it

does not take very long before buildings become chilled: at an outdoor temperature of 5 °C, it takes about two days for the temperature in a normal detached house from the 1970s (brick outer wall and 95 mm insulation) to fall from +20 to +5 °C. Any long interruption in the supply of district heating can mean that evacuation may be necessary.

The two most important production sources in Sweden, hydro power and nuclear power, are associated with various types of risks. Hydro power depends on inflow to reservoirs and on the level of the reservoirs, while nuclear power is dependent on availability. Strict safety regulations for nuclear power stations mean that if a fault occurs in a reactor, it may be necessary to close other plants of the same type in order to inspect for the fault. The event in Forsmark in July 2006, for example, resulted in several reactors being shut down at the same time for several months.

## Oil and motor fuels

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

In the worst case of power shortage, Svenska Kraftnät may be forced to disconnect supplies to some users.

Year	Event
2005	Storm Gudrun, 730 000 customers without electricity
2006	Shutdown of four nuclear reactors, at the same time as reservoir levels were low
2007	Storm Per in January, 440 000 customers without electricity
	Bomb threat to a nuclear power station
2008	Several storms in January and February in southern Sweden affected electricity supply
	Oskarshamn 1 shut down when entry systems detected traces of explosive
	Power failure in southern Stockholm in June, 42 000 customers without electricity

**Table 7:**  
Serious events in  
Swedish energy supply  
since 2005

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

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

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

All users of electricity, whether private individuals or businesses, should be aware that interruptions can occur, and decide whether they can accept the resulting consequences, or whether they need to take preemptive action.<sup>109</sup>

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

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

109 The Swedish Energy Agency has prepared concrete guidelines and examples for householders (whether in detached houses or apartments), care personnel and local authorities on how to prevent and ameliorate the consequences of electricity or heat supply failures. Information on this and similar aspects can be found at [www.energimyndigheten.se/tryggenergi](http://www.energimyndigheten.se/tryggenergi).

# 6

## Summary

It is difficult to imagine a society without energy, as most of our daily activities require some form of energy. That the energy system is vulnerable was illustrated, for example, by storm Per, which caused the most severe power failure of 2007: 440 000 customers without electricity, some for up to ten days.

The energy system is complex, with the availability of one form of energy affecting the supply of others. Electricity is particularly important, as it is needed for essentially all other forms of energy supply.

The concept of an assured energy supply is subjective, dependent upon users' needs and wishes. The energy system cannot meet all users' requirements for reliability of supply. With effect from 2011, electricity suppliers will be required to ensure that failures do not last for more than 24 hours, but if individual users have higher reliability requirements than this, they would be well advised to consider additional solutions.

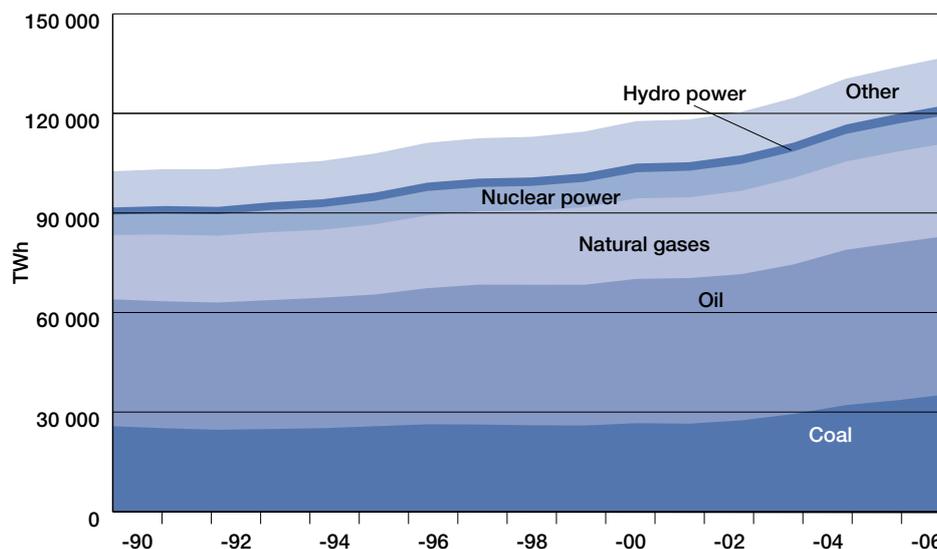
# An international perspective

World energy supply is still dominated by fossil fuels (80 %), with oil being the most important of them (33 %), followed by coal (33 %) and natural gas (21 %). The proportion of renewable energy (including hydro power) has remained at about 13 % over the last ten years, with nuclear power, at almost 6 %, supplying the rest. However, there are major differences in the use of energy between regions, both in terms of per-capita use and of the forms of energy supply. These differences are due to countries' different conditions in terms of availability of energy, economic development, infrastructure and climate. Any imbalance between supply and demand of some form of energy supply in a region quickly spreads via the price system to neighbouring energy markets and regions, and affects the whole world market.



**Figure 49:**  
Global primary energy  
supply, 1990–2006

SOURCE: IEA ENERGY BALANCES  
OF NON-OECD COUNTRIES, 2008



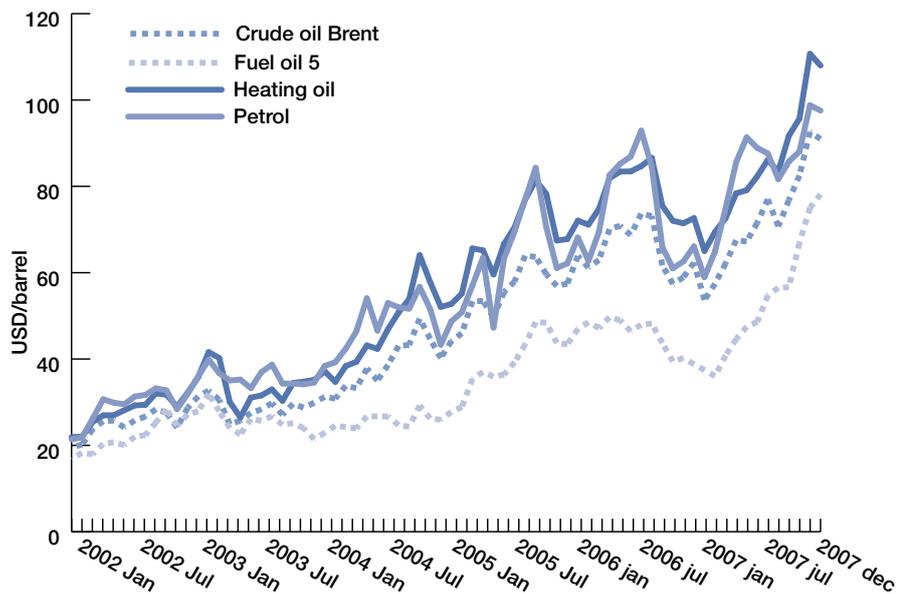
## Overview

Global energy use, excluding biomass<sup>110</sup>, increased by 2.4 % in 2007, which is the average rate of increase over the last ten years. China alone was responsible for more than 50 % of the increase in the demand for energy. The rest of Asia and North America each accounted for about 17 % of the increase. Africa, the Middle East and Latin America each increased their use by about 8 %. Total energy use in the EU, on the other hand, decreased by 2.2 %.

Development in 2007 was characterised by continued rising prices of fossil fuels (crude oil by over 11 %, coal by almost 18 % (EU) and natural gas about 2 % (EU 25)). As energy prices on the energy market are normally quoted in dollars, the fall in the value of the dollar that occurred over the same period had the effect of limiting the real price rise experienced by countries with currencies not tied to the dollar (mainly those tied to the euro and other European currencies). However, both climate concerns and the rising price of oil have meant a considerable increase in international interest in renewable forms of energy, and not least in biobased motor fuels. The EU, USA and Brazil are the leaders in manufacture of biobased motor fuels. According to an estimate by the IEA, production of biobased motor fuels in 2007 was equivalent to 1 million barrels of oil per day<sup>111</sup>.

110 Due to delays, there is no complete data for the use of biofuels after 2005.

111 IEA Medium Term Oil Market report, July 2007.



**Figure 50:**  
Oil prices in Europe,  
2002–2007

SOURCE: IEA OIL MARKET  
REPORT

Over the last five years, the use of coal has risen twice as rapidly as that of total energy use: in 2007, its use increased by 4.5 %. China alone produces and uses over 40 % of all coal. Within the EU, which as a whole is responsible for 10 % of global use, consumption in 2007 fell by about 0.5 %.

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

## Energy supply

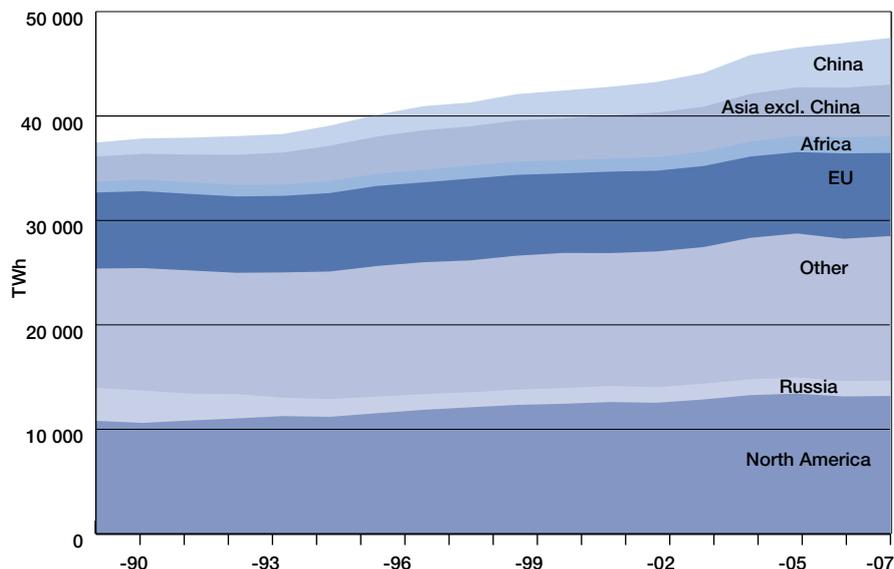
### Oil

The proportion of oil used in the global energy balance continues to decline slowly, so that it was down to about 33 % in 2007<sup>112</sup>. On the other hand, total use of oil increased by about 1.0 % over the year, as compared with 0.7 % in 2006. In 2005 and 2004, the

112 BP Statistical Review of World Energy, June 2008. BP's figures have been adjusted to reflect the estimated proportion of biofuels.

**Figure 51:**  
World use of oil,  
1990–2007

SOURCE: IEA ENERGY BALANCES  
OF NON-OECD COUNTRIES,  
2008. BP STATISTICAL REVIEW OF  
WORLD ENERGY, 2008



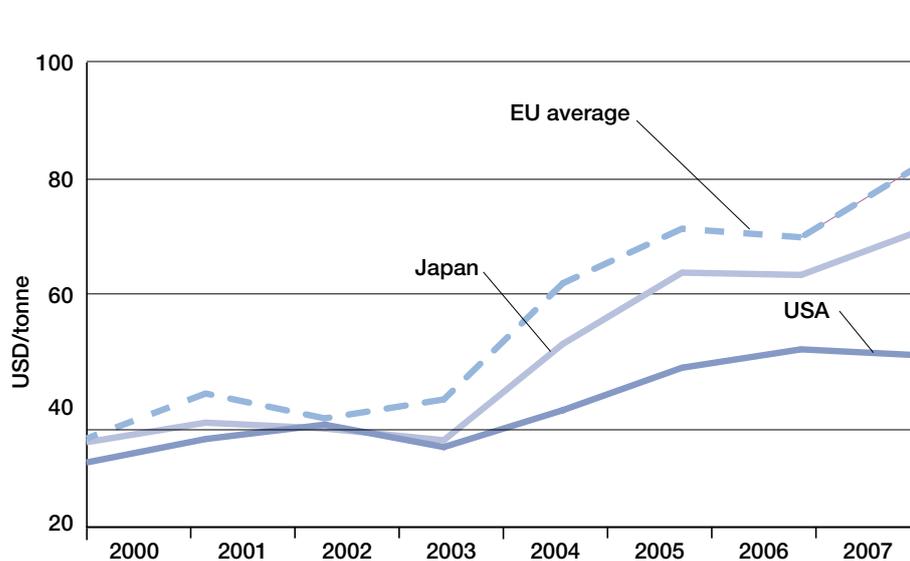
corresponding increases were 1.2 % and 3.7 % respectively. In the USA, consumption fell for the third year running, which also occurred in a number of EU countries. For the first time, oil consumption in the EU as a whole fell by 2.5 %. In principle, China, the Middle East and Latin America accounted for the entire increase in the use of oil.

Total oil production declined by about 100 000 barrels per day, although production in North America, Africa and Russia increased in comparison with 2006. Production in other regions, as well as in the OECD group as a whole, declined or remained constant.

As in previous years, the use of fuel oils continues to decline, after temporary increases in 2004 and 2005. In Europe, the use of petrol continues to decline as, for the first time, did also the use of diesel fuel. However, the underlying long-term trend remains, of the demand for intermediate distillates - i.e. diesel oil and aviation paraffin - increasing the most rapidly.

Prices continued to rise substantially in 2007, from a little below USD 54/barrel in January to over USD 90/barrel in December. Over the whole year, the average price was a little over USD 72/barrel, or about 11 % higher than in 2006. This upward trend has continued in 2008. By August 2008, the price of oil had risen by an average of 60 %, although the trend after the halfway point of the year has been downwards.

Political instability in important oil-producing countries has continued during the year. Growth in reserves did not quite offset production. Investments in new oil



**Figure 52:**  
Coal prices in the  
EU, USA and Japan,  
1999–2007

SOURCE: IEA ENERGY PRICES &  
TAXES, QUARTERLY STATISTICS,  
SECOND QUARTER 2008

production increased substantially during the year, as did the marginal costs of new projects and of recovery from existing fields. Bottlenecks have delayed the coming on stream of planned projects, both in new oilfields and in refineries. The high trading prices for fossil energy in particular have resulted in a growing trend of nationalisation of resources. Over 90 % of oil production are nowadays controlled by nationally owned oil companies.

### Coal

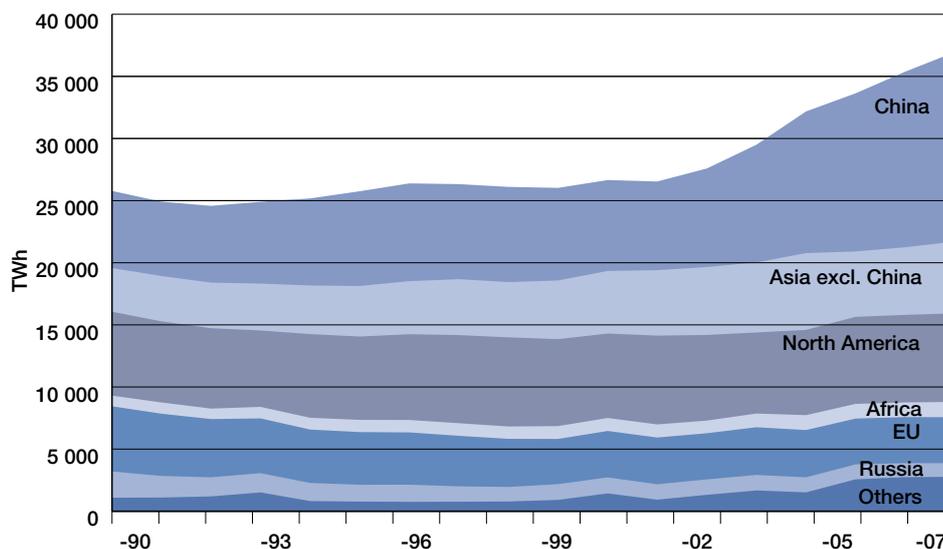
The use of coal increased by about 4.5 % in 2007. Almost all of this increase (70 %) occurred in China, which alone is responsible for over 40 % of all world consumption. Consumption increased in all regions except the EU. Over the last five years, the use of coal has grown more rapidly than that of natural gas, so that coal maintains its place as the second largest world energy source, with about 26 %.

Coal prices increased substantially in 2007, after a stabilisation in 2006. The cost of transport makes up a significant proportion of the price of coal, which means that prices vary from one part of the world to another. In Europe, the average import price to the EU rose by 18 %, from EUR 61/tsce in 2006 to EUR 72/tsce in 2007<sup>113</sup>. This upward trend has continued in 2008: the price of steam coal has risen by about 50 % during the first half of the year.

113 tsce: tonnes of steam coal equivalent. 1 tsce is equivalent to 7780 kWh.

**Figure 53:**  
World use of coal,  
1990–2007

SOURCE: IEA ENERGY BALANCES  
OF NON- OECD COUNTRIES, 2008,  
IEA ENERGY BALANCES OF OECD  
COUNTRIES, 2008,  
BP STATISTICAL REVIEW OF  
WORLD ENERGY, 2008



China increased its production of coal by 6 % in 2007, and now produces over 40 % of global coal, followed by the USA with 19 % and Australia with 7 %.

Closure of financially unviable pits in the EU continues. Production fell by 2.5 %.

### Natural gas

The use of gas increased by 3 % in 2007, which means that it is still the world's third largest energy source, with a market share of about 21 %. China increased its use by almost 20 %, although its total use of gas is still less than 3 % of world consumption. In terms of absolute quantities, the USA accounted for the greatest increase; of 36 000 million m<sup>3</sup>, or nearly 42 % of the total increase. The use of gas in the EU fell for the second year running (by about 1.5 %). Even in the EU -15 countries, gas consumption decreased somewhat.

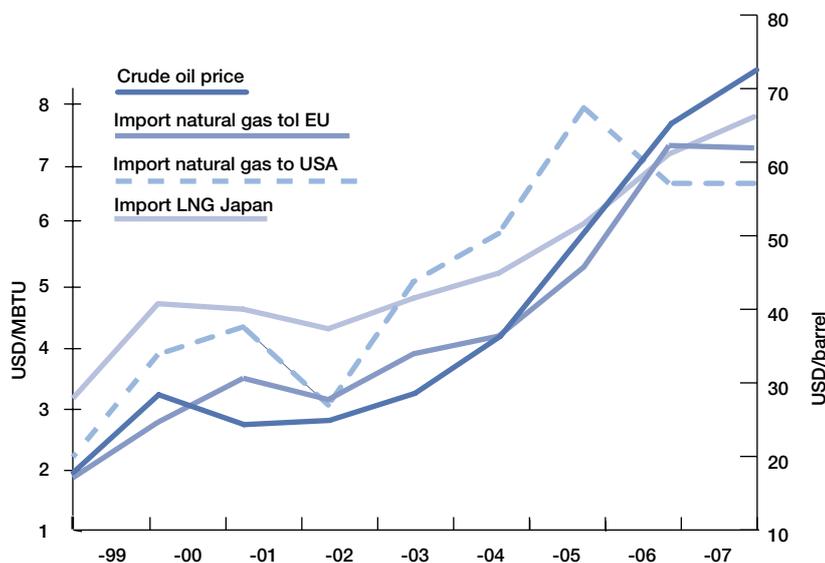
The price of natural gas is linked to the price of oil, either directly through contract provisions or by gas and oil often being alternatives for each other on the end user market. In Europe, the price has more than quadrupled since 1999, from USD 1.8 to USD 8.9/MBTU<sup>114</sup>. However, at 3 %, the increase in 2007 was relatively modest. The price of natural gas rose in Japan by 8 % and in the USA by during 2007. This rising trend continued in 2008, so that the price had increased by about 30 % by the halfway point of the year.

The market for LNG<sup>115</sup> has grown substantially in recent years. According to preli-

114 BP Statistical Review of World Energy 2007.

115 Liquefied Natural Gas.

116 Cedigaz is the international sector organisation for natural gas.



**Figure 54:**  
Import prices of natural gas and crude oil, 1999–2007

SOURCE: IEA ENERGY PRICES & TAXES, QUARTERLY STATISTICS, SECOND QUARTER 2008

minary calculations by Cedigaz<sup>116</sup>, about  $679 \times 10^9 \text{ m}^3$  (679 000 million  $\text{m}^3$ ) of natural gas were carried internationally via pipelines (an increase of 0.4 %), and about  $226 \times 10^9 \text{ m}^3$  in the form of LNG (an increase of 7 %). However, the proportion of gas carried between countries in international trading makes up only a small part of the total production of almost  $2920 \times 10^{12} \text{ m}^3$  (2.9 million million  $\text{m}^3$ ): almost 75 % of all gas is used locally.

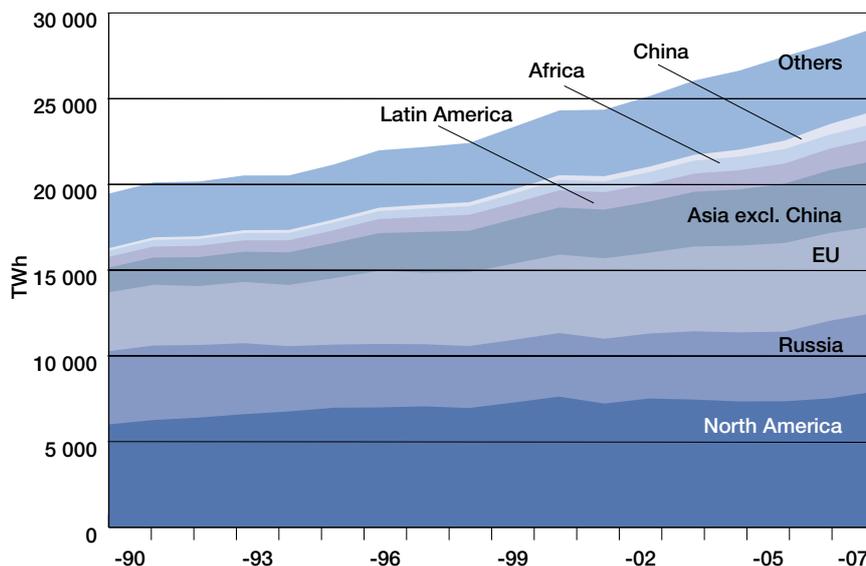
### Other energy

Other forms of energy sources and carriers include hydro power, nuclear power, biofuels, wind power, geothermal power, solar cells etc., i.e. which, with the exception of nuclear power, are mainly various forms of renewable energy. Statistics for nuclear power and hydro power are available for 2007, but those for other forms of energy are at present available only up to 2005. In 2007, production in nuclear power plants provided over 6 % of total world energy supply, while hydro power provided over 2 %. In 2005, renewable energy other than hydro power supplied over 10 % of world energy, with the total proportion of renewable energy (including hydro power) during the year, accounting for somewhat over 13 %.

Over a ten-year period, the total proportion of renewable energy has remained relatively stable. In Africa, almost half of total energy use is in the form of renewables; in Asia, the proportion is almost one-third, while in Latin America it is about one-fifth. In the former Soviet Union, on the other hand, less than 2 % of energy is

**Figure 55:**  
World use of gas,  
1990–2007

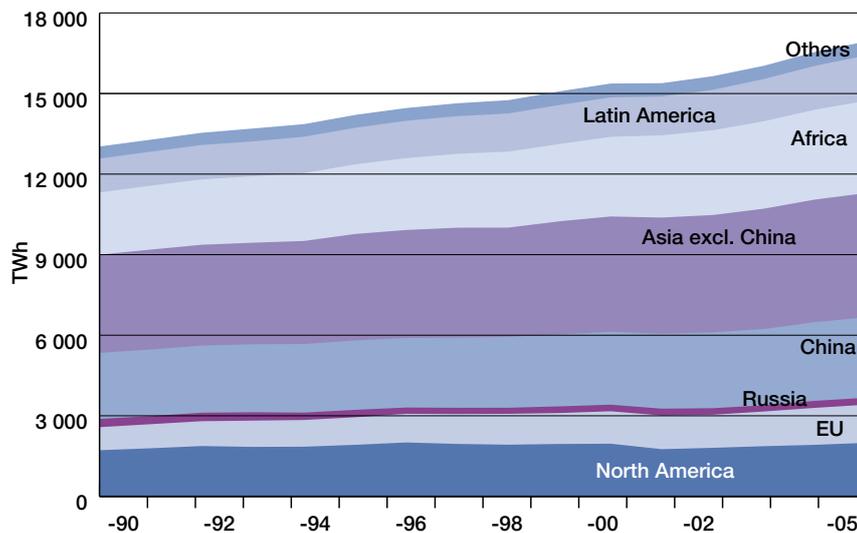
SOURCE: IEA ENERGY BALANCES  
OF NON-OECD COUNTRIES, 2008,  
IEA ENERGY BALANCES OF OECD  
COUNTRIES, 2008,  
BP STATISTICAL REVIEW OF  
WORLD ENERGY, 2008



from renewable sources, and the Middle East trails even further behind with less than 0.5 %. The proportions of renewable energy are declining slowly in Africa, Asia and Latin America, although this fall is offset by a corresponding increase in the OECD countries and in non-OECD European countries.

Although the use of renewable energy has probably increased more rapidly than has the use of fossil alternatives in 2006 and 2007, this growth has not been sufficient significantly to increase the actual proportion of energy supply provided by renewable energy. However, the high prices of fossil fuels, particularly during the last four years, have increased the competitiveness of biofuels, and particularly that of biobased motor fuels.

There is considerable interest in the production of biobased motor fuels, biodiesel oil and ethanol from palm oil, sugar cane and various grain crops, particularly maize and wheat. This has resulted in exploitation of virgin forests in order to increase land areas for agricultural cultivation, and has also reduced the previous grain surpluses to levels that have driven up world market prices for grain. During the first half of 2008, this has resulted in an intensive debate on the balance between biomass for energy purposes or for food. In its Mid-Term Oil Market Report of July 2008, IEA has recently estimated that world wide production of biobased fuels in 2007 was equivalent to about 1 million barrels of oil per day. If so, this would mean that over 4 000 TWh of



**Figure 56**  
World use of renewable energy, 1990–2005

SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES, 2008, IEA ENERGY BALANCES OF OECD COUNTRIES, 2008

biobased motor fuels were supplied to the market. According to the report, the USA, Brazil, China and Germany produced over 80 % of this.

Investments in wind power and solar cells have also reached record levels during the year. However, at present, there are no reliable statistics.

## Energy use

### Industry

In 2005 the use of energy by industry increased by over 3 % after the record increase of almost 6 % in 2004<sup>117</sup>. Seen over the past ten-year period, the annual rate of increase has been a little over 2 %. China accounted for 85 % of the increase in energy use in the industrial sector. Industry's share of total energy use was 26 % in 2005.

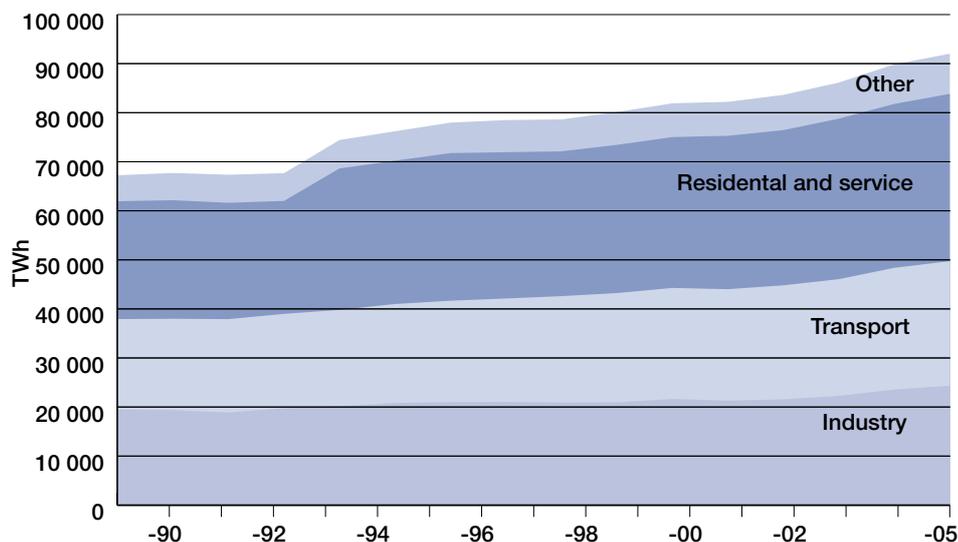
### Transport

Energy use in the transport sector increased with over 2 % in 2005. Although this is about half the increase seen in 2004, it is about the same as the average rate of increase over the last ten years. Energy use is dominated by oil (95 %), with natural gas providing 3 % and coal and electricity together providing 2 %. As yet, the use of biofuels and other alternatives is statistically negligible. Seen over a longer period of time, the transport sector's proportion of total energy use has remained relatively stable at about 28 %.

117 2004 is the latest year for which overall statistics are available, dividing the use of energy up into different application areas.

**Figure 57:**  
World energy use, by  
sectors, 1990–2005

SOURCE: IEA ENERGY BALANCES  
OF NON-OECD COUNTRIES, 2008



### The residential and service sector<sup>118</sup>

Over the last decade, energy use in the residential sector has increased at about 4 % per annum, although in 2005, the increase was only about 2 %. The sector's proportion of total energy balance remains constant at about 37 %. Almost all of the increase during the last ten years has occurred in the domestic sub-sector. The use of electricity in particular has increased.

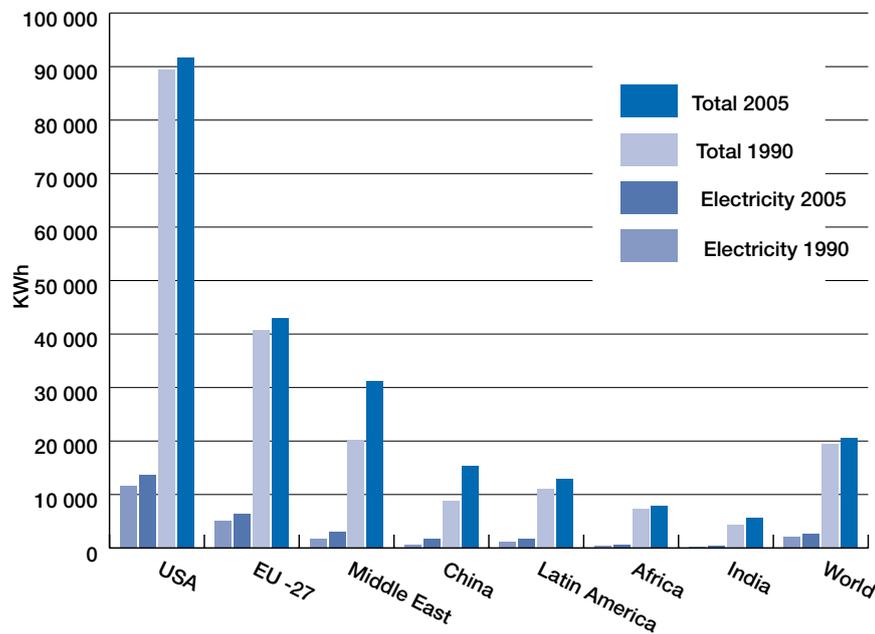
The residential sector is traditionally the largest user of renewable energy, although its proportion of renewable energy has declined from almost 80 % in 1994 to 77.5 % in 2005. 32 % of total energy use in the residential and service sector in 2005 was in the form of renewable energy, 27 % in the form of electricity and 25 % in the form of natural gas. Oil has retained its proportion of 15 % between 1990 and 2005.

## Electricity production and use

World electricity production use increased by about 4 %, to over 15 000 TWh in 2005. The average rate of increase in electricity use has been slightly less than 3 % per annum since 1994.

Coal is still the predominant source of energy input for electricity production, increasing to over 40 % in 2005. Natural gas continues to increase its proportion, fuelling almost 20 % of electricity production in 2005. Renewable electricity production, in the

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



**Figure 58:**  
Regional per-capita  
energy use, 1990  
and 2005

SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES, 2008, IEA ENERGY BALANCES OF OECD COUNTRIES, 2008

NOTE: THE FIGURES IN THE TABLE REFER TO PRIMARY ENERGY USE, INCLUDING LOSSES. THE FIGURES IN ENERGY IN SWEDEN 2007 EXCLUDED THE LOSSES.

form of geothermal power, solar energy and wind power, together with electricity produced from biofuels and waste, has increased its proportion from 1.6 % in 2000 to 2.2 %.

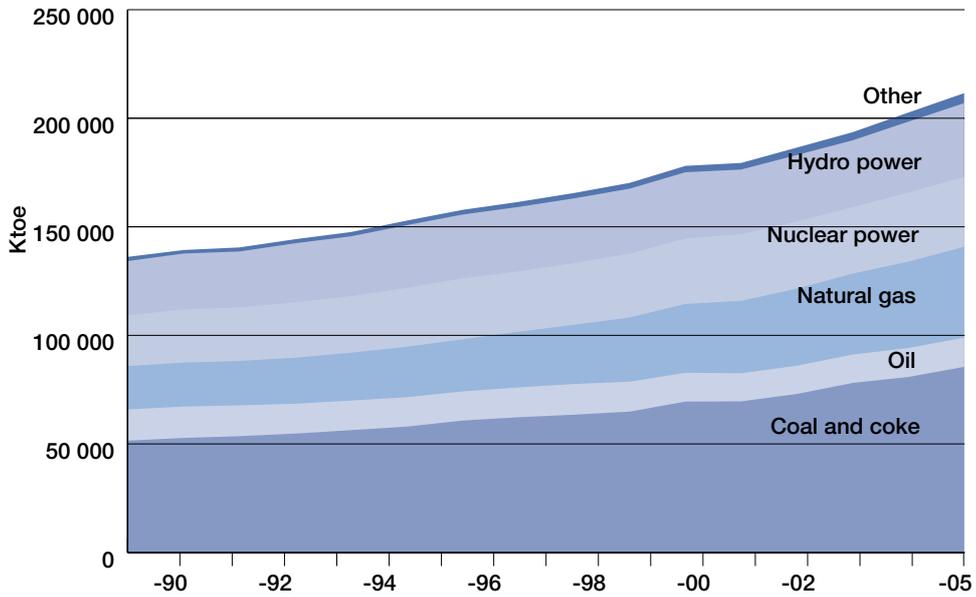
Although the OECD states dominate world electricity use, with a proportion of almost 60 % in 2005, demand is increasing most rapidly in non-OECD countries. Over the last three years, electricity use in China has increased by over 15 % per annum, which means that China has been responsible for almost 40 % of the world increase.

The residential and service sector used 57 % of all electricity, but there are considerable differences from country to country. Within the OECD, the proportion was over 60 %, but in China was only 32 %. The proportions used by the industrial and transport sectors have remained relatively stable at about 41 % and 2 % respectively, but there are substantial regional differences here, too. In 2006, 67 % of all China's electricity was used by industry, whereas this proportion for the OECD was 35 %.

**Figure 59:**

World electricity production, by type of plant, 1990–2005

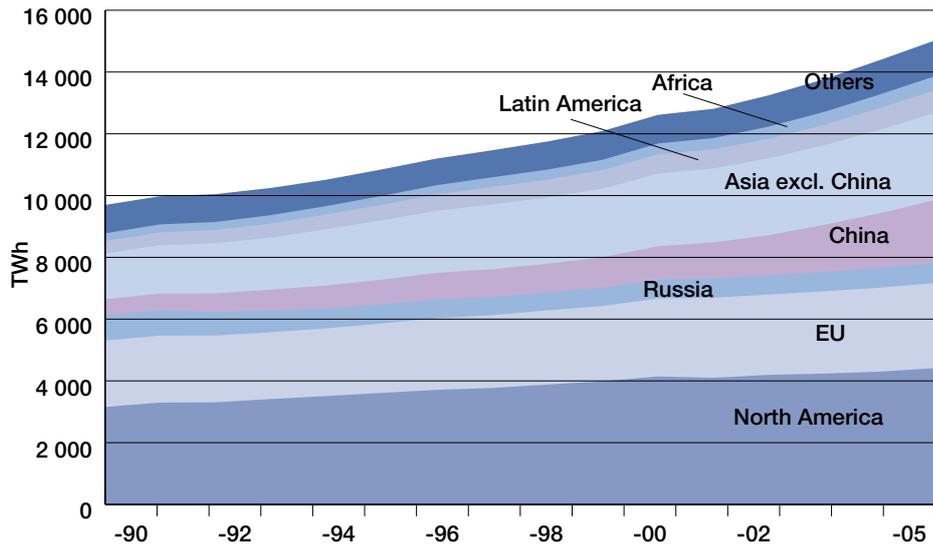
SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES, 2008, IEA ENERGY BALANCES OF OECD COUNTRIES, 2008



**Figure 60:**

Regional electricity use, 1990–2005

SOURCE: IEA ENERGY BALANCES OF NON-OECD COUNTRIES, 2008, IEA ENERGY BALANCES OF OECD COUNTRIES, 2008





# Summary

Increase in world wide energy use in 2007 followed a stable trend, not only in terms of relative proportions between countries but also in terms of proportions of energy sources. The rapidly growing economies in Asia account for about two thirds of the total increase. Increases in the use of coal and renewable energy sources are growing the most rapidly, but from completely different levels. Coal meets about 25 % of world energy demand, while renewable energy (including large scale hydro power production) meets about 7 % (2005). Oil is slowly losing market share, but increased by 1 % in terms of absolute quantities.

Use of oil declined in both the USA and the EU during 2007, although most of the demand is still for the use of oil products as motor fuels.

2007 was somewhat of a breakthrough year for biobased motor fuels, with total production during the year having been estimated as equivalent to about 1 million barrels of oil per day.

Price rises, which have been substantial for all forms of energy raw materials over the last few years, continued throughout 2007. The prices of crude oil and steam coal rose by 11 % and 18 % respectively, as expressed in USD. Prices rose even more steeply towards the end of the year, and have continued to rise in 2008. By August 2008, the price of oil had risen by an average of 60 %, although the trend has been downward after the half-way point of the year. Over the same period, the price of steam coal had risen by about 50 % and that of natural gas by about 30 %.

# The environmental situation

All recovery, conversion and use of energy or energy materials have some kind of environmental impact. The most significant direct environmental effects are those related to emissions from combustion of fuels: they include the increase in concentration of greenhouse gases in the atmosphere, precipitation of acidifying substances and emissions of health-hazardous or environmentally harmful compounds in flue gases and vehicle exhaust gases. Although less environmentally harmful energy sources and production processes, such as hydro or wind power generation, can have positive effects on some environmental problems, they may have some other adverse environmental impact, such as in the form of their impact on nature and the landscape.



## Swedish environmental targets

Parliament has set targets for environmental quality in sixteen areas. They describe the quality and conditions for the country's environmental, nature and cultural resources that are regarded as ecologically sustainable in the long term.

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

The purposes of the targets are to:

- Support human health
- Safeguard biological diversity and the natural environment
- Care for the cultural environment and culture-historical values
- Maintain the long-term productivity of ecosystems
- Ensure good conservation and management of natural resources

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

- Reduced climate impact
- Clean air
- Natural acidification only
- A good built environment quality
- Living lakes and waterways
- Maintenance of the grandeur of uplands and mountains

### Reduced climate impact

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

Sweden's emissions are low in per-capita and per-GNP terms in comparison with those of most other industrialised countries, but are considerably higher than corresponding emissions in the developing countries. Emissions of greenhouse gases have lain below the values for 1990 for every year since 1999. In 2006, emissions were 8.7 % less than in 1990. In parallel with this reduction, the economy has grown. The Swedish Energy Agency's and the Swedish Environmental Protection Agency's most recent forecast for Sweden expects carbon dioxide-equivalent emissions in 2010 to be about 4 % below their 1990 levels.

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

### **Clean air**

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

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

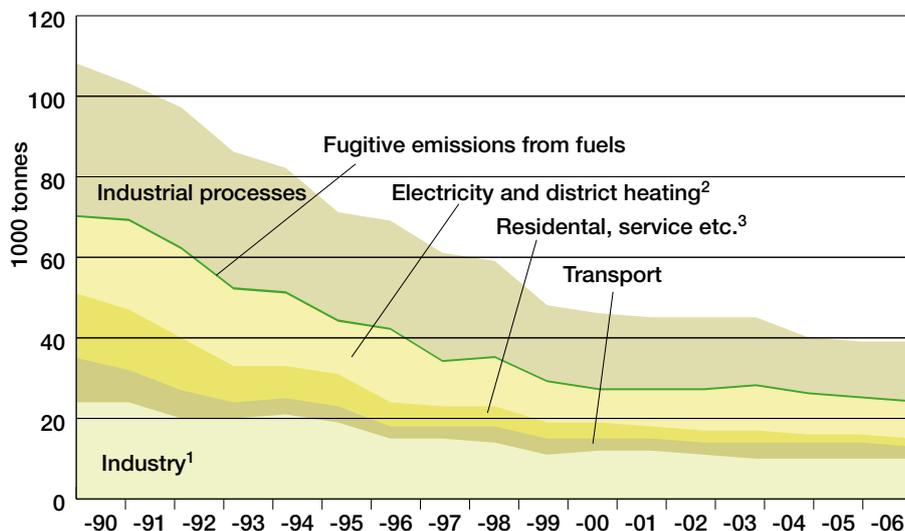
There are many air pollutants that are detrimental to human health. Particularly in urban areas, high concentrations of pollutants can result in bronchial problems and allergies and, in the longer term, also in cancer. Among those that cause such effects can be named oxides of nitrogen, sulphur dioxide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

**Figure 61:**  
Sulphur dioxide  
emissions in Sweden,  
1990–2006

SOURCE: SWEDEN'S REPORT TO  
THE UN AIR POLLUTION CONVEN-  
TION, SWEDISH ENVIRONMENTAL  
PROTECTION AGENCY, 2008,  
ADDITIONAL PROCESSING BY THE  
SWEDISH ENERGY AGENCY

NOTE: THE METHOD OF CALCUL-  
ATION FOR EMISSIONS TO AIR  
HAS BEEN REVIEWED BY THE  
SWEDISH ENVIRONMENTAL  
PROTECTION AGENCY AND BY  
STATISTICS SWEDEN. FIGURES  
FOR ALL YEARS HAVE BEEN  
REVISED IN COMPARISON WITH  
THOSE SHOWN IN THE PREVIOUS  
ISSUE OF ENERGY IN SWEDEN.

1. INCLUDES INDUSTRIAL BACK-  
PRESSURE PRODUCTION AND  
WASTE INCINERATION.
2. INCLUDES COKING PLANTS  
AND OIL REFINERIES.
3. INCLUDES AGRICULTURE,  
FORESTRY AND FISHING.

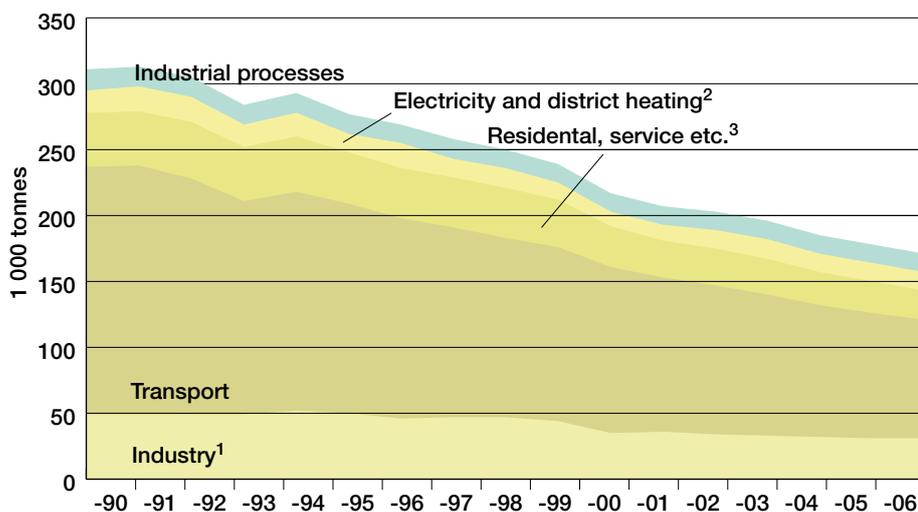


### Natural acidification only

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

One of the effects of acidification is the release of metals such as aluminium in the ground and water, making them available for uptake by plants and organisms. This adversely affects the growth of forests and harms many sensitive species of plants and animals, both on land and in water. The main cause of acidification is the emission of sulphur in the form of sulphur dioxide, with ammonia and oxides of nitrogen (NOx) also contributing to the effect. Sulphur dioxide emissions arise from the presence of sulphur in fuels, while oxides of nitrogen are formed mainly by the effects of combustion on the nitrogen in combustion air.

The main source of sulphur dioxide is combustion of fossil fuels, although emissions have been reduced as a result of flue gas cleaning and sulphur removal from fuels before use. Sulphur dioxide is oxidised in the atmosphere to sulphuric acid, which is then brought down to the surface of the earth in precipitation, and thus referred to as 'wet deposition'. Sulphur emissions can also be deposited directly in the form of sulphur dioxide, known as 'dry deposition'. As the conversion process of sulphur dioxide in the atmosphere for wet deposition takes a few days – sometimes up to a week – it means



**Figure 62:**  
NOx emissions in  
Sweden, 1990–2006

SOURCE: SWEDEN'S REPORT TO  
THE UN AIR POLLUTION CONVEN-  
TION, SWEDISH ENVIRONMENTAL  
PROTECTION AGENCY, 2008

1. INCLUDES INDUSTRIAL BACK-PRESSURE PRODUCTION AND WASTE INCINERATION.
2. INCLUDES COKING PLANTS AND OIL REFINERIES.
3. INCLUDES AGRICULTURE, FORESTRY AND FISHING.

that precipitation over Sweden originates primarily from sources in other countries. In 2002, Swedish emissions of sulphur dioxide amounted to about 50 000 tonnes in total. Sweden's 'import' of sulphur on wind streams from other countries is much greater than the country's own emissions. On the other hand, Sweden 'exports' about 60 % of its own sulphur emissions to the ground and water in other countries.

### **A good built environment quality**

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

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

### **Living lakes and waterways**

*Lakes and waterways shall be ecologically sustainable, and their rich variety of living environments shall be maintained. Natural productivity, biological diversity, cultural environmental values and the land's ecological and water conservation function shall be retained, in parallel with respecting conditions for outdoor life.*

Much of Swedish electricity production is provided by hydro power. However, the presence of hydro power stations affects the ecosystems along the rivers, and can constitute an obstacle for fish. A research project, under the title of 'Hydro power and the environment', has been sponsored by the Swedish Energy Agency with the aim of ensuring that the environmental impact of hydro power production is as low as possible. The EU's Framework Directive for Water Quality requires member states to achieve or ensure good ecological status of waterways by not later than 2015. Special rules apply for lakes and waterways that have been substantially modified, such as for power production purposes. Modifying existing hydro power stations generally means the provision of salmon and eel ladders, and ensuring that there is always a certain minimum discharge of water through the dams even during low water periods. In this latter case, experience shows that hydro power production may be reduced by 5–10 %. Hydro power production does not result in the emission of greenhouse gases or other contaminants: it has contributed to Sweden's status as being among those with the lowest per capita emissions among industrialised countries.

### **Maintenance of the grandeur of uplands and mountains**

*Uplands and mountains shall be as little altered as possible in terms of their biological diversity, emotional impact and nature and cultural features. Activities should be carried out in the light of these values, and in such a way as to encourage sustainable development. Particularly valuable areas shall be protected against development, external influences and other foreign activities.*

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

### **The Swedish Environmental Objectives Council's in depth evaluation**

The Environmental Objectives Council has been instructed by the Government to evaluate the environmental quality targets. The Council presented its report, '*Sweden's Environmental Objectives : No time to lose*' in 2008. The purpose of the review is to provide material for the Government's Environmental Targets Bill and for Sweden's continued work on both national and international levels to achieve an improved environment.

The report is based on material from public authorities, sector authorities and county councils responsible for achieving or implementing various aspects of environmental targets.

In its report, the Council notes that work in several of the areas that Sweden can influence is going in the right direction, but that the pace of the work is not sufficient to ensure that the targets will be met by 2020. The Council's assessment is that nine out of the sixteen environmental targets will be difficult or very difficult to achieve. The *Reduced Climate Impact* target is regarded as being very difficult, or impossible, to achieve. With present emission trends, global emissions are expected to rise more rapidly over the next 20–30 years than they have done in the past 35 years. The Council regards climate changes and their effects on other targets as alarming.

The *Good Built Environment* target has also been reviewed and its assessment revised. This target, too, is regarded as being very difficult, or impossible, to meet, partly because several of the detailed aspects of the target will be difficult to achieve in time. In addition, several of the interim targets linked to the fundamental values on which the environmental objectives rest are difficult to achieve. This applies particularly to human health, which is affected by poor indoor environments, and to the cultural heritage, where insufficient is being done to identify and protect the cultural assets. In addition, the report suggests several actions intended to achieve the interim objectives and, in some cases, has also set new interim targets.

The Swedish Energy Agency's '*Energy as an environmental target*' report was one of those reviewed by the Council, proposing among its views that energy should be treated as a comprehensive environmental target. Although energy is a key factor in achieving many of the targets that have been set, the sector's environmental impact has not been consistently and comprehensively treated within the environmental objectives structure. The Agency believes that it is important that energy matters should be considered as an integral part of the development of society in general. For this



A successful, environmental restoration work must be carried out in an international arena.

reason, it is important that all sectors of society should have a greater understanding of the importance of energy aspects on development and of the environmental effects associated with the supply and use of energy. Improved awareness of the energy system, together with an overall view of energy related matters, are also needed.

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

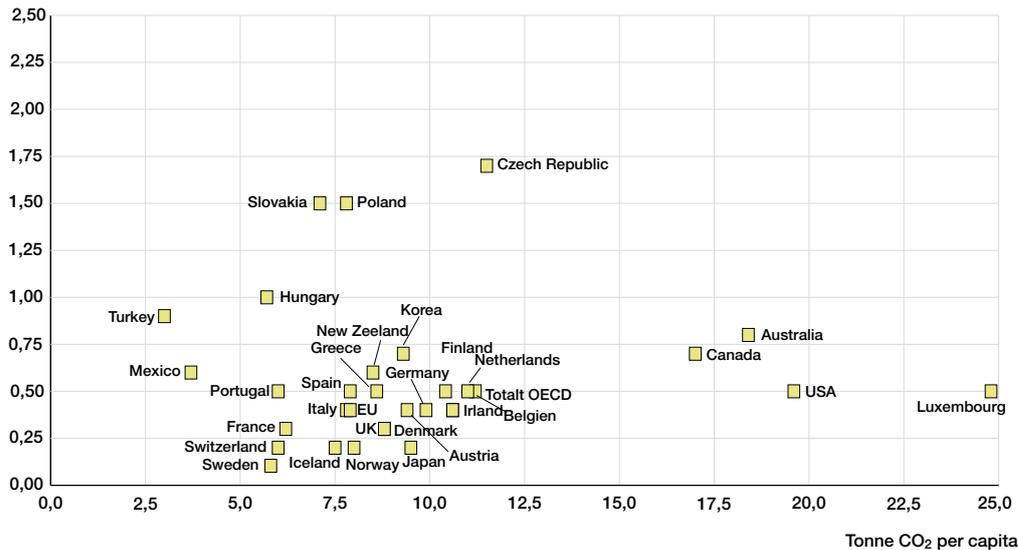
The Government has appointed a special commission to investigate how the environmental objectives system can be given a more international approach and how it can be developed in order to consider aspects such as the slow rate of restoration of healthy natural conditions. The commission will put forward proposals intended to improve efficacy and flexibility in order to update the environmental objective system to reflect changes in the surrounding world.

## The environment - an international concern

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

### The European Union

In the environment field, the European Union works through binding decisions (directives), information, research and development, and international negotiations. It also plays an important part as a source of funding and as the initiative-taker in research and development, not least in the environmental sector.

Kg CO<sub>2</sub> per BNP (2000, US dollar)

**Figure 63:**  
Carbon dioxide emissions from combustion, per capita and GDP, 2005 in the EU and OECD states

SOURCE: OECD IN FIGURES, 2007 EDITION

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

A range of activities in the climate field was started in 2000 under the umbrella name of the European Climate Change Programme (ECCP), the purpose of which is to assist the EU in achieving its commitments under the Kyoto Protocol. A second commitment period, ECCP II, was agreed at the end of 2005. The main activity continues, but on a broader front, in order to improve the prospects of the EU achieving its commitments under the Kyoto Protocol. One of the most important activities is that of emission allowances trading in a single EU market. In February, the European Commission put forward a new package of climate and energy measures, intended to provide the basis for the EU's work on countering climate change and to encourage the use of renewable energy in all sectors of society. The Commission's proposals include binding targets for greenhouse gas emissions and for the proportion of renewable energy required in each member state by 2020. It is expected that the package will be followed up by new measures intended to support improvements in the efficiency of energy use.

Achieving the **Clean Air** and Only **Natural Acidification** targets will require continued work throughout the EU. One of the cornerstones of this work is the strategic Clean Air for Europe (CAFE) programme, ranging over all types of air pollutants. The Commission is updating the Emissions Ceiling Directive (2001/81/EC), to provide targets for emission limits beyond 2010. The Commission has also put forward proposals for a revised IPPC Directive (coordinated measures to prevent and limit pollution), bringing together several directives concerned with industrial air pollution emissions into one, in order to simplify cooperation and the associated legislative structure.

### **The United Nations**

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

The Commission on Sustainable Development was established by the General Assembly after the 1992 Rio Summit. Its first task was to follow up the work after the Rio conference (nowadays after the Johannesburg Summit) by monitoring and reporting if countries achieve their targets. It was also at the Rio Summit that the Climate Convention that has subsequently formed the basis of international climate work was set up. Read more about international climate policy in Chapter Climate Policy.

# 8

## Summary

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

On the national level, Sweden has been working with environmental targets since 1999 as a way of structuring the work aimed at improving the environment. They provide

a national measuring stick, against which progress towards ecologically sustainable development can be measured. In addition to providing an indication of how actual conditions in the Swedish environment compare with the targets, they are also suitable for supporting the national perspective in international contexts.

## Energy units and conversion factors

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

Conversion factors are revised when changes in the values of energy contents of fuels have occurred. Calorific values were reviewed in the autumn of 2007, with the result that some revisions will be made, particularly for oils. These revisions will apply for statistics collected on and after 1<sup>st</sup> January 2008. As the statistics in this publication relate to 2007, the changes are not included in it. Note that these conversion factors are averages for various fuels, and that there are differences between qualities, not least for various wood fuels and coal.

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

**Table 8:**  
Conversion factors  
between energy units

	GJ	MWh	toe	Mcal
GJ	1	0,28	0,02	239
MWh	3,6	1	0,086	860
toe	41,9	11,63	1	10 000
Mcal	0,0419	0,00116	0,0001	1

**Table 9:**  
Prefixes used with  
energy units

Prefix		Faktor	
k	Kilo	10 <sup>3</sup>	thousand
M	Mega	10 <sup>6</sup>	million
G	Giga	10 <sup>9</sup>	thousand million
T	Tera	10 <sup>12</sup>	million million
P	Peta	10 <sup>15</sup>	thousand million million

Fuel	Fysisk kvantitet	MWh	GJ
Wood chips	1 tonne	2.00–4.00	7.20–14.4
Peat	1 tonne	2.50–3.00	9.00–11.0
Pellets, briquettes	1 tonne	4.50–5.00	16.0–18.0
Coal	1 tonne	7.56	27.2
Coke	1 tonne	7.79	28.1
Nuclear fuel	1 toe	11.6	41.9
Crude oil	1 m <sup>3</sup>	10.1	36.3
Topped crude oil	1 m <sup>3</sup>	11.1	40.1
Petroleum coke	1 tonne	9.67	34.8
Asphalt, road dressing oils	1 tonne	11.6	41.9
Lubricating oils	1 tonne	11.5	41.4
Road fuel petrol	1 m <sup>3</sup>	9.04	32.6
Other light oils	1 m <sup>3</sup>	8.74	31.5
Aviation paraffin and other intermediate oils	1 m <sup>3</sup>	9.58	34.5
Other paraffins	1 m <sup>3</sup>	9.54	34.3
Diesel fuel and gas oil	1 m <sup>3</sup>	9.96	35.9
Heavy fuel oils and bunker oil	1 m <sup>3</sup>	10.6	38.1
Propane and butane	1 tonne	12,8	46.1
Town gas and coke oven gas	1000 m <sup>3</sup>	4.65	16.7
Natural gas <sup>1</sup>	1000 m <sup>3</sup>	11.0	39.8
Blast furnace gas	1000 m <sup>3</sup>	0.93	3.35

**Table 10:**  
Calorific values as  
MWh and GJ per  
physical quantity

NOTE: CONVERSION FACTORS IN THIS TABLE ARE GIVEN TO THREE SIGNIFICANT FIGURES. MORE SIGNIFICANT FIGURES ARE USED IN THE CALCULATIONS.

1. THE VALUE FOR NATURAL GAS IS THE NET (LOWER) CALORIFIC VALUE.





## Our target – better use of energy

The Swedish Energy Agency's work is aimed at the establishment of a reliable, low-environmental-impact and efficient energy system. Energy and climate are closely linked: through international cooperation and engagement, we can help to achieve climate targets.

The Agency finances research and development of new energy technologies. We provide pro-active support for commercial ideas and innovations that can lead to the establishment of new companies. We also run information campaigns and demonstrations to show Swedish companies and domestic users how they can make better use of energy.

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

The following publications provided more in-depth information. They can be ordered directly from our publications department, or be downloaded from our web site [www.energimyndigheten.se](http://www.energimyndigheten.se).

Energiläget 2008 – printed  
Energiläget 2008 – PDF  
Energiläget i siffror 2008 – printed  
Energiläget i siffror 2008 – PDF  
Energiläget i siffror 2008 – Excel  
OH-bilder (svenska) – PDF  
Energy in Sweden 2008 – printed  
Energy in Sweden 2008 – 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.

