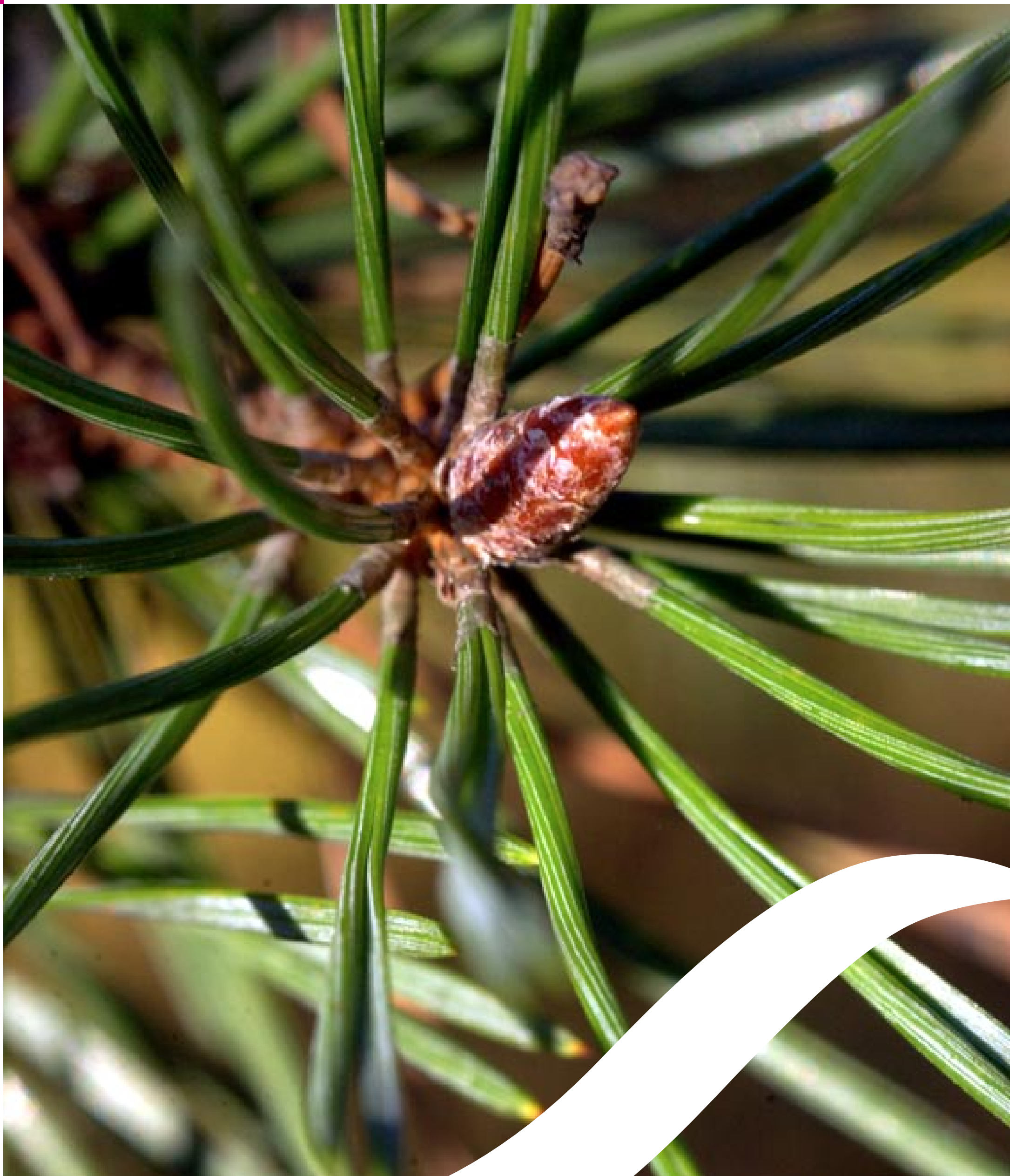
Publication Year 2008

# Energy Indicators 2008

## Theme: Renewable energy



Books and reports issued by the Swedish Energy Agency can be ordered from
the Energy Agency Publications Service.
Order fax: +46 16 544 22 59
e-mail: publikationsservice@energimyndigheten.se


Photos: Per Westergård
Print run: 700 copies
ET 2008:21

# Energy Indicators 2008

Theme: Renewable energy

Books and reports issued by the Swedish Energy Agency can be ordered from the Energy Agency Publications Service.
Order fax: +46 16 544 22 59
e-mail: publikationsservice@energimyndigheten.se


Print run: 700 copies

ET 2008:21

ISSN 1403-1892

# Preface

The Government Bill 2001/02:143 ”Cooperation for a secure, efficient and environmentally friendly energy supply” states that there is a need for systematic follow-up of the energy policy objectives by means of indicators. The Swedish Energy Agency has been instructed to develop these indicators. The first report on indicators was published in 2002 and was entitled “Energy indicators for 2002 for following up Sweden’s energy policy objectives”. The theme for 2003 was the electricity market, the theme for 2004 was the district heating and natural gas markets, the theme for 2005 was energy use, the theme for 2006 was oil use, and the theme for 2007 was secure energy supply. The theme in this year’s publication is renewable energy.

Several of this year’s theme indicators have been significantly affected by the EC directive on the promotion of renewable energy that the Commission has tabled as a proposal and that is currently being negotiated. The definitions used that are based on the draft directive may therefore be modified. A reference group has been linked to the project. This includes representatives from the Ministry of Enterprise, Energy and Communications, the Swedish Environmental Protection Agency, the Swedish District Heating Association, Statistics Sweden, the Swedish Petroleum Institute, the Swedish Road Administration, the National Board for Housing, Building and Planning, the Confederation of Swedish Enterprise, Swedenergy, the Swedish Bioenergy Association, Swedish Wind Energy, SERO, World Wide Fund for nature, Swedish Heat Pump Association, Svenska kraftnät, the Home Owners’ Association, SABO, Swedish Competition Authority and Swedish Consumer Agency.

The purpose of the report is to present indicators for following up the energy policy objectives. The publication begins with a brief review of the energy policy objectives, followed by theme indicators for renewable energy. This is followed by five background indicators and the twenty base indicators. Each indicator is described with a commenting text. The theme indicators from earlier years are not included in the updating, but the earlier publications (only in Swedish) are available at the Energy Agency website www.swedishenergyagency.se (www.energimyndigheten.se).

While this report is intended to serve as a tool for following-up the energy policy objectives, we are hoping that it will also serve as an important contribution to the discussion on the development of the future Swedish energy system.

The project leaders have been Carola Lindberg and Eva Centeno López.

*Eskilstuna, July 2008*

Tomas Kåberger
*Director General*

# Contents

# Objectives of the Swedish energy policy

The purpose of the indicators is to follow up the energy policy objectives. In the 2002 Government Bill "Collaboration for a secure, efficient and environmentally friendly energy supply", the objectives of the energy policy were summarized as follows: *"The objective of the Swedish energy policy is to secure the availability of electricity and other energy in the short and long term on globally competitive terms. The energy policy shall create the conditions for efficient and sustainable energy use and a cost-effective Swedish energy supply with a low negative impact on health, the environment and the climate, and to facilitate the conversion to an ecologically sustainable society. Good economic and social development in the whole of Sweden will thereby be promoted."*

The objectives of the energy policy are expressed more comprehensively and in greater detail in the further text of the Government Bill. There are also reports of further objectives in other documents. The compilation of objectives presented below is based on the following sources:

- Budget Bill 2007/08, Expenditure area 21 (Energy)
- Energy Government Bill 2001/02:143 "Collaboration for a secure, efficient and environmentally friendly energy supply", from March 2002
- Government Bill 2004/05:150 "Swedish environmental objectives – a joint assignment" from 2005, and Environmental and Agricultural Committee report 2005/06:MJU3
- COM (2008) 19 final. Proposal for a Directive of the European Parliament and of the Council on the promotion of the use of energy from renewable sources.

The objectives in the energy policy can be divided into the three activity areas of Electricity market policy, Other energy market policy, and Policy for a sustainable energy system. In addition, there are objectives linked to energy within the Swedish environmental objectives and the policy area of Protection and preparedness for accidents and severe strains.

Examples of how the indicators agree with the three activity areas in the energy policy are shown below. An indicator may have links to more than one activity area. In the next section, Choice of indicators, examples are given of how the indicators are linked to the general energy objectives: secure energy supply, competitiveness, and low impact on the environment.

### General energy policy objectives

Secure availability of electricity and other energy on globally competitive terms.
*See base indicators "3. Degree of self-sufficiency", "5. Power balance", "10. Energy prices to industrial customers, including relevant taxes", "13. Energy prices to domestic customers, including relevant taxes", "18. Electricity price on the Nord Pool spot market".*

Efficient and sustainable energy use.
*See base indicators "2. Use of fossil fuels in relation to the total energy used", "4. Combined heat and power", "8. Energy use of industry per value added", "9. Electricity use by industry per value added", "12. Energy use for heating and domestic electricity/property electricity/operating electricity per unit of area for dwellings and premises" and theme indicator "I. Total renewable energy", "III. Renewable energy in transport" and "IV. Use of renewable energy in dwellings, public services/commercial premises and industry" and "V. Development of bioenergy in the Swedish energy system".*

Efficient energy use in the energy-intensive industry should be promoted, while also safeguarding the competitiveness of industry.
*See base indicators "8. Energy use by industry per value added", "9. Electricity use by industry per value added", "10. Energy prices to industrial customers, including relevant taxes" and "11.Energy cost as a proportion of the total variable costs, in different sectors of industry".*

### Electricity market policy

The objective for the electricity market policy is to achieve an efficient electricity market that generates reliable access to electricity at internationally competitive prices. The objective reflects an effort to achieve a smoothly performing market with efficient utilization of resources and efficient pricing. The objective covers a further development of the joint electricity market in the Nordic countries.

*See base indicators "6. Total market share for the three largest electricity suppliers", "7. Proportion of end customers for electricity who have renegotiated their contracts, including those who have switched to a different electricity supplier", "10. Energy prices to industrial customers, including relevant taxes", "13. Energy prices to domestic customers, including relevant taxes", "18. Electricity price on the Nord Pool spot market" and "19. Total market share of the three largest electricity generators".*

### Other energy market policy

The remainder of the energy market policy is focused principally on other network based energy than electricity, i.e. piped natural gas and district heating. The objective is that the energy policy shall be formulated so that the energy markets will provide reliable access to energy – heat, fuels and motor fuels – at reasonable prices.
*See base indicators "10. Energy prices to industrial customers, including relevant taxes", "11. Energy cost as a proportion of the total variable costs, in different sectors of industry", "13. Energy prices to domestic customers, including relevant taxes" and "14. Energy expenses by households, including motor fuel, in relation to the total expenditure of households".*

The guiding target is that the use of motor biofuel and other renewable motor fuels in Sweden in 2010 shall amount to at least 5.75% of the total use of petrol and diesel fuel for transport purposes, reckoned on the energy content. In January 2008, the European Commission presented its draft directive for renewable energy, which will supersede, among others, directive 2003/30/EC. The directive includes binding targets on every country for 10% renewable energy in the transport sector by 2020.
*See theme indicator "III. Renewable energy in transport".*

### Policy for a sustainable energy system

The objective is that energy should be used as efficiently as possible, taking into account all resources available. Strict demands shall be made on safety and care for health and the environment in the conversion and development of all energy technology.
*See base indicator "4. Combined heat and power", "8. Energy use by industry per value added", "9. Electricity use in industry per value added" and "12. Energy use for heating and domestic electricity/property electricity/operating electricity per unit of area for dwellings and premises".*

The use of renewable electricity shall increase by 17 TWh from year 2002 up to 2016, at the same time as technical development is stimulated and costs are minimized. The target for wind power was set in 2002 and involves planning conditions being provided for expansion by 10 TWh by 2015. The Swedish energy policy emphasizes the importance of increasing the input of energy from renewable sources. This is regarded as an important step in the direction of sustainable development.
*See theme indicators "I. Total renewable energy" and "II. Renewable electric power, district heating and district cooling generation".*

The use of fossil fuels should be maintained at a low level.
*See base indicator "2. Use of fossil fuels in relation to the total energy used".*

### Swedish environmental objectives linked to energy

The total energy use per unit of area heated in dwellings and public/commercial premises is declining. The reduction should be 20% up to 2020 and 50% up to 2050 in relation to the use in 1995. The dependence on fossil fuels for energy supply in the buildings sector shall be broken by 2020, while the proportion of renewable energy will continuously increase.
*See base indicator "12. Energy use for heating and domestic electricity/property electricity/operating electricity per unit of area for dwellings and premises" and theme indicator "IV. Use of renewable energy in dwellings, public services/ commercial premises and industry".*

The average value of Swedish emissions of greenhouse gases in the period 2008–2012 shall be at least 4% lower than the emissions in 1990. The emissions shall be reckoned as carbon dioxide equivalents and shall comprise the six greenhouse gases in accordance with the Kyoto Protocol and the IPCC definitions. The partial target shall be achieved without compensation for take-up in carbon sinks or by means of flexible mechanisms (within the "Reduced climate impact" environmental objective).
*See base indicator "15. Carbon dioxide emissions by sector".*

By 2010, the emissions of sulphur dioxide to air in Sweden shall have declined to 50 000 tonnes (within the "Natural acidification only" environmental objective).
*See base indicator "16. Sulphur dioxide emissions by sector".*

The emissions of nitrogen oxide to air by 2010 shall have declined to 148 000 tonnes (within the “Natural acidification only” environmental objective).
*See base indicator “17. Nitrogen oxide emissions by sector”.*

### Draft European Commission directive on promoting the use of renewable energy

The Swedish energy, environmental and climatic policies are increasingly formed on the basis of collaboration within the EU. In March 2007, the European Council adopted a general target of 20% for the use of renewable energy by 2020 compared to the 2005 level. In January 2008, the European Commission published a draft directive for renewable energy. According to the draft, Sweden’s target amounts to 49% by 2020. The directive also includes binding targets on every country for 10% renewable energy in the transport sector by 2020. The draft directive is being negotiated, and agreement is expected to be reached by the end of 2008.

# Choice of indicators

The energy indicators in this report are divided into three groups: theme indicators, background indicators and base indicators. The theme indicators follow up the energy policy objectives within a special area selected every year. The background indicators do not follow up any energy policy objectives, but their purpose is to provide increased understanding of causality and what it is that drives development in the Swedish energy system. Base indicators follow up energy policy objectives in various policy areas, and are updated every year.

### Indicators for the renewable energy theme[1]

In this year's theme indicators, our point of departure has been the European Commission definition of renewable energy sources in accordance with the draft directive on the promotion of the use of renewable energy[2]. The draft directive is being negotiated in 2008 and agreement is expected to be reached by the end of 2008. This means that the definitions used in this report may have to be adjusted. An example of a definition that may be altered relates to heat pumps.

This year's theme is illustrated by the following indicators:

I. Total renewable energy
II. Renewable electric power, district heating and district cooling generation
III. Renewable energy in transport
IV. Use of renewable energy in dwellings, public services/commercial premises and industry
V. Development of bioenergy in the Swedish energy system

In addition to the theme indicators, there are base indicators that have links to this year's theme. These are mainly Base indicator 1 – Proportion of energy from renewable sources in relation to various types of utilization, and Base indicator 20 – The quantity of motor biofuels and the number of biofuel-fuelled vehicles. This year, these have been replaced by Theme indicators I and II, and Theme indicator III respectively.

[1] For practical reasons, we are using the expression renewable energy in this publication. A more correct statement would be energy from renewable energy sources.

[2] {COM(2008) 19 final}

There are limitations in the statistics that make it difficult to follow up the development of certain renewable energy sources. These limitations include non-commercial energy, i.e. energy that is not sold/purchased on any market such as heat from solar collectors or electricity from solar cells on the roof or from a wind turbine on the site. Another area for which development of statistics is needed is waste incineration. In the current situation, there are no official annual statistics that show the origin of the waste divided onto fossil and renewable constituents. Statistics are prepared every other year for reporting to the EU in accordance with the EC ordinance on waste statistics (2150/2002/EC). The first report was issued in 2006 and covered the statistics for 2004. The problem is that the definition of what can be classified as waste in the waste statistics differs from that in the energy statistics. This makes it difficult to use the waste statistics for estimating the proportion of the incinerated waste that is renewable in accordance with the definition by the Commission in the draft directive for promoting renewable energy. Another area in which statistics need to be developed is the heat extracted by heat pumps. The official statistics show the total heat extracted for district heating generation, but not the various types of heat pumps by means of which the heat is extracted. The heat extracted by small heat pumps (<1MW) is totally lacking in the official statistics. Biofuel statistics also need to be developed to be better able to present the different biofuels used, the sectors in which these are used, and from where the raw material for biofuels originated (forest, forest industry, agriculture, imports, recovery, etc.).

### Background indicators

In addition to the base indicators and theme indicators, a number of "background indicators" are reported, the purpose of which is to provide as complete a picture as possible of the energy system. These background indicators shall hopefully make it easier for the reader to set the other indicators in a wider context. The following background indicators have been selected:

A. Total energy supply by energy carriers, and the energy intensity on the supply side
B. Total final energy use by energy carriers
C. Total final energy use by sectors, and the energy intensity on the utilization side
D. Total energy supplied for electricity generation by energy carriers and by generation technologies
E. Total energy supplied for district heating generation by energy carriers

**Base indicators**

Since many of the energy policy objectives are expressed in general terms and are not quantitative, the choice of indicator is not self-evident. A number of requirements have served as the points of departure in the choice of indicator. The indicators should:

- correspond to one or several objectives, it is not sufficient to show something that is of "general interest"
- be easy to understand
- measure what is intended
- be based on reliable data information, preferably official statistics
- be suitable for expressing in time series
- not be too numerous, i.e. a maximum of 25

A number of base indicators have been evolved on the basis of the energy policy objectives. These base indicators, are numbered from 1 to 20, are updated annually and are developed further in some cases. Since 2002, when the report was published for the first time, some base indicators have been added. The new base indicators have been located last, which may seem inconsistent in some cases, since base indicators related to the same area end up far from one another. In spite of this, we have chosen to retain this numbering of base indicators in order to simplify the comparison of base indicators between the publications in different years. The list below shows the selected base indicators, and the changes made in each indicator compared to the previous year's publication are shown within brackets

The following base indicators have been selected:

1. Proportion of energy from renewable sources in relation to various types of utilization (replaced in this year's publication by Theme indicators I and II)
2. Use of fossil fuels in relation to the total energy used
3. Degree of self-sufficiency
4. Combined heat and power (CHP) generation (has been supplemented with the fuel used for electric power and heat generation in CHP generating stations connected to the district heating system)
5. Power balance
6. Total market share of the three largest electricity suppliers
7. Proportion of end customers for electricity who have renegotiated their contracts, including those who have switched to a different electricity supplier
8. Energy use of industry per value added, in a number of industrial sectors
9. Electricity use of industry per value added, in a number of industrial sectors
10. Energy prices to industrial customers, including relevant taxes
11. Energy cost as a proportion of the total variable costs, in different sectors of industry
12. Energy use for heating and domestic electricity/property electricity/operating electricity per unit of area for single-family houses, multi-family houses and public and commercial premises
13. Energy prices to domestic customers, including relevant taxes
14. Energy expenses by households, including motor fuels, in relation to the total expenditures of households
15. Carbon dioxide emissions by sector (have been supplemented with emission intensity in the form of total emissions of greenhouse gases per GNP and per capita)
16. Sulphur dioxide emissions by sector
17. Nitrogen oxide emissions by sector
18. Price of electricity on the Nord Pool spot market
19. Total market share for the three largest electricity generators
20. The quantity of motor biofuel used and the number of biofuel-fuelled vehicles (replaced in this year's publication by Theme indicator III)

**Previous year theme indicators**

A special theme is chosen every year for following-up the energy policy objectives within a specific area. The table below describes past year themes and theme indicators. Past year theme indicators are included in past year's publications and updating of some of them is shown at the Swedish Energy Agency website www.energimyndigheten.se.

| Year 2003 | Theme: Electricity market | Designation |
|---|---|---|
| Theme indicator I | Price of electricity on the Nord Pool spot market (Base indicator 18 in the 2008 publication) | – |
| Theme indicator II | Proportion of Sweden's electricity use procured on the Nord Pool spot market | T03II |
| Theme indicator III | Limitations in electricity transmission | – |
| Theme indicator IV | Trading margins for electricity supplying companies for sales of purchased electricity to the end customer | T03IV |
| Theme indicator V | Total market share for the largest electricity generators (Base indicator 19 in the 2008 publication) | – |
| **Year 2004** | **Theme: District heating market and natural gas market** | |
| Theme indicator I | Energy use for heating | T04I |
| Theme indicator II | Development of price of district heating in relation to some other important energy carriers for heating | T04II |
| Theme indicator III | Natural gas as a proportion of total energy supplied in Sweden, and for the area in which gas is available | T04III |
| Theme indicator IV | Consumption of natural gas per sector | T04IV |
| **Year 2005** | **Theme: Energy use** | |
| Theme indicator I | Energy use per capita | T05I |
| Theme indicator II | Energy use per sector | T05II |
| Theme indicator III | Energy use for heating per construction year | T05III |
| Theme indicator IV | Energy use for heating | T05IV |
| Theme indicator V | Number of newly registered biofuel-fuelled vehicles and the amount of motor biofuel used (Theme indicator III in the 2008 publication) | – |
| **Year 2006** | **Theme: Oil use** | |
| Theme indicator I | Oil use per sector, total and as a proportion of total energy used | T06I |
| Theme indicator II | Index for delivery volume and price of petrol, diesel fuel and Eo1 fuel oil | T06II |
| Theme indicator III | Oil use for transport per GNP and per fuel type | T06III |
| Theme indicator IV | Transport of goods distributed onto groups of goods | T06IV |
| Theme indicator V | The Swedish vehicle fleet | T06V |
| **Year 2007** | **Theme: Secure energy supply** | |
| Theme indicator I | Long-term marginal costs of oil, natural gas, coal and electricity compared with current market prices | T07I |
| Theme indicator II | Capacities and limitations in electricity transmission links to other countries, and differences in the prices of electricity between the Sweden price area and the system price on Nord Pool | T07II |
| Theme indicator III | Conductor types and interruptions in the electricity distribution network | T07III |
| Theme indicator IV | Flexibility in heating systems in single-family houses, multi-family houses and in premises | T07IV |
| Theme indicator V | Flexibility in district heating generation | T07V |

**The relationship between indicators and their objectives**

The energy policy objectives are subdivided into three areas: security of energy supply, competitiveness and environment. The table below shows to which energy policy objectives the base indicators in this publication apply. There are also indicators for environmental policy objectives since *low negative impact on the environment* is a comprehensive goal of the energy policy. The overall goal of *security of supply* is also an objective in the policy area *protection and preparedness for accidents and severe strains*, since energy supply is considered a service that is vital to our society that must not break down.

Theme indicators from this and previous years are also connected to the objectives below, but have not been included in the table due to space considerations. This year, base indicators 1 and 20, which to some extent are referred to in the table below, are incorporated into, and replaced by, theme indicators I, II and III.

| *Objectives* | *Indicator* |
|---|---|
| **Security of energy supply** | |
| Secure availability of electricity and other energy supplies. | 3, 5 |
| Electricity supply shall be secured by an energy system that is based on durable, preferably domestic and renewable energy sources, and on efficient energy utilization. | 1*, 3, 4 |
| Good quality of electricity supply shall be maintained. | 3, 5 |
| Energy supply shall to an increasing extent be based on renewable energy. | 1* |
| The investments in research, development and demonstration of new energy technologies shall reduce the costs for, and during the next ten years, substantially increase the electricity and heat generation from, renewable energy sources. | 1* |
| Reduce the risk and consequences of accidents and strains on society at a time of peace. | 5 |
| **Competitiveness** | |
| Competitive terms. | 10, 11, 13 |
| Cost-effective Swedish energy supply. | 10, 13 |
| Efficient and sustainable energy use. | 1*, 4, 12 |
| An efficient electricity market that generates a secure availability of electricity at internationally competitive prices. | 6, 7, 10, 13, 18,19 |
| The system for switching between energy suppliers should operate in a satisfactory manner. | 7 |
| Consumers and small- and medium-sized companies shall have sufficient information in order to be able to take advantage of the deregulated electricity market. | 7 |
| Energy should be used as efficiently as possible, taking into account all available resources. | 4, 12 |
| Stable conditions for competitive trade and industry and for the renewal and development of Swedish industry. | 10, 11 |
| Efficient natural gas market with real competition. | 10, 13 |
| Energy markets should provide reliable access to energy – heat, fuels and transport fuels – at reasonable prices. | 3, 5, 8, 9, 10, 11, 13, 14 |
| The use of electricity by industry shall not be restricted by anything other than the prevailing regulations in taxation and environmental legislation. | 5 |
| Efficient energy use in energy-intensive industries should be promoted, while also safeguarding their competitiveness. | 8, 9, 10, 11 |

*** Base indicators 1 and 20 have been replaced by theme indicators I, II and III in the 2008 publication.**

| *Objectives* | *Indicator* |
|---|---|
| **Environment** | |
| Energy supply with a low negative impact on health, the environment and the climate. | 15, 16, 17 |
| Facilitate the conversion to an ecologically sustainable society. | 1* |
| Swedish environmental and climatic objectives shall be taken into account. | 15, 16, 17 |
| The use of fossil fuels should be maintained at a low level. | 2, 20* |
| The total energy use per unit of area heated in dwellings and public/commercial premises should be reduced by 20% by 2020 and by 50% by 2050 compared to 1995 levels. | 12, 15, 16, 17 |
| The use of renewable electricity shall increase by 17 TWh from year 2002 to year 2016. | 1* |
| The proportion of transport biofuels and other renewable transport fuels in Sweden shall by 2010 be at least 5.75 % of all petrol and diesel used for transport purposes, calculated on the basis of energy content. | 20* |

**Source:**
**Budget Bill 2007/08, Expenditure area 21 (Energy)**
**Energy Government Bill 2001/02:143 ”Cooperation for a secure, efficient and environmentally friendly energy supply”, from March 2002**
**Government Bill 2004/05:150 ”Swedish environmental objectives – a joint assignment” from 2005, and Environmental and Agricultural Committee report 2005/06:MJU3**

# Theme 2008: Renewable energy

***The theme in this year's publication is renewable energy. The theme is described by means of five theme indicators and is also illustrated by some of the other indicators.***

# I. Total renewable energy

*The proportion of renewable energy in Sweden in relation to the final energy use has increased steadily since the beginning of the 1990s, and amounted to 43.3% in 2006. Electricity generation contributes most to the proportion of renewable energy in Sweden, principally due to hydropower. The next largest contribution to the proportion of renewable energy comes from the industrial sector. This is followed by district heating generation and the residential sector. The use of renewable energy in the transport sector accounts for a very small proportion of the total use of renewable energy, and so does the use for the generation of district cooling. In total, wood fuel, including liquors[3], is the renewable energy that is used most in Sweden, followed by hydropower, heat extracted by heat pumps, renewable waste, motor biofuels and wind power. Sweden has the highest proportion of renewable energy in relation to final energy use in the whole of the EU, and is among the four countries that have increased their proportion most during the period between 2000 and 2005.**

## Energy policy objectives

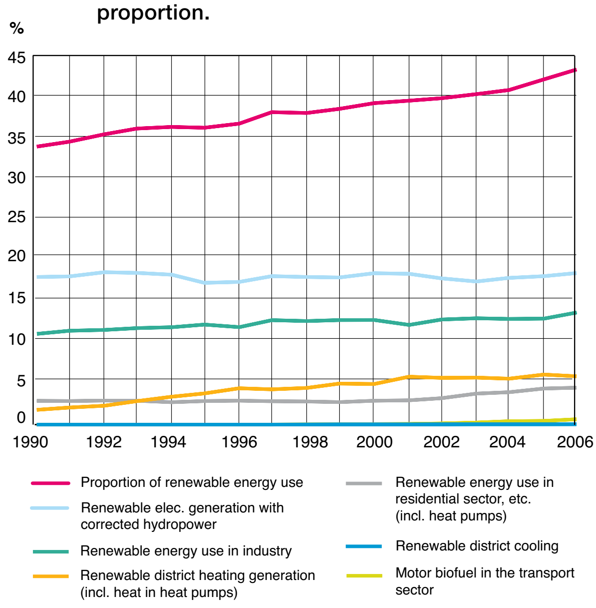
The energy policy objectives emphasize the importance of increasing the proportion of energy from renewable sources and maintaining the use of fossil fuels at a low level. This is regarded as an important step in the direction towards sustainable development. Continued conversion to a sustainable energy system in which the impact on the environment and the climate is minimized and higher security of supply through diversification are two important reasons for promoting the use of renewable energy sources in Sweden. In March 2007, the European Council adopted an overall target of 20% for the use of renewable energy by 2020, compared to the level of 8.5% in 2005.

In January 2008, the European Commission published a draft directive for renewable energy[4]. The draft contains a burden sharing of the 20% target of renewable energy based on the solvency of the various countries (GNP per capita). All countries should increase their proportion of renewable energy by at least 5.75 percentage points, and no country should need to have a proportion in excess of 50%. According to the Commission's proposal, the target for Sweden is 49% in 2020, compared to the Eurostat estimate of 39.8% in 2005. The proposal is in the course of negotiation and an agreement is expected by the end of 2008.

## Trends in Sweden

In this indicator, we used the European Commission definition of the proportion of renewable energy as the basis. According to the definition, the proportion of renewable energy should be reckoned as the ratio of renewable energy (see the facts box) to final energy use, including transmission and distribution losses and use of electricity and heat for electricity and heat generation.

**Figure I:1. Sweden's total proportion of renewable energy, and the contributions of all sectors to the total proportion.**




* Note. In the theme indicators in this publication the word biofuels refers to all fuels (solid, liquid or gaseous) produced from biomass. Biofuels for transport purposes are referred to as motor biofuels or transport biofuels.

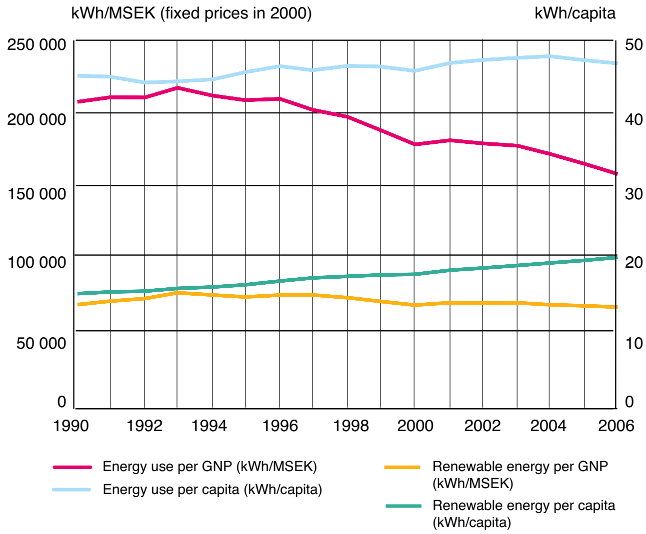
[3] Wood fuel including liquors means here the use in the end-user sector, and also electricity and district heating generation from these fuels according to the numerator definition in the draft directive. Peat is not included.

[4] COM (2008) 19 final. Proposal for a directive of the European Parliament and the Council on the promotion of the use of energy from renewable sources.

The proportion of renewable energy used in Sweden has increased from 33.9% in 1990 to 43.3% in 2006. Out of the 43.3% in 2006, renewable electricity generation accounted for 18 percentage points, the industrial sector for 14 percentage points, the district heating sector for 6 percentage points, the residential and services sector, etc. for 5 percentage points and the transport sector for about 1 percentage point. The contribution of the renewable generation of district cooling as a proportion of total renewable energy in 2006 was negligible. Note that the proportions of renewable energy for the various sectors given in this indicator are calculated in relation to the total final energy use in Sweden, including transmission and distribution losses and use of electricity and heat for electricity and heat generation, and not in relation to the energy use in that particular sector.

The use of renewable energy (numerator) has increased from 130 TWh in 1990 to 183 TWh in 2006. Out of this increase, district heating accounts for the largest part at about 18 TWh, followed by the industrial sector at 15 TWh, the renewable electricity generation at around 9 TWh, the residential sector (incl. heat extracted by small heat pumps) at 8 TWh, the transport sector at 2.7 TWh and finally, the district cooling sector at 0.2 TWh.

**Figure I:2. Renewable energy per GNP and per capita, and final energy use per GNP and per capita from 1990 to 2006**




Sweden's fulfillment of the renewable target is also affected by the magnitude of the energy use. According to the denominator definition in the draft directive, energy use has increased from 385 TWh in 1990 to 423 TWh in 2006, i.e. an increase of

### FACTS Calculations and assumptions for this particular indicator

Defined as renewable energy sources are wind power, hydropower, wave power, solar energy, landfill gas, gas from sewage treatment plants, biogas, the biologically degradable fraction of products, waste and residues from agriculture (including substances of vegetable and animal origin), forestry and related industries, and the biologically degradable fraction of industrial and municipal waste. Peat is not defined as a renewable energy source in the draft directive.

The numerator in the ratio is defined as the sum of renewable power generation, renewable district heating/cooling generation, the use of renewable energy for the generation of heat and cooling in the industrial sector, residential sector (including services, agriculture, forestry and fisheries) and the use of renewable energy in the transport sector. According to the draft directive, the heat extracted by heat pumps (heat generated excluding the energy input for driving the heat pumps) that use geothermal energy is included in the numerator. The heat extracted by heat pumps using ambient heat from the air can be included only if these heat pumps comply with the efficiency requirements in accordance with the eco-labelling[5]. It is still uncertain which energy sources are defined as geothermal energy. The interpretation by the Swedish Energy Agency is that the heat extracted by heat pumps that use surface water, lake-bottom water and heat in rock or soil as the source of heat and those that use ambient air and comply with the requirements in accordance with the eco-labelling can be regarded as renewable energy.

The denominator is defined in the draft directive as the energy use in the industrial sector, residential sector (including services, agriculture, forestry and fisheries) and in the transport sector, plus use of electricity and heat for electricity and heat generation, and transmission and distribution losses in the electricity grid and in the district heating network. The Swedish Energy Agency interpretation is that the energy use for international transport is not included in the denominator.

[5] See ordinance (EC) No. 1980/2000 and decision 2007/742/EC

**Figure I:3. Contribution to Sweden's total proportion of renewable energy from different energy carriers during the period 1990–2006**

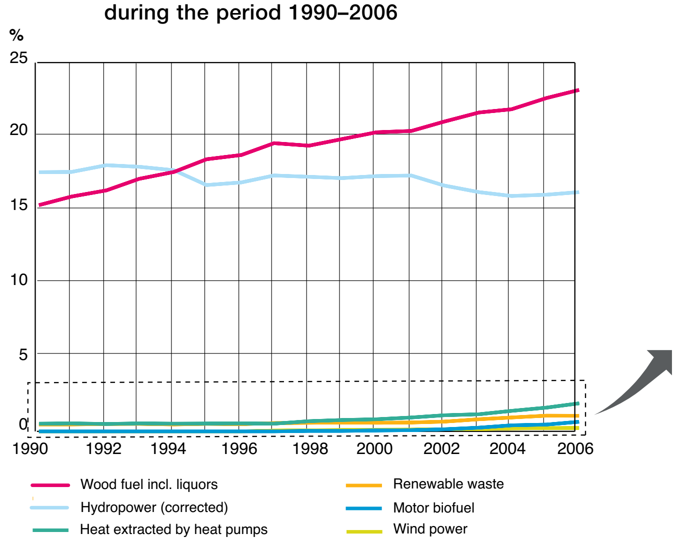
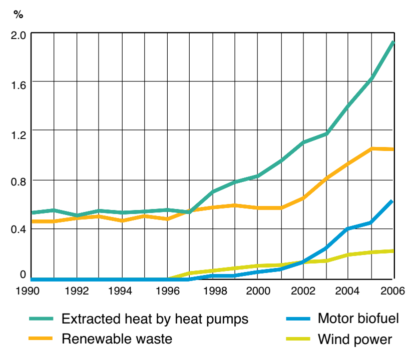



**Figure I:4. Detail from Figure I:3**




38 TWh, which represents an annual increase of 0.58%. Out of the 423 TWh of energy used in 2006, the use in the end-user sectors, i.e. the industrial sector, residential sector and services sector, etc. and in the transport sector accounted for 402 TWh, the transmission and distribution losses in the electrical grids for 11 TWh, the distribution losses in the district heating network for 5 TWh, and the use of electricity for heat and electricity generation for 5 TWh. The latter three items have been very stable since the early 1990s, which means that the increase in the numerator can be explained in its entirety by the increased energy use in the end-user sectors.

It is important to point out that the trends in the development of the numerator and denominator are affected by the weather conditions since, in accordance with the draft directive, it is only hydropower that has been corrected for a normal year. Wind power generation depends on the wind conditions, but no correction has been made in accordance with the draft directive. This may play an increasing role in pace with the increase in the number of wind turbines installed. The energy use for space heating varies with the temperature but, as in the case of wind power, it will not be corrected in accordance with the draft directive.

Energy use in Sweden per GNP has decreased substantially during the period, which means that the economic development during the period between 1990 and 2006 has taken place with a less increase in energy use. On the other hand, the per capita energy use in Sweden has been stable during the period, and so has the renewable energy per GNP. The renewable energy per capita has increased substantially during the period.

Wood fuels, including liquors, are the energy source that has contributed most to the total proportion of renewable energy during the period between 1995 and 2006, and contributed 23 percentage points in 2006 to the total proportion of renewable energy in Sweden. The use of wood fuels, including liquors, has increased by about 39 TWh, which represents 74% of the increase in use of renewable energy. Hydropower accounts for the next largest contribution to the total proportion of renewable energy in Sweden at 16 percentage points in 2006. The ban on developing hydropower in the four large unexploited rivers in Sweden limits the scope available for increased hydropower generation. However, there is scope for efficiency improvement and for new plants in the already developed watercourses. The contribution of hydropower to increased use of renewable energy during the period has been modest and amounts to about 2%. The heat extracted by heat pumps contributes 2 percentage points to the total proportion of renewable energy. The renewable heat extracted by heat pumps has increased by more than 6 TWh and accounts for 12% of the increase in renewable energy. The development in large heat pumps connected to the district heating system differs from the development in small heat pumps in the residential sector, since generation by large heat pumps has decreased somewhat, whereas generation by small heat pumps has increased very significantly and thus has also the heat extracted. Renewable waste[6] and motor biofuels contribute about 1 percentage point each to the total proportion of renewable energy. Each has increased by about 3 TWh and each accounts for about 5% of the increase in renewable energy. The percentage of wind power has increased robustly, but is still at a moderate level and contributes only about 0.2 percentage points to the total proportion of renewable energy, which corresponds to 2% of the increase in renewable energy.

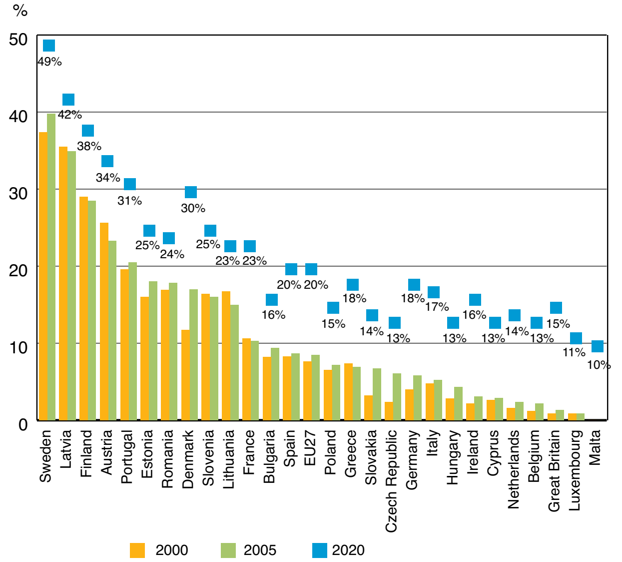
## International perspective

The proportion of renewable energy in Sweden is the highest among EU countries. According to the Eurostat statistics, the proportion in Sweden in 2005 amounted to 39.8%, followed by Latvia and Finland at 34.9% and 28.5% respectively. Great Britain, Luxembourg and Malta had the lowest proportions at 1.3%, 0.9% and 0% respectively. Denmark had by far the highest increase during the period 2000–2005 at 5.5 percentage points, followed by the Czech Republic and Slovakia at 3.7 and 3.5 percentage points respectively. Sweden comes in fourth place with an increase of 2.4 percentage points. There are also countries in which the proportion of renewable energy has decreased during the period, e.g. Austria with the highest decrease at 3.7 percentage points, followed by Lithuania and Latvia with a decrease of 1.7 and 0.6 percentage points respectively. The proportion in Finland has also decreased slightly during the period.

Eurostat statistics have been chosen for this comparison in order to use comparable data. Since information on the proportions of renewable energy for the 27 EU member countries has been published only for the period 2000 to 2005, this period has been used for all comparisons. The proportion in Sweden according to Eurostat calculations differs, for several reasons, by more than 2 percentage points from the calculations by the Swedish Energy Agency for 2005 (39.8% and 42.1% respectively). Eurostat has not included the heat extracted by heat pumps, which explains 1 percentage point of the difference. There are also certain differences in the use of renewable energy in the industrial sector, which explains the remaining difference of 1 percentage point. The differences in the industrial sector are due mainly to the waste heat generated in the industrial sector and used for district heating generation being

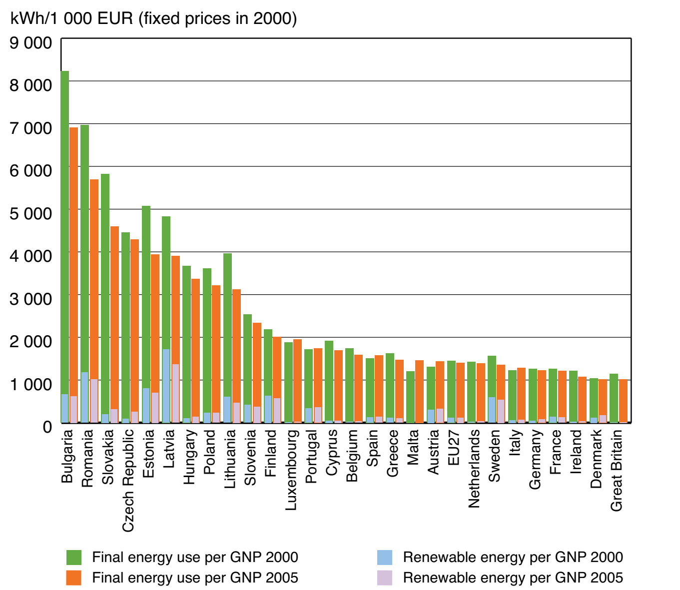
[6] Waste means here the use in the end-user sectors and waste-based electricity and district heating generation according to the numerator definition in the draft directive.

**Figure I:5. Proportion of renewable energy for all 27 EU member states in 2000, 2005 and targets for 2020 according to the draft directive of the Commission**




Source: Eurostat database, Swedish Energy Agency calculations

**Figure I:6. Final energy use, including transmission and distribution losses and use of electricity and heat for electricity and heat generation, per GNP and renewable energy per GNP for the years 2000 and 2005**



handled in different ways in the Swedish official statistics and in the Eurostat balances.

The use of renewable energy in relation to the GNP in 2005 was highest in Latvia, Romania and Estonia and lowest in Malta, Great Britain and Luxembourg. The highest increase in renewable energy per GNP took place in the Czech Republic, followed by Belgium and the Netherlands in which the increased use of renewable energy was 10, 4 and 3 times respectively more than the average of 20% in the EU. The GNP development in the Czech Republic was twice as high as the average for the EU, whereas the development in Belgium and the Netherlands was below average. The highest reductions were in Lithuania, Latvia and Greece, principally due to strong economic development but also due to a lower increase in renewable energy compared with the average for the EU. The use of renewable energy in Sweden per GNP had dropped somewhat between 2000 and 2005.

It is also of interest to see how energy use has developed in the various member states. As regards energy use per GNP in 2005, Bulgaria, Romania and Slovakia display the highest proportions, whereas Ireland, Denmark and Great Britain the lowest. The countries with the highest values in 2000 have reduced their energy use per GNP most during the period, both in absolute terms and in relation to the levels of the countries in 2000. These countries have increased their energy use during the period more than the EU 27 average, but have simultaneously undergone very strong economic development. In the case of Estonia, for instance, the GNP increase was more than five times higher than the average for the EU 27. The energy use per GNP in Sweden in 2005 was among the very lowest. Sweden is the country in which the final energy use, including transmission and distribution losses and use of electricity and heat for electricity and heat generation, decreased most in absolute terms during the period 2000–2005, the reduction being 2%.

### Reasons and relationships

There are several reasons for the proportion of renewable energy in Sweden increasing substantially during the period 1990–2006. Sweden has pursued an active energy policy to enable conversion to a sustainable energy system, in which renewable energy plays a very important role. The carbon dioxide tax was introduced in the early 1990s, which led to substantially lower use of fossil fuels for heating than would otherwise have been the case[7]. The tax has also been a strong contributory reason for biofuel development. The general level of carbon dioxide tax in 2008 is 101 öre*/kg of carbon dioxide. Biofuel is exempt from both carbon dioxide tax and energy tax. Another very important regulatory instrument that directly promotes the use of renewable energy for electricity generation is the green electricity certificate system introduced in May 2003. The objective of the system is to increase renewable electricity generation by 17 TWh by 2016 from 6.5 TWh in 2002. The European system for trading in emission allowances also promotes the use of renewable energy. Waste incineration is also on the increase due to the landfill bans introduced in 2002 and 2005. Other regulatory instruments, such as the climate investment programme (KLIMP), have also contributed to increased use of renewable energy. Within the framework of KLIMP, state investment support has been granted since 2003 for purposes such as transition to biofuels and extension of district heating systems. The conversion support[8] for converting from oil-based heating systems to heat pumps, biofuel-based heating systems or district heating, which was introduced in January 2006 for measures that were to be completed no later than 31 October 2007, is a further example of regulatory instruments that have led to increased use of renewable energy.

The fact that the proportion of renewable energy in Sweden is much higher than the proportion in other countries is not only due to the high Swedish assets of renewable energy, such as hydropower and biomass, but is also due to the pursuit of an active energy policy. This is clear when considering developments from 2000 to 2005, since Sweden is among the four countries in which the proportion of renewable energy has increased most. Further efforts are needed in Sweden to attain the target of 49% in 2020.

* Note. An öre is 1/100 of a SEK

[7] Swedish Energy Agency report on Economic regulatory instruments in the energy sector, an evaluation of its effects on the carbon dioxide emissions from 1990, ER 2006:06

[8] Ordinance (2005:1256) on support for conversion from oil-fired heating systems in residential houses

# II. Renewable electric power, district heating and district cooling generation

*Renewable electricity generation in Sweden in 2006 accounted for 52% of all electricity generation, of which 45% was in large-scale hydropower and just over 5% was power generation from wood fuels and liquors. Wind power, small-scale hydropower[9] and electricity generated from renewable waste each accounted for just over 0.5% of the electricity generation in 2006. The green certificate–entitled electricity generation in 2007 has increased by 6.8 TWh compared to 2002. Renewable district heating generation amounted to 55% in 2006. District heating from wood fuels, liquors, etc. accounted for 43% of all district heating generation in 2006. It is also the renewable district heating generation that has increased most since the 1990s. District heating generation from renewable waste accounted for 8% of all generation in 2006, followed by district heating generation in heat pumps[10], which amounted to 4%. Renewable district cooling generation accounted for 37% of the total district cooling generation, although this is very small in absolute terms.**

### Energy policy objectives

An objective in Sweden and the EU is to increase the proportion of renewable energy in order to achieve a sustainable society. The promotion of electricity generated from renewable energy sources is an important priority for protecting the environment and climate, and for diversifying and securing the energy supply. The EU directive[11] on promoting electricity generation from renewable energy sources in the internal market for electricity aims at increasing the proportion of renewable electricity generation in relation to the use. The directive sets no binding targets, but requires the member states to set national targets and gives reference values for these targets. The national target for renewable electricity generation in Sweden is to increase the annual electricity generation from renewable energy sources in the green electricity certificate system by 17 TWh by 2016 compared to the 2002 level (6.5 TWh), i.e. to a total of 23.5 TWh. The green electricity certificate system has been extended to 2030 and the quota levels have been raised, which is also expected to lead to increased willingness to invest in renewable electricity generation. According to the planning target for wind power, one of the aims is that the siting plans for wind power corresponding to an annual generation of 10 TWh shall have been decided by the municipalities or in the Swedish economic zone by 2015. The Swedish Energy Agency has drawn up a new proposal for a planning target for wind power for 2020 of 30 TWh, of which 20 TWh is wind power on land and 10 TWh is sited offshore. There is no specific target for district heating, although district heating is an area with great potential for efficient use of renewable energy. The Swedish environmental quality objectives (Sustainable forests, Flourishing lakes and streams, etc.)[12] apply also to renewable energy, and they have to be considered during the expansion of renewable energy.

### Trends and analysis – Electricity

The total renewable electricity generation in Sweden in 2006 amounted to about 78 TWh, of which hydropower (corrected) accounted for 69 TWh (about 1 TWh was small-scale hydropower), wood fuel including liquors accounted for just over 7 TWh, wind power for 1 TWh and renewable waste for around 0.8 TWh. The total electricity generation (with corrected hydropower) in the same year amounted to 150 TWh, which means that 52% of all electricity generation in Sweden was renewable.

According to the draft directive, renewable electricity generation consists of corrected hydropower[13], both large-scale

* Note. In the theme indicators in this publication the word biofuels refers to all fuels (solid, liquid or gaseous) produced from biomass. Biofuels for transport purposes are referred to as motor biofuels or transport biofuels.

[9] Small-scale hydropower refers to generation in plants with an installed capacity of less than 1.5 MW.

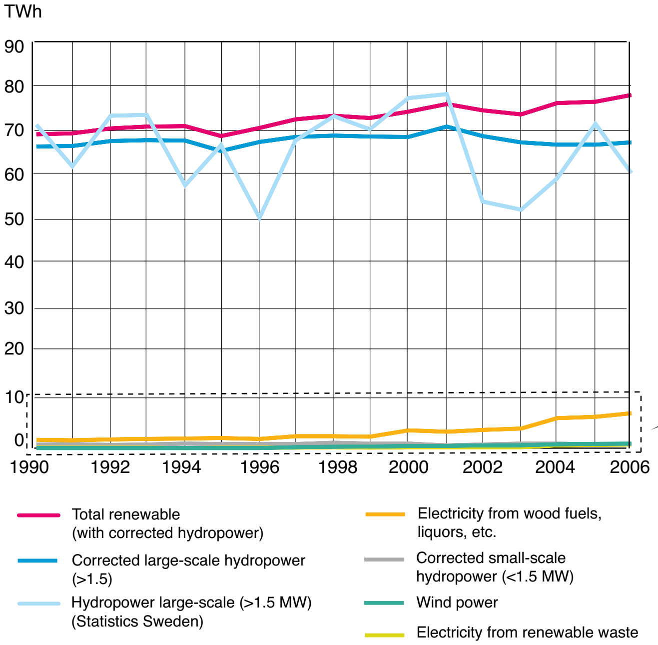
[10] Only heat extracted by heat pumps that are classified as renewable have been included in the calculation. The extracted heat means the heat generated minus the electricity input for driving the heat pumps.

[11] (2001/77/EC)

[12] See www.miljomal.nu

[13] Hydropower should be corrected in accordance with the method described in Annex II in the draft directive. For correction, consideration is given to the installed capacity and an average of the ratio of electricity generated to installed capacity for the past 15 years.

**Figure II:1. Renewable electricity generation in Sweden by energy sources during the period 1990 – 2006**




Source: Statistics Sweden, Swedish Energy Agency calculations

**Figure II:2. Detail from Figure II:1**

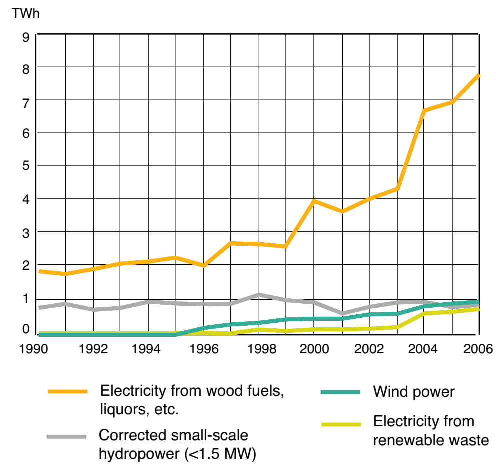



**Figure II:3. Proportion of renewable electricity in relation to the total electricity generated (with corrected hydropower) in Sweden during the period 1990–2006**

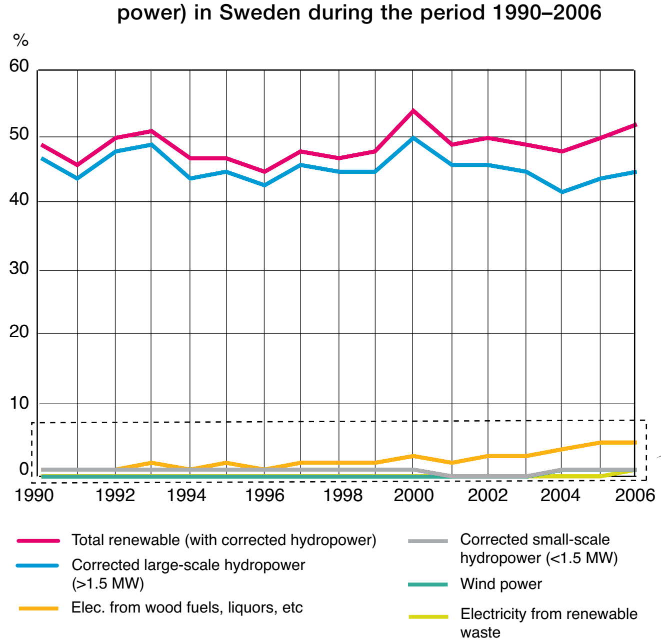
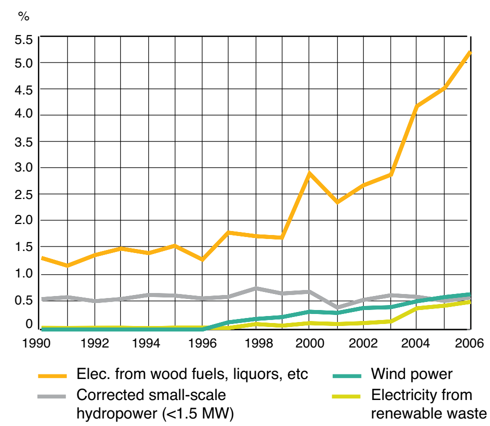



**Figure II:4. Detail from Figure II:3**




Source: Statistics Sweden, Swedish Energy Agency calculations.

and small-scale (<1.5 MW), electricity generation based on wood fuels, including liquors, etc., where peat is not included, renewable waste, wind power, solar electricity and wave power. Waste is associated with the problem of dividing the total quantity of waste into renewable and non-renewable waste. Since there are no annual statistics that employ the definition used in energy statistics[14] in Sweden, the Swedish Energy Agency has used the Eurostat default value of 50%, i.e. the Swedish Energy Agency has assumed that 50% of the energy content of all burned waste for electricity and heat generation can be defined as renewable.

As regards solar electricity, it is important to mention that the official statistics used here do not include the non-commercialized electricity (e.g. solar electricity and small-scale wind power), i.e. electricity generated and consumed without passing through the local, regional or transmission grid. This applies, for example, to solar cells on the roofs of single-family houses, multi-family houses or public/commercial premises, and wind turbines on the site. This type of electricity generation is considered to be currently very small, although development of the statistics in this area is needed.

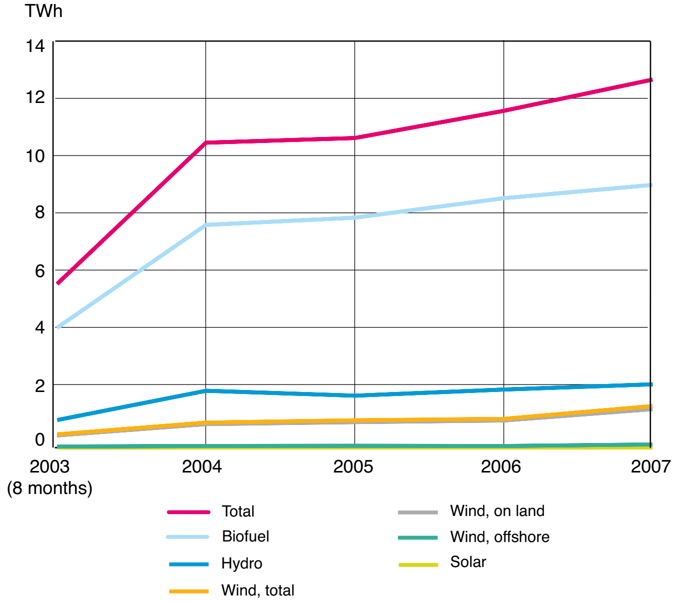
It is also important to mention that the official statistics show somewhat lower renewable electricity generation than the information from the register of the green electricity certificate system. The Swedish Energy Agency has decided to use official statistics that ought to be more comprehensive in the long term, bearing in mind that plants are phased out of the certificate system after 15 years, even though they can continue to generate electricity.

Wood fuels including liquors account for the highest increase in renewable electricity, with an increase of about 6 TWh from 1990 to 2006. Wind power and waste-based electricity generation are also increasing, but still account for a small proportion of the total electricity generation.

The proportion of renewable electricity generation has fluctuated around 50 percent between 1990 and 2006, but an increasing trend has been discernible in recent years. It is mainly electricity generation based on wood fuels and liquors that has contributed to the rise by increasing from 1% of the total electricity generation in 1990 to about 5% in 2006. Small-scale hydropower generation remains at the same level as in 1990.

[14] From 2006, Sweden reports waste statistics in accordance with the EC ordinance on waste statistics (2150/2002/EC) every other year. The first report was issued in 2006 and covered statistics for 2004.

**Figure II:5. Renewable electricity generation in the green electricity certificate system distributed onto hydropower, wind power (on land and offshore) biofuel-based power and solar electricity (peat is excluded).**




Source: Swedish Energy Agency

**Table II:1 Target follow-up of the renewable electricity generation in the green electricity certificate system (TWh)**

| Year | Hydro | Wind | Bio | Solar | Total* |
|---|---|---|---|---|---|
| 2002 | 1.7 | 0.5 | 4.3 | 0.0 | 6.5 |
| 2007 | 2.2 | 1.4 | 9.0 | 0.00002 | 12.7 |
| *Increase* | *0.5* | *0.9* | *4.7* | *0.00002* | *6.2* |

**Note. Peat (approx. 0.6 TWh) is not included*

Source: Swedish Energy Agency

A market-based support system for renewable electricity generation based on green electricity certificates was introduced on 1 May 2003 (see facts box). The purpose of this system is to achieve the national targets for renewable electricity generation and allow for a cost-effective increase in electricity based on renewable energy sources. The green electricity certificate system includes the target of increasing the annual electricity generation from renewable energy sources (and peat) in the system by 17 TWh by 2016, compared to the 2002 level (6.5 TWh), i.e. to a total of 23.5 TWh.

During 2007, electricity generation entitled to green electri-

**Figure II:6. Electricity generation in biofuel plants included in the green electricity certificate system in 2007 (total of 9 TWh) by fuels used**

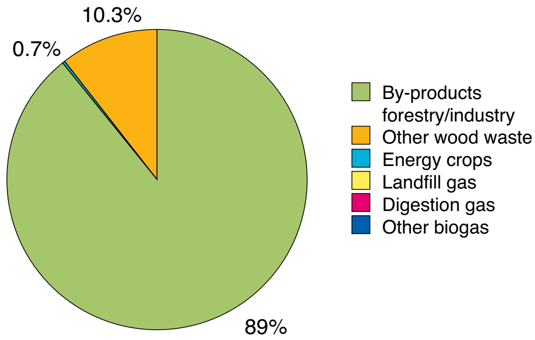
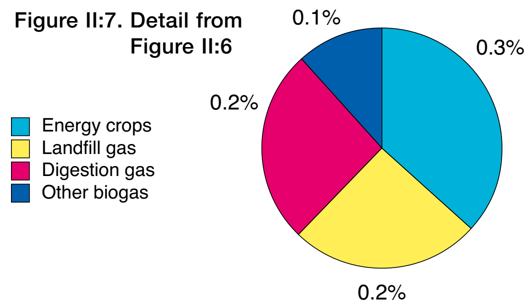



**Figure II:7. Detail from Figure II:6**



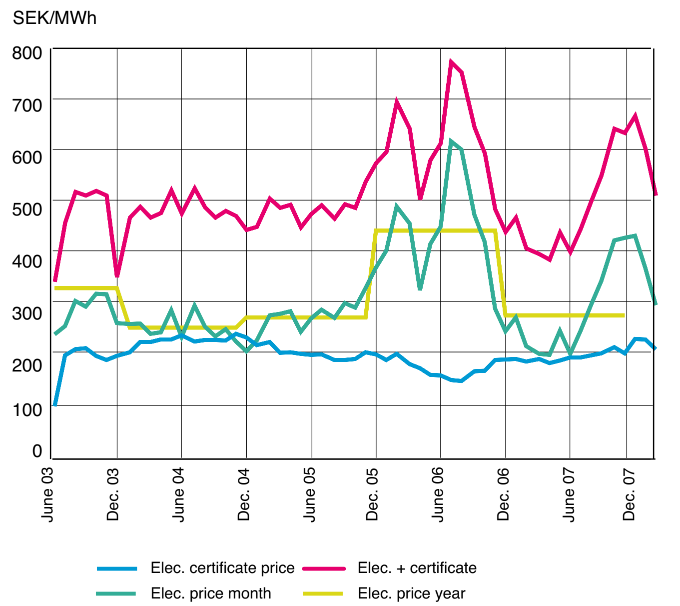

Source: Swedish Energy Agency

city certificates amounted to 13.3 TWh. Peat accounted for 0.6 TWh and electricity generation from renewable energy sources within the green electricity certificate system was 12.7 TWh. Out of these, 6.5 TWh[15] were already available during 2002. Compared with 2002, the renewable electricity generation had increased by 6.2 TWh. Government Bill 2005/6:154 specifies how renewable electricity generation (and peat) is expected to develop year by year up to 2030, based, among other factors, on the quotas that have been set. For 2007, the total generation of electricity from renewable sources and peat was estimated to be 15.46 TWh. The actual yield for 2007 was 13.3 TWh. The increase in the green electricity certificate system in 2007 by 6.8 TWh (including peat) is thus not in phase with the forecasted increase of 8.96 TWh in the Government bill. However, it is an indicative partial target, and the Swedish Energy Agency has estimated that the growth in renewable electricity generation follows the expected development sufficiently well. Just over 10 TWh is lacking before the target of 17 TWh for 2016 is reached.

Biofuel-based electricity accounted for more than 70% of the renewable electricity generation in the green electricity certificate system in 2007, of which industrial back-pressure was highest at 5.6 TWh. Out of the 9 TWh of electricity from bioenergy in the electricity certificate system, by-products from forestry and the forest industry accounted for 89% and the remainder of wood waste for 10%. Biofuel-based electricity has increased rapidly since the green electricity certificate system was introduced. This is due to factors such as the expansion of biofuel-based electricity in industry (industrial back-pressure) and in district heating (combined heat and power), on increased production in the forest industry, with the consequent increase in by-products and the fact that conversion has taken place from fossil fuels to biofuels in order to gain the benefit of the certificates.

The green electricity certificate price (expressed as average

**Figure II:8. Average monthly prices of green electricity certificate transactions between accounts in the Cesar register and of Nord Pool electricity spot prices in the Sweden price area. Also the annual average of the electricity spot price. June 2003 – March 2008. SEK/MWh**




Source: Svenska Kraftnät Cesar register, and the Nord Pool ftp-server.

[15] Particulars of peat in the 6.5 TWh are lacking.

**FACTS Green electricity certificate system**

On 1 May 2003, a market-based support system was introduced for renewable electricity generation based on green electricity certificates. The purpose of this system was to achieve the national objectives for renewable electricity generation, and to allow for a cost-effective increase in electricity based on renewable energy resources. The electricity generator receives one green electricity certificate for every MWh of renewable electricity generated. These certificates can then be sold on the market. The renewable energy sources that are entitled to certificates are wind power, solar energy, geothermal energy, certain biofuels[16], wave energy and certain hydropower[17]. As from 1 April 2004, electricity generated from peat in CHP stations is also entitled to green electricity certificates. All electricity suppliers and certain electricity users must purchase green electricity certificates corresponding to a certain proportion of their electricity sales or electricity use. The proportion of green electricity certificates that should be purchased (quota) is regulated by law and varies from year to year. The quotas are designed so that the system shall be a tool for achieving the objective of increasing the generation of electricity from renewable energy sources (and peat) by 17 TWh by the year 2016 compared to the 2002 level of 6.5 TWh. A time limit has been introduced in the right to be allocated green electricity certificates for the purpose of avoiding costs to the consumers for commercially self-sustaining plants, and so that competition will not be distorted by subsidizing commercially self-sustaining generation. Plants that have been taken into operation after the introduction of the system have the right to green electricity certificates for 15 years, although no later than to the end of 2030. Most of the plants that were in operation when the certificate system was introduced have the right to electricity certificates up to the end of 2012, whereas those that had investment support during 2001–2002 have the right to certificates up to the end of 2014.

The green electricity certificate system is supplemented with transitional rules for wind power in the form of an energy tax deduction (known as environmental bonus) that, during 2007, amounted to 4 öre/kWh for wind power on land and 14 öre/kWh for wind power offshore. The magnitude of the environmental bonus is gradually reduced between 2004 and 2009, and the bonus during 2009 will be 12 öre/kWh for offshore wind power and 0 öre/kWh for wind power on land. The difference in the magnitude of the bonus between land and offshore reflects the higher costs incurred in development offshore. The certificate system replaced the then investment subsidy for investing or modernizing the plant, and the operating support for small-scale power generation, known as “the 9-öre grant”.

[16] Biofuels in accordance with the ordinance (2003:120) on green electricity certificates. Waste gives no entitlement to certificates.
[17] Small-scale hydropower that, at the end of April 2003, had an installed power not exceeding 1 500 kW per generating unit, new plants, resumed operation of shut-down plants, increased generation capacity in existing plants, plants that can no longer produce profitable long-term generation due to decisions by the authority or extensive rebuilding.

price for transactions in the Cesar register) was 21.4 öre/kWh in March 2008. The monthly average price of green electricity certificates has stayed within the range of 15 – 25 öre/kWh since July 2003, and the electricity spot price for the period has stayed at an average of around 32 öre/kWh. This gives an indication of the reimbursement levels for the renewable electricity in the green electricity certificate system. The market believes that these electricity price levels will remain or increase, since the forward prices of electricity for the coming years have been in the range of 40–50 EUR/MWh during the last year.

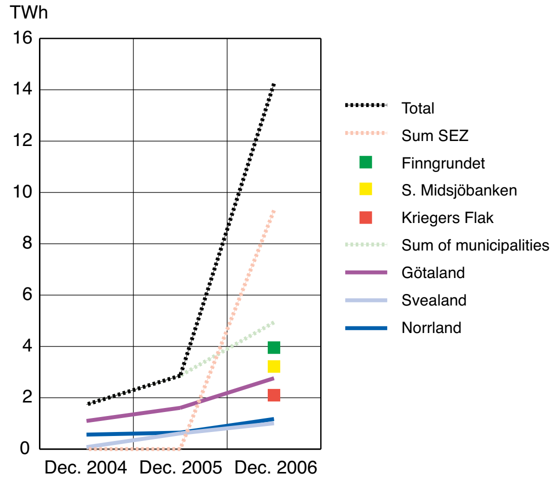
The monthly average prices of green electricity certificates given above are not the same as the current market prices, but are based on information from the Svenska Kraftnät Cesar register, in which the price at which the transaction has been concluded is registered when the green electricity certificate changes account, but in which the sale itself may have taken place earlier. Indicative spot prices for green electricity certificates given by the biggest broker on the green electricity certificate market show that the prices of green electricity certificates have increased since the end of 2007. These spot prices of electricity certificates, expressed as monthly average values, have been within the range of 25–31 öre/kWh during the first four months of 2008, which may partially be due to the fact that the market has perceived that the accumulated surplus of green electricity certificates is decreasing.

Electricity generation from renewable energy sources can be increased by building new plants or by uprating existing plants. Out of all the plants in the green electricity certificate system, a total of 470 are new plants that have been taken into operation since the beginning of the system on 1 May 2003 and up to the end of December 2007. Out of these, wind power accounts for 365, biopower for 29, hydropower for 73 and solar electricity for 3 plants. During 2007, these plants generated about 1.6 TWh. The plants that were taken into operation since 2002 generated about 2.3 TWh of electricity in 2007. The increase in the plants that have been in operation before 2002 will thus be around 3.9 TWh, excluding power generation from peat.

A planning target for wind power was set in 2002[18], whereby planning conditions shall be available by 2015 for expanding wind power by 10 TWh. The planning target for wind power involves creating conditions in public planning for generating annually a certain number of TWh of electricity from wind power. This provides signals concerning the amount of wind power to be managed in the physical planning, so that planning preparedness is created in the general municipal plans by the municipalities identifying and deciding on suitable areas for wind power. The actual construction of wind power will probably be lower than the planning target, since the planning target reflects the situation with really good economic conditions for investments in wind power. The planning target should create incentives for measures that ensure that matters such as siting of wind power in good wind locations or access to transmission and distribution capacity in the electricity grid will not be obstacles to quick expansion.

Wind power in Sweden generated around 1.4 TWh of electricity in 2007. In December 2006, the possible annual generation of electricity in areas that are allocated to wind power in the siting plans of the municipalities amounted to 4.9 TWh, and the planning level offshore in the Swedish economic zone (SEZ) was just over 9.3 TWh, which totals 14.2 TWh. The planning target can therefore be regarded as having good prerequisites for attainment, even though other parameters, such as planning of network connection, must also be in place for the planning target to be achieved. It would be difficult to state when possible commissioning of the wind power followed-up in the planning target could take place. This varies widely from county to county, but is probably largely in the period 2011–2015. In some cases, it may be appreciably closer in time. The Swedish Energy Agency has carried out an overview of the existing planning target and has produced a new proposal for a planning target of 30 TWh of wind power by 2020, of which 20 TWh is wind power on land and 10 TWh offshore.[19] The Swedish Energy Agency considers that areas for wind power

**Figure II:9. Possible annual electricity generation in areas that are allocated in plans for wind power, according to the Swedish Energy Agency follow up (Goverment Bill 2001/02:143)**




Source: Swedish Energy Agency

corresponding to 10 TWh on land should be planned no later than 2010 and the remaining 10 TWh no later than 2012. There are already plans for about 9 TWh offshore. However, the work of planning offshore should continue with the aim of finding optimum areas. To achieve construction corresponding to the new planning target proposal, the conditions needed are a quicker permission process, a more ambitious quota obligation in the green electricity certificate system, special support for offshore wind power, and more regulating power.

## Trends and analysis – District heating

The total renewable district heating generation in 2006, excluding district heating generated by renewable waste heat and with renewable electricity in electric boilers, amounted to 25 TWh, of which 20 TWh were generated with wood fuel, including liquors, etc., more than 3.5 TWh with renewable waste and more than 1.5 TWh was renewable heat extracted by heat pumps.

According to the draft directive, renewable district heating generation is defined as generation that is based on wood fuel, including liquors, etc., renewable waste and heat extracted by heat pumps that use geothermal energy. District heating generation based on waste heat of renewable origin, such as most of the waste heat from the pulp and paper industry, is not regar-

[18] Government Bill 2001/02:143

[19] Report entitled ”New planning target for wind power for 2020”, ER2007:45

**Figure II:10. Renewable district heating generation in Sweden by energy source during the period 1990–2006**

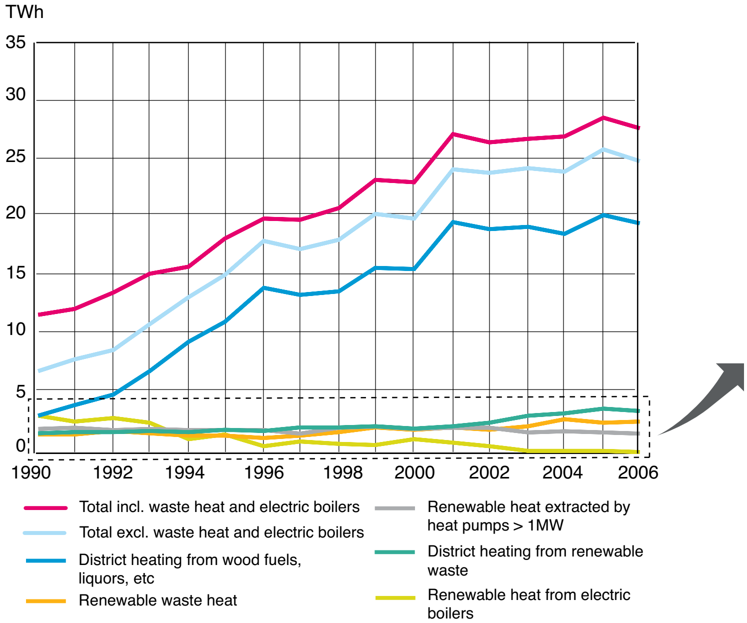
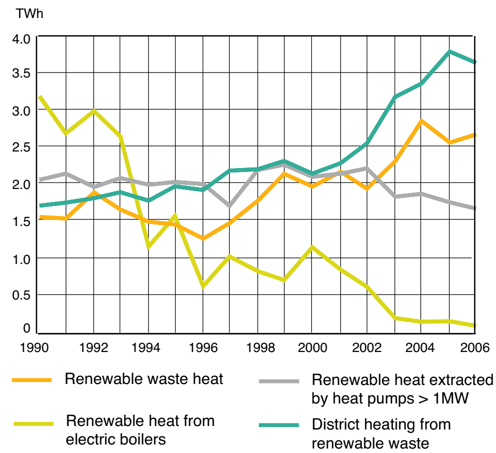



**Figure II:11. Detail from Figure II:10**




Source: Statistics Sweden and Swedish District Heating Association, Swedish Energy Agency calculations.

**Figure II:12. Proportion of renewable district heating generation in relation to the total district heating generation, excluding district heating based on waste heat and electric boilers.**

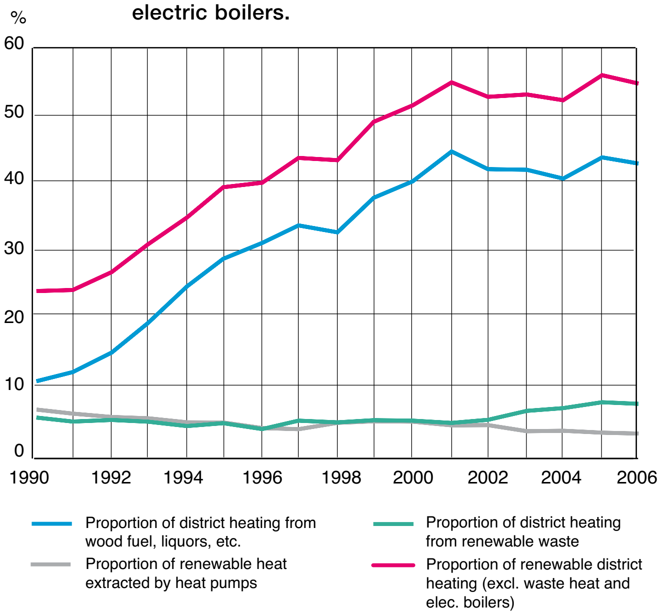
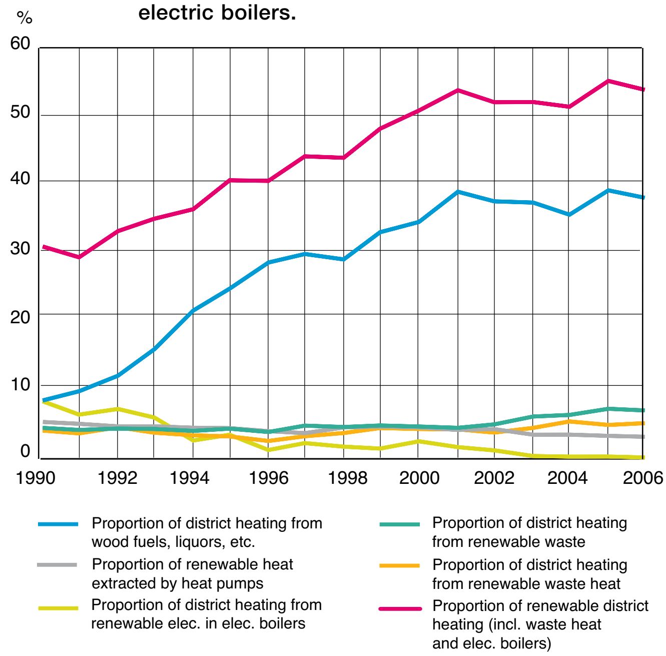



**Figure II:13. Proportion of renewable district heating generation in relation to the total district heating generated, including district heating based on waste heat and electric boilers.**



ded as renewable. Renewable electricity used in electric boilers (almost none in 2006) is included either in the power generation sector or in the district heating sector, but not in both.

District heating generation from renewable waste heat accounted for around 3 TWh in 2006, which represents 0.7% of the final energy use of 422 TWh according to the definition in Theme indicator I.

The total district heating generation in 2006 amounted to just over 51 TWh, of which 39.6 TWh was fuel-based, 5.9 TWh was generated by heat pumps, 5.7 TWh consisted of waste heat and only 0.1 TWh was generated in electric boilers. Out of the total generation, 46.4 TWh was used in end-user sectors, i.e. residential and services sector and in industry, and 5 TWh consisted of losses in the district heating network.

The proportion of renewable district heating generation, excluding waste heat and electric boilers, in relation to the total district heating generation, excluding waste heat and electric boilers, amounted to 55% in 2006. If district heating generation from waste heat and electric boilers is included in the calculation, the proportion will instead be 54%.

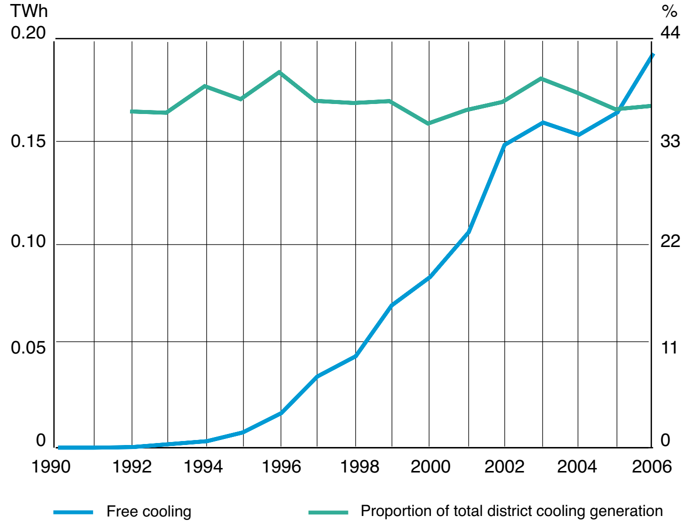
The different definitions lead to almost the same proportion of renewable district heating at 55% and 54% respectively. The remainder of district heating is generated by natural gas, fossil waste, coal, coking oven and blast furnace gases, peat and oil products.

The draft directive includes no definitions of how the proportions of renewable energy for different sectors shall be calculated, except for the transport sector that has a special target of 10% of renewable energy. For Sweden, it is difficult to report sectors individually, since there are energy carriers that are first used in one sector and then again in other sectors, such as waste heat generated in industry and then used in the district heating sector as input for conversion into district heating and then in the residential sector, for example, as district heating.

### Trends and analysis – District cooling

The total generation of district cooling in 2006 amounted to about 0.8 TWh. Out of this, about 0.2 TWh was generated from free cooling energy, i.e. cold water in lakes, etc., which is defined as renewable energy according to the Swedish Energy Agency interpretation. The draft directive has no definitions for renewable energy sources used in the generation of district cooling. District cooling generated by heat pumps and by the absorption principle has not been included as renewable. In 2006, district cooling generated by refrigeration machines

**Figure II:14. Renewable district cooling generation during the period 1990–2006**




accounted for 52% of the generation, and this district cooling is not defined as renewable energy. Just over 37% of district cooling generation in 2006 was renewable.

### Reasons and relationships

Development towards a more renewable electricity and district heating sector is affected to the greatest extent by developments in generation costs, price of electricity and support systems. It is also important how administrative procedures, e.g. for permit appraisal, perform. Another important matter is the connection to the electricity grid, which is particularly relevant for plants located in sparsely populated areas, such as wind power in the highlands or offshore.

According to the Elforsk report entitled ”Electricity from new plants in 2007”, the highest cost increase from 2003 has taken place in biofuel-based CHP generation, so that it now approaches the cost range for coal-fired condensing power. In

**Table II:2 Generation costs for different types of renewable electricity generation**

| | |
|---|---|
| Biopower (CHP) 80 MW | 50 – 70 öre/kWh |
| Wind power (on land) 40 MW | 30 – 50 öre/kWh |
| Wind power (offshore) 750 MW | 65 – 102 öre/kWh |
| Hydropower, 90 MW | 15 – 30 öre/kWh |

Source: Elforsk report entitled “Electricity from new plants in 2007” spite of this, biofuel-based power generation accounts for the highest increase.

Out of the support systems, the green electricity certificate system is what has mainly led to increased biofuel-based electricity generation. On the heat side, it is mostly the carbon dioxide tax that has steered developments towards a more biofuel-based district heating system.

The times involved in the permit processes are usually mentioned as a factor that makes it more difficult to expand renewable energy. An investigation[20] has been set up to suggest organizational and legislative changes for coordinating and simplifying the rules and organization in the field of environmental legislation (Environmental Code, and Planning and Building Act). A general purpose of the investigation is to improve the efficiency of environmental assessment, i.e. make it quicker and simpler. The point of departure is that the processing times should be made as short as possible, without making it more difficult to achieve the environmental objectives or disregarding the right of the general public to insight and participation. The investigation is continuing during 2008, and it is proposed that the new rules should come into force on 1 January 2009.

The Network Connection Investigation submitted its report[21] in February 2008. Some of the proposals of the investigation are that a fund should be set up for financing the connection of new plants that have high connection costs and that meet the requirements for awarding green electricity certificates, and that small[22] electricity generators should be relieved of the hourly metering requirement. The investigation also contains administrative guidelines for the connection of renewable electricity. The Government Offices are currently studying the proposals and a decision is expected during the year, which means that changes in legislation may not come until some time during 2009. The proposals are expected to give better conditions for the connection of renewable electricity generation. The sources of energy that will presumably be favoured most if the proposals are adopted in law are wind power and small-scale solar electricity generation, since their connection costs will be reduced significantly if the hourly metering requirement is withdrawn.

The planning target for wind power is aimed at creating preparedness for handling permit processes and connection issues for wind power.

Although the times in the permit processes are long and the efficiency of the processes must be improved, the environmental quality objectives also apply to renewable energy, and consideration must be given to the environment in the expansion of renewable energy. The energy conversion in flowing energy sources, such as wind power, hydropower and solar electricity, produce only very small emissions or none at all, since no fuel need to be used. When energy conversion takes place by combustion, this leads to emissions of gases and particles with varying negative environmental and hygienic effects, depending on the fuel. For biofuels, the carbon dioxide emissions are regarded as climate neutral since, during their growth period, these fuels have absorbed roughly the same amount of carbon dioxide as that emitted during combustion.

Wind power and hydropower contribute to meeting the climate objective and indirectly to meeting several other national environmental objectives. But wind power can affect the surroundings by means such as changing the landscape and by emitting noise. For hydropower, consideration must be given to factors such as the environmental objective of Flourishing lakes and streams. Biopower contributes to meeting the climate objective as long as the use of biomass for energy conversion does not exceed the growth rate. Biopower causes certain greenhouse gas emissions associated with felling, processing and transport necessary in conjunction with the utilization of biofuels, but compared to fossil power, biopower offers a $CO_2$ emission reduction of the order of 97%[23]. Biopower can influence the Sustainable forests environmental objective. It is important for the extraction of forest fuel to be made with due consideration given to, for example, biological diversity and regrowth of the forest.

Since 1 October 2003, electricity generators have had the right to be granted guarantees of origin for the electricity generated by using renewable energy sources. A guarantee of origin is a document that confirms that a certain amount of renewable electricity has been generated during a specific month. Guarantees of origin have been introduced to provide electricity generators with a document that proves that the electricity generated is renewable, principally for marketing reasons. The purpose is also for the guarantees of origin to enable electricity customers to make an active choice of electricity supplier and be able to choose a certain origin of the electricity purchased.

[20] Environmental Process Investigation M2007:04

[21] Better contact via the network – on the connection of renewable electricity generation, SOU 2008:13

[22] Small generators are regarded here as generation plants that are connected to low-voltage networks with a fuse rating not exceeding 63 ampere.

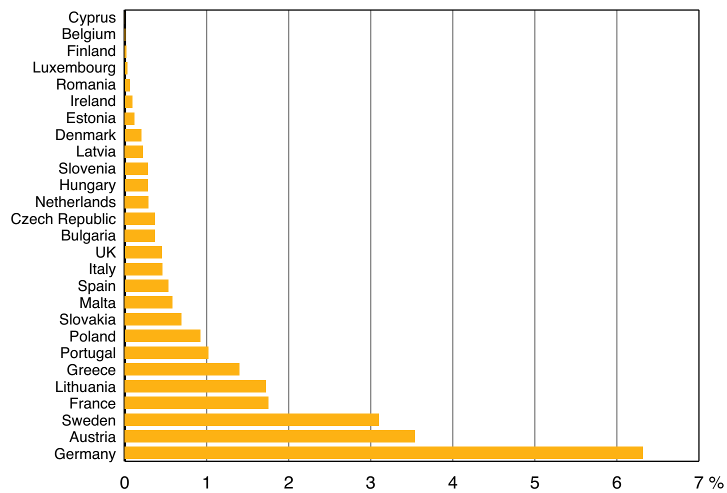
[23] Source: The Swedish Environmental Management Council

The EU draft directive on promoting the use of renewable energy opens the opportunity for trading in guarantees of origin between member states. This is intended to enable member states to achieve the target set for renewable energy by 2020 in a more cost-effective manner. The draft specifies that electricity and heating/cooling generation for which renewable energy sources are used shall be awarded standardized guarantees of origin. The guarantees of origin can then be used for enjoying support (e.g. feed-in, electricity certificates) or for labelling of origin. According to the draft, it shall be possible to trade in guarantees of origin between companies in the various member states, and also between member states. When trading in guarantees of origin across national borders, settlement shall take place from the renewable energy utilization of the selling member state to that of the buying member state.

# III. Renewable energy in transport

*The proportion of motor biofuel reckoned in energy content was 4.0% in 2007. Only two countries in EU 27 had a higher proportion than Sweden. It is the low-additive FAME that accounted for the highest increase last year, followed by highly concentrated ethanol. But low-admixture ethanol still accounts for the highest proportion of motor biofuel use. The number of passenger cars that can be run on predominantly renewable energy increased by 65%, but comprises only just over 2% of the total number of registered passenger cars. Just over 29% of the filling stations in the country sold renewable motor fuel in January 2008. The petrol-equivalent price of E85 has been lower than the price of petrol, with the exception of a period at the end of 2006 and beginning of 2007.**

**Figure III:1. Proportion of motor biofuels in EU-27 in 2006**




Source: Report in accordance with EC Directive 2003/30/EC, Swedish Energy Agency calculations.

## Energy policy objectives

EC Directive 2003/30/EC on the promotion of the use of motor biofuel or other renewable motor fuels gives general guidelines for the introduction of motor biofuels. Indicative targets for the EU of 2% motor biofuel by 2005 and 5.75% by 2010 are expressed. The target shall be set by each member country on the basis of reference values for the Community as a whole, and refers to the energy content of the petrol and diesel fuel for transport replaced on the market. Sweden set a target of 3% for 2005 and 5.75% for 2010. In January 2008, the European Commission presented its proposal for a directive on renewable energy intended to replace Directive 2003/30/EC and others. The Directive includes binding requirements on every country for 10% renewable energy in the transport sector by 2020. Sustainability criteria are also set, which must be met if a motor biofuel is to be regarded towards the target. The directive is now being negotiated between the member states and in the European Parliament and a decision is expected by the end of 2008. Clarifications of the target definitions and certain changes in the sustainability criteria can be expected.

## Trends and analysis

### USE OF RENEWABLE ENERGY IN TRANSPORT

The Directive from 2003 is aimed at promoting the use of motor biofuel that would replace petrol or diesel fuel for transport applications. The proportion of motor biofuel reckoned as energy content was 4.0% in 2007[24], corresponding to 3.6 TWh, which is an increase of 0.9 TWh or 0.9 percentage points on the year before. The renewable motor fuels used to any major extent in Sweden are bioethanol, FAME[25] and biogas. The ethanol, FAME and biogas motor biofuels are set in relation to the sum of petrol, diesel fuel and motor biofuels.

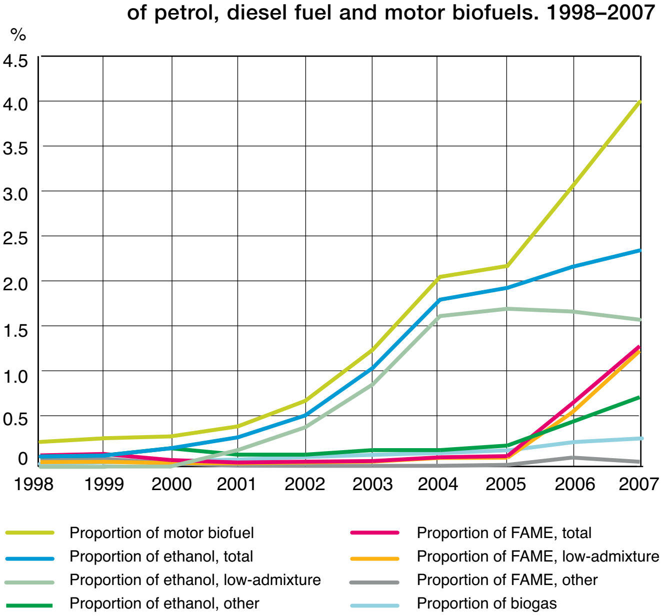
From among the countries in EU 27, it is only Austria and Germany that have higher proportions of motor biofuel than Sweden. In 2006, other countries were at levels substantially below 2%.

* Note. In the theme indicators in this publication the word biofuels refers to all fuels (solid, liquid or gaseous) produced from biomass. Biofuels for transport purposes are referred to as motor biofuels or transport biofuels.

[24] According to preliminary statistics of motor fuels for transport applications, Monthly fuel statistics, Statistics Sweden. Final statistics of motor fuel consumption for transport applications in 2007 will be published on 22 December 2008. It is primarily diesel fuel that usually deviates from the final statistics. In 2006, diesel fuel for transport applications was about 0.1 million $m^3$ lower in the final statistics. This means that the proportion of motor biofuel will be somewhat higher if final statistics are used. The difference is due to the fact that the diesel fuel consumption of certain commercial vehicles is included in the preliminary statistics, but these must not be included in the statistics for transport applications.

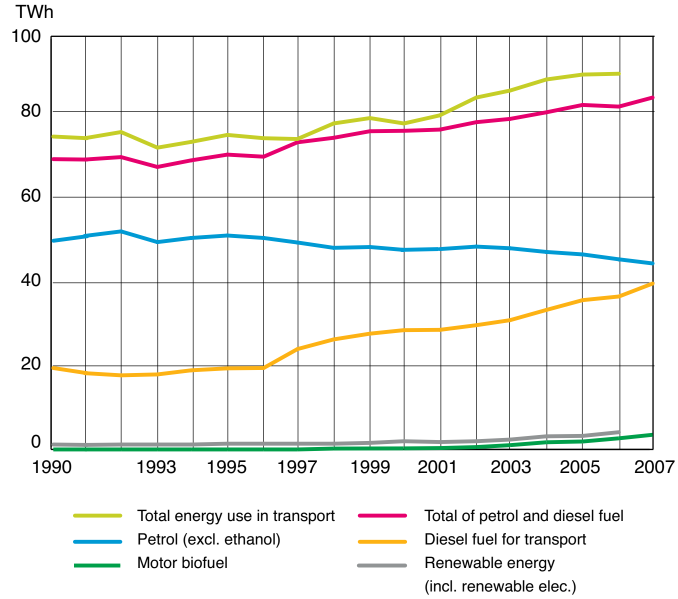
[25] FAME stands for Fatty Acid Methyl Ester. The most common in Europe is Rape Methyl Ester (RME).

**Figure III:2. Proportion of motor biofuel in relation to the sum of petrol, diesel fuel for transport and motor biofuel reckoned as energy content, % (2003/30/EC). Also divided into low-admixture ethanol, ethanol in highly concentrated form, low-admixture FAME, FAME in highly concentrated form and biogas as a proportion of petrol, diesel fuel and motor biofuels. 1998–2007**




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

**Figure III:3. Total final energy use (incl. electricity) for domestic transport applications and the use of petrol, diesel fuel and renewable energy (renewable electricity, ethanol, FAME, biogas) in 1990–2006/07, TWh**




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

The use of motor biofuel in Sweden increased by more than 30 percent between 2006 and 2007. The low-admixture FAME accounts for the highest increase during last year, followed by highly concentrated ethanol. But the low-admixture ethanol still accounts for the highest proportion of motor biofuel use.

Low admixture FAME increased substantially during the past two years, after it became possible to add 5% FAME to diesel fuel.[26] The proportion of diesel fuel that has low admixture has also increased. During 2007, 67% of all diesel fuel delivered had low admixture, which is an increase from 29% in 2006 and 11% in 2003. A total of 1.2 TWh of FAME was used in 2007, which is twice the amount in the year before. FAME in highly concentrated form contributed 0.05 TWh.

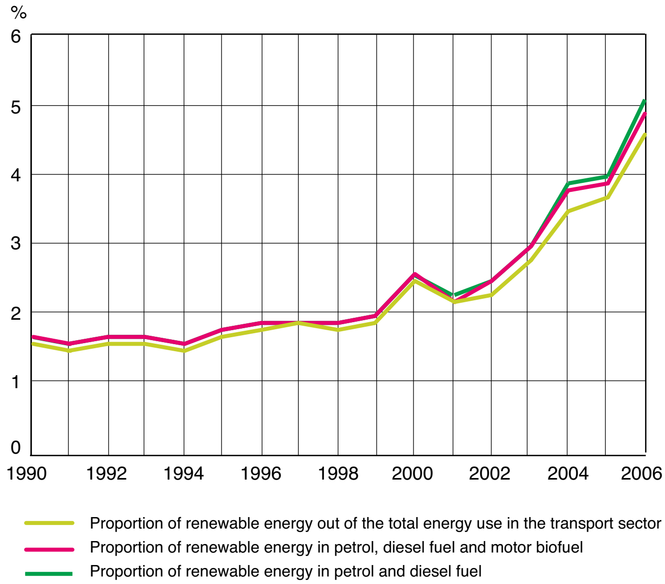
93 percent of all petrol had low admixtures of ethanol (5%) in 2007, and the proportion of low admixture thus continues to increase. But since petrol use has dropped two years in succession, the absolute quantity of low-admixture ethanol has dropped. In 2007, 1.4 TWh of low-admixture ethanol was used. The Swedish law on motor vehicle exhaust gas treatment and motor fuels and the EU fuel quality directive[27] restrict the low admixture to 5%. There is now a proposal for altering the EU fuel quality directive to allow a low admixture of up to 10%, which means that the quantity of low admixture ethanol is expected to increase. This, in turn, presupposes that the physical availability of ethanol in Sweden and the remainder of the world will be sufficiently high. However, running cars that have been type approved for petrol on petrol with 10% ethanol admixture is not entirely without problems. Even though most of the cars in the existing vehicle population are expected to cope with such an admixture, the German association of foreign car manufacturers states that about 3 million cars in Germany could not cope with the admixture. In Brazil, all petrol purchased at filling stations is mixed with 20–25% of ethanol, and cars are designed to cope with this. In the USA, low admixtures of up to 10% of ethanol are used in many states.

The total ethanol use in Sweden has increased steadily during the 21st century, which in the past two years can be

[26] As from 1 August 2006, low admixture of 5% (by volume) of FAME in diesel oil is permissible. The admixture permitted previously was 2%.

[27] Directive 98/70/EC

**Figure III:4. Use of renewable energy in the transport sector (ethanol, biogas, FAME, renewable electricity) as a proportion of the total energy use in the transport sector, as a proportion of petrol and diesel fuel, and as a proportion of petrol, diesel fuel and motor biofuel, %. 1990–2006**




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

ascribed mainly to the increased use of E85. The use of ethanol in highly concentrated form has increased by 60% last year and amounted to 0.68 TWh in 2007. The total ethanol use increased by 12% to 2.1 TWh.

In 2007, 0.28 TWh of biogas were used as motor fuel, which is 20% more than the year before.[28] Out of the biogas production in 2006, 19% were used as vehicles gas.[29]

The transport sector (domestic) accounts for almost one quarter of the country's total final energy use. The energy use in the transport sector has increased steadily during the 21st century, but tapered off slightly in 2006. Petrol and diesel fuel dominate as energy carriers in the transport sector, with a proportion of total energy use of about 90% in 2006.[30] It is mainly diesel fuel that has increased, while the petrol use is dropping. During the past decade, the energy use in the transport sector has increased by around 15 TWh, of which motor biofuels have contributed 2.7 TWh up to and including 2006 and 3.6 TWh by year 2007.

In 2006, 2.9 TWh of electricity[31] were used in the transport sector. In the new draft directive, the numerator in the binding 10% target is broadened to apply to renewable energy in the transport sector, unlike the directive from 2003 in which the calculations include only motor biofuel that replaces petrol and diesel fuel. Out of the total energy use for domestic transport in 2006, renewable energy (renewable electricity[32], ethanol, FAME and biogas) accounted for 4.6%. The proportion of renewable energy in petrol and diesel fuel use was 5.1%, and the proportion was 4.9% if biofuels are also included in the denominator.

### VEHICLES THAT CAN BE RUN ON PREDOMINANTLY RENEWABLE ENERGY

At the 2007/2008 turn of the year, there were around 4.3 million passenger cars on the roads in Sweden, of which about 92 000 were passenger cars that could be run on predominantly renewable energy.[33] The number of passenger cars run on renewables increased by 65 percent from the year before, but still only represent just over 2 % of the total number of registered passenger cars. By way of comparison, the proportion of diesel fuelled passenger cars had increased at the 2007/2008 turn of the year from 6.2% to 8.3%.

Ethanol E85 can be used as fuel in cars with so-called flexible fuel engines (also known as flexifuel cars). The engine can run on any mixture of petrol and ethanol. E85 consists of 85 percent ethanol and 15 percent petrol. Petrol is mixed into the ethanol in order to improve the starting characteristics and the cold-start emissions. In the past, motorists experienced certain problems when starting from cold during the winter months,

[28] According to Swedish Gas Association statistics on the quantities of vehicle gas that gas tank stations stated they have sold.

[29] Production and consumption of biogas in 2006, ER 2008:02

[30] The remainder consists of electricity, fuel oils, aircraft fuel, other light and medium oils, natural gas, propane and butane.

[31] Electricity was used in rail traffic (railways, underground trains and trams). The electricity consumption of electric cars (plug-in) is not included in the statistics, but is still very low.

[32] The renewable electricity has been calculated from the total final electricity consumption of the sector, multiplied by the renewables proportion of the total electricity generation (with corrected hydropower).

[33] The vehicles referred to here are vehicles that can be run on a predominant part of ethanol, biogas or electricity. The number does not include hybrids. Vehicles that can be run on 100% FAME are not included either, since they are originally built and approved for standard diesel fuel and cannot be distinguished in the vehicle register from other diesel vehicles, and since the use of pure FAME is relatively modest. According to Bil Sweden, 100% FAME cannot be used in any of the new vehicles sold today, with the exception of certain Scania truck models. However, certain older passenger car and truck models have been cleared by the manufacturers for running on pure FAME.

**Table III:1 Number of registered vehicles that can be run predominantly on electricity, ethanol and biogas, divided into passenger cars, buses, light trucks and heavy trucks. 31 December 2003–2007**

| | 2003 | 2004 | 2005 | 2006 | 2007 |
|---|---|---|---|---|---|
| Passenger car, electric | 179 | 144 | 123 | 118 | 126 |
| Passenger car, ethanol | 4 417 | 9 604 | 21 310 | 46 542 | 80 931 |
| Passenger car, gas | 2 876 | 3 917 | 5 847 | 9 242 | 11 001 |
| Light truck, electric | 275 | 260 | 241 | 207 | 188 |
| Light truck, ethanol | 15 | 33 | 105 | 223 | 411 |
| Light truck, gas | 563 | 601 | 741 | 1 282 | 1 926 |
| Bus, electric | 16 | 16 | 13 | 9 | 9 |
| Bus, ethanol | 399 | 379 | 366 | 490 | 491 |
| Bus, gas | 479 | 553 | 641 | 790 | 799 |
| Heavy truck, electric | 1 | 2 | - | - | 1 |
| Heavy truck, ethanol | 3 | 3 | 2 | 2 | 2 |
| Heavy truck, gas | 198 | 225 | 258 | 315 | 356 |

Source: Swedish Road Administration

but this is no longer a problem, since oil companies supply a winter grade of E85 during this period, and this contains a higher admixture of petrol. Vehicles that can be run on gas usually have two tank systems – one for petrol and one for gas (these are known as bifuel cars). Motor gas may be upgraded biogas or natural gas or any mixture of the two. Electric cars have batteries that are charged from the mains power supply and are driven only by an electric motor.

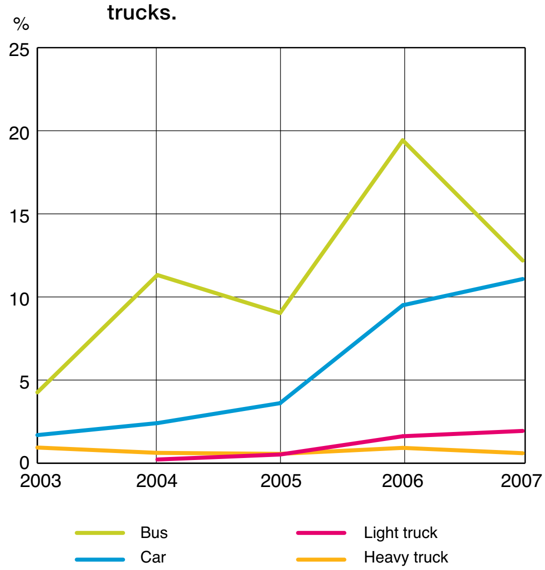
Ethanol fuelled cars account for almost 90% of passenger cars that can be run predominantly on renewable energy. Trucks and buses fuelled by renewables consist principally of vehicles that can be run on gas. More than one third of buses fuelled with renewables use ethanol in the form of E92.

Since vehicles that can use renewable fuel can usually also be fuelled with fossil fuels, it is of interest to find out what the motorist chooses at the filling stations. The Swedish Road Administration has calculated that flexifuel cars ran on E85 to an extent of 90 % in 2007.

Out of the new registrations in 2007, around 11 percent of the passenger cars and 12 percent of the buses could be run predominantly on renewable energy. The proportions for trucks were 2 percent (light) and 0.6 percent (heavy).

Factors that have contributed to the increase in the number of motor biofuel vehicles are that the availability of this type of vehicle has increased in recent years and the interest of con-

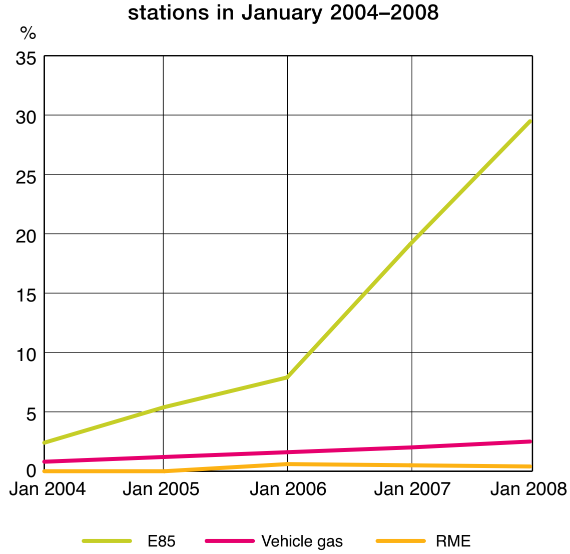
**Figure III:5. Proportion of newly registered vehicles that can be run predominantly on renewable energy, divided into passenger cars, buses, light trucks and heavy trucks.**




Source: Swedish Road Administration

sumers has grown. The latter has been affected by a number of regulatory instruments, most of which were introduced in recent years. The rules for benefit-in-kind taxation, whereby the taxable value for environmental cars is lowered, has had a great influence on the proportion of motor biofuel vehicles, since around 50% of all new cars are purchased by corporate bodies (as company cars and benefit-in-kind cars), of which more than half are benefit-in-kind cars. The carbon dioxide differentiated vehicle tax introduced in 2006 mainly provides guidance towards increased energy efficiency, but has an element of tax relief for cars that can be run on alternative motor fuels. There are some local incentives for this type of vehicle, such as free parking and relief from congestion charges. Procurement rules for state authorities also include the demand for a certain proportion of environmental cars. During the period 1 April 2007 – 31 December 2009, private persons who purchase an environmental car receive a premium of SEK 10 000. It is worth noting that there is still no uniform definition of environmental car (see the facts box).

**Figure III:6. Number of filling stations for E85, vehicle gas and RME as a proportion of the total number of filling stations in January 2004–2008**




Source: Swedish Petroleum Institute

### FILLING STATIONS

In January 2008, more than 29% of the 3586 filling stations in the country had a pump with renewable fuel. The corresponding proportion in 2007 was 19%. The filling stations that increased most rapidly are those for E85 and they account for by far the highest proportion of biofuel filling stations. The total number of filling stations in Sweden continues to decline.

Several Swedish cities have decided on biogas as the fuel for local buses. During 2007, there were biogas fuelled buses in operation in 16 cities, and the number of cities is gradually increasing. In conjunction with this trend, filling stations have also been created for passenger cars.

In January 2008, there were 1057 filling stations for ethanol, whereas the corresponding figure for RME was 16. Out of the total of 88 filling stations for vehicle gas, more than half have pure biogas, whereas the remainder have a mixture of natural gas and biogas or pure natural gas in the tanks.

A law[34] on the obligation to make renewable fuels available came into force on 1 April 2006. According to the law, filling stations with a certain sales volume must offer a renewable motor fuel in addition to petrol and diesel fuel. The law initially covers filling stations that have a sales volume in excess of 3000 $m^3$ of petrol or diesel fuel. These filling stations represent roughly 15% of the less than 4000 filling stations in the country. The requirement will gradually increase to 1000 $m^3$ of petrol or diesel fuel, and it is estimated that this will lead to around 60% of all filling stations being able to supply a motor

**FACTS Environmental car definition**

The Ministry of the Environment has announced the introduction of a uniform environmental car definition, but this has not yet been issued. For the time being, different rules apply. The environmental car definition that has applied for lowering the benefit-in-kind taxation is a car which is equipped with technology for operation entirely or partially on electricity, alcohol or gas other than LP gas. This definition is also applied to exemptions from the congestion charges in Stockholm. The Swedish Road Administration has proposed a definition that, in addition to the above, also includes fuel-efficient petrol and diesel cars with carbon dioxide emissions below 120 g/km. The emission demands on cars running on biofuel have been set at 218 g/km when running on petrol. This definition is linked to the environmental car premium of SEK 10 000. Certain cities have also adopted the Swedish Road Administration definition, and it is also used in government procurement.

[34] Act (2005:1248) on the obligation to make renewable motor fuel available

biofuel by 2010.[35] Investments are mainly made in ethanol pumps since these are the least expensive pumps to install in order to conform to the law. A grant is now available for pumps other than those for ethanol. A condition for the grant is that building of the pump shall start no later than 31 December 2008 and be completed no later than 31 December 2009. The Energy Markets Inspectorate has proposed that a tax relief on biofuel should follow with the biogas to the end consumer on distribution via the natural gas network, which will probably lead to an increased demand for biogas as vehicle gas along the run of the natural gas network.[36]

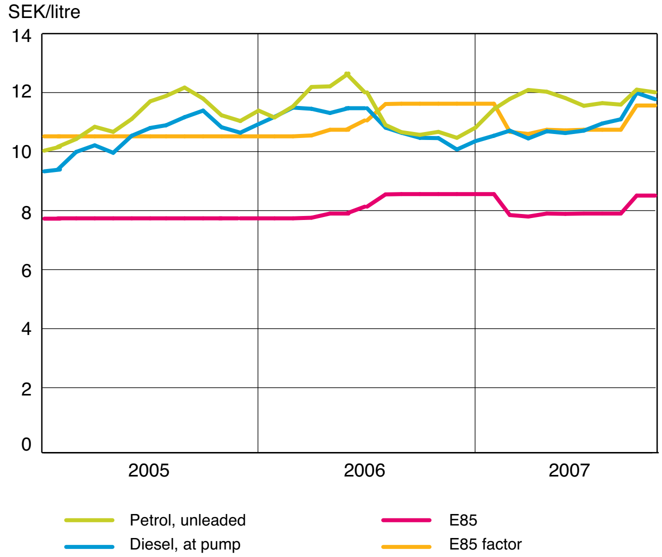
### RELATIVE MOTOR FUEL PRICES

The petrol-equivalent E85 price has been lower than the price of petrol, with the exception of a period at the end of 2006 and the beginning of 2007. Since ethanol vehicles can often be run on both ethanol and petrol or any mixtures of the two, it is important for the development in the use of E85 that the price of ethanol should be competitive in relation to petrol. The purchase of the car is also affected by the relative price relationship and belief in how the relationship will develop.

Motor biofuel is more expensive to produce than diesel fuel and petrol, but since motor biofuel is exempt from energy and carbon dioxide taxes, it has been economically attractive to use. The strategy for tax reduction for alternative motor fuels decided in the budget bill for 2002 began to be applied in 2004, and Sweden has been granted approval by the EU for using tax exemption up to 2013. However, it should be noted here that binding requirements on the proportion of renewable energy in the transport sector in accordance with the proposed Renewable Directive may mean that the possibility of using tax exemption will disappear by being in conflict with the Energy Tax Directive[37].

Sweden imports from Brazil most of the motor biofuel used, which is principally in the form of sugar cane ethanol. Why is the domestic production of ethanol not higher? An explanation is that the production of ethanol in Sweden is more expensive than sugar cane ethanol. Ethanol production in Sweden is concentrated to a wheat ethanol plant in Norrköping from 2001. The plant now has a production capacity of around 60 000 $m^3$/year, but is being extended to be able to produce more than 200 000 $m^3$/year. The price of wheat is currently high, which will probably affect the profitability of wheat ethanol production. Around 15 000 $m^3$ of ethanol is also produced annually at an old pulp mill[38] in Örnsköldsvik. Domestic production of FAME takes place principally in a new factory in Stenungsund that came on stream in 2007, and also in Karlshamn (mothballed), although a major part of FAME is imported from other European countries.

**Figure III:7. Development of prices for E85 in relation to prices of 95-octane unleaded petrol. In "E85 factor", the price of E85 has been multiplied by 1.35. 2005–2007, SEK/litre**




Soucre: Swedish Petroleum Institute, Swedish Energy Agency calculations

## Reasons and relationships

The Swedish Road Administration and the Environmental Protection Agency state in the "Bilindex"[39] for new registrations of cars in 2007 that the owner of an ethanol car who always fills up with E85 and whose car has the same fuel consumption as the average petrol car reduces the climate impact by around 65 percent compared to new petrol cars. The gas car owner who

[35] Forecasts for emissions and absorption of greenhouse gases, interim report 1 in the Swedish Energy Agency and Environmental Protection Agency source information for Check point 2008, ER 2007:27

[36] Energy Markets Inspectorate: Facilitation of joint distribution of biogas in the natural gas network. Ref. No. 2008-102961.

[37] Council Directive 2003/96/EC on a restructuring of the communities framework for taxing energy products and electricity.

[38] Paper pulp is produced here in a sulphite process, which is a method of pulp production that has lost out almost entirely in the competition with the sulphate process.

[39] Index of the climatic impact of new cars (Car index), Swedish Road Administration and Environmental Protection Agency, Report 5920, April 2008.

fills up with 100 percent biogas and whose car has the same fuel consumption as the average petrol car reduces his climate impact by around 85 percent.[40]

The advantages and disadvantages of motor biofuel have been the subject of lively discussion in recent years. It is difficult to estimate generally the effect of using motor biofuel, since the climate benefit and the energy efficiency of motor biofuel vary with the raw materials used and the production processes. The Swedish Energy Agency considers that the use of motor biofuel is a measure that can reduce the carbon dioxide emissions from the transport sector, but even if the use of biofuel in society could increase significantly, it could not meet all of the needs. The Swedish Energy Agency considers that it is more important to increase the energy efficiency in the transport sector than to introduce quickly a large quantity of motor biofuel. Priority is also given to what is generally known as the second generation motor biofuel, since it is expected to have a higher energy efficiency and also diversifies the raw materials used. An important aspect in the production of motor biofuel is to build combined plants that yield different products and increase the energy efficiency in production. Out of the motor biofuels available commercially today, ethanol from sugar cane and biogas offer good energy efficiency and climatic benefit, the latter particularly if different types of waste are used as the raw material that would otherwise give rise to methane emissions. Other driving forces for using motor biofuels are to break the virtually total oil dependence in the transport sector and to increase the security of supply.

Conflicts between food and bioenergy production, particularly motor biofuel, has been the subject of lively discussion. One reason for this is the food price increases that have recently taken place. There are several reasons for the price increases, and those that are highlighted are the increased world demand for meat products, increased bioenergy consumption and poor harvests in certain important areas due to droughts. It is difficult to decide what effect the various factors have on the price increases. On the other hand, what is important with the link to bioenergy is that efforts should be made to improve the efficiency of the conversion processes and to ensure a high yield per hectare. As regards motor biofuels, it is important to diversify the use of raw materials, so that a smaller proportion originates from food products.

[40] The calculations are based on assumptions, and the benefit can quickly change, e.g. depending on how the cars are filled up and on the origin of the ethanol and the composition of the gas.

There are several initiatives for trying to certify motor biofuels. The sustainability criteria in the new draft directive from the Commission can be said to be the beginning of a type of certification system, the purpose of which is to try to safeguard sustainable production of motor biofuels. These criteria include:

- minimum saving of 35% in the carbon dioxide emissions in a life cycle perspective
- avoiding raw materials for motor biofuel being taken from land that binds a great amount of carbon
- avoiding raw material being taken from land with high biodiversity

However, the draft directive states that no member states shall be able to refuse to trade in motor biofuel that meets the sustainability criteria in the directive. Only motor biofuel will initially be covered by these sustainability criteria, but the directive proposes that the conditions for including biomass in general shall be reviewed. Certain changes in the draft for the sustainability criteria can be expected, among other things in conjunction with the harmonization with the fuel quality directive.

There is no clear definition of what is the second generation motor biofuel, but what is often meant is motor biofuel from raw materials other than food raw materials, which are more area and energy efficient, such as, for example, dedicated energy crops or by-products from society and industry, and which are not yet commercially available but are in the course of development. There are three pilot and demonstration plants in Sweden for the so-called second generation motor biofuels. These plants are:

– ethanol production from cellulose in Örnsköldsvik
– synthesis gas production from black liquor in Piteå
– synthesis gas production from biomass in Värnamo.

The Värnamo gasification plant has now been mothballed due to difficulties in obtaining financing.[41]

[41] It is not the technology in the project that is questioned, but the problems concern issues related to rights to the technology.

# IV. Use of renewable energy in dwellings, public services/commercial premises and industry

*In 2006, 57 % of the final energy use in dwellings (including electricity and district heating) were renewable, compared to 39% in 1990. The renewable proportion of the energy use of dwellings, excluding electricity and district heating, has increased from 32% in 1990 to 75% in 2006. The conversion from oil-based heating principally to heat pumps but also to district heating is an important explanation. The use of renewable energy in industry has increased from 50% in 1990 to 57% in 2006. The increase in industry is due principally to the increased use of biofuels, but also due to increased use of renewable electricity and district heating.**

**Energy policy objectives**

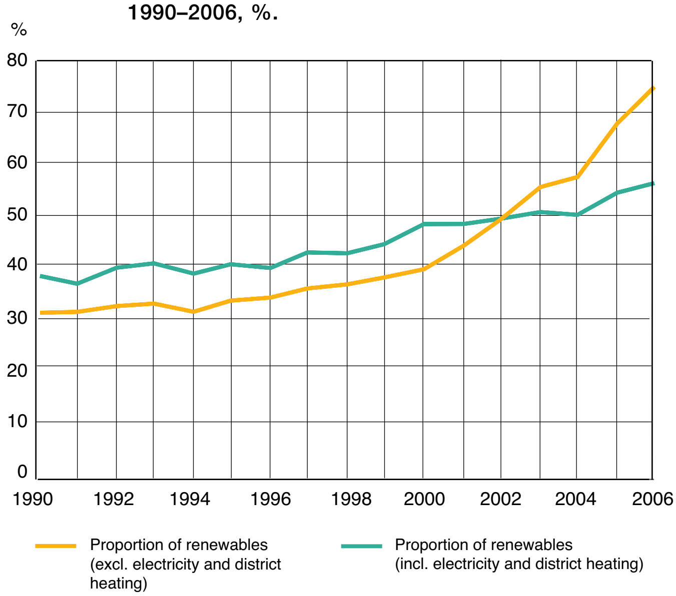
The energy policy objectives emphasize the importance of increasing the proportion of energy from renewable sources in order to achieve sustainable development. Promotion of renewable energy sources is important to the environment and the climate, and for a secure and diversified energy supply. This indicator shows the development in the use of renewable energy in dwellings, public services/commercial premises and in the industrial sector. The indicator describes the development for these sectors so far, and gives a picture of the changes that remain to be done for meeting the energy policy objectives.

DWELLINGS AND PUBLIC SERVICES/COMMERCIAL PREMISES

**Trends**

Households account for almost a quarter of the total final energy use in Sweden. The total energy use in the sector has remained relatively constant since 1990. Out of the energy use of dwellings, excluding electricity and district heating, the use of biofuels and a certain proportion of the heat extracted by heat pumps are renewable energy. Since 2000, the renewable energy, excluding electricity and district heating, has increased by almost 50%. It is principally the heat extracted by heat pumps that has increased, while biofuel has remained constant. The fossil fuel use in the heating systems of dwellings has decreased from just over 23 TWh in 1990, and 17 TWh in 2000, to 5.5 TWh in 2006. The renewable proportion of energy use, excluding electricity and district heating, has increased from 32% in 1990 to 75% in 2006. The highest increase has taken place from 2000, when the proportion was 40%. Converting, for example, from oil to direct electric heating increases this proportion of renewable energy by reducing the denominator but not adding anything either to the numerator or the denominator. It is therefore also of interest to study a renewable proportion that includes the total energy use of the households, including electricity and district heating.

**Figure IV:1. Renewable energy use in dwellings in relation to the final energy use in the sector, excluding and including electricity and district heating in 1990–2006, %.**

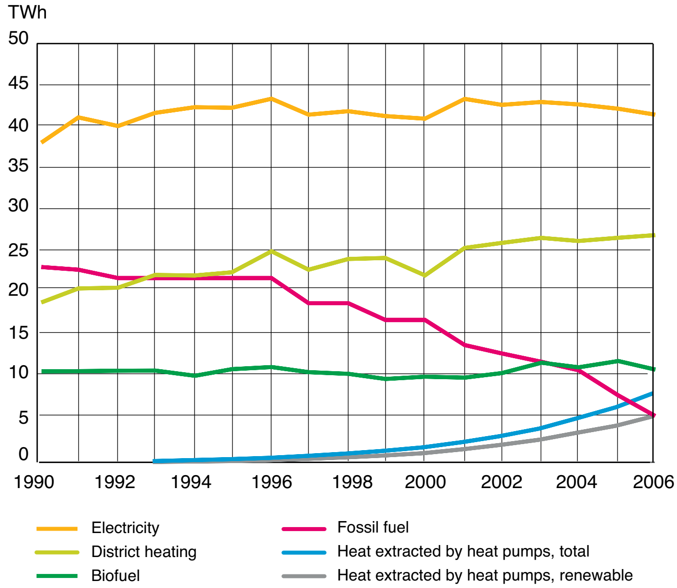



Source: Statistics Sweden, Nowab

Out of the total final energy use of households, electricity and district heating account for the largest proportions. A large proportion of the electricity and district heating in Sweden is generated by renewable energy sources. In 2006, 54% of the district heating and 52% of the electricity were from renewable sources. In 2006, 57% of the final energy use of households

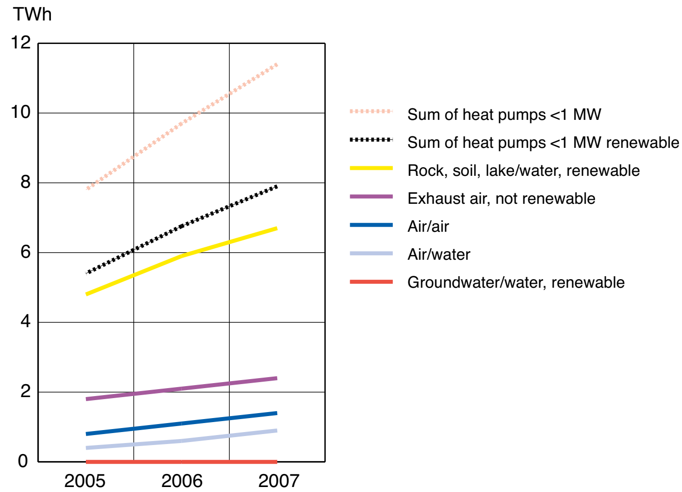
* Note. In the theme indicators in this publication the word biofuels refers to all fuels (solid, liquid or gaseous) produced from biomass. Biofuels for transport purposes are referred to as motor biofuels or transport biofuels.

**Figure IV:2. Final energy use in dwellings divided into electricity, district heating, biofuels, fossil fuels and heat extracted by heat pumps, total and renewable, in 1990–2006, TWh.**




Source: Statistics Sweden, Nowab

**Figure IV:3. Heat extracted by small heat pumps (<1 MW) total and total renewable and per heat pump type, 2005–2007, TWh.**

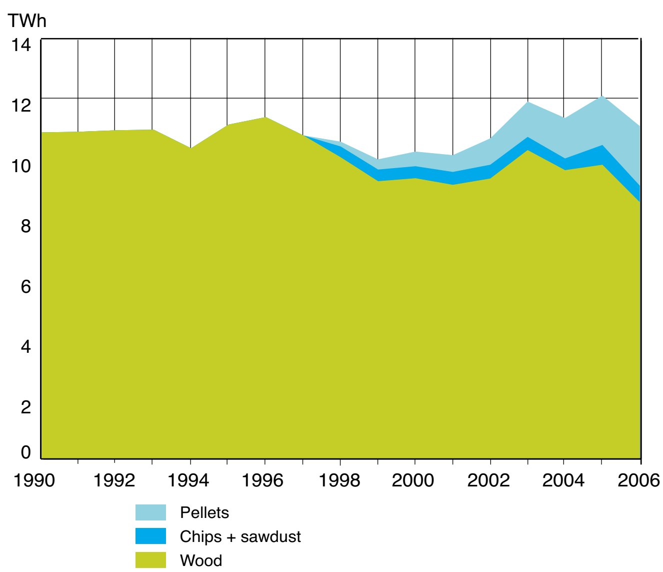



Source: Nowab

(including electricity and district heating) were renewable, compared to 39% in 1990 (see the facts box for calculations and assumptions). In addition to the high increase in the heat extracted by heat pumps, district heating has also contributed to the increase in the proportion of renewables. The use of district heating in households has steadily increased and contributes to the increase in the proportion of renewables on conversion from oil-fired heating, for example. In 1990, 31% of district heating was renewable compared to 54% in 2006, which also contributes to the increase in the proportion of renewables used by households.

The heat extracted by small heat pumps has increased substantially in recent years. A total of just over 11 TWh of heat extracted by heat pumps was used in single-family houses, multi-family houses and public services/commercial premises in 2007, of which almost 8 TWh were renewable. In the draft Renewable Directive, requirements are set on heat pumps for the heat extracted to be regarded as renewable energy. The heat generated by heat pumps that use geothermal energy is included, but it is still unclear what energy sources are defined as geothermal energy. The heat generated by ambient air source heat pumps can be included only if these heat pumps meet

**Figure IV:4. Use of biofuels[42] in dwellings in 1990-2006, TWh.**




Source: Statistics Sweden

[42] Peat could not be separated out in the statistics for dwellings and public services/commercial premises. A certain amount of peat may be included, but no major quantities.

the efficiency requirements in accordance with the eco-labelling[43]. The interpretation of the Swedish Energy Agency is that the heat extracted by heat pumps that use surface water, water from the bottom of a lake, heat from rock or heat from the soil as the source of the heat, those that use ambient air and meet the requirements in accordance with the eco-labelling, can be regarded as renewable energy. Around 5 TWh of electricity are used for driving these small heat pumps, but that energy has been deducted when calculating the heat extracted. 85% of the energy from these small heat pumps is assumed to belong to the residential sector and the remainder to the public services/ commercial premises sector.

Bioenergy accounts for the highest proportion of energy use in households, excluding electricity and district heating, and contributed 11 TWh in 2006, but the use has been relatively constant and has been in the range of 10–12 TWh during the period between 1990 and 2006. As late as 2004, bioenergy passed fossil energy in magnitude. The use of fossil energy has dropped steadily, particularly since 1996. Biofuels are dominated by wood, but the use of pellets has increased significantly in recent years. The use of pellets in households has quadrupled between 2000 and 2006.

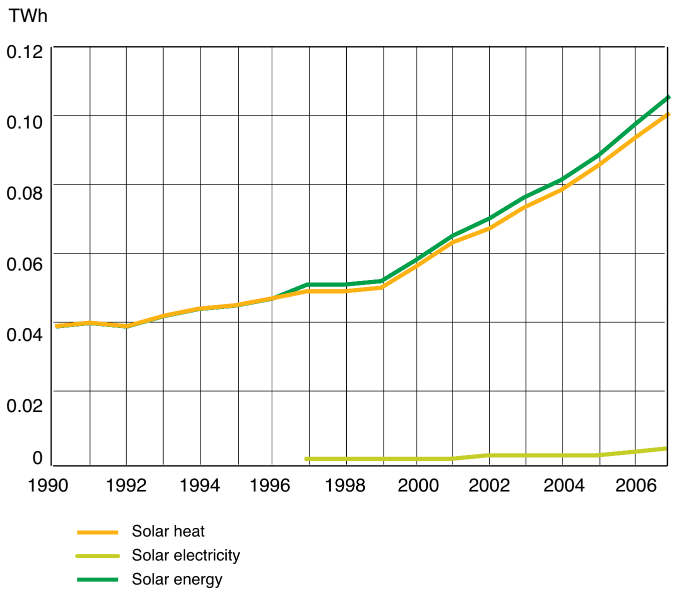
[43] See ordinance (EC) No. 1980/2000 and decision 2007/742/EC.

Official statistics for the annual energy balances do not include the heat extracted by heat pumps in the user sectors. Neither does it include solar energy or energy generated and consumed without having passed through the local or regional networks or the national transmission grid. This applies, for instance, to solar heat from solar collectors and solar electricity from solar cells on single-family houses, multi-family houses and commercial premises, and wind turbines on the plot. The statistics in this area need to be developed.

Solar energy is steadily increasing, but accounted for only 0.1 TWh in 2007. Solar heat is used principally in the residential sector, and accounts for most of the solar energy. Solar cells are used in various self-sufficient systems (such as highland cottages, beacons, etc.) and, in recent years, in mains-connected systems for various types of public premises.

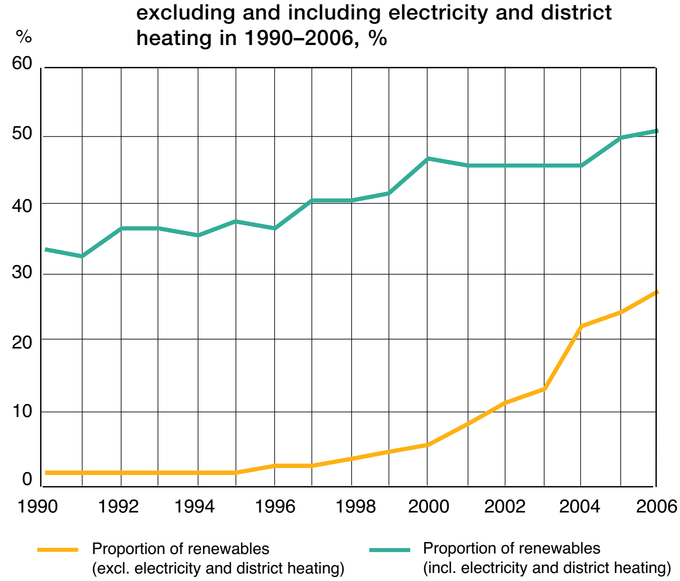
The final energy use in public services/commercial premises is roughly half of that of households, and the use in the sector has remained relatively constant since 1990. Appreciably less biofuel and less heat extracted by heat pumps are used in the services sector than in households. But a development of the proportion of renewable energy, excluding electricity and district heating, has nevertheless taken place from 2% in 1990 to 28% in 2006. In this case too, the use of fossil fuels

**Figure IV:5. Development of solar heat, solar electricity and total solar energy in Sweden in 1990–2007, TWh**



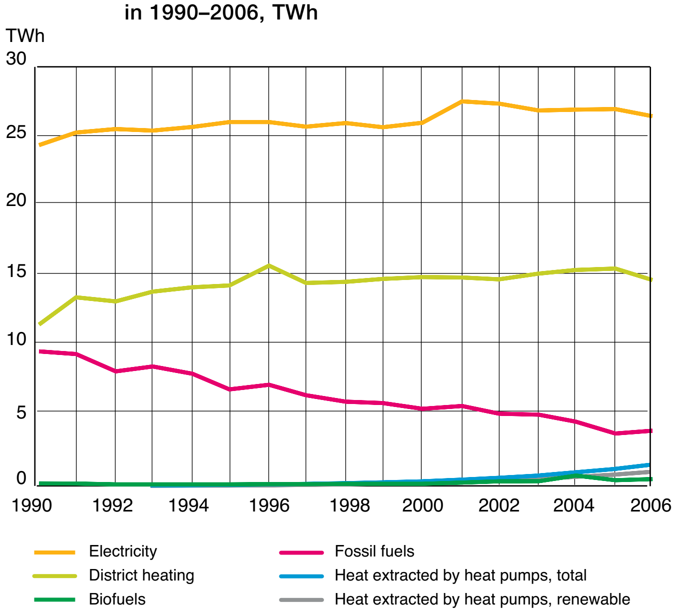

Source: Solar Energy Association of Sweden

**Figure IV:6. Use of renewable energy in the services sector in relation to the final energy use of the sector, excluding and including electricity and district heating in 1990–2006, %**




Source: Statistics Sweden, Nowab

**Figure IV:7. Final energy use in the services sector, divided into electricity, district heating, heat extracted by heat pumps, total and renewable, fossil fuels and biofuels in 1990–2006, TWh**




Source: Statistics Sweden, Nowab

has decreased. In 2006, 51% of the total final energy use in the services sector (including electricity and district heating) originated from renewable energy sources, compared to 34% in 1990. Electricity and district heating contribute most to the renewable proportion of the sector.

## Reasons and relationships

Households have been very successful in cutting the use of fossil fuels and switching to renewable energy, particularly since 2000. Sweden has pursued an active energy policy to enable conversion to a sustainable energy system, and regulatory instruments such as conversion support and investment support have contributed to the conversion to renewable energy. Increased awareness of consumers and high energy prices, and energy and carbon dioxide taxes are also assumed to have contributed to the conversion.

The latest conversion support for changing over from oil-fired heating to heat pumps (rock, lake and soil heat), district heating and biofuel-based heating systems that was started in 2006 and ran up to March 2007, had by the end of December 2007 granted almost 37 000 applications for support by single-family houses, of which heat pumps accounted for 43%, biofuel-fired systems for 37% and district heating for 20%. The purpose of the conversion support is to decrease oil dependence and to promote efficient and environmentally appropriate use of energy and reduced electricity use for heating purposes in dwellings. Conversion support is available to owners of properties with direct electric heating for changing over to district heating, heat pumps (lake/soil/rock) or biofuel. The support for conversion from direct electric heating is available during the period 1 January 2006 – 31 December 2010.

Whoever has a single-family house built is entitled to support for the installation of a biofuel system, e.g. a pellets boiler, as the primary heat source. Other current regulatory instruments include grants for the installation of solar heat systems in single-family houses, multi-family houses and certain premises. The purpose of the support is to promote the use of solar heat technology and is granted to systems for domestic hot water and/or space heating.

Owners of premises used for public activities can apply for support for conversion from electricity or fossil fuels to biofuels, solar heat, district heating or rock/soil/lake heat pump. Support is also given for the installation of solar cell systems in public buildings. Owners of commercial premises are entitled to support for the installation of solar heat.

The Swedish Energy Agency has estimated the environmental effects of existing heating systems with regard to acidification, over-fertilization, particulates and the greenhouse effect.[44] Solar heat causes the least environmental impact, but must be combined with other heating systems. After solar heat, pellets are the best alternative with regard to greenhouse gases, but have a medium-high environmental impact in other respects. Wood-fired boilers have a very high scatter in environmental impact between different types of boilers. Heat pumps that use electricity with a Nordic electricity mix have good environmental values.

Requirements for origin marking of electricity are made on the basis of the electricity market directive and are implemented in the Electricity Act from April 2006. The marking of the origin of electricity sold shall be made by electricity suppliers in order to enable consumers to make a conscious choice when purchasing electricity. Marking of origin is done today by electricity suppliers being able to use so-called guarantees of origin, procure electricity with known origin, such as Good Environmental Choice, or by other bilateral agreements in which the

[44] Heating in Sweden in 2007, EMIR 2007:03.

Figure IV:8. Use of biofuels in industry in total (SNI 10–37) and in the pulp, paper, paper goods and graphic industries (SNI 21–22) in 1990–2006, TWh

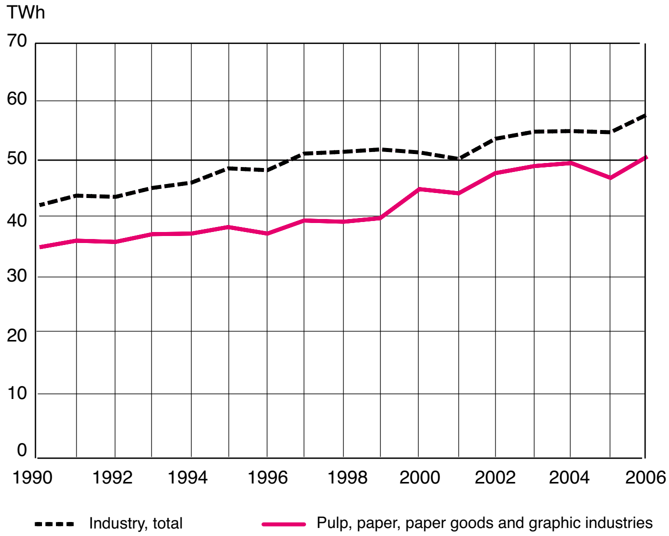
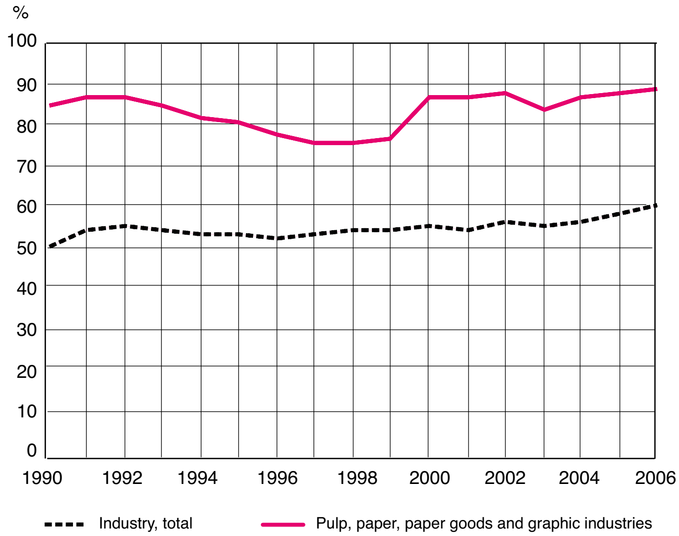



Figure IV:9. Use of biofuels in relation to the total fuel use in industry in total and in the pulp, paper, paper goods and graphic industries (SNI 21–22) in 1990–2006, percent.




origin of the electricity is known. There are no statistics in the area, and no checks are yet being made to determine whether settlement is done at the suppliers for the electricity sold as renewable or on its effect on the remaining electricity mix.

## INDUSTRY

### Trends

The use of biofuels by Swedish industry increased substantially during the period between 1990 and 2006, from 43 TWh to 58 TWh. This is equivalent to an increase of 36%, while the total industrial energy use increased by 12% during the same period.

The proportion of biofuels in relation to the total industrial fuel use[45] has increased from 51% in 1990 to 61% in 2006. The increase has taken place in the pulp and paper industry, which is the industry that uses most biofuels, and also in the remainder of industry. The use of biofuels has also increased in relation to the total industrial energy use (use of fuels, electricity and district heating) from 30% in 1990 to 37% in 2006.

[45] Calculation method a, see ”FACTS Calculations and assumptions for this particular indicator”. Due to the absence of statistics for renewable and total heat extracted by heat pumps in industry, only industrial use of biofuels is reported here in relation to the total fuel consumption of industry.

Figure IV:10. Total renewable energy use (biofuel, renewable electricity and renewable district heating) in industry distributed onto different energy carriers in 1990–2006, TWh

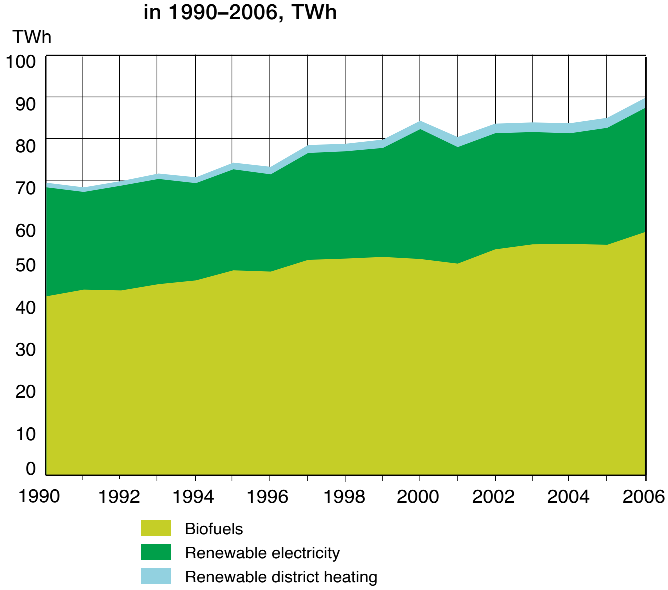


**Figure IV:11. Total use of renewable energy (biofuels, renewable electricity and renewable district heating) during the period 1990–2006 in different industrial sectors, TWh**

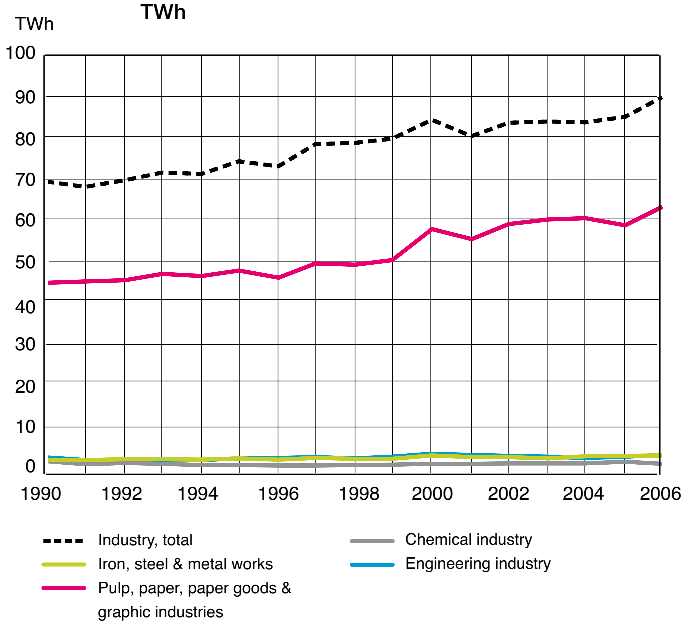
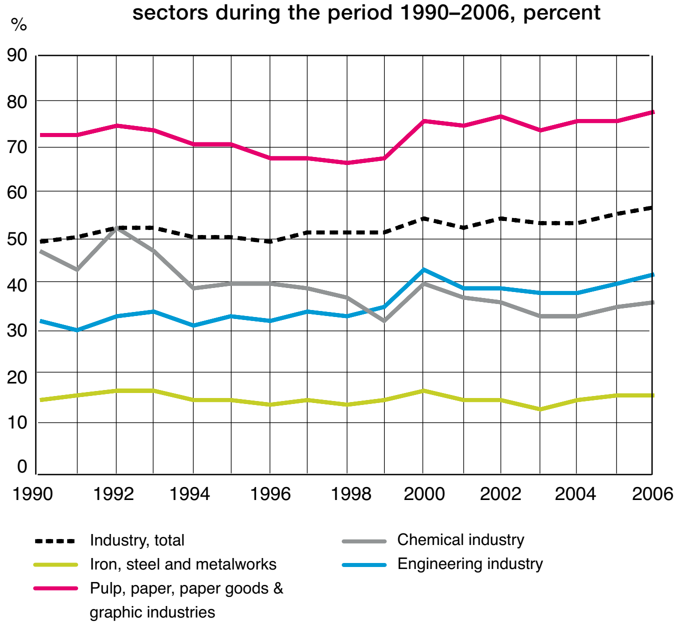



**Figure IV:12. Total use of renewable energy (biofuels, renewable electricity and renewable district heating) in relation to the final use of energy in different industrial sectors during the period 1990–2006, percent**




Biofuels in the industrial sector are used mainly in the forest industry, where by-products and residual products from the production of forest products are used internally as fuel in the industrial processes. In 2006, the pulp and paper industry accounted for almost 90% of the total industrial use of biofuels.

The total use of renewable energy (biofuels, renewable electricity and renewable district heating) in industry increased during the period between 1990 and 2006 from 70 TWh to 90 TWh, which represents an increase from 50% to 57% in relation to the total energy use in industry. The increase is due to a substantial rise in biofuel use, but also to increased use of renewable electricity and district heating.

The total use of renewable energy varies widely between different industries. In 2006, the use of renewable energy was 78% in the pulp and paper industry, while it amounted to 43% in the engineering industry and 17% in ironworks, steelworks and metalworks. The total use of renewable energy varied between different years in the various industries during the period. With the exception of the chemical industry, the total use of renewable energy in relation to the total energy use in the various industries has increased since 1990.

### Reasons and relationships

The total industrial energy use and the total use of renewable energy in industry are dependent, in the short-term perspective, on the volume of production. In the longer term, it is also influenced by taxes, energy price development, energy efficiency improvements, investments, technical development, and changes in the sector and product composition in industry. The total use of renewable energy is also dependent on renewable electricity and district heating generation.

There is a clear relationship with the development of the general economic climate. Industrial production recovered in 1993 and was followed by a high production upturn that lasted up to 2000. Industrial production increased by almost 8% annually during the period between 1993 and 2000. The production increase was also reflected in the total energy use and the total use of renewable energy, which increased by a total of 13% and 18% respectively during the same period. The general economic upturn was followed by a downturn in 2001 and a recovery during 2002–2006. During the period between 2000 and 2006, the total energy use increased by just over 2%, and the total use of renewable energy by a total of 6%.

The increased use of renewable energy in industry between 1990 and 2006 was largely due to the production increase in

**FACTS Calculations and assumptions for this particular indicator**

The total use of renewable energy in each sector consists of the sum of:

1. use of biofuels, including renewable waste, in the sector,
2. heat extracted in the sector by heat pumps with a rating of less than 1MW and that meet the requirements of the EU draft renewable directive,
3. the use of renewable district heating in the sector,
4. the use of renewable electricity in the sector.

The renewable proportion of waste was assumed to amount to 50%.

The statistics on the heat extracted covers the sectors of dwellings and public services/commercial premises, but not industry.

The use of renewable district heating represents the total final district heating use of the sector multiplied by the total proportion of renewable district heating generation. The total generation of renewable district heating consists of the sum of district heating generation from biofuels and half of the waste, heat extracted by heat pumps with a rating of more than 1 MW and that meet the requirements in the EU draft renewable directive, renewable waste heat and renewable district heating from electric boilers.

The use of renewable electricity consists of the total final electricity use of the sector multiplied by the total proportion of renewable electricity generation. The generation of renewable electricity consists of biopower, power from half of the waste, wind power and hydropower corrected for a normal year. The method of calculating renewable energy use means that the proportions for renewable electricity in the various sectors are the same. This is a rough simplification and is seldom true in reality. A more balanced method presupposes that the origin of the electricity used is known and that this information is collected for the official energy statistics. No such information is available today. In this indicator, it has therefore been impossible to take into account differences in renewable electricity use between various sectors.

The use of renewable energy in each sector relates to the proportion, excluding transmission and distribution losses in the electrical and district heating networks.

The proportion of renewable energy is calculated for the various sectors in two ways:

a. The sum of the biofuel use (1) of the sector and the renewable heat extracted by heat pumps (2) divided by the sum of the total fuel use in the sector and the total heat extracted in the sector by heat pumps.
b. The ratio of the total renewable energy use in the sector (1+2+3+4) and the final energy use in the sector.

the pulp and paper industry and the conversion from fossil fuels to biofuels. Fuel conversion has taken place both in the pulp and paper industry and in the remainder of industry. This fuel conversion has taken place in spite of reduced normal taxation rates for the industrial sector compared to the remainder of the social sectors. The scope available for fuel conversion varies between different industries.

Swedish industry is dependent on electricity to a significant extent. In 2006, electricity accounted for more than one third of the total industrial energy use. This means that the use of renewable energy in industry is largely dependent on how the electricity used in industry is generated. This also applies to the district heating used in industry. Renewable electricity generation in industry takes place in combined heat and power plants, also known as industrial back-pressure plants. This electricity is used by industry itself, but is also distributed on the electricity network. The gross electrical energy generated by back-pressure plants has increased from 3.0 TWh in 1990 to 5.2 TWh in 2006. In 2006, 74% of the gross electrical energy generated by these plants was renewable. For statistical reasons, it has not been possible to take especially into account in this indicator the use by industry of renewable electricity generated by industry itself. See the facts box with calculations and assumptions for this particular indicator.

# V. Development of bioenergy in the Swedish energy system

*Bioenergy, together with energy from other renewable sources, is essential in the conversion towards an energy system that is sustainable in the long term. Bioenergy is already of major importance to Sweden's energy supply and is expected to continue to play a significant role in a future energy system. The use of biofuels has increased continuously since 1990. In 2006, bioenergy accounted for 17% of the total energy supply.**

## Energy policy objectives

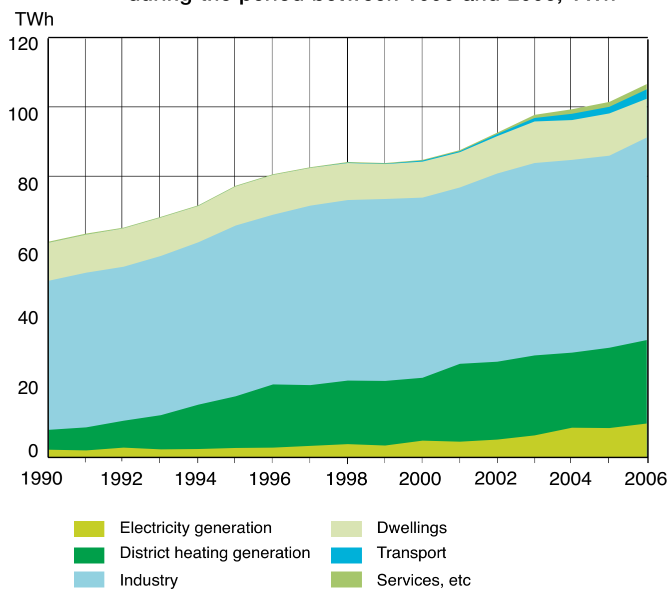
The Swedish energy policy objectives underscore the importance of increasing the input of energy from renewable sources. This is regarded as an important step in the direction towards sustainable development. The objectives also emphasize that the energy supply should be secure and environmentally friendly, and that the energy must be available at reasonable prices. Bioenergy concerns several of these objectives and is of importance to them. In addition to being based on renewable sources and contributing to the energy supply of society, bioenergy also concerns matters related to self-sufficiency, employment, regional policy, production, distribution and costs. Bioenergy and its importance to meeting the various objectives can therefore be viewed from different perspectives.

## Trends

### BIOFUEL USE IN 1990–2006

The use of biofuels[46] in the Swedish energy system has increased continuously during the period between 1990 and 2006, from 11% of the total energy supply in 1990 to 17% in 2006. The total biofuel use[47] in 2006 amounted to 107 TWh. The industrial sector used 58 TWh, the residential sector 11 TWh, the transport sector 3 TWh, and public services, etc. less than 2 TWh. A total of 24 TWh was used for district heating generation. For electricity generation in CHP plants and in industrial back-pressure plants, the use in each was about 5 TWh. Biofuel use increased from 1990 to 2006 in all sectors.

**Figure V:1. Use of biofuels (including conversion and distribution losses in electricity and district heating) during the period between 1990 and 2006, TWh**




Source: Statistics Sweden

The biofuel use for district heating and power generation has increased substantially during the period between 1990 and 2006. The industrial sector also displays a substantial increase. Since 2000, an upward trend in biofuel use is discernible in the residential and public services sectors, which is due to the increased use of pellets.

The pulp and paper industry is the largest biofuel user in the industrial sector and accounted in 2006 for just under 90% of the total industrial biofuel use. In 1990, the Swedish pulp and paper industry accounted for 58% of the total Swedish biofuel use, and in 2006, for 48%.

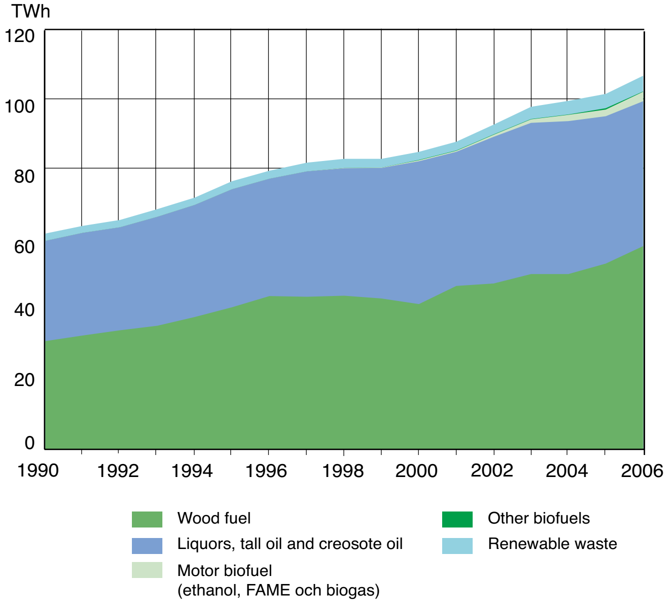
The biofuel use in the transport sector has developed robustly during the period and amounted to 3% of the total biofuel use in 2006.

* Note. In the theme indicators in this publication the word biofuels refers to all fuels (solid, liquid or gaseous) produced from biomass. Biofuels for transport purposes are referred to as motor biofuels or transport biofuels.

[46] Biofuels, including 50% of the waste.

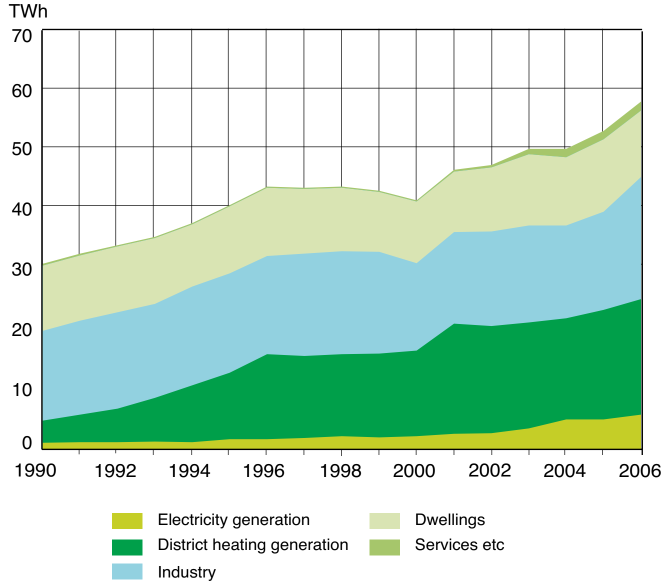
[47] Consumption refers here to biofuel consumption in the end-user sectors (industry, dwellings, transport and services, etc.) and the biofuel used for electricity and district heating generation.

Figure V:2. Use of various biofuels (incl. conversion and distribution losses in electricity and district heating) during the period 1990–2006, TWh




Source: Statistics Sweden

Figure V:3. Use of wood fuels (incl. conversion and distribution losses in electricity and district heating) during the period 1990–2006, TWh




Source: Statistics Sweden

Most of the biofuels used in the energy system are domestically produced and consist of:

- Wood fuels (unprocessed wood fuels: wood, bark, chips, felling residues, waste wood, energy forest, and processed wood fuels: pellets and briquettes)
- Liquors and tall oil (by-products of chemical pulp production)
- Renewable waste
- Motor biofuels (ethanol, FAME and biogas)

The use of biofuel in the Swedish energy system has developed positively during the years between 1990 and 2006. During this period, the use of biofuel increased by 73%. Two categories of biofuels have substantially influenced the increasing use of biofuels, namely wood fuels and liquors. The use of wood fuels increased by 88% and the liquors by 44% during the period.

In 2006, wood fuels comprised the largest single biofuel category and accounted for 54% of the total biofuel use. The increase in wood fuels has been particularly high in district heating and electricity generation, where the use has increased by 20 TWh between 1990 and 2006.

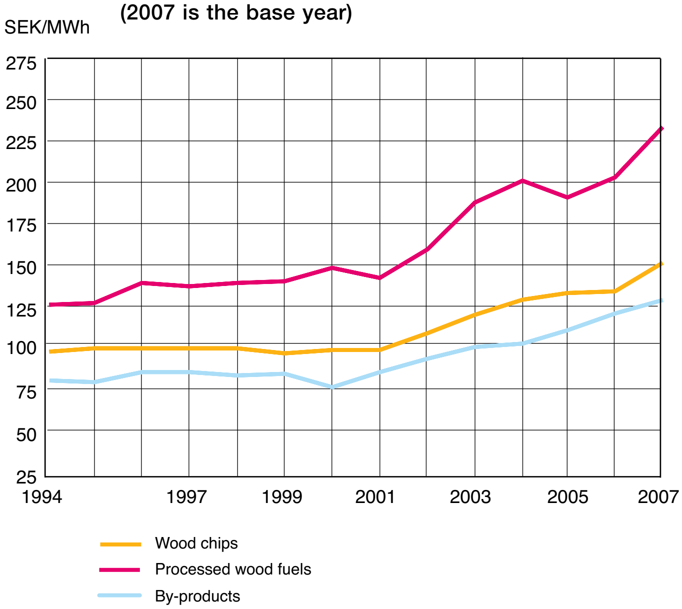
Most of the wood fuels come from forestry in the form of felling residues from felling and thinning, and firewood from traditional firewood felling on forest land and other land, and as solid by-products in the form of bark, sawdust and chips from the forest products industry and the pulp and paper industry. Biofuels from agriculture, such as Salix, reed canary grass, hemp, straw and rape still represent a minor quantity of about 1.5 TWh.

A growing proportion of wood fuels consists of processed wood fuels, such as pellets and briquettes. During the period between 1997 and 2006, delivery of pellets to the Swedish market increased by 6 TWh. In 2006, the Swedish pellets market amounted to a total of around 8 TWh.

The production of chemical pulp in the pulp industry gives rise to liquors, also known as black liquors, which consist of digester chemicals, lignin and extractives. The digester chemicals are largely recovered by burning the liquors. The energy from combustion is used in-house in the pulp industry and for electric power generation. Tall oil is also generated in the recovery of digester chemicals. The use of liquors and tall oil increased by 44% during the period between 1990 and 2006 and accounted for 39% of the total biofuel use in 2006. The use of liquors has increased as a result of increased production in the forest industry.

Combustible waste normally consists of mixed fractions of biological and fossil material. No information is collected

Figure V:4. Real costs incurred by district heating stations for wood fuels during the period 1994–2007, TWh (2007 is the base year)




Source: Swedish Energy Agency price sheet for biofuels, peat, etc.

on the renewable proportion of the combustible waste, and an assumption has therefore been made that the renewable proportion in the combustible waste amounts to 50%. The use of renewable waste (assuming 50% proportion of renewables) has increased by 2.2 TWh since 2000 and amounted to a total of 4.5 TWh in 2006.

### COSTS OF WOOD FUELS TO DISTRICT HEATING PLANTS IN 1994–2007

The increased use of biofuels for electricity and district heating generation has resulted in an increased demand for wood fuels in particular. Since the energy policy objectives specify that energy shall be supplied on globally competitive terms, it is of interest to see how other costs and prices of wood fuels have developed as a result of the increased demand.

During the 1990s, the costs incurred by district heating stations for wood fuels remained largely unchanged in real terms. This applies both to unprocessed fuels (wood chips and by-products from the industry) and processed wood fuels (pellets and briquettes). From 2000 and up to 2007, the real costs of wood fuels have risen somewhat more for processed wood fuels and somewhat less for unprocessed wood fuels.

### Reasons and relationships

There are several reasons for the increased total use of biofuels since 1990.

The Government and Parliament have had high ambitions with regard to renewable energy, which was expressed by various regulatory instruments and measures for achieving the energy policy objectives. Most of these have created the conditions in various ways for increased use of biofuels.

Since Sweden joined the EC (in 1995), the energy policy in Sweden has been affected to an increasing extent by the common EU climate and environmental policy. This has meant that common EU decisions and directives in climate and environmental matters have given rise to changes in the rules in the Swedish legislation which, in addition to influencing the climate and environment, also influenced the Swedish energy system. Many of the decisions and regulatory changes have had a bearing on developments in the biofuel sector and biofuel price development in Sweden.

Energy taxation, which comprises energy tax, carbon dioxide tax and sulphur tax, has been a regulatory instrument that increased the competitiveness of biofuels and that has prompted, to a large extent, conversion from fossil fuels to biofuels since the beginning of the 1990s. Energy taxes have gradually been raised since 1990.

Another important regulatory instrument that has promoted the use of biofuels is the green electricity certificate system introduced in 2003. The green electricity certificate system is a market-based support system aimed at cost-effectively increasing the generation of renewable electricity. The introduction of the electricity certificate system has had a clear influence on the use of biofuels for electricity generation.

Other examples of regulatory instruments that have promoted increased use of biofuels are: Support for biofuel-based CHP generation in 1991–1997, local investment programme (LIP) in 1998–2002, climate investment programme (KLIMP) (since 2003), trade in emission allowances (since 2005), support for conversion from electric heating and oil firing in single-family houses and support for conversion in public premises (2005–). In addition, the various measures aimed at promoting the use of motor biofuel have increased the use of biofuels. Examples of such regulatory instruments include the law on the obligation of filling stations to supply renewable motor fuels (2005–) and the environmental policy for state cars (2004–).

Another important explanation for the increased use of biofuels, in addition to various economic regulatory instruments, is the production increase in the forest industry during the period. The increase that took place in the industrial sector between 1990 and 2006 is mainly due to the production increase in the forest industry. Wood fuels and liquors are used internally in the production processes, and the use of biofuels in the forest industry therefore follows the production rate of forest products. The forest industry and its production volume play a significant role in the total use of biofuels in the Swedish energy system.

In recent years, the increasing market prices of fossil fuels have also stimulated the use of biofuels.

The increased waste incineration during the beginning of this century is due to the prevailing ban on dumping organic waste to landfill. Disposal of sorted combustible waste to landfill is banned since 2002, and there has also been a ban since 2005 on dumping other organic waste to landfill. In order to promote waste treatment other than incineration, the incineration of certain domestic waste – the fossil part – has been included in energy taxation since 2006.

The increased demand for wood fuel for district heating and electricity generation during the 1990s did not have any significant effect on prices on the wood fuel market. Historical cost statistics show that the changed demand for wood fuel in the 1990s could quickly be met by higher supply. This pattern has been broken since 2000, and statistics up to 2007 display instead an increase in wood fuel costs in real terms. The increased use of wood fuels during the 1990s and the continued growing demand during the 2000s appear to have led to greater shortage of wood fuels and consequently increased prices. If the demand for wood fuels continues to rise, growing competition for wood fuels can be expected in the future. Unless the supply increases, this will lead to increased costs of wood fuels for heat and electricity generation.

# Background indicators

***The background indicators shall make it easier for the reader to place the other indicators in a wider context. The aim is to provide as complete a picture as possible of the energy system.***

## A. Total energy supply by energy carriers

Since the beginning of the 1970s, the total energy supplied has increased by 36%[48]. The energy supply during 1970 amounted to 457 TWh and in 2006, it was 620 TWh[49]. The composition of the energy supply has changed significantly in the past 35 years. In 1970, 350 TWh of the total energy supply consisted of crude oil and oil products, compared to 205 TWh in 2006. During the past 30 years, nuclear power and biofuels have mainly replaced oil. In 2006, nuclear power accounted for 190 TWh of the total energy supplied, which gave just under 65 TWh of electricity (the remainder were conversion losses in nuclear power plants). As regards biofuels[50], including peat and waste, etc., the supply has more than doubled since 1970. In 1970, biofuels contributed 43 TWh, and in 2006, 113 TWh. Hydropower contributed about 41 TWh in 1970 and 61 TWh in 2006. Wind power has increased substantially from around year 1997 when building of wind farms began, but still accounts for only a small part of the total energy supply at around 1 TWh in 2006. District heating from heat pumps increased from 1980 and now accounts for around 6 TWh. The energy supplied from coal and coke has basically remained constant during this period. The natural gas supply has increased since its introduction in 1984.

Sources: Statistics Sweden, Statistical Memorandum series EN 20 Annual Energy Balances, and National Accounts

[48] The net import of electrical energy is included in the energy supply figures quoted. On the other hand, this net import is not included in the graph, since these values may be negative.
[49] Given in accordance with the international method, i.e. the conversion losses in nuclear power are included.
[50] In this and other background indicators, peat and waste have been included in the biofuel item. However, peat is neither renewable (in the short term) nor fossil in the geological sense, and waste can also have a certain proportion of fossil content.

**Figure A:1. Total energy supply by energy carriers**

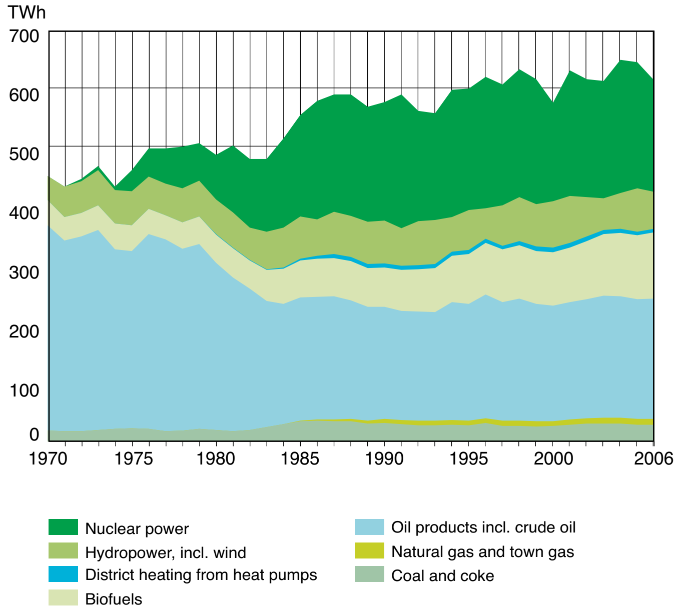



**Figure A:2. Energy intensity, total energy supplied and GNP**

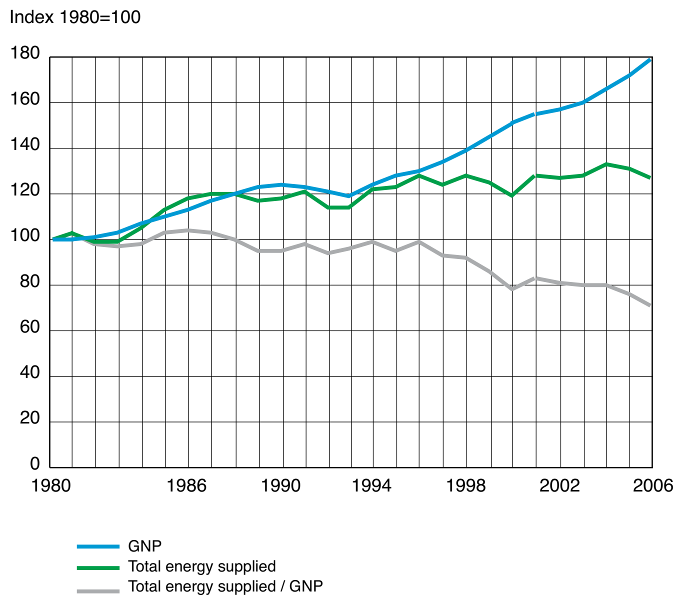
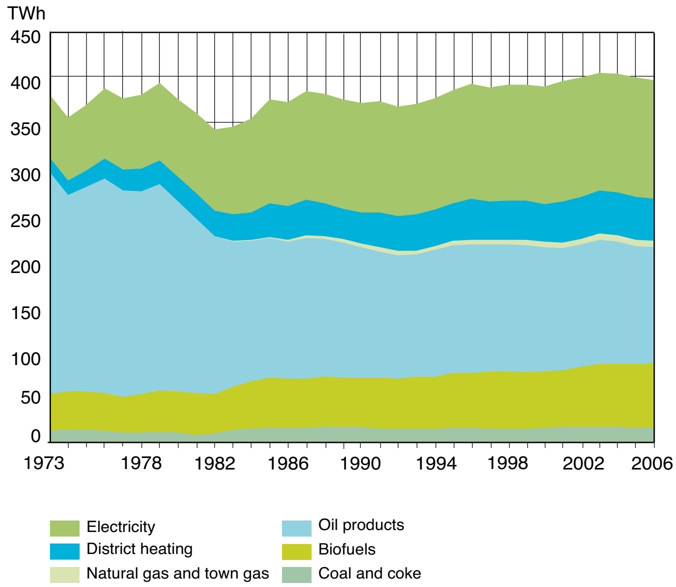


Figure B. Total final energy use by energy carriers

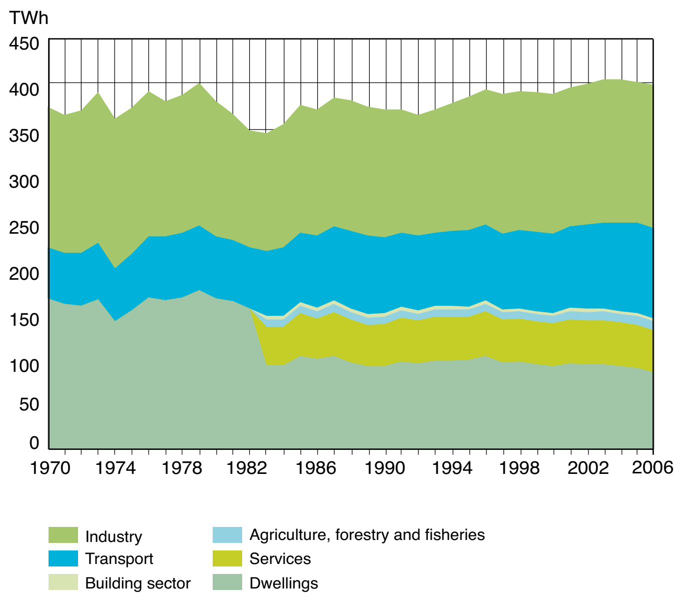



## B. Total final energy use by energy carriers

The total final energy use has increased from 381 TWh in 1973 to 398 TWh in 2006. This means that the final energy use has increased by only 4% in just over 30 years. The use of all energy carriers, with the exception of oil products, has increased at different rates. Oil use in Sweden has declined from 243 TWh to 127 TWh between 1973 and 2006. After the oil crises in the 1970s, the Swedish energy policy has been focused on reducing the use of fuel oils. In 1973, oil use accounted for 64% of the total final use, and in 2006, the proportion was 32%. Electricity, district heating and biofuels[51] have largely replaced oil for heating. The electricity use has increased from 69 TWh in 1973 to 130 TWh in 2006. During the same period, the use of district heating has increased from 16 TWh to 46 TWh. During the period, the biofuel use has increased from 40 TWh to 71 TWh.

Source: Statistics Sweden, Statistical Memorandum series EN 20 Annual Energy Balances

Figure C:1. Total final energy use by sectors




## C. Total final energy use by sectors

The total final energy use (excluding conversion and distribution losses) in the transport sector has increased most by 77% since 1970. The energy use in industry decreased between 1970 and 1982, and then resumed the upward trend. In 2006, the use was 2% higher than in 1970. At the same time, industrial production during the period has increased and continuous efficiency improvement work in industry has resulted in less energy being consumed per unit produced.

Before 1983, consistent data is available only for the building sector, agriculture, forestry and fisheries, public services and dwellings combined. After 1983, statistics are available for the individual sectors and show that the energy use in these sectors has remained relatively constant. The energy use in the residential sector (reckoned as purchased energy) is 9% lower than in 1983. Since 2006 was a warm year, the space heating requirements were lower. During cold years (e.g. 1985–1987 and 1996), the energy use in the residential sector is higher.

The energy intensity in the end user sector, i.e. final use per

[51] In this and other background indicators, peat and waste have been included in the biofuel item. However, peat is neither renewable (in the short term) nor fossil in the geological sense, and waste can also have a certain proportion of fossil content.

**Figure C:2. Energy intensity, total final energy use and GNP**

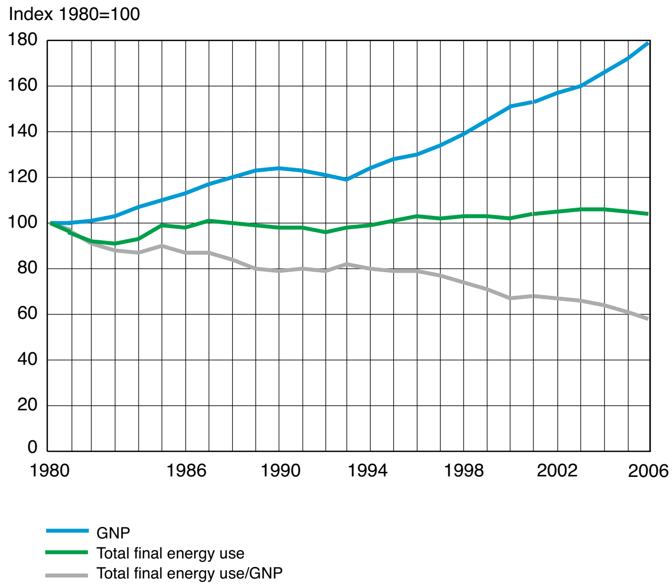
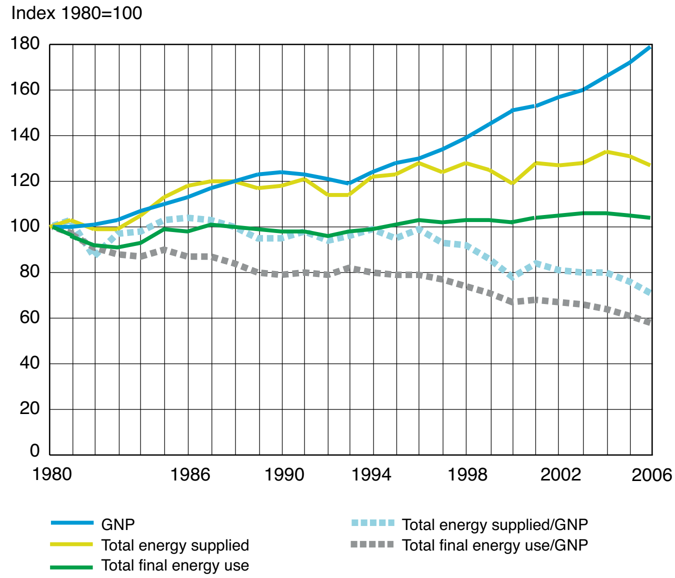



**Figure C:3. Total energy supplied, total final energy use and GNP**




GNP, has dropped during the whole of the period. The reduction is due to the GNP having increased, while the total final energy use has largely remained constant. An important factor is also that oil for space heating during the same period has been replaced to a large extent by electric heating and district heating. This means that the energy conversion losses have been moved from the end user sector to the energy conversion sector.[52] For a given heating requirement, the energy use on the end user side thus decreases.

Source: Statistics Sweden, Statistical Memorandum series EN 20 Annual Energy Balances and National Accounts

[52] The Swedish Energy Agency and Ångpanneföreningen AB (The Sweden Boiler Association) "All or nothing – On the system boundaries for space heating of buildings", 2004.

Figure D:1. Total energy supplied for electricity generation by energy carriers

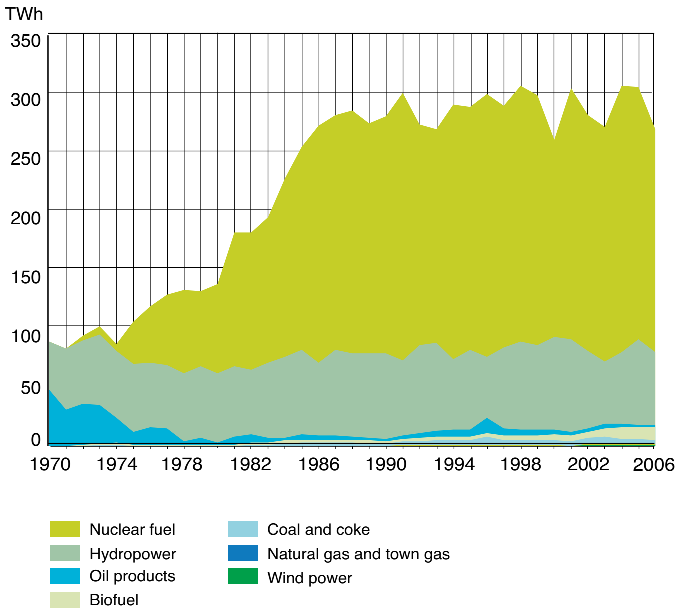
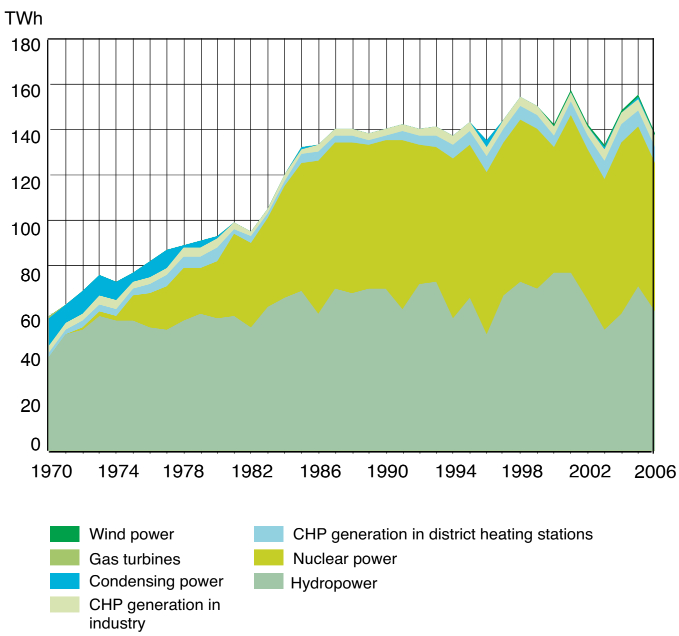



Figure D:2. Total electricity generation by generation technologies




## D. Total energy supplied for electricity generation by energy carriers

The total energy supplied for electricity generation has increased since 1970 from 89 TWh to 270 TWh in 2006. The composition of the energy for electricity generation has changed radically since the 1970s. In the early 1970s, hydropower and fossil fuel based condensing power accounted for most of the power generation in Sweden. One of the results of the change in the Swedish energy policy was an extensive expansion of nuclear power, which substantially increased the amount of energy supplied for power generation. The use of oil for electricity generation decreased substantially, and just over 2 TWh of oil were used in 2006 for electricity generation in Sweden. Today, almost half of the Swedish electricity generation comes from nuclear power, and hydropower also accounts for a very large proportion of the total electricity supply. CHP generation and industrial back-pressure dominate the combustion-based electricity generation (see Figure D:2), whereas oil-fired condensing power stations and gas turbines mainly serve as reserve capacity.

The use of biofuels[53] for generating electricity has increased substantially in recent years and amounted to 11 TWh in 2006. Regulatory instruments in the form of the green electricity certificates system and investment grants for biofuel-based CHP generation have made a substantial contribution to the increase in biofuel use for electricity generation. Wind power has increased robustly in relative terms since 1993, but it still makes only a small contribution in relation to the total power generation. In 1993, wind power accounted for 0.05 TWh, which had increased to about 1 TWh by 2006.

Source: Statistics Sweden Statistical Memorandum series EN 20 Annual Energy Balances

[53] In this and other background indicators, peat and waste have been included in the biofuel item. However, peat is neither renewable (in the short term) nor fossil in the geological sense, and waste can also have a certain proportion of fossil content.

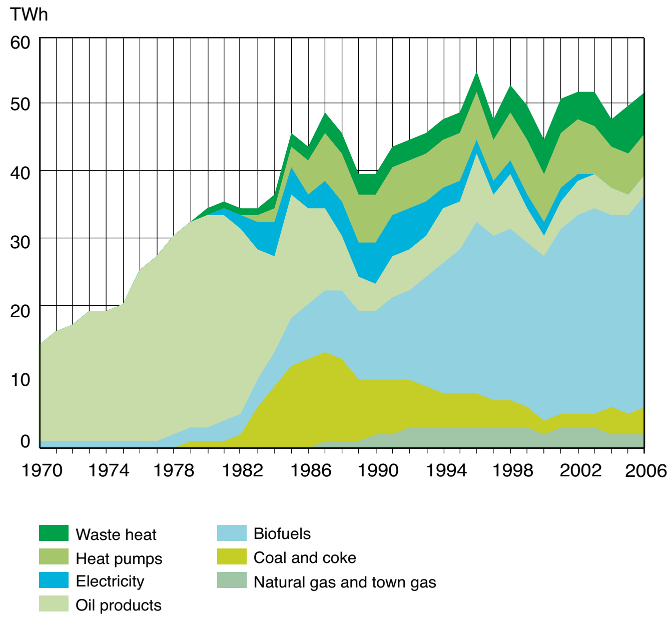
## E. Total energy supplied for district heating generation by energy carriers

In the early 1970s, oil was virtually the only fuel used for district heating generation. In spite of the oil crises in the 1970s, it was not until well into the 1980s that the use of oil for district heating generation declined. When oil was phased out in earnest in the early 1980s, the use of coal and coke for district heating generation increased, but during the 1990s this application also decreased. At the same time as the use of oil decreased, the energy supplied for district heating generation from electric boilers, heat pumps and waste heat from industry increased. Since the 1990s, the use of biofuels[54] for district heating generation has increased dramatically and has largely replaced oil. In 2006, the energy supplied from biofuels for district heating generation was 31 TWh, compared to 1 TWh in 1970. During cold years such as 1996, the use of oil for district heating increases. The reason for the increased use of oil during those years is that oil is generally used for peak load generation.

Source: Statistics Sweden, Statistical Memorandum series EN 20 Annual Energy Balances

[54] In this and other background indicators, peat and waste have been included in the biofuel item. However, peat is neither renewable (in the short term) nor fossil in the geological sense, and waste can also have a certain proportion of fossil content.

Figure E. Total energy supplied for district heating generation by energy carriers



# Base indicators

***The 20 base indicators are used for following-up the Swedish energy policy objectives and they are updated annually. This year, indicators 1 and 20 are incorporated in and replaced by theme indicators I, II and III.***

# 2. Use of fossil fuels in relation to total energy used

*Compared to many other countries, Sweden has a low proportion of fossil fuels[55]. During the past 20-year period, the proportion of fossil fuels in relation to the total use has declined. However, the use of fossil fuels varies widely in the different user sectors.*

### Energy policy objectives

The Swedish energy policy expresses the ambition to maintain a low level of fossil fuel use. In the Government declaration in 2005, the then Government formulated a new guiding objective: Conditions shall be created for breaking Sweden's dependence on fossil fuels by 2020. The Swedish climate objective is also closely linked to the use of fossil fuels.

### Trends

Viewed overall, the proportion of fossil fuels has decreased since the 1980s.

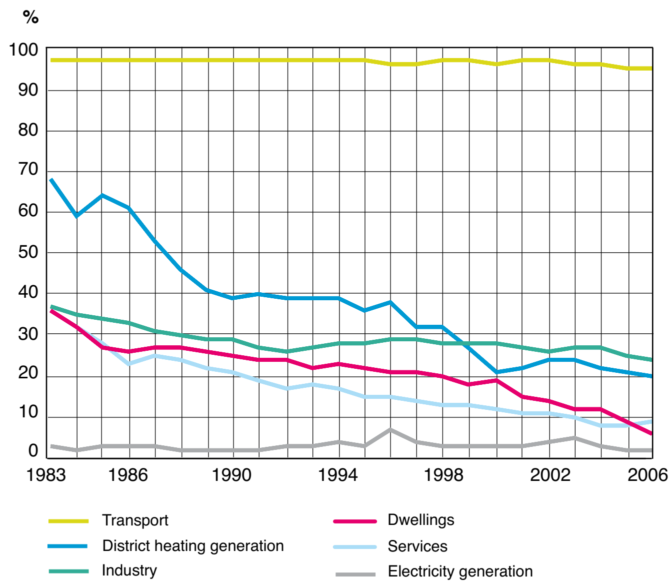
The transport sector still uses predominantly fossil fuels (petrol, diesel fuel, oil, aviation kerosene, etc.). The proportion of fossil fuels in relation to the total energy use in the transport sector has remained relatively stable during the period, but the proportion has decreased in recent years. Oil bunkered for foreign shipping is not included in the indicator. During the whole of the period, electricity generation has been largely free from the use of fossil fuels, although its use can be expected to increase somewhat in the future, since natural gas-based CHP generation plants are being built.

The proportion of fossil fuels used in other sectors has decreased during the period. The reduction was highest in district heating generation, the residential sector and the public services sector. The proportion of fossil fuels used in industry has decreased somewhat[56].

[55] The calculations in this indicator follow the same definitions as those in last year's publication. In certain cases, the definitions differ somewhat from those in the theme indicators for renewable energy, but have been maintained to provide a comparison with calculations for previous years.

[56] For industry, the use of fossil fuels is intended for energy applications, such as heating, furnace fuels and running of stationary engines. Fossil fuels used as raw materials in industry are not included in the indicator.

**Figure 2. Use of fossil fuels (and peat) in relation to the total energy used (including losses) in different sectors**




### Reasons and relationships

The transport sector is the end user sector that has the greatest difficulty in changing to a different energy carrier. Energy use for transport is continually increasing, and alternative solutions for transport are therefore one of the greatest policy challenges.

The fossil fuels used in dwellings and public services consist mainly of oil, but the use of oil in these sectors has steadily declined. An important reason for this is that the competitiveness of oil compared to other sources of energy has been significantly impaired due to increased taxes and higher world market prices. Oil is being replaced principally by heat pumps, district heating and pellet-fired boilers. Various regulatory instruments in the form of conversion support and investment support have contributed to the development.

The proportion of fossil energy used in industry has decreased, which is due to a combination of increasing energy prices and international competitive pressure. These factors have encouraged continuous efficiency improvement work in energy-intensive industries, at the same time as production has increased. The trade in emission allowances introduced in 2005 provides industry with increasing incentives for reducing the use of fossil fuels. Industrial companies that are included in the programme for energy efficiency improvement in electricity-intensive industry (PFE) are given tax relief on the electricity used in manufacturing processes, from the ordinary 0.5 öre/kWh to 0 öre/kWh. All industrial companies pay 21% of the carbon dioxide tax[57].

The low proportion of fossil fuels in the Swedish energy system can be explained in part by Sweden's high electricity use compared to other countries, and the fact that electricity generation is largely based on non-fossil energy carriers (hydropower, nuclear power, biofuels, wind). Within industry, principally the forest industry, biofuels are used to a large extent instead of fossil fuels.

Sweden has an extensive district heating sector that uses only small amounts of fossil fuels. Twenty years ago, district heating generation was mostly based on fossil fuels, but district heating generators have largely changed over to other energy carriers, principally wood fuels, waste, waste heat and heat pumps, in pace with increasing fuels prices and taxes.

**FACTS**

The fossil fuels in this indicator are coal, coke, oil, natural gas and town gas. Peat is also included in the calculation of the fossil proportion, although peat is neither renewable (in the short term) nor fossil in the geological sense. To a certain extent, waste has a fossil content, but is not included in the fossil proportion in this indicator.

[57] More about industry and PFE is included in Base indicator 9 – Electricity use in industry per value added.

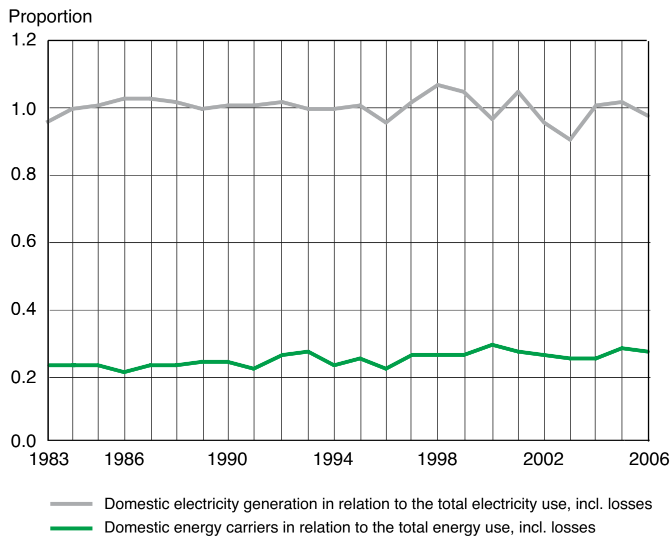
# 3. Degree of self-sufficiency

*The use of domestic energy carriers in the form of hydropower and biofuels is high, but since all oil, natural gas, coal and uranium are imported, the degree of self-sufficiency is stable at just under 30%. The proportion of domestic electricity generation corresponds to the domestic demand, but varies mainly with the weather conditions and hydrology.*

## Energy policy objectives

The energy policy objectives emphasize the importance of safe and secure energy supply. However, in pace with increased internationalization and the deregulation of the Nordic electricity market, the importance of the degree of self-sufficiency for secure energy supply has been toned down. The degree of self-sufficiency is still an interesting yardstick, as long as the legislation is not harmonized between the various countries. According to the objectives, electricity supply shall be secured by an energy system that is based on durable, preferably domestic and renewable energy sources, and on efficient energy utilization.

**Figure 3. Degree of self-sufficiency**




## Trends

The degree of self-sufficiency in the Swedish energy supply is relatively low and has been just below 30% in the past ten years. This means that more than 70% of the energy used is imported. The trend in the degree of self-sufficiency is very slightly on the increase. From the security of supply aspect, it is important to point out that, although just over 70% of the energy used in Sweden is imported, it is only 2% that cannot be replaced at short notice with energy from a different supplier or without the need for major investments. The corresponding figure for Finland is 10% and for Germany 26%, whereas Norway and Denmark are gas and oil producers and are thus not dependent on imports. In Sweden and Finland, it is the natural gas that accounts for the non-substitutable energy, whereas Germany has both a specific gas and oil requirement[58].

Even though the total trend is slightly on the increase, the changes in the respective shares of the various energy carriers are greater. The proportion of biofuels has increased significantly, and wind power has also increased. The proportion of heat pumps[59] increased robustly in the beginning of the period, but has declined in recent years. The proportion of hydropower has decreased somewhat, while the proportion of nuclear power has remained fairly stable. The proportion of oil has dropped significantly between 1983 and 1990, but has remained relatively stable since then. The proportion of natural gas has increased, whereas the proportion of coal has remained fairly constant during the period.

The proportion of domestic electricity generation remained relatively constant at more than 100% up to the deregulation of the electricity market in 1996. After deregulation, the proportion fluctuated somewhat from year to year, partially due to the increased trade between countries, but mostly due to

[58] OECD Countries Energy Balances 2006 published by IEA related to 2004, and Swedish Energy Agency calculations.

[59] In the official statistics, only the heat pumps in district heating systems are included. Small heat pumps have increased significantly, but they are not included in the official statistics used here.

the decommissioning of less profitable generation capacity and to purely meteorological conditions. During 1996, 2000, 2002 and 2003, which were dry and cold years, Sweden was a net importer of electricity. A degree of self-sufficiency in electricity higher than 1 means that Sweden generates more electricity than that needed in the country. It is important to emphasize that a degree of self-sufficiency higher than 1 in electricity admittedly means that the country is a net exporter of electricity, but additional electricity imports are still necessary during high-load periods, and there are many hours during the year when Sweden imports electricity from neighbouring countries, depending on where the generation price is lowest.

**Reasons and relationships**

Domestic energy in Sweden consists of hydropower, biofuels[60], district heating from heat pumps,[61] and wind power. The imported energy consists principally of nuclear fuel, oil, coal and natural gas and, in certain years, imported electricity. Domestically generated electricity is all electricity generated in the country, regardless of the fuel on which generation is based. This means that, for example, nuclear power generation, which accounts for around 45% of the total electricity generation, is domestic electricity generation even though the nuclear fuel is imported. This also applies to electricity generation based on fossil fuels.

Since 1987, which was the first year when all nuclear power plants were already commissioned, renewable energy, principally biofuels, basically accounted for the whole of the increase in energy use. Redistribution between the other energy carriers has taken place, but the total increase corresponds to the increase in biofuels. The use of biofuels has been stimulated principally by taxes on fossil fuels and by support measures, such as green electricity certificates, which have made biofuels more competitive.

Sources: Statistics Sweden, Statistical Memorandum series EN 20, Annual energy balances and EN 11, Electricity, gas and district heating supplies. Processed by the Swedish Energy Agency.

[60] Note that biofuels in this indicator are classified as domestic. But a proportion of biofuels is actually imported.

[61] Input energy to the heat pumps from rocks, lakes, the soil and atmospheric air.

# 4. Combined heat and power generation

*A combined heat and power (CHP) generation plant simultaneously generates electricity and heat. This is an efficient energy conversion method with low total losses. Sweden uses a relatively low proportion of the heat demand in district heating networks and in industrial plants as a base for electricity and heat generation in CHP plants. In 2006, 34 % of heat demand in the district heating system was covered by CHP generation. The generation of electricity in CHP operation accounted for about 8 % of the Swedish electricity use including transmission and distribution losses.*

**Energy policy objectives**

The energy policy objectives emphasize the importance of high energy efficiency and good conservation of resources. CHP generation provides scope for energy conversion at high efficiency and therefore leads to both of these objectives.

**Trends**

The long-term trend for electricity generation in CHP operation in relation to the electricity use is on the increase. In 2006, 8% of the electricity used was generated in CHP plants. The trend towards heat generation in CHP plants is also on the increase. In 2006, around 34% of the heat demand in the district heating systems was supplied by CHP generation, which is a relatively small proportion. A contributory reason for the heat base in the district heating systems not being used to a higher degree for CHP generation is that the district heating system consists of a large number of local networks in which the players are sometimes small companies that would find it difficult to raise the funds for investing in electricity generation.

The fuel used for generating electricity and heat in CHP plants in the district heating network has changed over the years. In 1983, just over 7% of the fuel used was biofuel[62], while oil was the most common fuel (57%), followed by coal (36%). In 2006, the proportion of biofuel had increased to almost 67%, while coal accounted for 19%. The amount of coal used is at the same level as in 1983, but has been higher during the period and has again decreased. Oil has been largely replaced by biofuels and now accounts for only 8%, even though much more electricity and heat are generated today in our CHP plants.

A high proportion of biofuels was used for power generation in industry already at an early stage, but the development has since then still been similar to that for electricity generation in the district heating network, although the increase has taken place somewhat later in time. Since the mid-1990s, a

[62] In this indicator, peat and waste have been included in the biofuel item. However, peat is neither renewable (in the short term) nor fossil in the geological sense, and waste can also have a certain proportion of fossil content.

**Figure 4:1. Electricity generation in CHP operation (district heating and industry) in relation to the total electricity use (including transmission and distribution losses)**

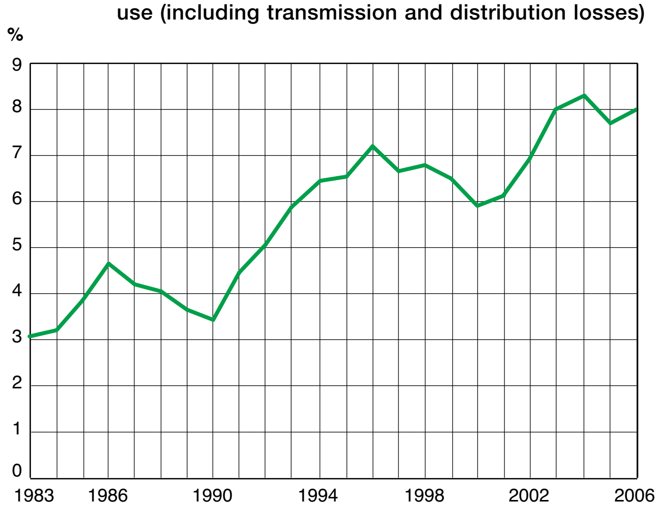



**Figure 4:2. District heating generation in CHP operation in relation to the total use of district heating (including distribution losses)**

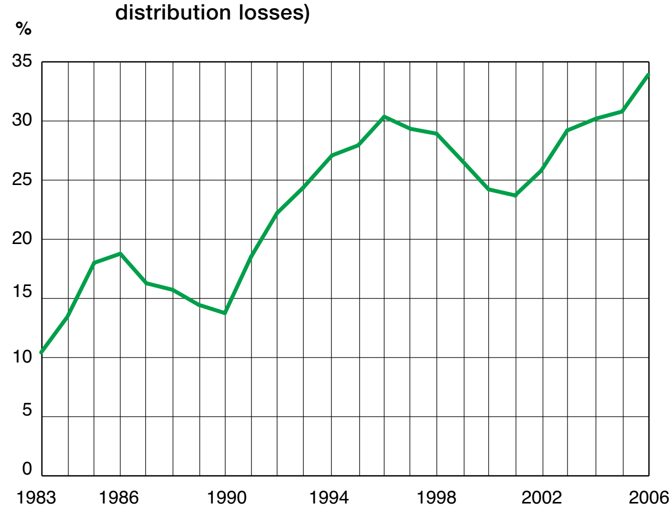
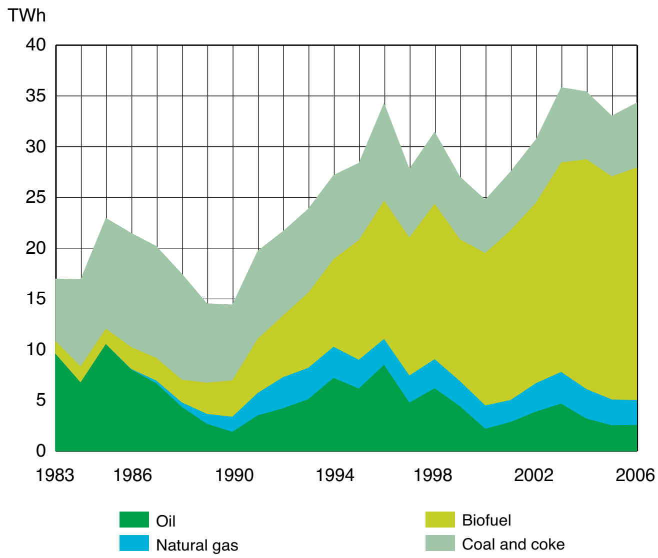


**Figure 4:3. Fuel input for electricity and heat generation in CHP plants in the district heating network.**




clear increase is discernible in the use of biofuels and reduced use of oil. Biofuel today accounts for more than 73% against 53% in 1983.

### Reasons and relationships

CHP generation is used both in district heating systems and in industry. The use of CHP generation in Sweden is still relatively low compared to Finland, for example. There are several reasons for this. One reason is that Sweden decided to invest in nuclear power as a supplement to hydropower, and did not therefore have the need for this electricity generation. Another reason is that electricity generation in CHP plants has earlier been treated unfavourably in taxation compared to Nordic generation in condensing power stations. Stricter environmental requirements than those for electricity generation in other countries have also contributed. Long periods of low electricity prices have made CHP generation unprofitable, even in existing plants.

The conditions for CHP generation have changed much over time. In the early 1990s, investment support was introduced for biofuel-based CHP generation, which resulted in an increase in generation. When the electricity market was deregulated in 1996, electricity prices dropped so much that CHP generation became economically uncompetitive and generation tapered off. New investment support was introduced in 1997 for biofuel-based CHP generation, and additional generation capacity was built.

The green electricity certificate system has been operative since 1 May 2003, which favours biofuel-fired CHP generation. Due to this regulatory instrument, biofuel-based CHP generation is normally by the far the most profitable alternative for district heating companies that need new heat generation. Before the introduction of the green electricity certificate system, many biofuel-fired hot water boilers were built, i.e. systems without electricity generation.

From 1 January 2004, CHP generation in district heating systems was put on an equal footing with CHP generation in industry, also known as industrial back-pressure generation, from the taxation viewpoint, which means that the taxation of CHP generation in district heating systems is taxed more favourably than in the past. The electricity generated is still tax exempt, whereas the heat generated is not subject to energy tax and the carbon dioxide tax is reduced to 21%.

Plants over a certain size can be included in the EU system for trading in emission allowances, which imposes an extra cost on plants that use fossil fuels.

The technical potential of CHP generation depends on the available heat demand base provided by the district heating systems and the process heat demand in industry. Two important parameters for the development of CHP generation are the extent to which the existing heat demand base is utilized and how the magnitude of the heat demand base develops.

Although the use of CHP generating stations is positive, there are also other ways of generating heat for district heating, which are valuable from the viewpoint of resource conservation and environmental considerations. One example is the utilization of industrial waste heat, i.e. heat that would otherwise not be put to use. The use of such waste heat has more than doubled during the past 20-year period, although the magnitude is still limited.

Sources: Statistics Sweden, Statistical Memorandum series EN11, Annual electricity, gas and district heating statistics, and series EN20 Annual balances.

### FACTS

The concept of combined heat and power (CHP) generation means that electricity and heat are generated simultaneously. CHP generation is much more efficient than other alternatives for fuel-based separate electricity generation and separate heat generation, viewed from the total utilization of the energy in the fuel. The system efficiency is roughly twice as high. The condition for CHP generation is proximity to an area where there is a heat demand. Heat generation can be used either for district heating or for process heat in industry.

# 5. Power balance

*The historically strong Swedish electricity balance was weakened drastically following deregulation. Power stations were shut down, while the power demand increased. However, since 2000, the installed capacity has steadily increased, while the peak load demand has remained stable in recent years. The electricity balance is now largely satisfactory, particularly taking into account the increased import capacity.*

## Energy policy objectives

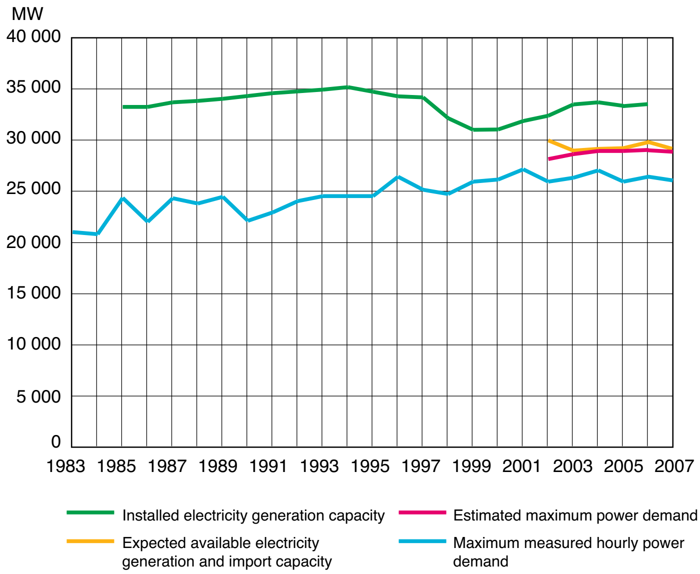
Securing the availability of electricity is a focal part of the energy policy objectives. These also state that secure availability of electricity at a reasonable price is an important condition for the international competitiveness of Swedish industry. It is also stated in the objectives that the use of electricity by industry shall not be restricted by anything other than the prevailing regulations in taxation and environmental legislation. Secure availability of electricity means that generation and/or import resources shall always be available, corresponding with a reasonable margin of safety to electricity demand. In the "Protection and preparedness for accidents and difficult circumstances" policy area, it is stated that one of the objectives for our safety should be to protect the functionality of society. Energy supply and thereby also electricity supply is classified as a socially important activity that must not break down.

## Trends

The indicator shows the maximum hourly power demand for electricity compared to the installed electricity generation capacity in Sweden. The indicator also shows the estimated available electricity generation and electricity import capacity compared to the estimated maximum power demand in a ten-year winter[63]. The maximum hourly power requirement is the measured mean power during the hour every year when the electricity use has been at its highest. The occasion on which this peak load occurs varies from year to year, but normally occurs in very cold weather in densely populated parts of the

[63] A ten-year winter is defined as the lowest three-day mean value of temperature that statistically occurs every ten years.

**Figure 5:1. Maximum measured hourly power demand for electricity compared with the installed capacity and estimated available electricity generation and electricity import capacities compared with the estimated maximum power demand.**




Sources: Nordel and Svenska Kraftnät

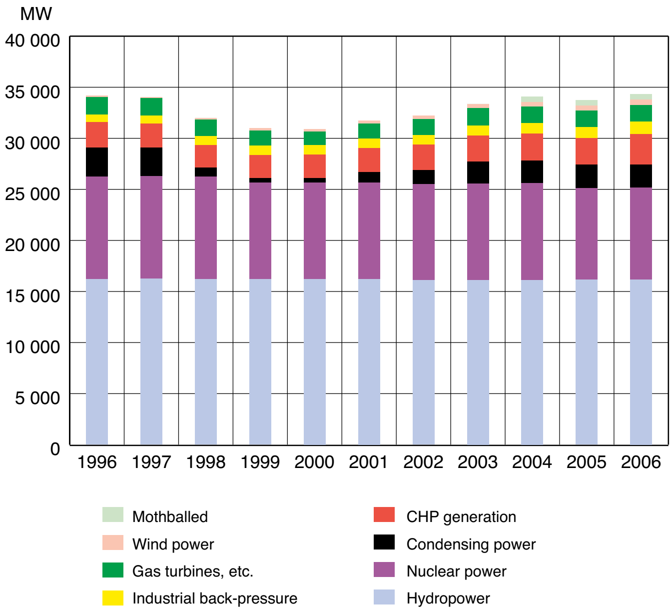
country, at the same time as the electricity use by industry is high. The maximum hourly power demand has increased slowly over time, but has fluctuated around 26 000 MW since 1996.

The installed generation capacity in Swedish power stations increased slowly up to the mid-1990s. However, the capacity decreased significantly during the second half of the 1990s. The installed capacity again increased after 2000, and is basically back at the same level as before deregulation. However, the power situation can still be strained during a so-called ten-year winter.

## Reasons and relationships

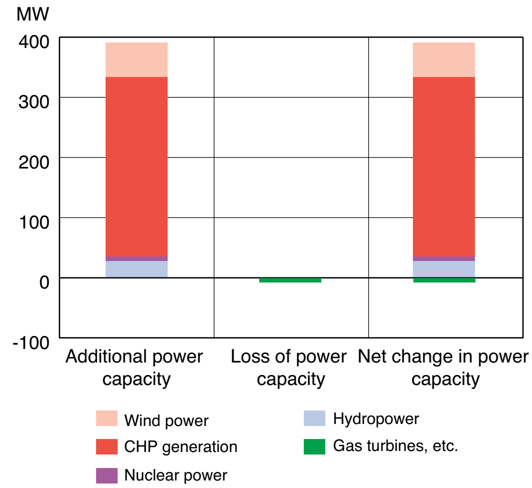
The maximum hourly power demand has flattened out during the past ten years. This can partially be explained by the fact

Figure 5:2. Installed electricity generation capacity in Sweden per power source between 1996 and 2006




Source: Nordel

Figure 5:3. Change in installed power generation capacity in Sweden in 2006




Source: Nordel

that the electrical energy use in recent years has flattened out, for reasons such as increased electricity prices. The maximum electric power demand is influenced by factors such as industrial business activity, price of electricity and temperature conditions during the relevant year. Low temperatures increase the space heating requirements and the electricity demand to the extent that the heating systems are based on electricity. The high increase in the heat pump capacity, principally for heat from rock, for heating single-family houses contributes to an increased power demand during the cold season of the year. Heat pumps are not normally rated for meeting the heat demand in very cold weather, so electricity is then used instead for heating. This contributes to the increased electricity demand at times of the year that are most critical from the power aspect. At the same time, the use of district heating has increased somewhat in recent years, which promotes lower electric power demand for heating. The conversion of electrically heated dwellings to other heating alternatives, such as district heating or biofuel boilers, could also be one way of reducing the power demand.

There are a number of difficulties associated with the interpretation of the relationship between maximum electric power demand and the installed power generation capacity. The electric power demand varies with the outdoor temperature and industrial business activity. This means that even if the maximum electric power demand is lower, with a comfortable margin, than the installed generation capacity over a number of years, this need not mean that the electricity supply is secure for the coming years. This may be due to earlier years having been mild, at the same time as the electricity demand in a coming year may be substantially higher. It should be emphasized in this context that all of the past ten years have been warmer than normal.

The estimated available electricity generation and electricity import capacities are reported annually by Svenska Kraftnät to the Government before the coming winter. The report includes all electricity generation capacity that is estimated to be available before every winter, excluding the disturbance reserves[64], with an estimate of the expected unavailability that reduces the capacity. The import capacity included is the one that can be expected during a ten-year winter, i.e. that due to the power situation in neighbouring countries, all import capacity cannot be expected to be available.

The reduction in electricity generation capacity at the end of

[64] The disturbance reserve consists of quick-starting generation capacity, such as gas turbines. The disturbance reserve is used in the event of disturbances in the power system, i.e. unscheduled events. These reserves are not used for balance control during normal operation, but may have to be used if there is risk of power shortage.

the 1990s was due principally to stand-by plants (condensing) being mothballed and the fact that Barsebäck 1 was shut down. At the same time, the additional capacity in the form of CHP plant and wind power was low. The increase after 2000 consists mainly of recommissioning of plants in the power reserve that were previously mothballed.

The shutdown of Barsebäck 2 on 31 May 2005 caused the loss of 600 MW of power. This was partially compensated by the uprating of Forsmark 3 by 50 MW and by the Ringhals reactors being granted permission to raise the power output by a total of about 200 MW. There are also plans for expanding biopower and CHP generation among companies in the forest industry and district heating sector. According to a newly published report on the expansion of CHP generation between 2007 and 2015[65], an increase of 1250 MW in the installed electric power generation capacity is expected by 2015 in CHP plants in the district heating system and by 300 MW in plants in the forest industry.

As a result of the deterioration in the power balance, the Swedish Parliament decided in 2003 to pass a law on power reserve. According to the law, Svenska Kraftnät was given the responsibility to procure a power reserve not exceeding 2000 MW. The power reserve is achieved by Svenska Kraftnät entering into agreements with electricity generators and electricity consumers for making further generation capacity available or allowing for a reduction in consumption. The validity of this law has now been extended by a further three years. During this period, the Energy Markets Inspectorate and Svenska Kraftnät shall submit a proposal for a new and more market-based model.

[65] The report is produced by the Swedish Bioenergy Association, Swedish Forest Industries' Federation, Swedish District Heating Association and Swedenergy, and was published in April 2008.

# 6. Total market share of the three largest electricity suppliers

*Efficiency and competition shall characterize the Swedish electricity market. Statistics show that the market share of the three largest electricity supplying companies increased from 48% to 50% between 2004 and 2005, and that it remained at 50% during 2006[66]. The market share dropped in preceding years, which is due in part to a couple of new electricity companies establishing themselves on the market. The fact that the three largest electricity supplying companies then regained market shares may be due to their intensified marketing.*

### Energy policy objectives

Electricity supply has a very important function in our society. Electrical energy is consumed daily by households and is included in virtually all production of goods and services. In the energy policy objectives, emphasis is placed on the importance of an efficient electricity market. Good conditions must be created for consumers and companies to act on the competitive electricity market. An electricity market that performs well and has a sound structural transformation and efficient utilization of resources creates effective pricing.

[66] In order to improve quality, this indicator has been calculated by a new method as from last year's publication. The old time series was recalculated in accordance with the new method. The reason for this change is that the old method in all probability over-estimated the market concentration as a result of an underestimate of the total market size.

### Trends

The electricity market in Sweden is characterized by vertically integrated groups of companies. Vertical integration means that groups of companies in the electricity market control the operations in electricity generation, electricity supply and electricity distribution. Vattenfall, E.ON and Fortum are the three companies that now dominate electricity generation, sales and distribution in Sweden. The market share of the three biggest electricity supplying groups in Sweden in terms of electrical energy sold dropped from 62% in 2000 to 50% in 2005. An opposite development took place during the period between 1997 and 2000 when the market concentration rose from 27% to 62%. During 2006, the market share of the three largest electricity supplying groups remained fairly constant at just under 50%[67].

The so-called Herfindahl-Hirschman index (see facts box), which is another way of measuring the market concentration, reveals a corresponding development. After deregulation of the electricity market, the index rose from 0.11 in 1997 to 0.14 in 2001. In 2002, the index dropped to approximately 0.10, where it remained up to 2006. According to the "US horizontal merger guidelines", the Herfindahl index shows that the mar-

[67] See also Base indicator 19 – Total market share of the three largest electricity generators.

### FACTS

When assessing the concentration on a market, it is practical to use an index that provides information with a single figure on the competitive conditions on that particular market. Several such indexes have been developed, two of which are more generally used. These are the Herfindahl-Hirschman index (sum of the squares of the market shares), and the total market share of the largest companies on the market (where the number of companies can usually be between three and ten). The figures for both indexes are between 0 and 1, whereby lower values of the concentration index indicate better conditions for competition. According to the "US horizontal merger guidelines", the market can be characterized in the following manner at different values of the Herfindahl- Hirschman index:

| | |
|---|---|
| < 0.10: | Unconcentrated market |
| 0.10 – 0.18: | Moderately concentrated market |
| > 0.18: | Highly concentrated market |

ket for electricity supply in 2006 was moderately concentrated. The Herfindahl index should be viewed with caution, since certain observers consider that the makeup of the index is not well suited for the electricity market. A comprehensive picture is needed for good assessment of the competition on the electricity market, whereby additional factors are considered, such as information, transparency and liquidity, and the effect of vertical and horizontal integration. This index should therefore be regarded as one yardstick among several that can be used for assessing the competition on the electricity market.

### Reasons and relationships

If the electricity market is to perform efficiently with effective competition on equal terms, there must be few market obstacles on the market or none at all. The electricity market is divided into a bulk power market and an end-user market. The conditions differ on the two parts of the market. The end-user market is mainly national, whereas the bulk power market is highly international.

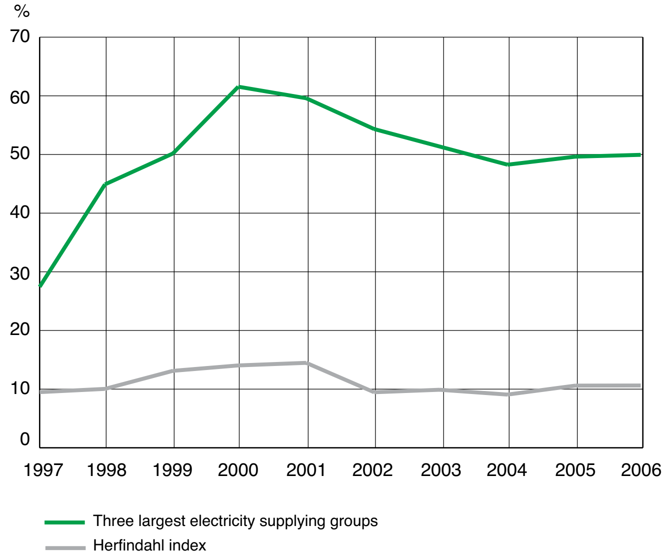
A number of new rules were introduced in the Electricity Act on 1 January 2007 in order to strengthen the position of the customer on the electricity market. The new rules give the electricity consumer clearer rights to information, and the time for implementing a change of electricity supplier was shortened. The increased information is intended to encourage consumers to be more active on the electricity market, to make a larger number of rational choices, and thereby make the market more efficient.

A condition for the electricity market to perform efficiently is also that cross-subsidizing between monopoly operations and competitive operations must be minimized. There were historical indications that profits from electricity distribution were used to cover losses in other electricity operations. The Electricity Act specifies that the corporate body that runs electricity network operations must not run generation of or trading in electricity. This reduces the opportunities available for cross-subsidizing of electricity generation and electricity trading by network operations. The European Commission and the European supervisory authorities act towards creating equal conditions on the EU internal market for electricity.

The number of electricity supplying companies on the Swedish market has been dropping over many years. In the mid-1950s, there were more than 1500 companies that distributed and sold electricity. Twenty years later, the number of companies had dropped to just over 500. Since the electricity market was deregulated on 1 January 1996, the number of electricity suppliers who pursue active sales of electricity to end customers has dropped from 221 companies to around 115 (in 2007). Out of these, most sell electricity to customers throughout the country, although few of them actively market their services nationally. Only 20-odd are entirely independent of the three large energy groups.

An important reason for the initially increasing market concentration is that, after deregulation of the electricity market, small independent and municipal companies faced the choice of either merging with other companies or selling their operations. The larger electricity supplying companies were looking for benefits of size and were thus interested in buying smaller companies, while many municipalities tried to sell their operations. There were benefits to be gained for both sellers and buyers, which led to many of the smaller companies being sold to larger electricity supplying companies. The number of municipally owned electricity supplying companies decreased during the period between 1996 and 2004 from 143 to 56.

**Figure 6. Total market share in Sweden of the three largest electricity supplying groups, and the Herfindahl index for the electricity supplying market in Sweden**

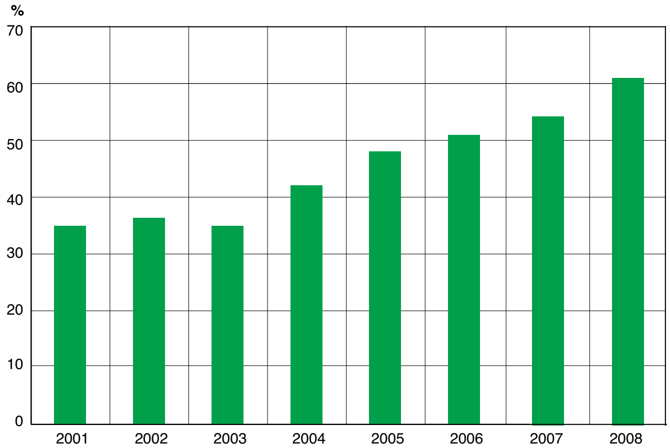



Sources: Statistics Sweden, Statistical Memorandum series EN11, Annual electricity, natural gas and district heating statistics, and the Energy Markets Inspectorate.

# 7. Proportion of end customers for electricity who have renegotiated their contracts, including those who have switched to a different electricity supplyer

*For a number of years, electricity customers have had full freedom to choose their electricity supplier. The information on how the electricity market operates and the scope available for comparing the various offers of the electricity supplying companies have been improved in the past year. On 1 January 2008, more than 61% of electricity customers had renegotiated their electricity contracts and/or switched to a different electricity supplier.*

**Figure 7:1. Proportion of end customers for electricity who have renegotiated their contracts, including those who have switched to a different electricity supplier, 1 January 2001–2008**




*Note. Figure 7:1 is an interpretation of the source information that, more correctly expressed, shows the proportion who do not have "until further notice" agreements.*

### Energy policy objectives

An electricity market that performs well and is efficient is an important objective in the Swedish energy policy. A market that performs well creates competitive electricity prices, which is of great importance to the international competitiveness of Swedish industry and to the economics of households. For the market to perform well, consumers must be well informed and active. The Swedish energy policy therefore emphasizes that electricity supplier changes should perform in a satisfactory manner. A number of new rules in the Electricity Act were introduced on 1 January 2007, with the aim of strengthening the position of customers on the electricity market.

### Trends

During the period between 2001 and 2003, the proportion of end customers for electricity who had switched to a different electricity supplier or renegotiated their contracts was relatively constant at around 35%. This was followed by a marked upswing and, by 1 January 2008, more than 61% of the end customers had renegotiated their contracts or switched to a different electricity supplier. This trend continued during the early part of 2008. During the last year, end customers who have decided to conclude variable price contracts have increased from 10% to 16%. On the other hand, the proportion who has decided on 1-year or 2-year contracts has decreased somewhat between 2007 and 2008. Customers who have decided on 3-year contracts have increased somewhat.

Viewed over the year, there are certain seasonal variations when customers change their electricity supplier, e.g. a low proportion make the change during June and a very high proportion of changes take place in January. The latter is presumably because, for practical reasons, many agreements begin on 1 January, although an additional reason may be that one or more electricity suppliers have price campaigns, in which contracts begin on 1 January.

### Reasons and relationships

End customers can choose from among various contract forms, such as fixed prices of electricity with different contract durations and variable price of electricity linked to the Nord Pool spot price. Customers who do not make an active choice are left on or assigned to a so-called "price until further notice".

The electricity user has full freedom to switch to a different electricity supplier and/or renegotiate his electricity contract. However, the electricity user cannot switch to a different supplier if the user has a contract with a definite duration that is still in force. Since 1 January 2007, electricity suppliers must notify the network company of a supplier change no later than the 15th of the calendar month before the turn of the month when the change is to take place. This means that the time for supplier change has been shortened to one and a half months at most.

There are several explanations for the increase in supplier changes and renegotiations of contracts from 2004 onwards. The prices of electricity during 2004 and 2005 were much lower than the record prices during the winter of 2002/2003. A consequence may be that many customers have used the opportunity to conclude contracts running for several years at a relatively low price compared to the previous year. Another reason may be that the knowledge of electricity customers of how the market performs has increased as a result of the electricity companies being afforded much space in the media in recent years. Moreover, several electricity supplying companies have intensified their marketing during the past year.

End customers with high electricity consumption have most to win by being active on the market, although customers living in apartments with low electricity consumption may also benefit from active choice of electricity supplier. In addition to finding an electricity supplier with a low price of electricity, customers with low electricity consumption should choose an electricity supplier who can offer an agreement either with no annual fixed charge whatever or with a low, fixed charge. The total price of electricity consists of the price of electrical energy (from 1 January 2007, including the price of green electricity certificates), the price of network service and taxes (energy tax and VAT). The end customer can affect only the first parameter by renegotiating his contract.

A number of new rules were introduced in the Electricity Act on 1 January 2007 in order to increase the activity on the electricity market and strengthen the position of customers. According to the changes, only a customer who has a network agreement can conclude an electricity supply agreement, which means that the same person in the household must be responsible for both agreements. Another change safeguards that the customer will receive information on who the designated electricity supplier is and when an electricity supply agreement ceases. Moreover, as mentioned earlier, the notification time for changing the electricity supplier has been shortened.

**Figure 7:2. Number of administered electricity supplier changes in the period January 2006 – January 2008**

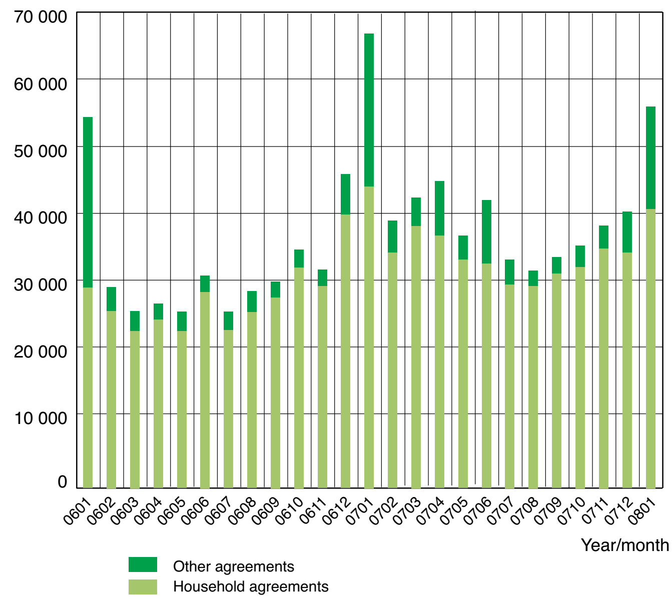
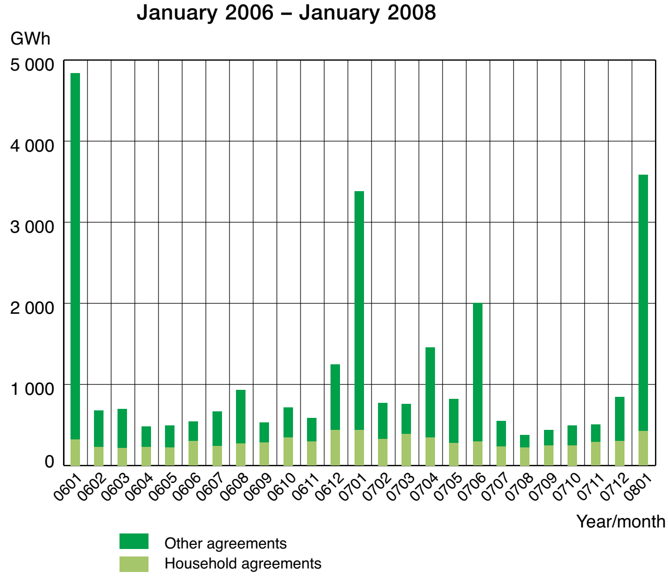



**Figure 7:3. Calculated annual volume of administered electricity supplier changes in the period January 2006 – January 2008**




Sources: Statistics Sweden, Statistical Memorandum series EN17, Prices of network services and electrical energy, and monthly electricity statistics.

# 8. Energy use of industry per value added, in a number of industrial sectors

*The energy use of industry per value added varies between different industries. For most sectors of industry in Sweden, the indicator demonstrates a slow reduction in energy use per value added, and in 2005, the energy use per value added in all industries studied decreased, with the exception of the pulp and paper industry. In an international comparison, the energy use of Swedish industry per value added is high. On the other hand, it is not correct to claim, on the basis of the relevant indicator, that Swedish industry uses energy less efficiently than industry in other countries. It is rather an expression of the different roles in the international work distribution, where industrial production in Sweden to a larger extent uses non-processed raw materials as the point of departure. In three out of four industries studied, Swedish industry has lower energy use per value added than the EU average.*

### Energy policy objectives

In the energy policy objectives, the importance is emphasized of reliable availability of energy at reasonable prices for the international competitiveness of industry. This particular indicator is of interest since it shows the energy intensity in Swedish industry compared with other countries and how heterogeneous Swedish industry is from the energy aspect. The indicator also shows how important energy is as an input commodity for different industries, and thus how sensitive different industries are to changes in the price of energy.

### Trends

The trend for most industrial sectors in Sweden is steadily declining energy use per value added. The energy use per added value has decreased by 48% between 1993 and 2005 in the manufacturing industry as a whole and by 76% in the engineering industry. However, in the pulp and paper industry[68], the energy intensity increased by about 12% during the same period. Ironworks, steelworks and metalworks in Sweden displayed increasing energy use per value added during the latter end of the 1990s. The upturn was broken in 2000, and the energy use of the industry per value added has decreased since then. During 2005, the energy use per value added decreased in all industries studied, with the exception of the pulp and paper industry, in which the indicator continued to rise.

The difference in energy use per value added is very wide between different industries. In 2005, the energy intensity was more than 0.3 kWh/Euro of value added in the engineering industry, while it was almost 10 kWh/Euro and more than 10 kWh/Euro in the pulp and paper industry, and in ironworks, steelworks and metalworks respectively. In each sector of industry, the differences are wide between different parts of the sector.

The energy use per value added in the EU-15 has been decreasing since 1993 in the whole of the manufacturing industry, basic chemical industry, engineering industry, and ironworks, steelworks and metalworks. During the same period, the energy use per value added in the pulp and paper industry increased by almost 20%. The manufacturing industry in Sweden has a somewhat higher energy use per value added than the average for the EU-15, but the engineering industry, chemical industry, and ironworks, steelworks and metalworks in Sweden have a lower energy use per value added than the EU average. In the pulp and paper industry, the energy intensity in Sweden is around three times higher than in the EU-15. Since 1993, the energy intensity in the Swedish manufacturing industry has been decreasing at a higher rate than in the EU-15.

### Reasons and relationships

Sweden has long been characterized by a large energy-intensive industry, partially due to the good availability of raw materials, such as forests and iron ore. A contributory factor for the declining energy use per value added in Sweden is that the growth rates in the Swedish engineering and pharmaceuticals industries have been high in recent years. These industries are not particularly energy intensive, which leads to the value added increasing more quickly than the energy use.

[68] The pulp and paper industry comprises here SNI 21-22, i.e. pulp, paper, paper goods and graphic industries.

**Figure 8:1. Industrial energy use per value added, in a number of industrial sectors, Sweden**

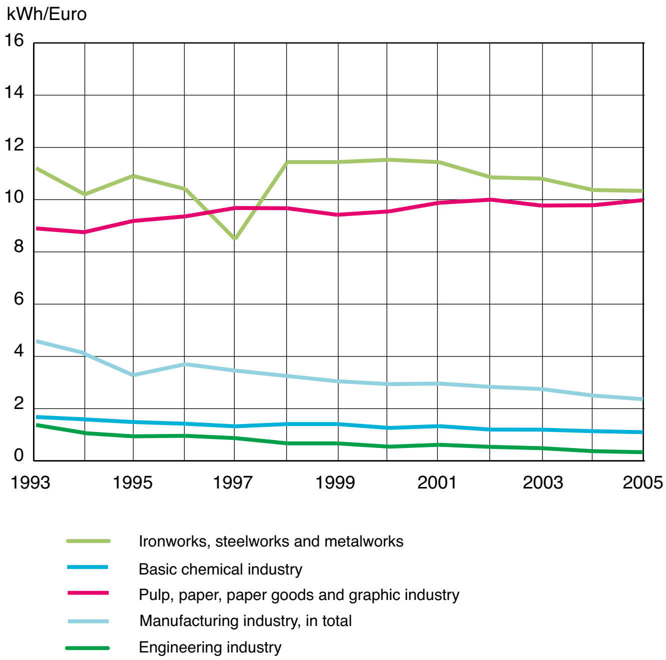



**Figure 8:2. Industrial energy use per value added, in a number of industrial sectors, EU-15**

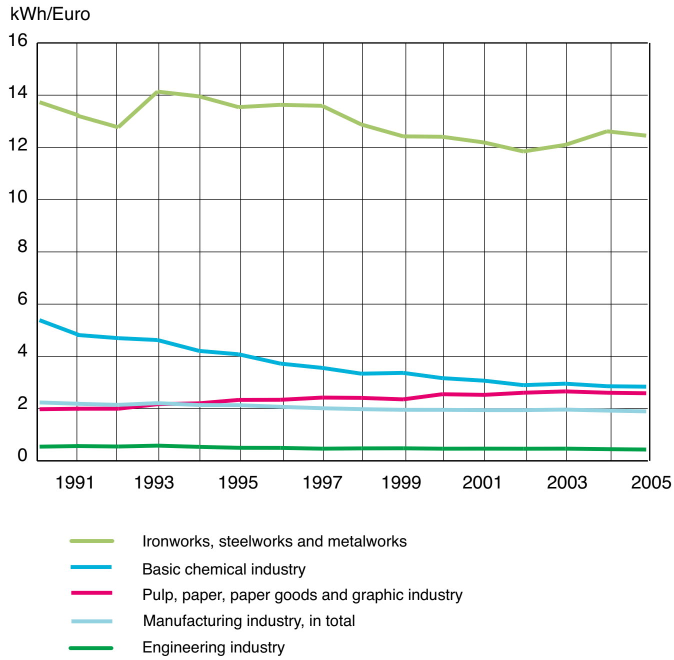



*Figure clarifying SNI codes:*
*15–37: Manufacturing industry, in total*
*21–22: Pulp, paper, paper goods and graphic industry*
*24.1: Basic chemical industry*
*27: Ironworks, steelworks and metalworks*
*28–35: Engineering industry*

It is close to hand to interpret the indicator as a measure of how efficiently energy is used. However, this particular indicator is not a good instrument for following up the energy efficiency, since the development of the indicator is influenced by a great deal more than the actual energy efficiency. Some examples of factors that lower the energy use per value added without a change in the actual energy efficiency are:

- Structural changes in a particular sector of industry. If part of a sector of industry with low energy use expands at the expense of a part with high energy use, the indicator will show a lower energy use per value added.
- Process changes in the sector of industry, e.g. that the demand switches to products with other properties.

For the same reasons, it is not correct to use this indicator as the basis for claiming the Swedish industry uses energy less efficiently than industry in other countries. Part of the explanation for the appreciably higher energy use per value added, mainly in the pulp and paper industry, is that Swedish industry is focused on products and processes that give rise to high energy use per value added, i.e. an expression for the different roles in the international work distribution. In Sweden and Finland, industry is based largely on unprocessed raw materials, e.g. forest, whereas countries in the remainder of Europe are largely based on recycled paper, for instance. This is the main reason for the difference in energy use, and with unprocessed raw materials as input, Sweden and Finland can never reach the "EU level".

Source: The annual energy use of industry is included in Sweden's official statistics and is published as tables on the Statistics Sweden homepage. The data for the value added comes from the Statistics Sweden national accounting. As from 1993, the rolling basic year is used, whereby the basic item is calculated in the fixed prices at the price in the immediately preceding year. The statistics for the EU are obtained from the EU/SAVE-financed Odyssee database.

*Note: These statistics have been revised from 1993 onwards, and the time series therefore differs from those given in this publication in earlier years.*

# 9. Electricity use in industry per value added, in a number of industrial sectors

*The electricity use in industry per value added varies widely between different sectors. During 2005, the electricity use per value added decreased in the Swedish manufacturing industry. However, electricity use per value added increased in the pulp and paper industry[69].*

### Energy policy objectives

The importance of reliable access to electricity at reasonable prices for the international competitiveness of industry is emphasized in the energy policy objectives. The indicator also intimates how the competitiveness of different sectors of industry is affected by changes in the price of electricity.

### Trends

Since 1993, electricity use per value added has been declining in most sectors of industry. However, this does not mean that the total electricity use has dropped, but indicates that the value added has been increasing more rapidly than the electricity use. During 2005, the electricity use per value added decreased in the whole of the manufacturing industry, chemical industry, ironworks, steelworks and metalworks, and also in the engineering industry. Electricity use per value added in the pulp and paper industry increased during the period between 1996 and 2001, then decreased up to 2003, followed again by an upturn.

The electricity use per value added differs widely between different sectors of industry in Sweden. In 2005, the electricity intensity was just over 0.2 kWh/Euro of value added in the engineering industry, while it amounted to around 3 kWh/Euro in the pulp and paper industry, and ironworks, steelworks and metalworks. In each sector of industry, the differences are also wide between various parts of a given sector.

The difference in electricity intensity between different countries in EU-15 and between individual sectors of industry is also wide. In the pulp and paper industry, the electricity intensity is almost three times as high in Sweden as in EU-15, whereas the electricity intensity in the Swedish chemical industry is lower than it is in the chemical industry in EU-15. In EU-15, there are comparable statistics only for these two sectors.

### Reasons and relationships

The indicator shows the electricity intensity in Swedish industry compared with EU-15 and how heterogeneous Swedish industry is from the electricity use viewpoint. The indicator also shows how important electricity is as input commodity for various sectors for industry and thus how sensitive these sectors are to changes in the price of electricity. However, this particular indicator is not a good instrument for following up the efficiency of electricity use, since the development of the indicator is affected by other factors than the electricity efficiency. In principle, electricity can thus be used increasingly efficiently even if the electricity use per value added indicator increases. Such development can be explained, for instance, by structural changes in the sector of industry and by process changes. As an example, the increase in electricity intensity in the pulp and paper industry at the end of the 1990s can partially

### FACTS

A programme for energy efficiency improvement in energy-intensive companies (PFE) has been operative since 2005. By participating in the programme, companies can receive complete exemption from the energy tax for electricity that they would otherwise have to pay from 1 July 2004. 117 companies are participating in the programme. These companies use a total of about 30 TWh of electricity annually in their production processes, which corresponds to roughly 50% of industrial electricity use. This means that they now receive total tax exemption amounting to around MSEK 150 annually. The participating companies include the pulp and paper industry, the mining industry and the chemical industry.

[69] The pulp and paper industry comprises here SNI 21-22, i.e. pulp, paper, paper goods and graphic industries.

**Figure 9:1. Industrial electricity use per value added, in a number of industrial sectors, Sweden**

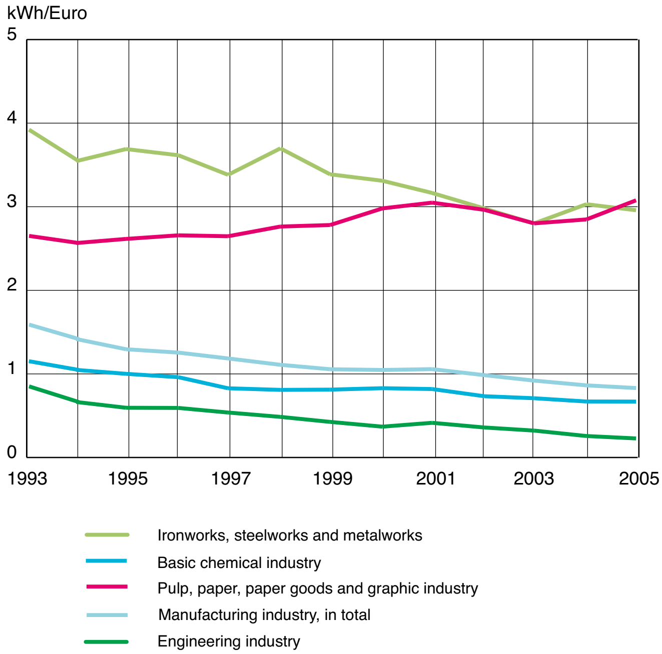
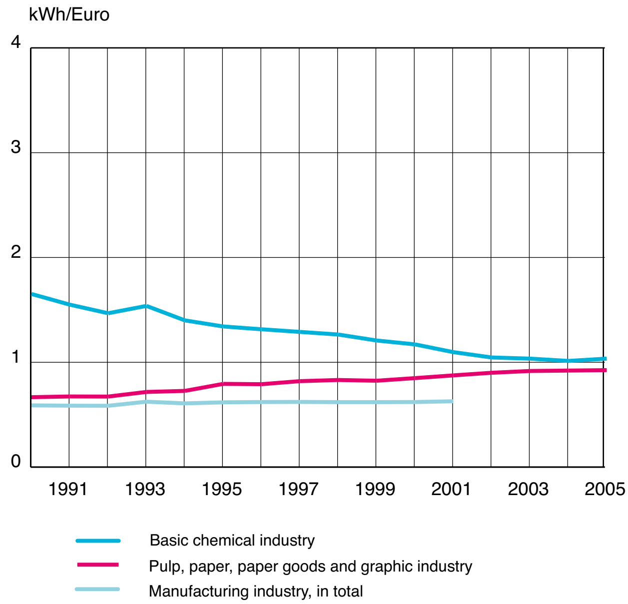



**Figure 9:2. Industrial electricity use per value added, in a number of industrial sectors, EU-15**




be explained by good production development having taken place during these years in mechanical pulp, in which the process is electricity intensive. The reduction in electricity use per value added in 2000-2003 and the increase from 2004 onwards can partially be explained by the fact that the proportion of mechanical pulp first decreased and then increased again.

The fact that the Swedish pulp and paper industry uses more electricity per value added than the corresponding industry in EU-15 need not mean that electricity use in Sweden is less efficient than in the EU. The main reason for the high electricity use is that Swedish industry has focused on products and processes that involve high electricity use per value added. Unprocessed raw materials, such as forest raw materials, are used to a large extent in Sweden and Finland, whereas countries in the remainder of Europe largely use more highly processed raw materials, such as waste paper. The indicator thus cannot be used without additions for electricity efficiency comparisons. In an international comparison, electricity is an important production commodity to Swedish industry.

*Figure clarification SNI codes:*
*15–37: Manufacturing industry, in total*
*21–22: Pulp, paper, paper goods and graphic industry*
*24.1: Basic chemical industry*
*27: Ironworks, steelworks and metalworks*
*28–35: Engineering industry*

Source: The annual energy use of industry is included in Sweden's official statistics and is published as tables on the Statistics Sweden homepage. The data for the value added comes from the Statistics Sweden national accounting. As from 1993, the rolling basic year is used, whereby the basic item is calculated in the fixed prices at the price in the immediately preceding year. The statistics for the EU are obtained from the EU/SAVE-financed Odyssee database.

*Note: These statistics have been revised from 1993 onwards and the time series therefore differs from those given in this publication in earlier years.*

# 10. Energy prices to industrial customers, including relevant taxes

*The price of oil rose during 2007. The reporting of statistics for electricity and natural gas prices has been revised, which makes it difficult to make a direct comparison with earlier years. However, statistics suggest that the price of natural gas has increased during 2007.*

## Energy policy objectives

The energy policy guidelines state that reliable access to energy at reasonable prices is important to international competitiveness of industry. It is therefore important to follow up energy prices. Efficient electricity and natural gas markets are also highlighted as objectives for the energy policy. There are also specific objectives for the electricity market concerning effective pricing, well-performing supplier changes and access to information on the electricity market.

## Trends

Reporting of statistics for electricity and gas prices has been revised. Up to and including 1 January 2007, statistics relate to the price a company had to pay if it concluded a one-year contract on 1 January of a particular year. The prices of electricity and natural gas are then reported as an average price per six months, calculated on the price that the companies actually paid, i.e. in current contracts. Companies with contract times longer than one year are also included here. Typical customers for whom statistics are collected have also been altered (see facts box). These half-yearly prices therefore cannot be directly compared with prices for 1 January. In the earlier January price series, the industrial electricity and network prices for 2005-2007 increased. On 1 January 2007, the electricity price for smaller users approached the 2003 record levels. The difference in the price of electricity payable by small and large users gradually decreased during the period 1996 to 2003. From 1 January 2003 to 1 January 2004, the price difference between customers of different sizes increased, but the price scatter has then been rather stable.

A comparison of the price of electricity on 1 January and the average price for the first half of 2007 shows how different the-

**Figure 10:1. Electricity and network prices to industrial customers, including relevant taxes**

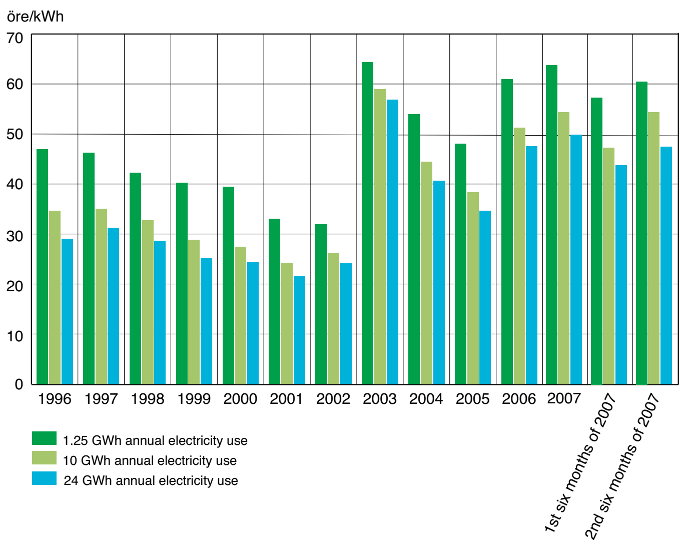
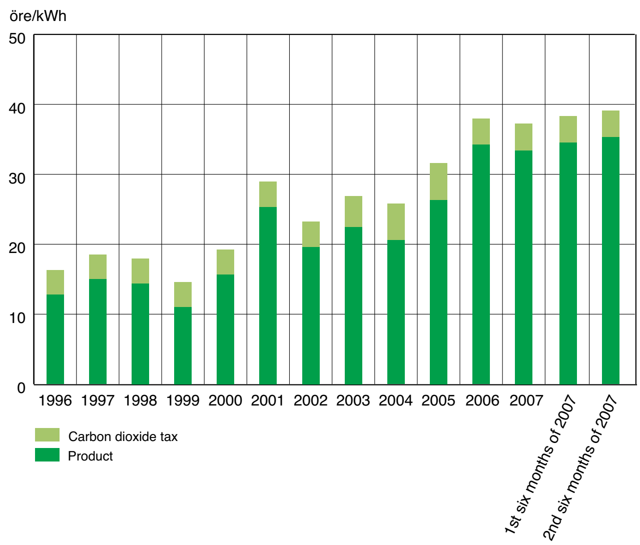



**Figure 10:2. Gas price to industrial customers, including relevant taxes**




*Note: The statistics have changed. Up to and including 1 January 2007, the price relates to 1 January of the respective year. As from the first six months of 2007, the average six-month price is reported instead. Also typical customers classification has changed, see facts box.*

se prices can be and how uncertain a comparison between these time series is. The average price is substantially lower than the January price. The average price for the second half of the year is higher than for the first half and approaches the January price for 2006. The fact that the average price is lower than the January price can partially be due to companies with other types of contracts also being included in the average price. The price of electricity in January also tends to be higher than in May, for example, but since the January price in the statistics applied to one-year contracts, consideration should have been given to that when the price was set. The development of prices in the Nord Pool electricity exchange should also have influenced the electricity prices for the indicator. The exchange price was relatively high during 2006, and was much lower during 2007. Up to 1 July 2004, industry paid no electricity tax. Since then, the electricity tax for industry amount to 0.5 öre per kWh.

The development of natural gas prices follows that of oil prices relatively well if January prices are used. However, the fluctuations of natural gas prices are more damped than those of oil. The prices in the first and second halves of 2007 were higher than the January 2007 price, which indicates that the price continued to rise during the year.

No changes have taken place in the reporting of the oil price, and it still relates to 1 January of each year. The price of light fuel oil increased by around 38% between January 2007 and January 2008, and the price of heavy fuel oil increased by about 50%. The prices of oil and natural gas include the carbon dioxide tax, and the price of heavy fuel oil also includes the sulphur tax. The taxes on these fuels have mainly been constant during the period studied, apart from the carbon dioxide tax on oil, which has increased somewhat. The price development for biofuels is not reported, since sufficient statistical material is not available.

### Reasons and relationships

The price of electricity dropped between 1996 and 2001. The most important reason is the hydropower generation capacity. The years between 1998 and 2001 were all wet years to varying extents, which contributed to low electricity prices. Another factor that assisted in maintaining low electricity prices was the surplus electricity generation capacity during the early part of the period studied. The declining prices also indicate that deregulation of the electricity market may initially have contributed to increased competition and lower prices. However, electricity prices rose drastically in 2003, which is due in part to 2003 being a dry year with low inflow to the water reservoirs. The prices then decreased, but increased again during 2005-2007 (January). This increase in the price of electricity is partially explained by the introduction of the emission allowances trading system.

**Figure 10:3. Price of light fuel oil to industrial customers, including relevant taxes**

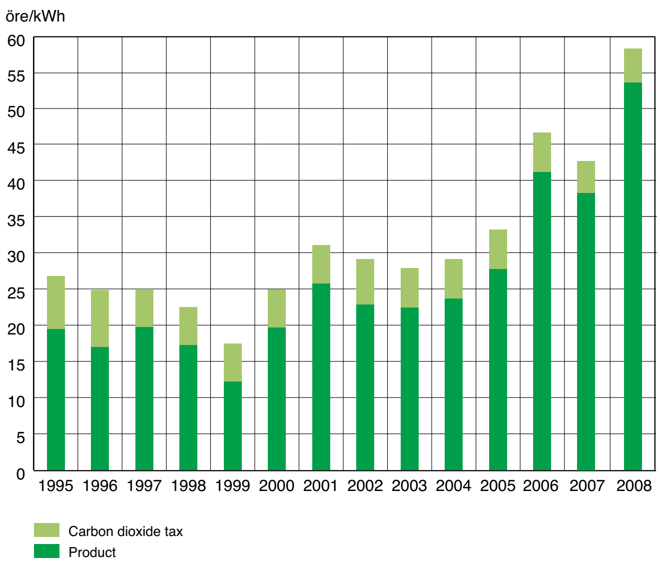
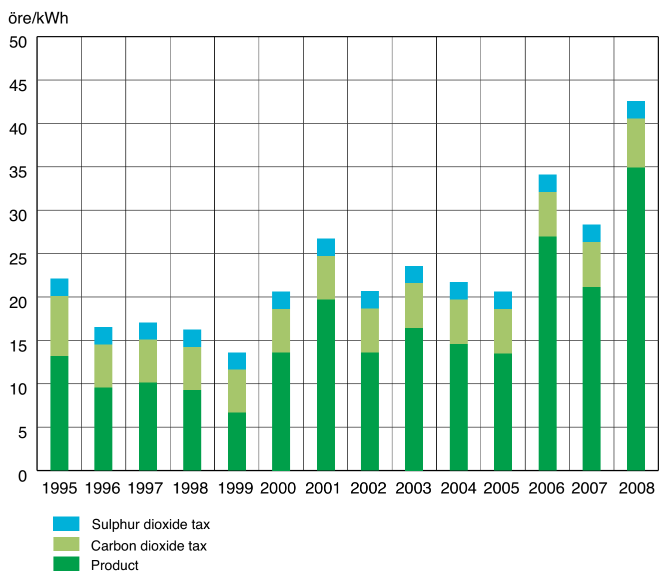



**Figure 10:4. Price of heavy fuel oil to industrial customers, including relevant taxes**



The price of oil to industry follows fairly well the variations in the world market price. The world market price of oil is reflected more in the price to industrial customers than to domestic customers, since the tax rate for industry is lower.

For electricity, the indicator clearly shows the relationship between the magnitude of the electricity consumption of the individual user and the specific price of electricity. Customers with high electricity consumption pay a lower price for electricity. The electricity price difference between small and large users has decreased in recent years. It is uncertain what the reduced price scatter is due to. It should be noted that the largest typical customer in the indicator, i.e. 70 GWh/year, is still a comparatively small industrial electricity user. The electricity consumption of electricity-intensive industry may be many times higher. There are several energy-intensive industrial plants that consume up to 2 TWh of electricity. According to a survey carried out in 2007, electricity-intensive industries have experienced a relatively high electricity price increase during the period 2002–2006. The median plant out of the 40 plants studied has experienced an electricity price increase of more than 60%[70] during the period. The competitiveness of these industries is heavily affected by the price of electricity.

Source: Reporting by Sweden to Eurostat. The information is based on a number of typical customers who are common to the whole of the EU. Data is acquired twice a year and is reported in the Eurostat publication on energy prices.

[70] Ungernet AB, Electricity price changes from 2002 to 2006 at 40 energy-intensive plants, 2007

## FACTS

The EC directive survey of electricity and gas prices was altered in 2007. The change means that the information given from this year consists of average prices over 6 months, distributed onto customer groups according to use. The results from the first study in accordance with the altered method relate to the average prices in the period January – June 2007, and the second survey relates to the period July – December 2007. In the earlier method, the price stated was that payable by a typical user within the specified customer category if the customer concluded a one-year agreement as of 1 January each year.

The indicator is based on different typical customers for electricity, and those have also been altered in the new survey method. In the past, typical customers were classified according to three criteria: maximum annual consumption in MWh, maximum annual power demand in kW, and maximum annual utilization time in hours. Three typical customers are used in this indicator up to and including 1 January 2007, as shown in the table below.

| Max. annual cons. | Max. power | Max. time in hours |
|---|---|---|
| 1 250 | 500 | 2 500 |
| 10 000 | 2 500 | 4 000 |
| 24 000 | 4 000 | 6 000 |

The new method classifies the typical electricity customer according to the standard consumption. The new typical customers for whom this indicator shows statistics are shown in the table below.

500 MWh to <2 000 MWh

2 000 MWh to <20 000 MWh

20 000 MWh to <70 000 MWh

Typical customers for natural gas were previously classified according to annual consumption and consumption profile. For the years up to and including 1 January 2007, the indicator shows a typical customer who has an annual consumption of 11 630 MWh and uses gas for 250 days or 4 500 hours a year. The annual consumption is used in the new typical customer classification, and the indicator shows an industrial customer who has an annual consumption between 30 000 and 300 000 MWh.

Consideration has been given to the fact that the industrial sector may apply mark-down rules that reduce the tax.

The method used for collecting the price of oil shown in the indicator remains unchanged and relates to the price on 1 January every year.

# 11. Energy cost as a proportion of the total variable cost, in different sectors of industry

*The energy cost as a proportion of the total variable costs in industry has decreased over a long time in all sectors analyzed, even though the absolute levels vary widely. Since the end of the 1990s, the reduction has slowed down in several sectors, but the energy cost proportion decreased in 2005 in all sectors analyzed.*

### Energy policy objectives

The energy policy objectives emphasize the importance of reliable access to energy at reasonable prices to ensure international competitiveness of industry. The cost of energy to industry depends both on the magnitude of the energy consumption and on energy prices. Competitiveness of industry is also affected by factors other than energy cost, e.g. costs of wages and costs of raw materials.

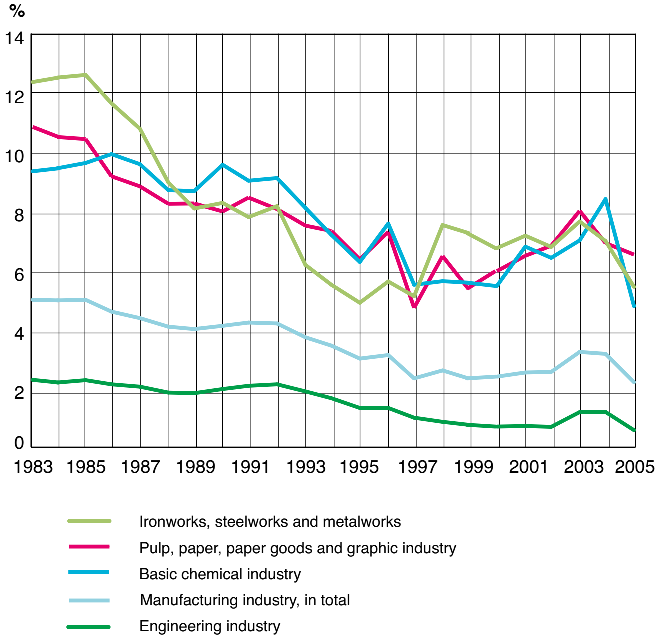
### Trends

The energy cost as a proportion of the total variable costs has decreased since the early 1980s. In 1983, the energy costs amounted to 5% of the total variable costs in the manufacturing industry. In 2005, this proportion had dropped to 2.2%. For the manufacturing industry as a whole, the energy cost proportion has dropped since the beginning of the 1980s. All analyzed sectors of industry display a declining long-term energy cost proportion, although the reduction has slowed down somewhat since the end of the 1990s, and the energy cost proportion has increased in certain sectors. However, the energy cost proportion in all sectors studied decreased during 2005.

### Reasons and relationships

The fact that the energy cost has decreased as a proportion of the total variable costs in industry is due to several factors. Base indicator 8 shows that the energy use in industry per value added has also decreased. Indicator 11 shows the development for a number of sectors of industry and from this it emerges that the differences in energy cost as a proportion of the total variable costs are wide. Wide variations also occur within each sector of industry. This means that individual industries may have an energy cost proportion that substantially exceeds the levels shown by the indicator. These are, for example, industries with electricity-intensive processes such as the production of mechanical pulp or electrolysis and electro-reduction processes. To these industries, the cost of energy may be entirely decisive to their competitiveness.

**Figure 11. Energy cost to industry in relation to the total variable costs to the companies, in different industrial sectors**




The energy cost proportion increased substantially during 2003 in several sectors, and for the manufacturing industry as a whole. This peak may partially be due to the price of electricity that, as shown by indicator 10, decreased up to 2003, when it increased substantially, and then decreased again up to 2005. The development of prices of other energy sources, such as coke, may also affect the energy cost proportion in certain sectors.

Source: Statistics Sweden. The variable costs include wages, raw materials, energy costs, etc. but, according to general practice, social charges, rental costs, wages processing at another company, and purchased maintenance and repair work on the company's buildings and plants are not included.

*Note: The wide fluctuations in the basic chemical industry in 2004–2005 may partially be due to the data acquisition method used causing a few companies in the sample to have a substantial influence on the results.*

# 12. Energy use for heating and domestic electricity/ property electricity/operating electricity per unit of area for dwellings and public and commercial premises

*The total energy use per unit of area for dwellings and commercial and public premises has decreased by around 9% between 1995 and 2006. To some extent, the reduction is due to the fact that recent years have been relatively warm. The reduction is also due to the conversion to other sources of energy, such as heat pumps, and to the energy improvement measures. The use of electricity for applications other than heating has increased.*

## Energy policy objectives

The energy policy objectives state that energy should be used as efficiently as possible, taking into account all resources available. It is thus not entirely a matter of minimizing energy use, but efforts should mainly be made to achieve low energy use in relation to the utilities achieved. The "A good built environment" environmental objective includes the objective of reducing the energy use in built-up areas. The objective was reformulated in 2006 and is now worded as follows: *"The total energy use per unit of heated area in dwellings and public and commercial premises is decreasing. The reduction should be 20% by 2020 and 50% by 2050 in relation to the use in 1995. By 2020, the dependence on fossil fuels for energy use in the built-up sector should be broken, while the proportion of renewable energy should continually increase."*

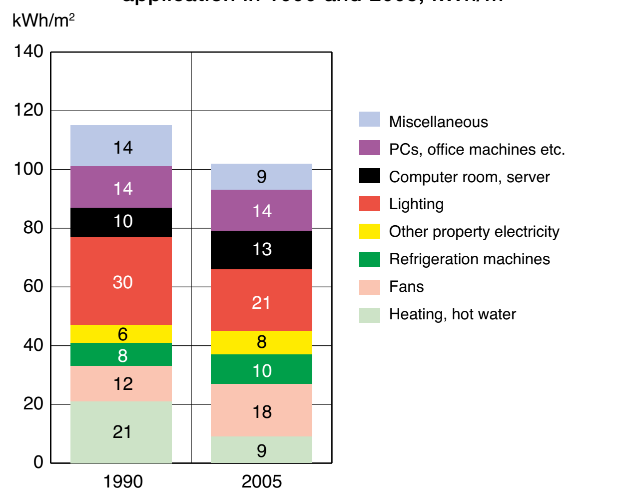
## Trends

The total energy use per unit of area of dwellings and public and commercial premises has dropped by around 9% between 1995 and 2006. To some extent, the reduction is due to the fact that most years since 1995 have been relatively warm. Further contributory reasons are the conversion of heating systems, e.g. from oil to heat pumps or district heating, and also energy efficiency improvement measures.

In following up the objective of 20% reduction in energy use by 2020, the energy sources will be weighted with regard to the primary energy use and the environmental impact[71]. How

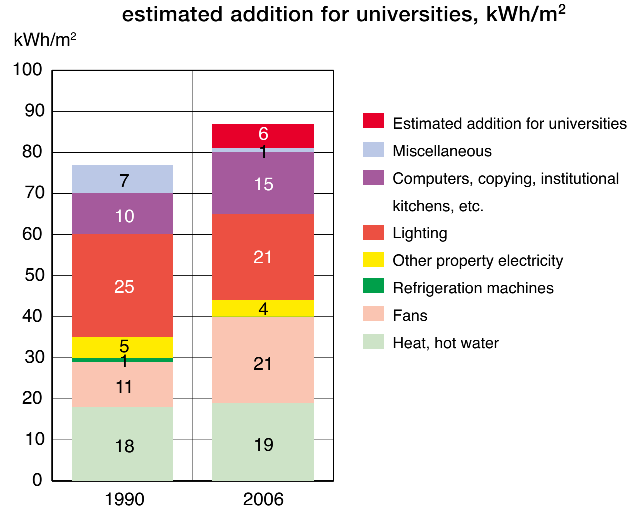
[71] "National programme for energy efficiency improvement and energy-intelligent building". Government Bill 2005/06:145

**Figure 12:1. Electricity use, including electric heating, in offices and administrative buildings, specific electricity by application in 1990 and 2005, kWh/m²**



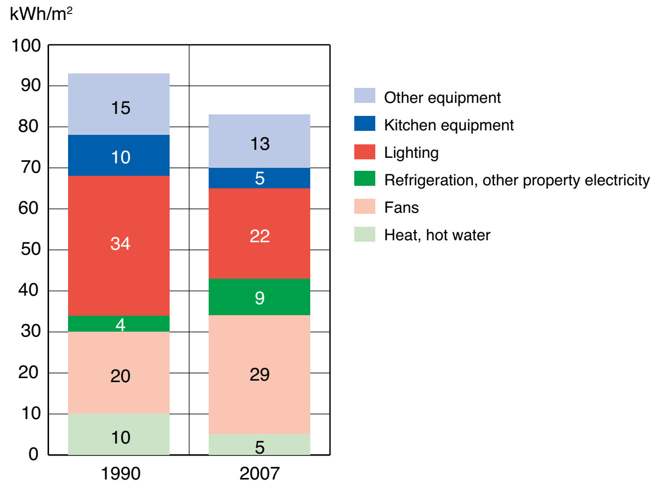

Source: Swedish Energy Agency – Improved energy statistics for premises – Staged STIL, report for year 1.

**Figure 12:2. Electricity use, including electric heating, in schools and nursery schools, specific electricity per application in 1990 and 2006, including estimated addition for universities, kWh/m²**




Source: Swedish Energy Agency – Improved energy statistics for premises – Energy use and indoor environment in schools and nursery schools.

**Figure 12:3. Electricity use, including electric heating in nursing buildings, specific electricity per application in 1990 and 2007, kWh/m²**




Source: Swedish Energy Agency – Improved energy statistics for premises – Energy use in nursing premises.

this weighting should be carried out is still not decided but is included as part of the study of the energy services directive set up in March 2007. Figure 12.5 shows the energy use without weighting.

Since 2004, the energy use for heating per unit of area of public and commercial premises has increased somewhat. The development for multi-family and single-family houses has been in the opposite direction, and the reduction has been relatively substantial during 2006, above all for single-family houses. The use of domestic electricity in dwellings is relatively constant, after having increased slightly in previous years. While the ownership of appliances is increasing, particularly home electronics such as TVs, computers, home movie equipment and peripheral equipment, development is moving towards more energy-efficient installations. The current measurements of domestic electricity[72] by the Swedish Energy Agency show that almost one third of the households in single-family houses have three or more TV sets and the same proportion have two or more computers.

Measurements also show that variations in electricity use between individual households are very wide. This is due to habits and behaviours, and also to installations such as lighting. The number of lamps per unit of area varies by a factor of three between different single-family houses, which explains to some extent the wide differences in electricity use between

[72] Electricity use at appliance level is measured in 200 single-family houses and 200 apartments in the project "Improved energy statistics in built-up areas", www.energimyndigheten.se

**Figure 12:4. Energy use for heating in different residential forms and public and commercial premises (not temperature corrected)**

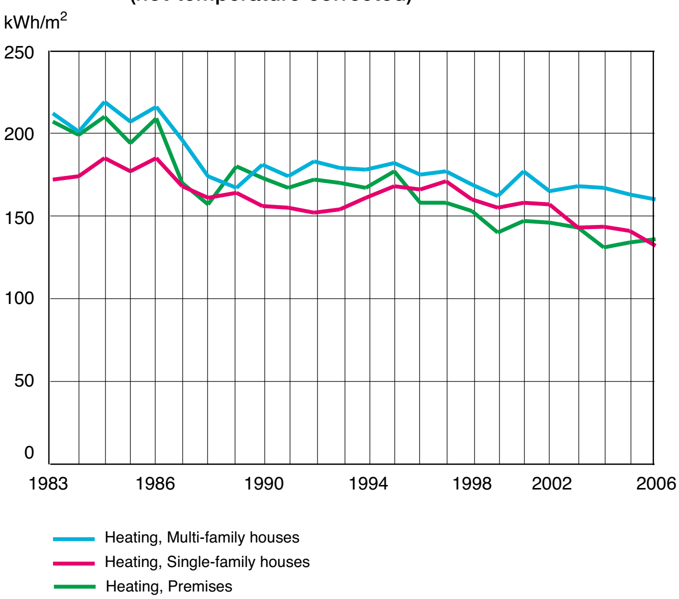
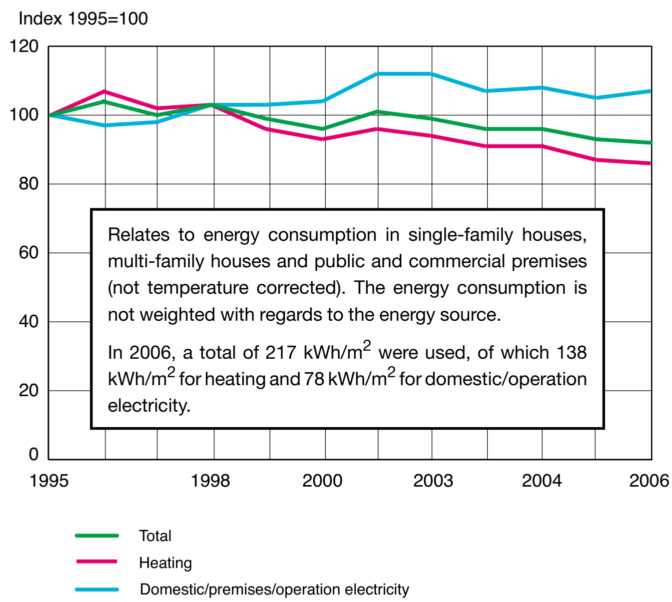



**Figure 12:5. Index of total energy use per unit of area in dwellings and public and commercial premises**



different households. Lighting together with refrigeration and deep-freezing account for most of the household electricity.

Electricity use for other than heating is much higher in premises other than dwellings. This is partially due to the fact that electricity use in that kind of premises includes electricity use for steam generation, hot water supply, sewage treatment and waterworks. The use of operating electricity in public and commercial premises has displayed a declining trend in recent years, although this development was broken in 2006. It is difficult to say whether this break in trend is only a temporary variation, as development has historically been characterized by fluctuations.

During 2005 and 2006, the Swedish Energy Agency carried out an energy survey of 123 office and administrative premises and 130 schools and nursery schools. In 2007, 159 nursing premises were inspected[73]. The results show that nursing premises use on average 218 kWh/m$^2$ per year, of which 83 kWh/m$^2$ is operating electricity. Offices use on average 212 kWh/m$^2$ per year, and the corresponding figure for schools and nursery schools is 216 kWh/m$^2$. In a comparison with the figures for 1990, the main trend for nursing premises is a reduction in the specific energy to three quarters of the 1990 level. The dominating items for operating electricity are fans and lighting, which agrees well with the results of the types of premises inspected earlier. Note that the values in the figure are estimated to a total national level and thus differ slightly from the averages of the inspected objects.

### Reasons and relationships

The heating demand during a certain year is affected by temperature conditions. The heating demand is high in a cold winter. After 1987, all years except 1996, were warmer than normal[74]. The annual average temperature in 2006 was 1.8 degrees above normal, which is reflected in the actual heating demand. The reduction in energy use per square metre in single-family houses in 2003 is due, to some extent, to the whole residential area being included in the 2003 annual survey. In other years, only the area heated to more than 10°C was included.

A part of the reduction in the temperature-corrected energy use is due to conversions in heating systems, e.g. from oil to heat pump in single-family houses. The magnitude of the conversion losses before energy is utilized depends on the energy carrier used. The official statistics of energy use in dwellings and the services sector includes only the losses occurring in

[73] Swedish Energy Agency, Improved energy statistics in built-up areas

[74] Swedish Meteorological and Hydrological Institute

**Figure 12:6. Energy use for heating, single-family houses**

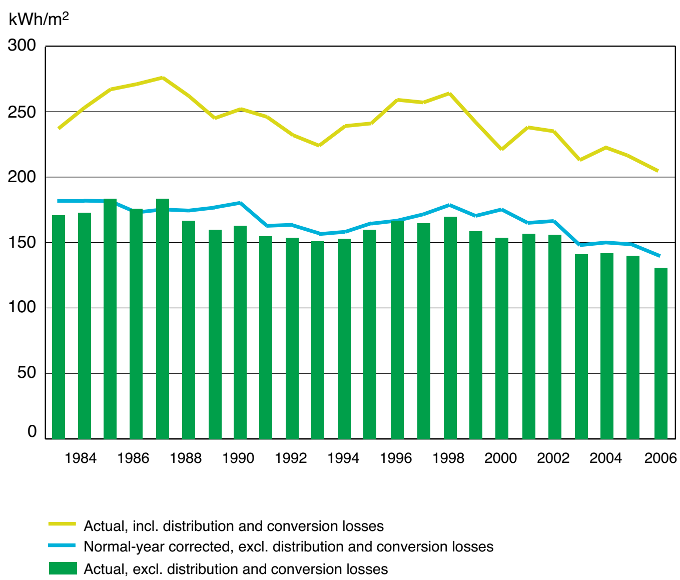
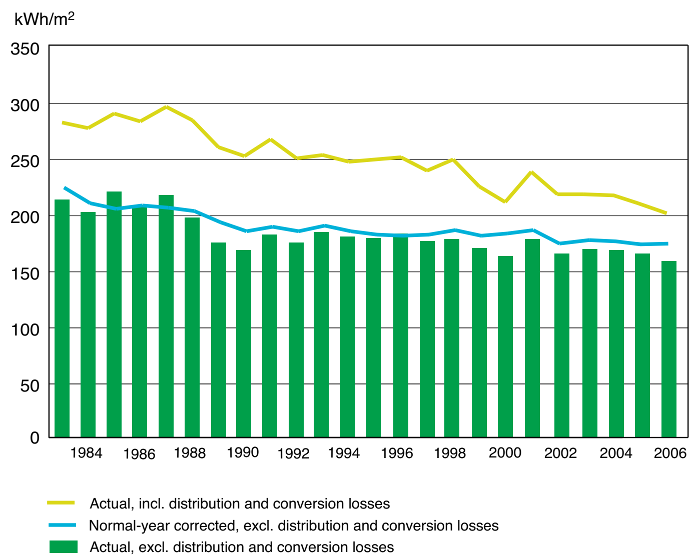



**Figure 12:7. Energy use for heating, multi-family houses**



the energy system of the building itself when different energy carriers are used. The losses occurring in the generation and distribution of electricity and district heating are assigned to the supply sector. If a customer changes, for instance, from oil-fired heating to electric heating or district heating, the energy use in the dwellings and services sector will therefore decrease, while the energy use in the supply sector will increase. The conversion rate for oil-heated single-family houses has been speeded up in conjunction with the introduction of the conversion grant in 2006. By 31 December 2007, 36 950 applications had been granted[75]. Since some single-family houses consist of two apartments, the applications granted cover 38 720 dwellings. Out of the 36 950 conversions made, 43% were to heat pumps, 37% to biofuel and 20% to district heating.

The fact that energy use for heating is decreasing may also be due to energy efficiency improvements in existing houses and thus a reduction in the average energy use. Increased use of heat pumps also contributes to reducing the energy use for heating[76]. The energy costs have increased for many households in recent years due to the higher cost of electricity and oil and the increased taxes, which give the incentive to adopt energy saving measures. More energy-efficient equipment and installations may be assumed to be the reason for electricity use increasing only moderately, in spite of the growing numbers of appliances and installations in homes and at workplaces.

Source: Statistics Sweden, Statistical Memorandum series EN16: Energy statistics for single-family houses, multi-family houses and public and commercial premises and SM series EN 11, Annual electricity, gas and district heating statistics. The energy use has been divided onto residential and public and commercial premises areas and heated garage areas. Basements, stairwells and laundries are not included in the area calculations. The normal Statistics Sweden temperature correction principle was used for temperature correction of the heating requirement, where half of the heating demand is assumed to be linked to the temperature conditions and half is assumed to be temperature-independent. The temperature conditions are described by means of the number of so-called degree-days for that particular year in relation to the assumed number of degree-days for a normal year[77].

[75] National Board of Housing, Building and Planning

[76] Heat extracted by heat pumps in the end user sectors is not included in the existing official statistics and is perceived instead as an energy-improvement measure, even though it is not such a measure.

[77] In Figure 12:9, the distribution of deliveries onto the various consumer groups is uncertain. Great differences from preceding years may be an effect of the customer registers being revised in conjunction with the integration of network companies as a result of takeovers or mergers. The latest information would then be the most reliable.

**Figure 12:8. Energy use for heating, public and commercial premises**

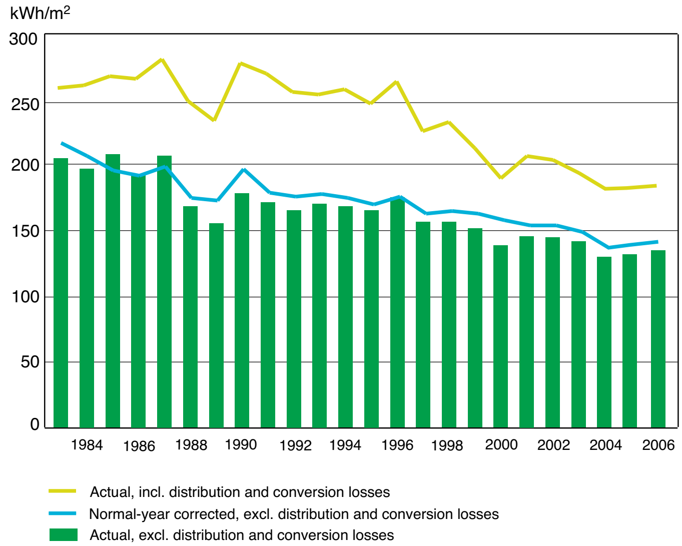
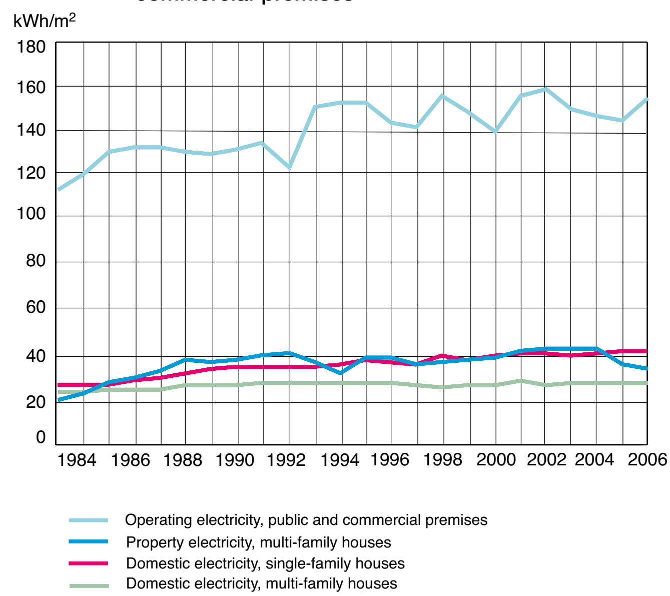



**Figure 12:9. Domestic electricity and operating electricity in different residential forms and public and commercial premises**



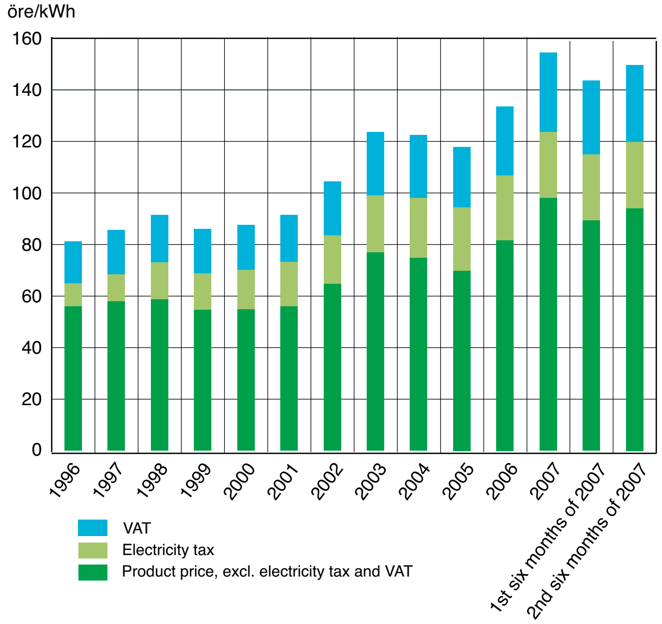
# 13. Energy prices to domestic customers, including relevant taxes

*The price of oil, including taxes, to homeowner customers has more than doubled between 2000 and January 2008. During the same period, the price of electricity, including taxes, has risen by around 70 percent and the price of district heating by around 50 percent. Increasing taxes and increasing oil and natural gas prices on the international markets are the main reasons for the rising prices. However, the reporting of statistics for electricity and natural gas prices has been revised, which makes it difficult to make direct comparisons with earlier years.*

**Energy policy objectives**

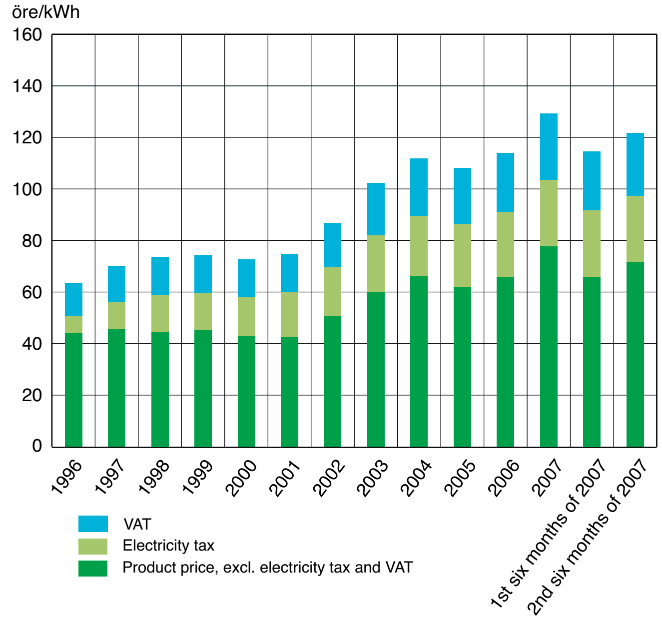
The energy policy objectives emphasize the importance of reliable access to energy at reasonable prices. Efficient electricity and natural gas markets are also highlighted as objectives for the energy policy. The objectives also specify that the energy policy should contribute in the conversion to an ecologically sustainable society and to energy supply with low negative influence on health, the environment and the climate.

**Figure 13:1. Electricity and network prices to domestic customers with annual consumption of 3 500 kWh**



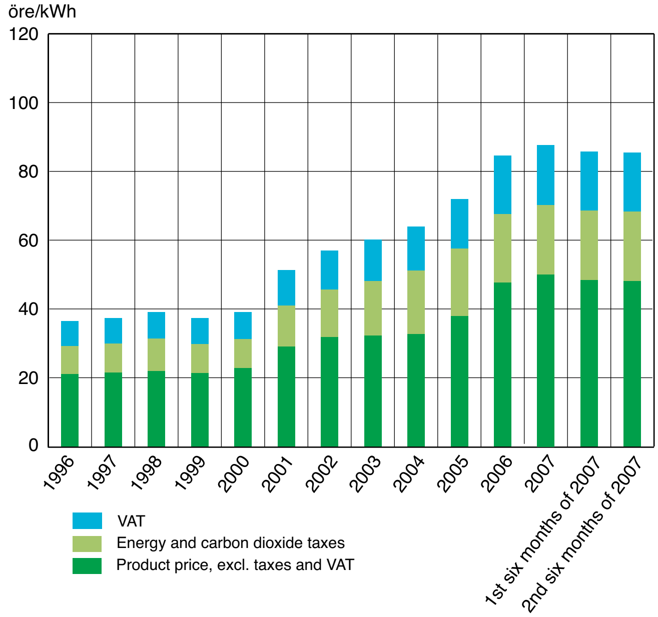

*Note that the statistics have been changed. Up to and including 1 January 2007, the price relates to 1 January each year. As from the first six months of 2007, the average price for six months is reported instead. Also note that the typical customers changed in 2007. Annual consumption 2 500 kWh – 5 000 kWh.*

**Figure 13:2. Electricity and network price to domestic customers with annual consumption of 20 000 kWh**




*Note that the statistics have been changed. Up to and including 1 January 2007, the price relates to 1 January each year. As from the first six months of 2007, the average price for six months is reported instead. Also note that the typical customers changed in 2007. Annual consumption 15 000 kWh and above.*

**Figure 13:3. Natural gas price to domestic customers with annual consumption of 34 890 kWh**



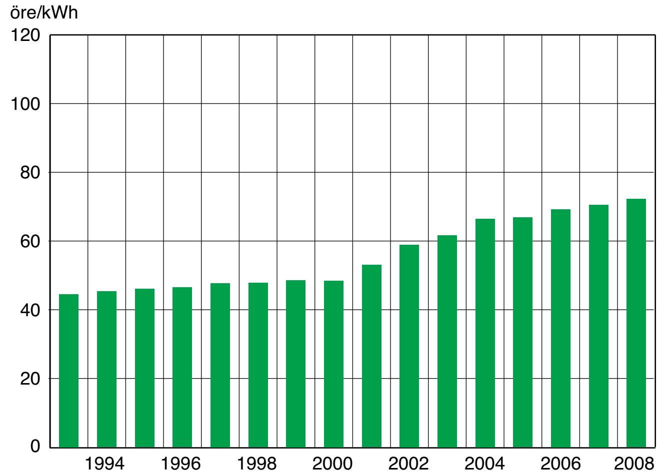

*Note that the statistics have been changed. Up to and including 1 January 2007, the price relates to 1 January each year. As from the first six months of 2007, the average price for six months is reported instead. Also note that the typical customers changed in 2007. Annual consumption 5 500–55 000 kWh.*

## Trends

Reporting of statistics for electricity and natural gas prices has been revised. Up to and including January 2007, the statistics relate to the price that a typical user had to pay in fixed and variable charges on 15 January every year. Subsequent to this, the price of electricity and natural gas is reported as an average price per six months, calculated on the price that customers actually paid. The typical customers for whom the statistics are gathered have also been changed. These six-monthly prices cannot therefore be compared directly with the prices back in time. See also the facts box.

The energy prices to domestic customers have risen throughout since 1996. During a number of years at the end of the 1990s, the price of electricity was constant or even decreased, whereas high price increases were noted in 2003, 2006 and 2007. Viewed overall, the price of electricity, including taxes, has risen by 80 percent between 1997 and 2007. A comparison between the price on 1 January and the average price for the first six months of 2007 shows how different these prices may be and how uncertain a comparison between these time series

**Figure 13:4. District heating price to domestic customers in multi-family houses, including relevant taxes and VAT**




is. The average is significantly lower than the January price. The average price for the second six months is higher than for the first six months and approaches the price for January 2007.

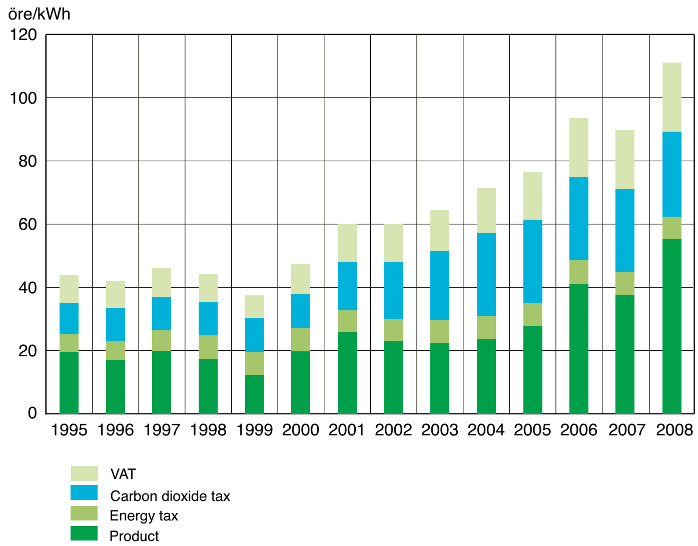
The oil and natural gas prices remained relatively unchanged during the period between 1995 and 1999, but subsequently increased. The oil price on 1 January 2006 was very high, but dropped somewhat by 1 January 2007. In 2007, the natural gas price decreased somewhat, while the price of oil again increased substantially. Viewed overall, the price of oil to domestic customers, including taxes, more than doubled between 2000 and 2008.

The price of district heating has increased slowly since 2004, by a few percent annually. The Nils Holgersson report[78] shows that the differences between municipalities can be very high. In 2007, the annual cost per square metre was SEK 78 in the least expensive municipality and SEK 157 in the most expensive. The average annual cost was SEK 129 per square metre. Viewed over the entire period between 1998 and 2008, the price of district heating increased by around 50 percent.

Biofuels such as wood and pellets are important energy sources to domestic customers. This is particularly true for those living in single-family houses that use almost 10.4 TWh

[78] HSB National Association, Tenants' National Association, Riksbyggen, SABO and the Swedish Federation of Property Owners have formed the Charge Group that carries out annual surveys (known as the Nils Holgersson survey) of municipal charges for heat, hot water, water and sanitation, electricity and cleaning.

Figure 13:5. Price of light fuel oil to domestic customers




of biofuel annually. In total 11.1 TWh of biofuel were used in 2006 for single-family houses, multi-family houses and commercial and public premises. The total used in the previous year was 12.0 TWh. In other words, the use of biofuels for space heating and hot water decreased by a total of almost 8%. In April 2008, the price of pellets, including taxes, to single-family house customers was about 2 300 – 2 600 SEK per tonne[79]. The reason that time series for prices of pellets are not given here is the shortage of statistical material. As an example, there are no official price statistics for pellets, and only compilations by the industry itself are available at the present time. Most of the wood used by domestic customers is not purchased and sold on the market, but consists of own felling or barter trade.

### Reasons and relationships

The price of electricity to domestic customers increased substantially between 1 January 2006 and 1 January 2007. Since the spot price on the Nord Pool electricity exchange is a price reference for the Swedish electricity market, the price of electricity to customers is affected by developments on this exchange. The spot price in 2006 was comparatively high, and has been much lower in 2007. More information on the spot price development can be found in indicator 18.

The product price of oil follows relatively well the development of the world market price of oil, and the natural gas

[79] www.pelletspris.com

### FACTS

In 2007, the EC directive survey of electricity and gas prices was changed. The change means that the information given from that year onwards consists of average prices over six months, distributed onto customer groups according to electricity use. The results of the first survey in accordance with the altered method relates to the average prices during the period January-June 2007, and the second survey using the new method relates to the period July-December 2007. The indicator is based on typical customers that also changed in 2007. For domestic electricity customers, this means that the lower annual consumption in the new method corresponds to 2 500 kWh – 5 000 kWh, and the higher annual consumption corresponds to 15 000 kWh and above. For domestic gas customers, statistics are presented for the consumption group 5 500 – 55 000 kWh. It is also worth noting the changes in the prices that are reported. The new method gives the average price that a typical end customer has paid during the latest six-month period.

In the earlier method, the price stated was the one that a typical consumer within the specified customer category had to pay in fixed and variable charges on 15 January.

The two typical customers that, according to the earlier method, are used for prices of electricity to domestic customers in this indicator up to and including January 2007 are:

| Annual consumption | Corresponds to household |
|---|---|
| 3 500 kWh | 4 rooms and kitchen, of around 90 $m^2$ (household electricity) |
| 20 000 kWh | 5 rooms and kitchen, of around 120 $m^2$ (house with electric heating) |

For domestic gas customers, the typical customer had a consumption of 34 890 kWh, which would correspond to a detached house with heating and domestic gas.

The method of gathering the price of district heating and oil given in the indicator remains unchanged and relates to the price on 1 January every year.

price largely follows the oil price development. A reason for the increasing prices of oil and natural gas to households has been the green tax switching, whereby the taxes on electricity and fossil fuels were gradually raised and transferred back to households and companies in the form of reduced tax on work. In the six years between 2000 and 2006, the tax on oil has increased by almost 75%.

The reasons for the price development in district heating are difficult to specify generally, since Swedish district heating consists of the sum of a large number of district heating systems. The increased cost of the energy carriers used is a contributory factor in the increasing prices of district heating. Another reason is that the rules for at-cost pricing no longer apply, and the price of district heating is instead increasingly set in relation to the prices of alternatives and on the basis of the return on capital requirements of the companies.

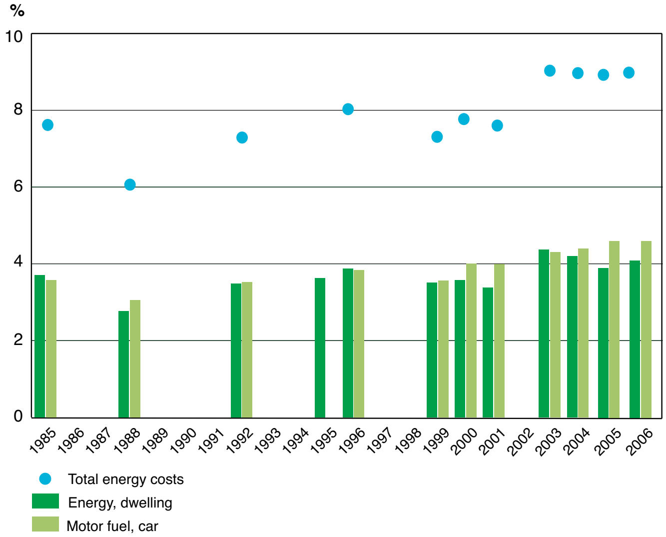
Since the indicator shows running prices, it is of interest to set the energy price increases in relation to the general price development, e.g. expressed as consumer price index (CPI). It will then be found that the price of all energy carriers analyzed increased much more rapidly than the CPI.

Source: District heating prices have been obtained from the Statistics Sweden price statistics. The prices of electricity, oil and natural gas have been obtained from Sweden's reports to Eurostat.

# 14. Energy expenses of households, including motor fuel, in relation to the total expenditures of households

*The energy expenditure as a proportion of the total expenditure of households is around 9%. The proportion has basically remained unchanged between 2003 and 2006. Developments in recent years, with increased proportions for motor fuel and reduced proportion for the energy use expenditure of dwellings have now stagnated. The proportion going to the dwelling has instead increased, while that for motor fuel has remained unchanged.*

**Figure 14. Energy expenditure of households, including motor fuel costs in relation to the total expenditure of households**




### Energy policy objectives

The energy policy objectives state that dependable access to energy at a reasonable price is important. The objectives also specify that the energy policy shall contribute to conversion to an ecologically sustainable society and to energy supply with low negative impact on health, the environment and the climate.

### Trends

Energy expenditure as a proportion of the total expenditure of households is less than 9% and has remained relatively unchanged between 2003 and 2006. The expenditure for the energy use of the dwelling (space heating, hot water and domestic electricity) and the expenditure for the motor fuel for the vehicles of the household were previously roughly of the same magnitude for the average household. In recent years, the proportions spent on energy for the dwelling displayed a decreasing trend, although it began increasing again in 2006. Conversely, the proportion spent on motor fuel increased between 2003 and 2005, but stagnated in 2006.

The energy expenditures included in the indicator are those that are paid directly by the household for energy. The heating costs that are included in the rent, for example, are thereby not included. Motor fuel costs that are indirectly paid for public transport are not included either. Viewed overall, the energy expenditure accounts for a larger part of the household expenditure than that given by the indicator[80].

### Reasons and relationships

Taxes on energy have increased substantially during the period studied[81]. The green tax exchange introduced in 2001 means that tax increases on fossil fuels and electricity are repaid to taxpayers in the form of reduced tax on work to companies and households. The effect of tax exchange on households with low consumption of electricity and fossil fuels may be that the disposable income increases, whereas the disposable income of households with high energy consumption decreases.

The energy costs are greatly influenced by circumstances in specific years, e.g. the temperature conditions, hydropower water inflow (and thereby the price of electricity[82]) and the price of oil on the world market. The high electricity price in 2003 contributed to the increase in energy expenditure during

[80] Further discussion on the risks of high energy prices is included in the Swedish Energy Agency report How secure is our energy supply?, ER 2007:06

[81] The development of energy taxes is illustrated in Base indicator 13 – Energy prices to domestic customers, including relevant taxes.

[82] Price of electricity on the Nord Pool spot market is given in Base indicator 18

that year. In 2004, the price of oil increased substantially, while the price of electricity remained at a relatively high level.

The disposable incomes of households increased by 29% between 1996 and 2006[83], and the energy use of households during the same period decreased somewhat[84]. The fact that the energy costs to households as a proportion of the total expenditure nevertheless increased since 1999 is partially because of the tightened-up economic regulatory instruments for household customers, e.g. increased carbon dioxide tax.

Source: Investigations by Statistics Sweden of the ”Expenditure of households” (1985, 1988 and 1992) and ”Expenditure barometer” (1995, 1996, 1999, 2000, 2001, 2003 and 2004). The investigations are not annual, and there are thus breaks in the time series. The expenditure for motor fuel is not included for 1995, since it was measured in a different way.

[83] Statistics Sweden

[84] Which is illustrated in Base indicator 12 – Energy use for heating and domestic electricity/property electricity/operating electricity per unit of area for dwellings and public services/commercial premises.

# 15. Carbon dioxide emissions by sector

*The carbon dioxide emissions in 2006 were roughly 9% lower than in 1990. The transport sector caused the highest emissions, and these have increased slightly since 1990. On the other hand, carbon dioxide emissions from dwellings and services have decreased. The reason is principally the displacement of carbon dioxide emissions from dwellings and services to the energy sector (electricity and district heating generation) during the period. The emission intensity in terms of emissions per GNP has decreased by one third during the period 1990 – 2006, and the emissions per capita have also decreased during the same period.*

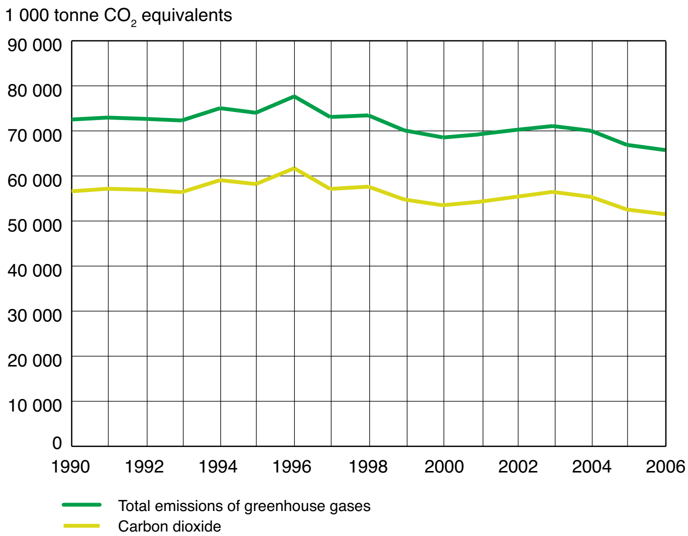
## Energy policy objectives

According to the energy policy objectives, energy supply shall have a low negative impact on health, the environment and climate. It is also emphasized that the Swedish environmental and climate objectives shall be taken into account. As a result of Sweden's undertaking in accordance with the Kyoto Protocol and the EU burden sharing agreement, Sweden can increase its emission of greenhouse gases by 4%, reckoned as the average for the years 2008-2012, compared to the level in 1990. However, the Swedish climate strategy specifies that the average emissions of greenhouse gases during the period 2008-2012 shall decrease by 4% compared with the 1990 emissions. The objective shall be achieved without compensation for absorption in carbon sinks or utilization of the so-called flexible mechanisms. There is also a specific national objective that the environmental loading from dwellings and public services/commercial premises shall decrease.

## Trends

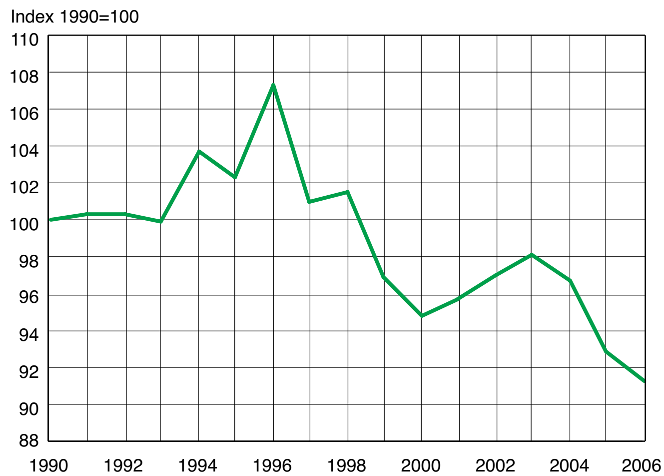
The carbon dioxide emissions increased somewhat during the period 2001-2003, but decreased again during 2004 and ended up 9% lower in 2006 than in 1990. The emissions level has varied between years during the period, and there are examples of both lower and higher emissions than in 1990.

**Figure 15:1. Carbon dioxide emissions and total emissions of greenhouse gases**




Source: Sweden's report on greenhouse gas emissions 2008

**Figure 15:2. Index of total emissions of greenhouse gases**




Source: Sweden's report on greenhouse gas emissions 2008

**Figure 15:3. Carbon dioxide emissions by different sectors**

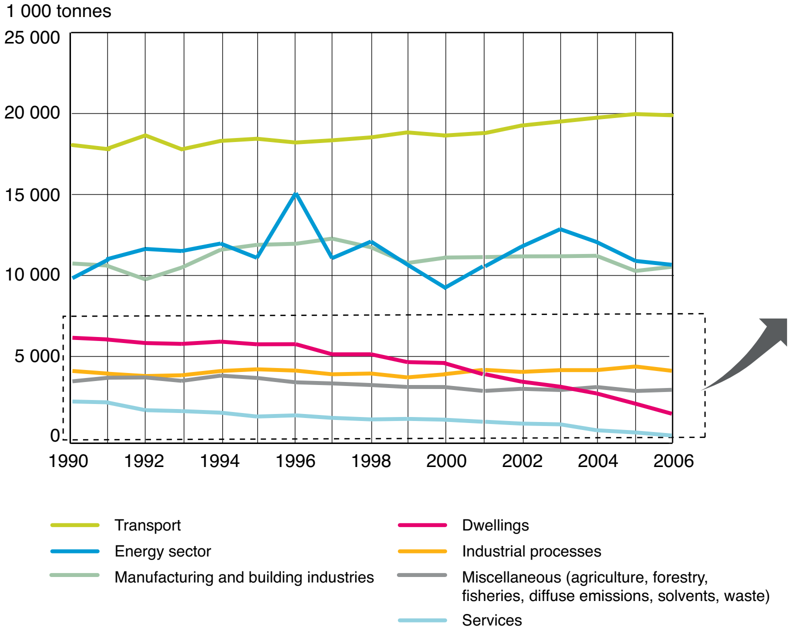
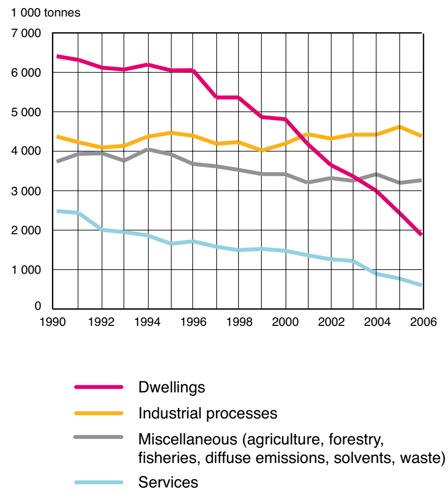



**Figure 15:4. Detail from Figure 15:3**




Source: Sweden's report on greenhouse gas emissions 2008

The sector that contributes the highest emissions is the transport sector (domestic transport). The carbon dioxide emissions of the transport sector have increased by 10% from 1990 to 2006, and the carbon dioxide emissions account for around 95% of the total emissions of greenhouse gases by the transport sector. In terms of magnitude, this is followed by the energy sector (electricity and district heating generation and refineries), and the manufacturing and building industries (excluding industrial processes). The energy sector is in second place as regards percentage increase of carbon dioxide emissions from 1990 to 2006, with an increase of 8%. However, the emissions from district heating generation have decreased during the period studied, in spite of an increase of more than 30% in the heat delivered. This is due principally to the increased use of biofuels for district heating generation. The sectors from which emissions have decreased the most during the period are dwellings and services. The carbon dioxide emissions from dwellings and services in 2006 were only a quarter of the value in 1990.

The official Swedish emissions statistics have been revised since the 2007 indicator publication, which has resulted in a reduction in the total emissions of greenhouse gases compared with earlier reporting by an average of 0.3%. The reporting of carbon dioxide remains about the same. However, the reported value for industry in 1990 has decreased, which gives a difference in the reported carbon dioxide in that year of about -0.2%.

The emission intensity reckoned as emissions per GNP and emissions per capita has decreased substantially since 1990. The emission per GNP has decreased most and was about 37% lower in 2006 than in 1990. This denotes that economic development is possible without a corresponding increase in emissions. During the same period, the GNP increased by 44%. The emissions of carbon dioxide per capita have decreased by 14% between 1990 and 2006, and were 7.2 tonnes of CO2 per capita in 2006 compared to 8.4 tonnes in 1990. The population increased by 6% during the period.

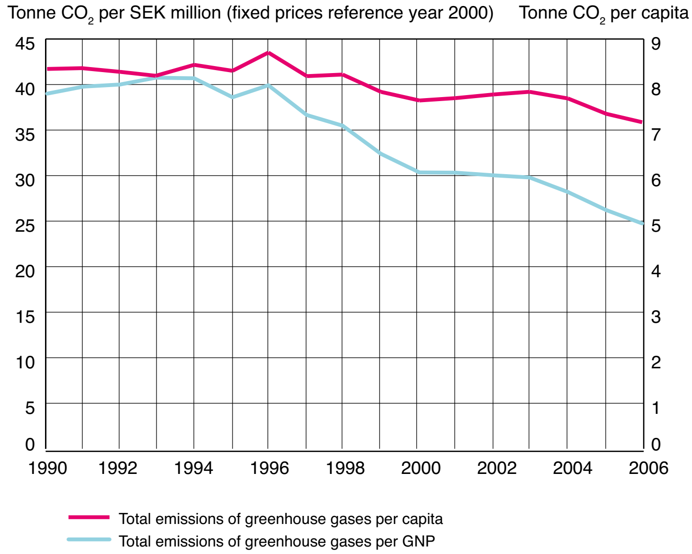
## Reasons and relationships

The emissions of carbon dioxide from dwellings and services have continuously decreased. This is due to a large extent to the decrease in oil use, which has largely been replaced by biofuels, heat pumps, electricity and district heating. This has led to increased use of electricity and district heating. However, this increase has taken place without a corresponding carbon dioxide increase in the energy sector in which electricity and district heating generation are included. This can be explained by the fact that the additional electricity and district heating generation is based to a large extent on non-fossil energy carriers, principally biofuels. The emission intensity in the transport sector has decreased, i.e. the emissions have increased at a lower rate than the transport work, which can be explained by more fuel-efficient cars and increased low admixture of motor biofuel to petrol and diesel fuels.

To a large extent, the carbon dioxide emissions vary with the outdoor temperature, the general economic climate and also with the generation capacity of different energy sources, such as hydropower and nuclear power. The year that differs most, with carbon dioxide emissions that were 9% higher than in 1990, is 1996. That was a dry year in the Nordic countries, and hydropower generation was therefore much lower than normal. In addition, it was a cold year. This led to more fossil fuel-based electricity generation being used, which is demonstrated by much higher emissions from the energy sector than in other years. The precipitation pattern in 2002 and 2003 was also very different from that in a normal year, which may be a contributory factor to the increased emissions. During the 2002/2003 winter, the dry year problem did not lead to emissions that were as high as in 1996, since the shortage of hydropower generation was largely compensated by imports. On the other hand, the precipitation in the winters of 2004 and 2005 was normal, which explains why the emissions have again decreased.

Increasingly strong regulatory instruments were used during the period between 1990 and 2006 in order to restrict the carbon dioxide emissions. Increased carbon dioxide taxes on fossil fuels to domestic customers are an example of such a regulatory instrument. Trading in emission allowances is another regulatory instrument aimed at restricting carbon dioxide emissions. Evaluations have shown that the emissions of carbon dioxide would have been at a much higher level today if these carbon dioxide tax increases had not been implemented. Increases in the prices of fossil fuels have made a further contribution to the development.

**Figure 15:5. Total emissions of greenhouse gases per GNP and per capita**




Source: Swedish Energy Agency processing of Sweden's reporting of greenhouse gas emissions 2008, and Statistics Sweden statistics

# 16. Sulphur dioxide emissions by sector

*The sulphur dioxide emissions have more than halved from 1990 to 2006. The industrial sector and the energy sector are the highest emission sources. The emissions from the residential, services and miscellaneous sectors and from transport are very low.*

### Energy and environmental policy objectives

According to the energy policy objectives, energy supply shall have low negative impact on health, the environment and the climate. It is also emphasized that Swedish environmental and climatic objectives shall be taken into account. The Swedish environmental quality objectives were revised during 2005, and the target for emissions of sulphur dioxide were tightened up from 60 000 to 50 000 tonnes by year 2010.

### Trends

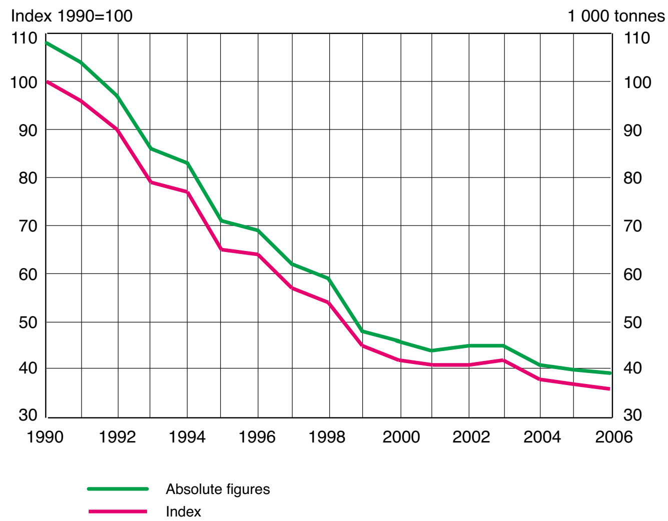
The emissions of sulphur dioxide have decreased continuously during the period studied. This applies to all sectors. In total, the emissions of sulphur dioxide in 2006 amounted to 39 279 tonnes, which is around one third of the emissions in 1990. The national environmental objective will be met if the emissions are maintained at the present low level.

During most of the period, industrial processes have been the highest single source of sulphur dioxide emissions. The next emissions source was the manufacturing and building industries, followed by the energy sector (electricity and district heating generation and refineries).

The sulphur dioxide emissions from the energy sector have been halved in the past five years compared to the 1990 level. The fluctuations in the emissions from the energy sector between different years are higher than in other sectors. As an example, the emissions from this sector in 1996 were 40% higher than in adjoining years. The percentage reduction in emissions from the services sector is highest, followed by the residential sector and the transport sector.

The total emissions of sulphur dioxide from the residential, services and transport sectors in 2006 were less than 10% of the total sulphur dioxide emissions in Sweden.

**Figure 16:1. Sulphur dioxide emissions and index**




Source: Sweden's report on greenhouse gas emissions 2008

### Reasons and relationships

In 2006, the total sulphur dioxide emissions were just over 39 000 tonnes. There are thus margins for achieving the national environmental target. The residential and services sectors display a substantial reduction in sulphur dioxide emissions. This can be explained both by falling oil use in favour of electricity and district heating, and the use of more "sulphur-deficient" fuel oils. The sulphur tax has been a contributory factor to the substantial reduction in the sulphur content of the oils used in Sweden.

The fact that the emissions from the energy sector vary relatively widely between different years can mainly be explained by the influence of hydropower. As an example, 1996 was a dry year, and fuel-based electricity generation was therefore much higher than normal. The fuels that were used contained sulphur, which increased the emissions.

The reduction of emissions from the transport sector (domestic transport) from around 11 000 tonnes in 1990 to around 3 000 tonnes in 2006 cannot be explained by reduced use of

**Figure 16:2. Sulphur dioxide emissions by different sectors**

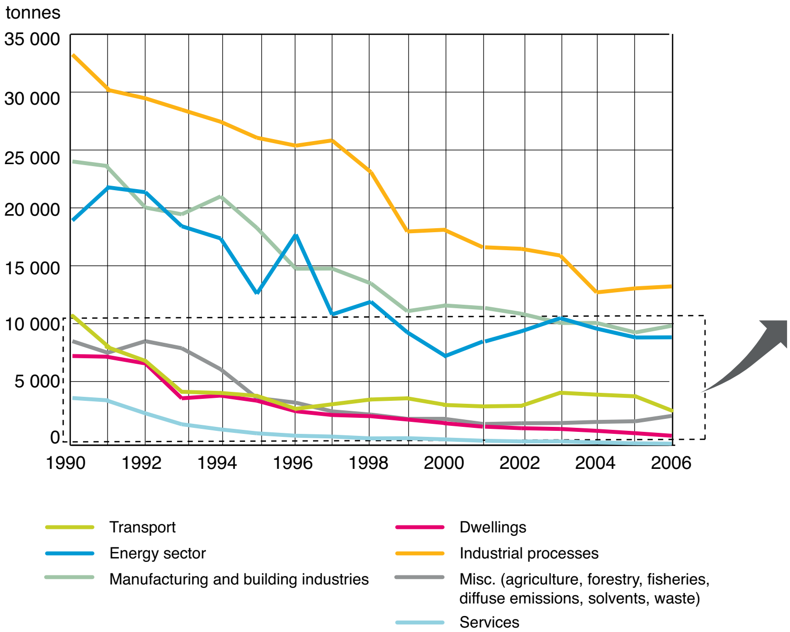
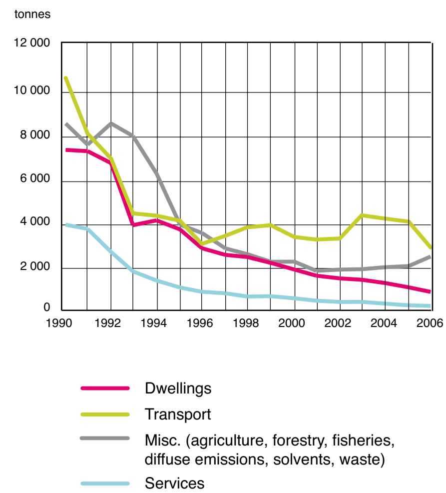



**Figure 16:3. Detail from Figure 16:2**



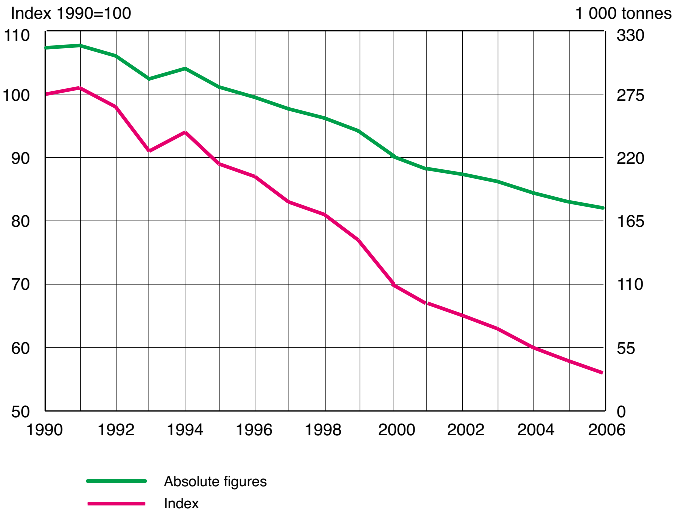

Source: Sweden's report on greenhouse gas emissions 2008

oil products. The reduction in this case is due, for example, to increased demand for tax-beneficial environmental class 1 diesel fuel with very low sulphur content.

# 17. Nitrogen oxide emissions by sector

*The total nitrogen oxide emissions have dropped by around 44% between 1990 and 2006. The transport sector is the highest emissions source, followed by the manufacturing and building industries (excluding industrial processes) and by the miscellaneous sector (agriculture, fisheries, forestry, waste sector and diffuse emissions). The emissions from the residential, services and energy sectors are very low.*

**Figure 17:1. Nitrogen oxide emissions and index**




Source: Sweden's report on greenhouse gas emissions 2008

### Energy policy objectives

According to the energy policy objectives, the energy supply shall have low negative impact on health, the environment and the climate. It is also emphasized that the Swedish environmental and climatic objectives shall be taken into account. The Swedish environmental quality objectives specify that the annual emissions of nitrogen oxides shall have been reduced to 148 000 tonnes by year 2010.

### Trends

The nitrogen oxide emissions have dropped at a relatively uniform rate during the whole of the 1990s. In total, the emissions have dropped by around 44% from 1990 to 2006.

The transport sector is by far the highest source of nitrogen oxide emissions in Sweden (refers here to domestic transport). The manufacturing and building industries are the next highest emissions sources, but the emissions from these industries are much lower than those from the transport sector. In 1990, the transport sector accounted for around 61% of the total nitrogen oxide emissions. However, the emissions from the transport sector have dropped significantly and the proportion of emissions in 2006 had fallen to around 53%. Nevertheless, about half of the nitrogen oxide emissions still originate from the transport sector.

The emissions form the residential and services sectors have been decreasing slowly over the whole of the period. Viewed over the whole period from 1990, the emissions from industrial processes have decreased, but they have increased slightly from 2002. The nitrogen oxide emissions from the miscellaneous sector have decreased by 38% from 1990, and the decrease has been highest since 1999. The emissions from the energy sector vary from year to year, and were around 15% lower in 2006 than in 1990.

The official Swedish emissions statistics have been revised since the 2007 indicator publication. This has meant that the emissions of nitrogen oxides have dropped by an average of 3% during the period 1990-2005 compared with last year's report. It is principally the emissions in the industrial sector and the miscellaneous sector during the period 2000-2005 that have been lowered.

### Reasons and relationships

The total nitrogen oxide emissions in 2006 amounted to around 175 000 tonnes. So there is some way to go to the target of 148 000 tonnes for 2010. Continued reduction in emissions is thus necessary to achieve the target. To reach the target, the emissions must be reduced at a more rapid pace than during the 1990s.

The principal explanation for the fall in nitrogen oxide emis-

**Figure 17:2. Nitrogen oxide emissions by different sectors**

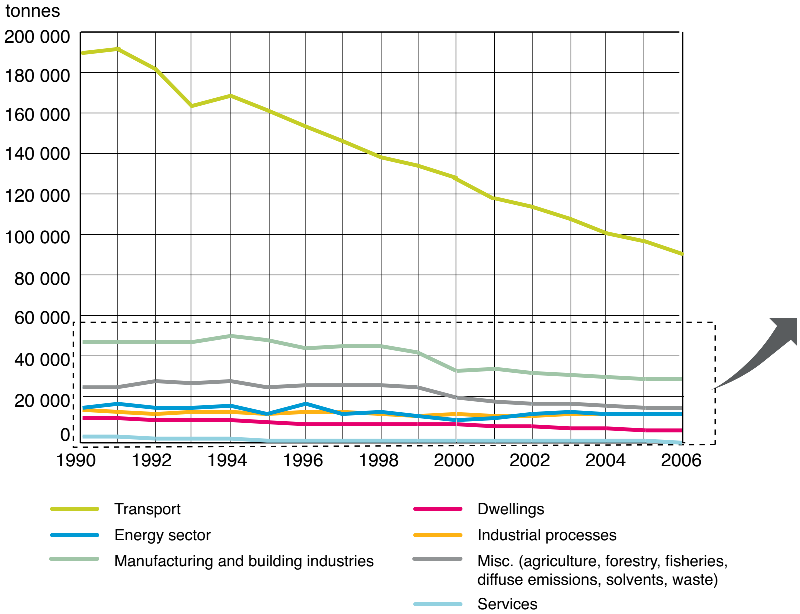
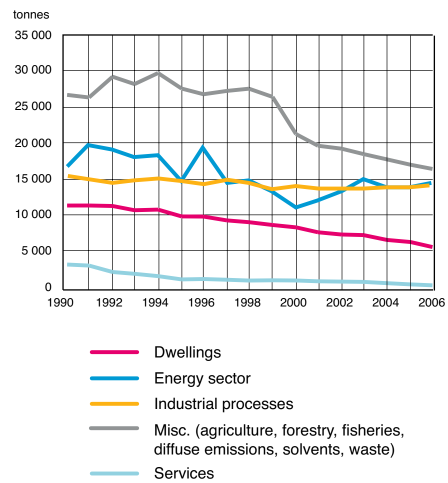



**Figure 17:3. Detail from Figure 17:2**




Source: Sweden's report on greenhouse gas emissions 2008

sions in the transport sector is the increased use of catalytic converters. Catalytic converters for new petrol-fuelled vehicles were made mandatory at the end of the 1980s, and nitrogen oxide emissions gradually decrease in pace with cars without catalytic converters being replaced by cars with catalytic converters. The reduction in emissions from the energy sector (electricity and district heating generation and refineries) can largely be explained by the $NO_x$ charge system introduced in 1992. This means that a charge of SEK 50 per kg of nitrogen oxide is imposed on emissions from large boilers, and the charge is then repaid in proportion to the utilized energy generated. The emissions from the manufacturing and building industry sectors and from industrial processes can be related to the general economic climate and the turnover of the companies. The development in the miscellaneous sector depends principally on emissions from contracting machinery (preliminary conclusion).

# 18. Electricity price on the Nord Pool spot market

*In order to achieve the objective of an efficient electricity market, it is important to have pricing that performs well. The spot price on the Nord Pool electricity exchange serves as a price reference for the Nordic electricity market. Since Swedish deregulation in 1996, the price on the electricity exchange has varied widely, both from year to year and within individual years. Since hydropower represents a large proportion of the Nordic electricity generation, the price on the electricity exchange is seriously affected by the conditions for hydropower generation, e.g. the inflow of water and the reservoir levels.*

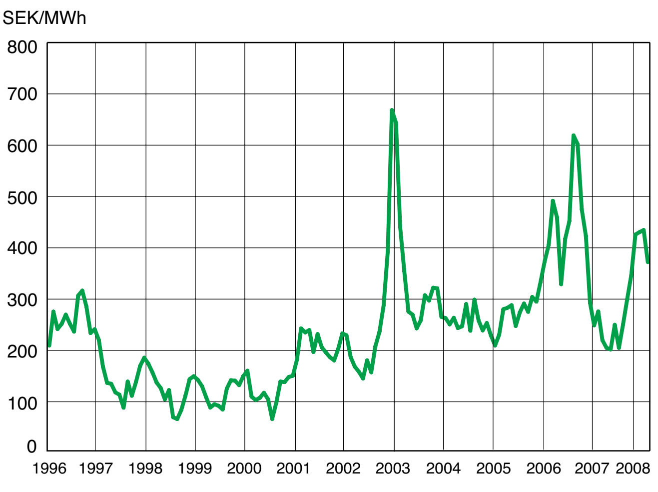
**Energy policy objectives**

Electricity is a very important element in the Swedish energy system. An efficient electricity market with competitive prices is therefore an important objective for the Swedish energy policy. In the energy policy, the importance is also emphasized of pricing that performs well.

**Trends**

In the hydropower-dominated Nordic electricity system, the price of electricity is highly dependent on the availability of water. Another factor that has affected the price of electricity

**Figure 18:1. Price of electricity on the Nord Pool spot market for the Swedish price area, monthly average values, January 1996–February 2008**




is the introduction of trading in emissions allowances on 1 January 2005. The initially high prices of emission allowances were followed at the end of a poor 2006 by plummeting emission allowances prices. The reason for this is that the market did not have comprehensive information on the availability of and demand for emission allowances. In conjunction with the publication of the verified emissions from the first year of the trading system (2005) in April–June 2006, emissions proved to have been 97.2 million tonnes lower than the allocation, which meant that the market had a substantial surplus of emission allowances. The price of an emission allowance dropped from around 30 Euro to less than 14 Euro in a matter of days. The price stabilized during the summer at around 16 Euro, but it began to drop again in the autumn and reached levels below 1 Euro per tonnes in February 2007. The emission allowances prices in the second trading period of 2008–2012 have so far been 19–22 Euro per tonne in 2008. Other factors that affect the price of electricity are the fuel prices for thermal power generation, temperature conditions and the operating status of the nuclear power plants in Sweden and Finland, as well as the available generation capacities. Due to the electricity interchange with the Continent, the prices of electricity abroad and the available transmission capacities have also affected the Nordic price.

The price of electricity on the spot market has varied widely since 1996. Prices varied both between years and within individual years. The price difference between different years is principally dependent on the hydropower generation conditions (wet year/dry year), although the temperature conditions (warm and cold years) also affect the price of electricity. The price of electricity is usually lowest in the summer and highest in the winter. The reason for this is that when the demand for electricity is high (high power demand/simultaneous demand) in the winter, plants with high generation costs must be taken into service. In principle, it is only during the spring floods and the summer that the demand can be met by plants with low generation costs. But the fact that a large proportion of the water can be saved in water reservoirs along the rivers means that controllable water is priced on the basis of the so-called

Figure 18:2. Price of electricity on the Nord Pool spot market for the Swedish price area, 24-hour average values and 24-hour minimum and maximum, 1 January 2006–28 March 2008

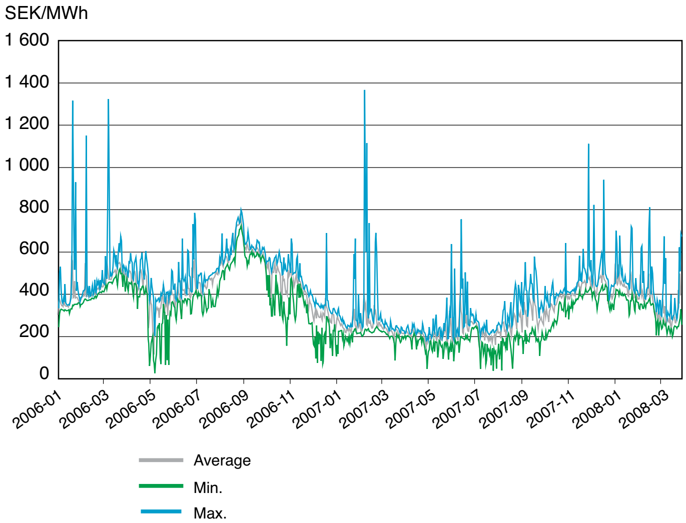
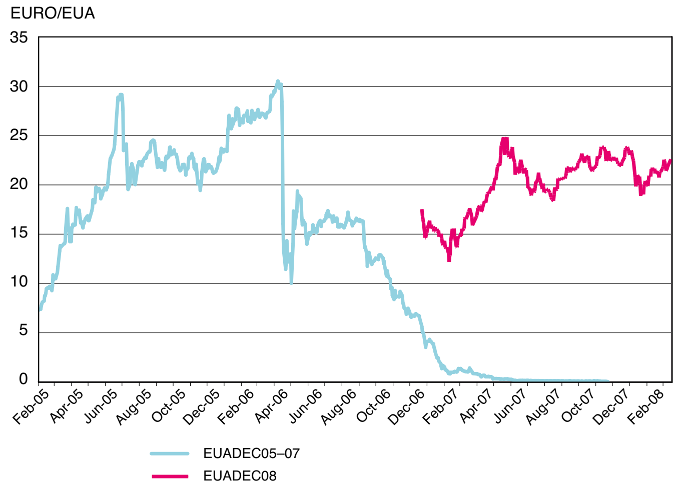



Figure 18:3. Development of prices for emission allowances, 24-hour average values (Nord Pool) 11 February 2005–26 March 2008




water value instead of its low variable cost. The price of electricity is closely related to the hydrological balance, i.e. the availability of snow and surface water, and also water in the water reservoirs at a certain time in relation to the normal level at that time.

The inflow to the Swedish water reservoirs varies over the year and between years. The inflow is usually low during the winter, since the precipitation is usually in the form of snow. The inflow increases drastically in conjunction with the melting of snow during the spring and early summer. To a certain extent, water also flows in during the autumn in the form of rain. The reservoir levels also vary widely. They are usually highest during the summer and autumn, decrease during the winter and early spring, and rise rapidly in conjunction with the melting of snow. During the second half of 2002, for example, the reservoir levels dropped drastically, but were then gradually restored during 2003–2004. Although the water reservoirs were more than normally filled in 2005, the price of electricity did not drop to earlier levels. This was due principally to rising prices of emission allowances and the high fuel prices.

In spite of the relatively normal inflow volume for the year as a whole, the price of electricity in 2006 reached the record high average level. However, at the end of the year, the price was down to the same level as in 2005. In the first four months of 2006, the increase in the price of electricity was due principally to rising prices of emission allowances, but when the emission allowances price dropped at the end of April, the price of electricity followed suit. The highest 24-hour mean value for the year was reached at the end of August. Nuclear power generation disturbances during the late summer and autumn, and the low water reservoir levels contributed to the high electricity price. The situation changed in October, the water inflow increased and the Swedish Nuclear Power Inspectorate approved the restart of Forsmark 1 and 2, while the mild weather caused a low demand, which was also reflected in the price of electricity. The hydrological balance became positive in November and continued to be so during 2007 and early 2008 which, together with a mild winter, partially compensated for the substantially higher prices of emission allowances. In spite of a low average price of electricity, the highest spot price for one individual hour during the studied period 1 January 2006–28 March 2008 shown in Figure 18:2, was recorded in February 2007.

### Reasons and relationships

There is thus a clear link between the price of electricity and hydropower generation conditions: much hydropower gives a low price of electricity and vice versa. What can be distinguished is that the wet year 2001 gave evidently higher electricity prices than earlier wet years during the period studied. This

**Figure 18:4. Weekly inflow difference for the Swedish water reservoirs compared with a normal year**

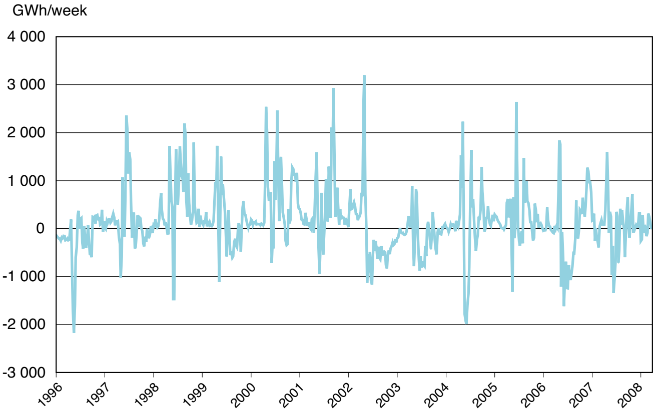
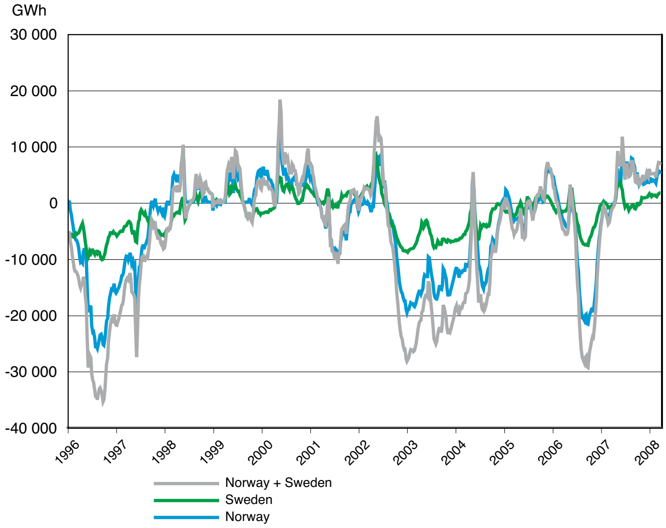



**Figure 18:5. Reservoir level, deviation from normal**




indicates that the increased demand for electricity in the Nordic countries, together with the so far very limited expansion of electricity generation capacity, has gradually raised the price of electricity in the Nordic countries. Part of the explanation for the high price of electricity in 2001 is also that nuclear power had been refuelled less than normal, since the inflow of water had been good for three years in a row. The links and trade with the Continent also affect the price upwards when the prices on the Continent are higher than in the Nordic countries, and electricity is therefore exported. However, a long-term development is generally difficult to distinguish clearly, since the electricity price variation caused by the hydropower generation conditions and the effects of the varying climatic conditions are wide and are constantly "superimposed" on the long-term trend.

Both the power balance and the energy balance are important from the security of supply aspect, and both balances affect the pricing. In an energy-rated power system such as the Nordic system, the difference in the energy available between wet years and dry years may be very large, even though the installed power is the same.

Figure 18:2 gives examples of extremely high hourly prices. Spread over 24 hours, these peaks are evened out and even more so if they are spread out over weekly or monthly average values. To some extent, it can be said that a brief, high peak is linked to a temporary situation in which the power supply cannot or cannot be expected to meet the demand, whereas a longer peak that may perhaps be reflected in the average prices of several days in succession and thus also in weekly average values maybe linked to a greater extent to an energy shortage situation.

### FACTS

In the Nordic countries, hydropower accounts for around half the electricity generated in a normal year. In Norway, generation by hydropower in a normal year amounts to 119.7 TWh, in Sweden, it is 67.5 TWh and in Finland, 13 TWh. Since the electricity market is Nordic, Sweden is largely affected by conditions in neighbouring countries. On the Nordic electricity market, it is actually the inflow to the hydropower plant reservoirs in all countries that is decisive, although the Swedish inflow of water still gives a good indication of the conditions. The inflow difference (for 2007) has been produced in relation to the median value for the period 1950-2005, and the median inflow of water in Sweden amounts to 62 TWh on an annual basis. The levels in the water reservoirs also play a role. The Norwegian reservoir capacity (82 TWh) is clearly larger than the Swedish (34 TWh). For 2007, the reservoir level has been described as the deviation from the median value for the period 1990-2006 for Norway and as the deviation from the median value for the period 1950–2005 for Sweden.

Source: Nord Pool. The information does not represent official statistics, but is considered to be of high quality.

# 19. Total market share of the three largest electricity generators

*A larger number of market participants could stimulate the competition which, in turn, would contribute to an efficient and well-performing electricity market. In 2007, the market share of the three largest electricity generators on the Nordic electricity market was around 41%. Since 2002, this market share has increased somewhat.*

**Energy policy objectives**

The electricity market is a central part of the Swedish energy policy. The importance of efficiency in the energy supply is emphasized in the energy policy objectives. An efficient electricity market is highlighted in particular. It is generally considered that a larger number of players stimulates competition which, in turn, contributes to an efficient market that performs well.

**Trends**

A common Nordic electricity market was established a number of years ago, which includes the Nord Pool electricity exchange. The electricity generated in the Nordic countries by the three largest electricity generating groups amounts to a market share of about 41%, if the total Nordic electricity generation is used to define the market size. In the report entitled "Pricing and competition on the electricity market"[85] the Energy Markets Inspectorate expresses concern that the increased concentration on the Nordic market by mergers and takeovers has reached such a level that it is no longer unproblematic. The market share of the three largest electricity generators in Sweden in relation to the total Swedish electricity generation is around 85%.

**Reasons and relationships**

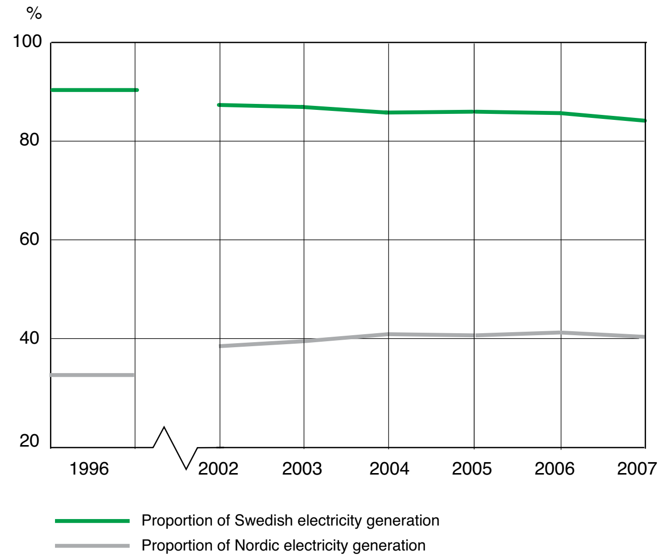
Svenska Kraftnät and other system operators in the Nordic countries bear responsibility for the transmission links having sufficient capacity to ensure an efficiently performing electricity market. How dominant the three largest electricity generation groups are depends on the geographic market being considered. In most cases, it is the Nordic market that is relevant to study.

As a consequence of limitations of electricity transmission, the Nordic electricity market is divided into different sub-markets known as price areas. This takes place when the market demand for electricity transmission for price equalization is greater than that allowed by certain transmission links. This occurs fairly often, but on such occasions, Sweden forms almost always a common price with other price areas, such as Finland and Denmark. It is extremely seldom that there is one price only for Sweden.

This indicator includes wholly-owned generation and partially-owned generation, with deductions for minority owners and additions for replacement power. In addition to the parent company, an electricity generation group also includes subsidiaries in which the parent company has a holding of at least 50%. In this publication, the term Nordic electricity market refers to the Nordic countries excluding Iceland.

Among the electricity generators who have electricity generation in Sweden, Vattenfall, Fortum, and E.ON are by far the largest. On the Nordic electricity market the largest generators are Vattenfall, Fortum and Statkraft.[86]

**Figure 19.** Market share of the three largest electricity generators in relation to the total Swedish electricity generation and the total Nordic electricity generation




Source: Swedenergy and Energy Markets Inspectorate

[85] Swedish Energy Agency and Energy Markets Inspectorate, ER 2006:13

[86] Note that the indicator relates to the three largest electricity generators on the Swedish and Nordic markets. Which these companies are can thus differ between years.

# Sources and quality

The source information for the indicators in this publication has predominantly been obtained from Swedish official statistics (SOS). If statistics other than SOS have been used, this is given under the corresponding graph or indicator text. If comments need to be made concerning individual sources of statistics or source information, this is also given under a corresponding indicator.

The quality of a product or statistics is determined by the user's perception of the product and its usability. To enable the user to assess or value the quality of a product, a number of aspects of a product are listed, which users take into account when they assess how well it meets their needs and expectations.

A description of the quality related to statistics contains the following five main components: (1) Contents, that mainly relate to statistical target characteristics, (2) Reliability that relates to uncertainty sources and their effects on the statistics, (3) Topicality that comprises time aspects that play a role in how well the statistics describe the current situation. (4) Comparability and usability that refer to the possibility of making comparisons, over time ad between groups, and for use in combination with other statistics. (5) Accessibility and intelligibility, which concern the physical accessibility of the statistics and its intelligibility.

A description of the quality in statistical sources from the SOS system can be obtained from the Statistics Sweden homepage (www.scb.se). The statistics used here that are not included in the SOS system have been assessed from the same quality aspects as for SOS statistics in order to guarantee a level of quality that is high for the purpose.

A further dimension in the description of quality is needed for indicators. The underlying statistics must have good quality for the purpose with regard to the components given above, and the indicator as such must have good quality for the purpose.

The quality of the indicator is determined by comparability between component series with regard to matters such as population, variables and quantities, and their definitions. In this publication, the statistical information for the indicators has been taken to meet the requirement for good quality of the indicator. Good quality for this purpose thus means that the underlying statistics can be combined in one indicator, but also that both the statistics and the indicator as such are suitable for the purpose. In cases where one of the quality aspects for the indicator could not be fully met, these requirements have been noted under the corresponding indicator.

As regards the quality of the indicator with regards to what it measures, a number of factors must be assessed. The indicators should be relevant, i.e. linked to the objectives that are to be followed up, they should be easy to understand, and should be meaningful in the sense that they should show what they are intended to show. They must also be comprehensive and well substantiated, and the parameters in the source information must be well defined. The source information for the indicator should be based on available statistics of an official nature, which is reported and well described.

www.swedishenergyagency.se

**Our objectives – smarter energy use**

The Swedish Energy Agency is a state authority working to achieve a secure, environmentally-friendly and efficient energy system.

We can help achieve the climate objectives through international cooperation and involvement.

The Agency finances the research and development of new energy technology. We actively support business concepts and innovations that can lead to the establishment of new companies.

We also show Swedish households and companies the way to accomplishing smarter energy use.

ET 2008:21 I December 2008 I 700 copies I Production: Svensk Information I
Printed by: Edita Västra Aros, Västerås I Photo: Per Westergård

Swedish Energy Agency, P.O. Box 310, SE-631 04 Eskilstuna, Sweden, Phone +46 16 544-2000, Fax +46 16 544-2099