



Government Offices of Sweden

Ministry of the Environment and Energy

Sweden's draft integrated national energy and climate plan

According to Regulation (EU) 2018/1999 of the European
Parliament and of the Council on the Governance of the Energy
Union and Climate Action

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1 Overview and process for establishing the plan

1.1 Executive Summary

This draft of the integrated national energy and climate plan is a summary of Sweden's climate change and energy policies. A climate policy framework was adopted by the Riksdag (the Swedish parliament) in June 2017 and the energy policy is expected to be adopted in June 2018. In Table 1 an overview with key climate and energy policy objectives are represented, for more detailed information see chapter 2.

Table 1 An overview with key climate and energy policy objectives

Target	Target year	Base year
Sweden will not have any net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions	2045	1990
Reduction of -75 percent of emissions from sectors outside the EU ETS	2040	1990
Reduction of -63 percent of emissions from sectors outside the EU ETS	2030	1990
Reduction of - 70 percent of emissions from domestic transport	2030	2010
Reduction of -40 percent of emissions from sectors outside the EU ETS	2020	1990
50 percent share of renewable energy in gross final energy consumption	2020	
100 per cent renewable electricity production (this is a target, not a deadline for banning nuclear power, nor does mean closing nuclear power plants through political decisions)	2040	
Sweden's energy use is to be 50 percent more efficient than in 2005	2030	2005

To achieve the targets in a cost-effective manner, regular monitoring of targets and conditions for achieving the targets are required. Such requirements related to the climate targets are stated in the climate policy framework. Thereafter existing instruments can be changed or new ones introduced.

1.2 Overview of current policy situation

This draft NECP is a description of Sweden's integrated national energy and climate policies.

Sweden's national climate policy framework

In June 2017, the Riksdag, adopted a proposal on a national climate policy framework for Sweden (Government Bill 2016/17:146). The climate policy framework consists of a Climate Act, new national climate targets and a climate policy council. It creates order and stability in climate policy and sets long-term conditions for the business sector and society. The climate act will impose responsibility on the current

Government, and on future governments, to pursue a climate policy that is based on the national climate targets and to provide clear feedback on the progress. Sweden will have long-term climate targets beyond 2020 and a council that independently reviews climate policy. The reform is a key component of Sweden's efforts to live up to the Paris Agreement. For details of Sweden's national climate objective and targets see section 2.1.

CLIMATE ACT

The Climate Act legislates that the Government's climate policy must be based on the national climate targets and specifies how the work should be carried out.

In its Budget Bill, the Government must submit a climate review to the Riksdag every year. The climate review must contain:

- A report on emissions development.
- A report on the key political climate decisions taken during the year.
- An assessment to identify the need for additional policies and measures, and when and how decisions about such policies and measures can be adopted.

Every fourth year, the Government must develop a climate policy action plan which provides information on planned policies and measures to achieve emission reductions.

The new Climate Act entered into force on 1 January 2018.

CLIMATE POLICY COUNCIL

The climate policy council will provide independent assessments of how the overall policy presented by the Government is compatible with the national climate goals.

Sweden's national energy policy

On the 10th of June 2016, a framework agreement was reached between five political parties (representing a majority in the Parliament): the Swedish Social Democratic Party, the Moderate Party, the Swedish Green Party, the Centre Party and the Christian Democrats¹. The 12th of April 2018 the government decided on an energy bill based on the framework agreement (Government Bill 2017/18:228). Sweden's energy policy should build on the same three pillars as energy cooperation in the EU. The policy therefore aims to combine:

- ecological sustainability

¹ <http://www.government.se/49d8c1/contentassets/8239ed8e9517442580aac9bcb00197cc/ek-ok-eng.pdf>.

- competitiveness
- security of supply

The energy bill also contains new energy targets:

- By 2030, Sweden's energy use is to be 50 percent more efficient than in 2005. The target is expressed in terms of primary energy use in relation to gross domestic product (GDP).
- The target by 2040 is 100 per cent renewable electricity production. This is a target, not a deadline for banning nuclear power, nor does mean closing nuclear power plants through political decisions.

Implementing national energy and climate policies

The implementation of energy and climate policy is done in the same way as other legislation.

1.3 Consultations and involvement of national and EU entities and their outcome

Involvement of the Parliament

The content of the draft national climate and energy plan is based on new climate policy framework adopted by the Riksdag in 2017 (Government Bill 2016/17:146) and the energy bill (Government Bill 2017/18:228).

Involvement of local and regional authorities

Sweden has a structure in place where local authorities, business community and other relevant stakeholders are involved in policy planning. Both the climate policy framework and the energy bill are based on proposals from government inquiries. Before the Government takes up a position on the recommendations of a commission of inquiry, its report is referred for consideration to the relevant bodies. These referral bodies may be central government agencies, special interest groups, local government authorities or other bodies whose activities may be affected by the proposals. The public are also welcome express their opinions on the proposals in this process. When the ministry responsible has received the consultation responses, the officials go through them and discuss them with the minister responsible. After that they draft the legislative proposal the Government will put before the Riksdag.

Consultations with stakeholders, including social partners, and engagement of civil society

The Swedish Energy agency had the main responsibility to develop the draft of the NECP. The NECP proposal was presented for stakeholders in

January and they had the opportunity to comment the draft between the 19 of January until the 23 of February.

The NECP has been revised to answer questions and supplement from the stakeholders of e.g. description of instrument. A general point of view is that the stakeholders want more information and want to get involved earlier in the process for the first NECP which they also will be.

Relevant stakeholders have also already been involved in the regular referral process described under ***Involvement of local and regional authorities*** above for the policies and measures of this NECP.

Consultations with other Member States

Cooperation and dialogue with other neighboring member states takes place in the Nordic council. The early version of the Swedish draft NECP was circulated to the other EU Member States within the Nordic Co-operation (Denmark and Finland) for comments before it was uploaded to the NECP platform in June. No comments were given from the other member States. The structure for consultation of the final plan is under discussion.

Iterative process with the European Commission

Dialogue with the commission has taken place within the structure of the technical expert group for the national climate and energy plan. There has also been some informal dialogue on the early version of the draft.

1.4 Regional cooperation in preparing the plan

The Nordic countries has a well established long standing, broad and good cooperation on energy and climate matters. Through the Nordic Council of Ministers (the official body of the Nordic Co-Operation), Sweden participates in the Nordic Center of Excellence issues related to the Arctic climate and adaptation as well as in other areas of climate change research.

The Nordic perspective is also important for understanding challenges related to our national energy systems. The Nordic integrated power market is a good example of how different sources of power production can complement each other across borders. Cross-border trade of electricity enables a better use of the energy resources, increases security of supply and makes it easier to integrate new renewables in to the system.

A group within the Nordic Co-operation has been formed to promote collaboration between the Nordic countries. A first meeting was held in May, among other things Sweden's early version draft of NECP was presented and discussed. The early version of the Swedish draft NECP

was circulated to the countries in the group within the Nordic Cooperation (Denmark, Finland and Norway) for opinions before it was uploaded to the NECP platform in June. No comments were given from the other countries.

Sweden is also part of The North Seas Energy Cooperation (NSEC), consisting of 10 countries with participation from the European Commission: Belgium, the Netherlands, Luxembourg, France, Germany, UK, Ireland, Norway, Sweden and Denmark. NSEC is a voluntary, bottom up, market-oriented, regional cooperation initiative established in 2016, which seeks to create synergies and to avoid incompatibilities between national policies and to foster joint strategies where possible and beneficial.

2 National objectives and targets

2.1 Dimension Decarbonisation

The EU has adopted a target to reduce GHG emissions by 40 percent compared with 1990 levels until 2030 as part of its nationally determined contribution (NDC) to the Paris Agreement.

With the 2030 climate and energy framework, the EU is making a fair and ambitious contribution to the Paris Agreement. The 2030 climate and energy framework shall ensure that the target of 40 percent reduction of total GHG emissions from 1990 levels is achieved, which is equivalent to a 36 percent reduction compared with 2005 levels. The target of 40 % is divided into two sub-targets, where 43 percent of the reduction effort shall be achieved within the EU Emissions Trading System, regulated by the EU ETS Directive (2018/410) and 30 percent to non-EU ETS sectors, regulated by the Effort Sharing Regulation (842/2018/EU).

Recent development within the 2030 climate and energy framework include a revised EU ETS-directive, a new Effort Sharing-Regulation (ESR) and a new Land Use, Land Use Change and Forestry-regulation (LULUCF). In the ESR, a national emission reduction targets to 2030 have been assigned to each Member State. The emission reduction targets range from 0 to 40 percent to 2030 compared to 2005. Sweden has committed to reduce emissions in sectors covered by the ESR by 40 percent compared to 2005. The modalities and procedures for monitoring and review under Regulation 842/2018/EU, ESR will be harmonised for all EU member States through the Governance Regulation.

The LULUCF sector is part of the EU NDC from 2021 until 2030. The objective is to ensure that no net emissions are generated within the sector (meaning that emissions within the sector shall not exceed removals) as well as establishing accounting rules for specific land use sectors.

The Swedish environmental quality objective Reduced Climate Impact

To provide a clear structure for environmental efforts in Sweden, the Riksdag has adopted 16 environmental quality objectives. One of these, Reduced Climate Impact, forms the basis for climate change action in the country. The interpretation of the objective is “Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Sweden will work internationally for global work to address this goal” (Government Bill 2016/17:146).

Targets under Sweden's national climate policy framework

In June 2017, the Riksdag adopted a proposal on a national climate policy framework for Sweden (Government Bill 2016/17:146). For more information see section *Sweden's national climate policy framework*.

TARGETS

- By 2045, Sweden is to have no net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions. This means emissions from activities in Swedish territory are to be at least 85 percent lower by 2045 compared with 1990. Supplementary measures may count towards achieving zero net emissions, such as increased uptake of carbon dioxide in forests and land, and investments in other countries. International accounting guidelines will be followed for this.
- Emissions in Sweden outside of the EU ETS should, by 2030, be at least 63 percent lower than emissions in 1990, and by 2040 at least 75 percent lower. To achieve these targets by 2030 and 2040, no more than 8 and 2 percentage points, respectively, of the emissions reductions may be realised through supplementary measures.
- Emissions from domestic transport are to be reduced by at least 70 percent by 2030 compared with 2010. Domestic aviation² is not included in the goal since this subsector is included in the EU ETS.

Table 1. Sweden's national climate targets, reflected in percental reduction between 1990 and target year, 2005 and target year and target level in tonnes (calculations based on the National Inventory Report, Submission 2018)

	<i>Emissions covered</i>	<i>Decided emission reduction targets</i>	<i>Emission reduction target relative to 2005</i>	<i>Target level (million tonnes³)</i>
<i>Milestone target, 2020</i>	Emissions covered by ESD (406/2009/EC)	40 % relative to 1990	33 %	28,7
<i>Milestone target, 2030</i>	Emissions covered by ESR (842/2018/EU)	55 - 63 % relative to 1990	50 - 59 %	17,2 - 20,9
<i>Transport target, 2030</i>	Domestic transport (excl. aviation)	70 % relative to 2010		5,9

² The emissions only include CO₂.

³ The time series is updated for all years at each publication to ensure that the calculation methods are consistent for all years. This means that target levels in number of tonnes and compared to other starting years only apply to a specific publication (in this case, the 1990 -2016 time series published in 2017). The statistics are published with a one year lag in November/December.

<i>Milestone target, 2040</i>	Emissions covered by ESR 842/2018/EU	73 - 75 % relative to 1990	70 - 72 %	11,6 - 12,6
<i>No net emissions of GHG, 2045</i>	Emissions from activities within Swedish territory	85 - 100 % relative to 1990	84 - 100 %	0 - 10,7

The Swedish target for 2020

Current climate policy is also set out in two Government Bills, entitled An Integrated Climate and Energy Policy, passed by the Riksdag in June 2009 (Government Bills 2008/09:162 and 163). The first of these Bills sets a national milestone target for climate, calling for a 40 percent reduction in emissions by 2020 compared with 1990. If the target in 2020 is met, greenhouse gas emissions from the non-ETS sector would be around 20 million tonnes of carbon dioxide equivalent lower than in 1990. This target applies to activities not included in the EU Emissions Trading System and does not include the LULUCF sector.

2.2 Dimension Renewable energy

The climate target described in section 2.1 has consequences for the share of renewable energy, but Sweden has no explicit national target for renewable energy by 2030. However, the 2016 reference scenario from the Swedish Energy Agency⁴ points to a 65 percent share of energy from renewable sources in gross final consumption of energy by 2030. The reference scenario is based on existing policies and measures and the recommended EU-parameters. New scenarios are currently under work and will be used for the final plan.

The binding 2020 target for Sweden from the RED is 49 percent share of energy from renewable sources in gross final consumption of energy, but Sweden have a national target of 50 percent for 2020. The indicative trajectory starting from the national target of 50 percent in 2030 is shown in Figure 1 below.

⁴Energimyndigheten, Scenarier över Sveriges energisystem 2016, ER 2017:6.

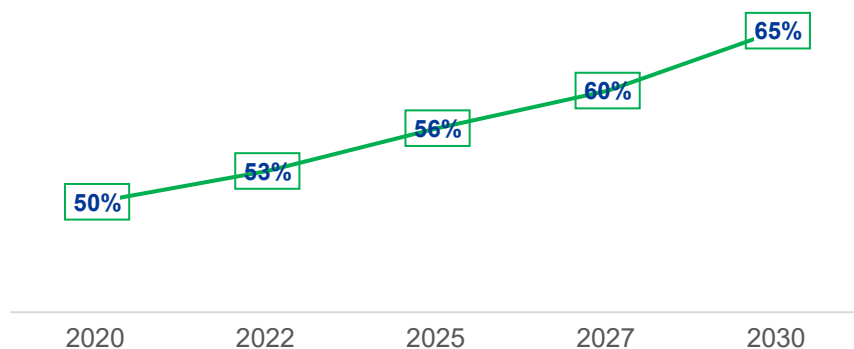


Figure 1. Sweden's indicative trajectory for share of renewable energy sources in gross final consumption.

The reference scenario is described in detail in chapter 4.2.3 *Projections of developments with existing policies and measures*, including trajectories for shares of renewable energy in electricity, heating and cooling, and the transport sector.

Sweden believes it is more cost efficient to deploy the renewable technologies which the market deems most profitable instead of determining the share of each technology beforehand. However, the expected renewable energy by source in the reference are shown in chapter 4.2.3 *Projections of developments with existing policies and measures*.

In the reference scenario without any additional measures⁵, consumption of bioenergy⁶ increases by 21 TWh between 2014 and 2020, reaching at total bioenergy consumption of 151 TWh. This increase is mainly explained by an increase of 11 TWh biofuels in the transport sector, dominated by HVO which is primarily produced using waste and residue. There is also an increased use of waste for district heating, as other bioenergy use increases by 5 TWh. After 2020, bioenergy consumption remains more or less constant until 2040.

2.3 Dimension Energy efficiency (2030 Framework target)

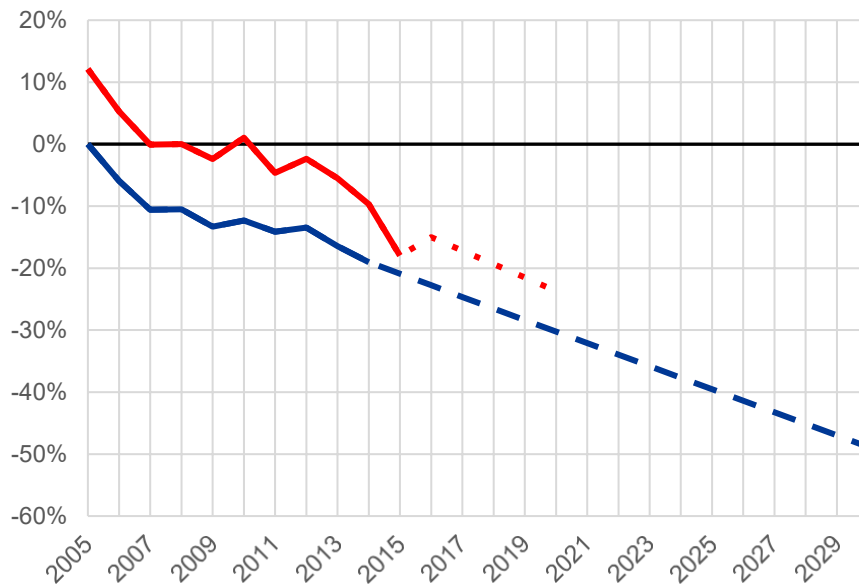
Sweden have a new energy efficiency target, by 2030, Sweden's energy use is to be 50 percent more efficient than in 2005. The target is expressed in terms of primary energy use in relation to gross domestic product (GDP), (Government Bill 2017/18:228). The definition of energy supply is the same as the one used for the above-mentioned Union target, i.e. excluding non-energy use and international transportation.

⁵ Case "Reference EU" using prices on fossil fuels and emission allowances recommended by the Commission. The scenario is explained in more detail in chapter 4.

⁶ Including the renewable part of waste.

Figure 2 shows the energy intensity targets for 2020 and 2030. The target for 2020 is a 20 percent reduction in energy intensity compared to 2008 whereas the target for 2030 is a 50 percent reduction compared to 2005. Another difference is that primary energy also includes non-energy use for the 2020-target.

Figure 2 Energy intensity targets for 2020 and 2030, assuming a linear progress from 2017 for the 2020-target and from 2015 for the 2030-target, percent.



In the reference scenario from 2016⁷, using the recommended EU-parameters, Sweden will have a primary consumption of 482 TWh and final consumption of 364 TWh by 2030. The development of the energy intensity depends on the development of GDP and primary energy which is due to energy efficiency measures, structural changes in industry, nuclear power and the development of the Swedish economy.

2.4 Dimension Energy security

Energy security is together with ecological sustainability and competitiveness part of the overarching objective for Swedish energy policy, and is also an integral part of general policies for emergency preparedness and civil defence. The objective of these policies is qualitative in character and based on the principle of well-functioning energy markets which prevent and mitigate disruptions and shortages. This means that Sweden does not have detailed quantitative objectives for most of the areas requested below.

⁷ Energimyndigheten, Scenarier över Sveriges energisystem 2016, ER 2017:6.

As for diversification of energy sources, Sweden has objectives for increasing supply of renewable electricity as described in section 2.2.

As for storage there is no specific objective. Regarding emergency stocks of oil, objectives for minimum stocks follow from Council Directive 2009/119/EC and the International Energy Program Agreement that requires International Energy Agency member countries to hold oil stocks equivalent to at least 90 days.

As for the gas supply, the Swedish implementation of the gas supply security regulation requires that protected customers, i.e. consumers, have access to gas for at least 30 days in the event of supply disturbances or disruptions.⁸

As for electricity, there is an objective, expressed as a requirement aimed at the network operator, that outages must not last longer than 24 hours, unless caused by a factor not controlled by the operator. There is also an objective for the operational reliability of the national grid, which states that an individual failure at the level n-1⁹ in the Swedish national grid must not be critical for electricity delivery. Should such a failure occur, consequences are to be remedied within 15 minutes and the electricity system should then be ready for a potential new failure. If the grid is damaged, necessary repair measures are to be initiated without delay.

2.5 Dimension Internal energy market

Electricity interconnectivity (2030 Framework target)

Sweden don't have a specific target for interconnectivity by 2030, but projections from the Swedish TSO Svenska Kraftnät points to a level of 27 percent by 2030, given from an expected import capacity of 12 350 MW and an installed electricity generation capacity of 46 049 MW.

Sweden had at the end of 2017 an interconnection level of 26 percent. Total import capacity was 10 250 MW and installed electricity generation capacity was 39 799 MW.

Energy transmission infrastructure

It is the Swedish TSO Svenska kraftnät that has the responsibility for electricity transmission. The current network development plan from Svenska kraftnät extends to 2027¹⁰.

⁸ REGULATION (EU) 2017/1938 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 25 October 2017 concerning measures to safeguard the security of gas supply and repealing Regulation (EU) No 994/2010

⁹ n-1 is referred to as any single component failure in the supply network will not affect the electricity supply.

¹⁰ <https://www.svk.se/siteassets/om-oss/rapporter/2017/svenska-kraftnats-systemutvecklingsplan-2018-2027.pdf>

Market integration

Although there are measures aimed at protecting energy consumers and improving the competitiveness of the retail energy sector, Sweden has no explicit objectives in this area.

Energy poverty

Sweden does not treat energy poverty differently from poverty in general and so has no specific objectives for energy poverty.

2.6 Dimension Research, innovation and competitiveness

The objective for public research and innovation in the energy area is to contribute to Sweden's energy and climate targets, long term energy and climate policy and energy related environmental objectives. More specifically, it aims at

- building scientific and technological knowledge and competence in order to enable, through new technology and new services, a transition to a sustainable energy system in Sweden, uniting ecological sustainability, competitiveness and energy security,
- developing technology and services that can be commercialised by Swedish enterprises, thus contributing to sustainable growth and the transition and development of the energy system in Sweden as well as in other markets, and
- contributing to and taking advantage of international cooperation in the energy area.

As for public funding, the latest budget constitutes an increase in spending from SEK 1.3 billion in 2017 to SEK 1.6 billion in 2020 annually. Beneficiaries in the private sector are expected to contribute private funding equalling at least half the amount of public funding received.

The goal of Swedish enterprise and industrial policy is to enhance Swedish competitiveness and create conditions for more jobs in an increasing number of growing companies. Enterprise policy initiatives are also to contribute towards the global sustainable development goals and the goals of the EU's common strategy for growth and employment, Europe 2020. In addition, Government Bill 2016/17:146 *A climate policy framework for Sweden* states that Sweden aims to show that it is possible to unite climate transition with welfare and competitiveness.

3 Policies and measures

3.1 Dimension Decarbonisation

Sweden has introduced a range of policies and measures meant to directly or indirectly affect greenhouse gas emissions. The emphasis in Sweden's climate strategy is on the use of general economic instruments, but in many cases the general economic instruments are supplemented with targeted measures, for example to support the development and market introduction of technology and eliminate barrier effects. Many instruments which interact with the carbon dioxide tax and emissions trading have also been adopted to achieve other policy goals than the climate objective, such as energy policy objectives. The policies and measures originating at the EU level, such as the fuel quality directive, emission performance standards for new vehicles, the regulation on fluorinated greenhouse gases, the landfill directive and the common agricultural policy are not described further in this section. An overview of key policies affecting greenhouse gas emissions are presented in Table 2, where policies at the EU level are marked in bold. Policies and measures targeting renewable energy and energy efficiency (described in section 3.1.1 and 3.2) also affect the reduction of greenhouse gas emissions in Sweden.

Table 2. Overview of key policies affecting the national climate target to 2030
(EU policy instruments are marked with bold and instruments marked with**
are not included in the projection due to recent decisions)

Cross-sectoral	Energy supply	Residential	Industry	Transport	Waste	Agriculture
Energy and carbon dioxide taxes	Energy and carbon dioxide taxes	Energy and carbon dioxide taxes	Energy and carbon dioxide taxes	Energy and carbon dioxide taxes	Bans on landfill disposal	Energy and carbon dioxide taxes
Climate Leap	Electricity certificate system	Building regulations	Grants for energy audit	Emission performance standards	Methane recovery	Rural Development Programme
Environmental Code	Initiatives for wind power	Energy declaration	Energy and climate coaches	Climate Leap	Producer responsibility	Support for biogas production
Information	Support for solar power	Eco Design Directive and energy labelling	Energy efficiency network	Urban environmental agreements	Municipal waste plans	The rural network
		Information Centre for Sustainable Building	Energy step	Differentiated vehicle tax	Landfill tax	
		Support for energy efficiency in apartments*	Environmental Code	Requirements of renewable fuels at filling stations		
		Training programmes*	Industrial Leap*	Electrical bus premium*		
		Technology procurement	Regulation on F-gases and BREF	Emission reduction obligation*		
				Bonus-Malus system*		
				Electrical vehicle premium*		
				Charge at home grant*		
				Eco-bonus system for heavy transport*		
				Fossil free Sweden initiative*		
				Tax on air travel*		

Energy tax and carbon dioxide tax

The Swedish system of taxation on energy is based on a combination of a carbon dioxide tax, an energy tax on fuels, and an energy tax on electricity¹¹. The key taxes influencing greenhouse gas emissions in Sweden are the carbon dioxide tax and the energy tax on fuels, which are described below in general and more in detail for each sector.

Carbon dioxide tax

A carbon dioxide tax, based on the fossil carbon content in the fuel, was introduced in 1991 and aims at reducing the emissions of carbon dioxide

¹¹ Taxation on energy is a collective term for excise duties on fuels and electrical power and is governed by the Act of Excise Duties on Energy (1994:1776).

in sectors outside the EU ETS. The tax has been raised in several steps since it was first implemented. In total, the tax has increased from corresponding to SEK 0.25/kg carbon dioxide (1991) to SEK 1.15/kg (2018). A yearly indexation of the tax level is applied. The tax level is proportionate to the calculated amount of carbon dioxide emissions on the basis of the fuel's fossil carbon content. This means that sustainable biofuels currently are not subject to carbon taxation. As regards motor fuels, following the Government's budget proposal for 2018 changes to carbon taxation of biofuels low-blended into petrol and diesel came into force on 1 July 2018.

Due to the risk for carbon leakage, some sectors have a reduced tax or are exempted from the tax.

Energy tax

Taxation of energy have been used in Sweden for a long time. An energy tax on petrol and diesel was introduced in 1924 and 1937, respectively. Heating fuels and electricity became subject to an energy tax in the 1950s.

The aim of the energy tax was initially fiscal. In more recent years, the aim has also been to steer energy use towards Sweden's energy efficiency and renewability targets¹². The energy tax on motor fuels also aims at internalizing some external costs from the traffic, such as road wear, noise, etc.

The energy tax level on fuels varies depending on whether it is used as motor fuel or for heating purposes. The energy tax level on heating fuels also varies between households and the service sector on one hand and industry, agriculture, forestry, aquaculture and production of heat in combined heat and power plants on the other hand.

Carbon dioxide tax and energy tax in the transport sector

Petrol and diesel are covered by both an energy tax and a carbon dioxide tax. The carbon dioxide tax is also levied on natural gas. Energy and carbon dioxide taxes on fuels are adjusted to changes in the consumer price index (CPI), to take into account inflation. As of 2017, tax rates on petrol and diesel are also adjusted to take into account the development of the gross domestic product (GDP).¹³

Low-blended biofuels covered by the reduction obligation scheme are subject to the same carbon tax and energy tax rates as if they were of fossil origin. High-blended biofuels are not covered by the reduction

¹² The energy efficiency target and the renewable target for 2020 are part of Government Bills 2008/09:162 and 163.

¹³ This is achieved through a flat-rate increase of 2% per year. The combined change in the carbon and energy tax rates is, however, added exclusively to the energy tax rate (i.e. the carbon tax rate is only directly affected by the indexation to CPI).

obligation scheme and the part of biomass origin in high-blended sustainable biofuels are exempt from both carbon tax and energy tax.

Carbon dioxide tax and energy tax for heat production

Liquid and gaseous heating fuels as well as coal and coke used for heat production is subject to the energy tax as well as the carbon dioxide tax. Sustainable biofuels are exempt from energy tax and the carbon dioxide tax. Fuels used for heat production in combined heat and power plants (CHPs) within the EU ETS have a reduced level of the carbon dioxide tax – 11 percent as of 2018 – and pay 30 percent of the energy tax. Other heating plants within the EU ETS than CHPs and industrial plants are subject to 100 percent of the energy tax and, since 2018, 91 percent of the carbon dioxide tax. CHPs outside the EU ETS pay 30 percent of the energy tax and, from 1 January 2018, the full carbon dioxide tax rate on fuels used to produce heat. No carbon dioxide tax is charged for fuels used for heat production supplied to industrial manufacturing processes if the industrial activity is part of the EU ETS.

Carbon dioxide tax and energy tax for electricity production

Fuels used for electricity production are not subject to energy tax nor carbon dioxide tax, but the produced electricity is subject to the energy tax on electricity. Electricity is in general produced in installations covered by EU ETS.

Carbon dioxide tax and energy tax in the industrial sector

The manufacturing industry covered by the EU ETS pays 30 percent of the general energy tax and is, since 2011, exempted from the carbon dioxide tax. The manufacturing industry not covered by the EU ETS also pays 30 percent of the general energy tax on fuels used in industrial manufacturing processes. Earlier, this part of industry had reductions in the carbon dioxide tax, but in recent years the tax has been raised in a stepwise manner and the tax reduction was totally abolished from 1 January 2018.

Carbon dioxide tax and energy tax in the agricultural, forestry and aquacultural sectors

The agriculture, forestry and aquaculture sectors pay 30 percent of the general energy tax rate on heating fuels. The sectors have also had reductions in the carbon dioxide tax on such fuels, but the tax reduction was abolished from 1 January 2018.

A reimbursement of the carbon dioxide tax on diesel used for machinery in agricultural, forestry and aquaculture activities was lowered in a stepwise manner from SEK 2.10 per litre (2011) to SEK 0.90 per litre in 2015. However, in 2016 the repayment was increased to SEK 1.70 per litre for the period until the end of 2018, when the repayment will be SEK 1.43 per litre.

Cross sectoral

Local Climate Investment Programme (Climate Leap)

A programme for local and regional investments (Climate Leap) to cut greenhouse gas emissions was introduced in 2015. Investments in all sectors, except those included in the EU ETS, and all types of organizations are eligible to apply for grants¹⁴ Applicants compete based on the estimated greenhouse gas reduction of each investment.

For the 2018 the budget was SEK 1 500 million.

The Environmental Code and planning legislation

General legislation in the area of the environment has been collected in the Environmental Code since January 1999. Among other aspects, the Environmental Code contains general rules for consideration to be observed in all activities and measures that affect the environment. Significant environmentally hazardous activities require obtaining a permit. Greenhouse gas emissions form part of the permit assessment procedure and the Code also includes requirements to use the best available technology. However, effective 2005, issuing emissions limit values for carbon dioxide or limiting the use of fossil fuels for installations covered by the EU Emissions Trading Scheme is no longer permitted.

Measures in public planning are principally governed by the Planning and Building Act¹⁵, but many measures, as for major infrastructure projects, are also covered by the Environmental Code. Since May 2011, the Planning and Building Act introduced new requirements on considering the environmental and climate aspects of planning.

Climate change communication

The overall objective of climate communication in Sweden is to provide useful knowledge and tools on how to mitigate climate change and adapt to climate change. Moreover, the communication activities are aimed to enhance other climate policy instruments and measures.

Communication on possible measures in different sectors is disseminated through several channels. The Swedish Environmental Protection Agency and the Swedish Meteorological and Hydrological Institute (SMHI) are responsible for gathering and communicating information on climate change, as mandated by the Government.

The Swedish Government has adopted the objective to make Sweden one of the world's first fossil-free welfare states. This ambition requires a

¹⁴ Investments in sectors included in the EU ETS may still be eligible for grants if these result in an increased utilisation of waste heat.

¹⁵ Swedish Code of Statutes 2010:900

mobilisation of the entire society, not least municipalities, cities and business. To that end the government has launched the Fossil-Free Sweden initiative which mobilises and supports key actors in their climate efforts by providing a platform for dialogue, cooperation and inspiration between themselves and the Government. It is furthermore an arena where difficulties and complications can be discussed and brought to the government's attention¹⁶

Dialogue and cooperation with stakeholders also take place within other Government initiatives such as the Strategic innovation partnership programmes, Smart Industry – a strategy for new industrialisation for Sweden and the National Forest Programme.

Moreover, in agriculture and forestry, advice and training for landowners and managers play a major role in, for example, reducing climate gas emissions from manure management and use, and improving energy efficiency. The Swedish Board of Agriculture maintains an informative website covering both global aspects of climate change and issues relating to biodiversity and the individual farmer. The Swedish Forest Agency has a website providing information on the climate and, in particular, guidance on climate adaptation to forest owners.

Energy and climate advisory services

The Swedish Energy Agency provides financial support to municipal energy and climate advisory services. The local climate and energy advisers, which are present in nearly all Swedish municipalities, aim to provide objective and locally adapted information and advice about energy-efficiency measures, energy use and climate-related issues in buildings and households.

The Swedish Energy Agency also provides financial support to 15 regional energy offices, which coordinate the energy and climate advisors. The energy offices initiate and participate in several projects on energy efficiency and renewable energy sources, funded by the EU, county administrative boards, regional federations and other organizations. The offices also cooperate regionally with business, county administrative boards, municipalities and others, for example with plans and strategies.

Since 2016 municipalities are eligible to apply for the cost of one half- duty climate and energy coach. The coach provides targeted advisory services to small and medium-sized enterprises¹⁷. One round of applications was completed during 2016 and the coaching activities will start in 2017. The support is available until 2019. The coaching activities aim to increase energy efficiency and reduce greenhouse gas emissions.

¹⁶ Fossilfritt Sverige (2017) <http://fossilfritt-sverige.se/in-english/>

¹⁷ Businesses using less than 300 MWh.

By doing this, the enterprises will benefit from reduced costs, strengthened competitiveness and new opportunities for growth.

Regional Climate and Energy Strategies

County Councils are to coordinate regional climate and energy initiatives and support regional actors, for example by information collection and dissemination. Strategies are designed in collaboration with other regional and local actors to contribute to effective measures and synergies. In addition, they take action in areas such as environmental assessment and surveillance, local and regional spatial planning, regional development and growth policy and infrastructure planning.

Support for market introduction, technology procurement and networks

The Swedish Energy Agency grants support for market introduction to energy related projects in the form of a grant with limited royalty, that is a subsidy that is refunded at commercial success. Technology procurement is an instrument designed to initiate a market transition and disseminate new, more efficient technology, such as new products, systems and processes. Network-based procurement of technology is an approach that encompasses the entire decision-making process, from feasibility study and purchaser group, to requirements specification and dissemination and further development of more energy-efficient technology. It is being used in areas like heating and control, ventilation and lighting. The Swedish Energy Agency coordinates procurement networks for housing (BeBo), commercial and institutional premises (BeLok), small houses (BeSmå), public sector bodies that rent premises (HyLok) and food distribution (BeLivs).

Energy supply

Policies and measures for this sector are described in 3.1.1.

Residential sector

Policies and measures for this sector are described in 3.2.

Industrial sector

Policies and measures for this sector are described in 3.1 and 3.2.

Transport sector

Tax on air travel

With the aim to reduce climate impact from aviation, a tax on air travel has been introduced with effect from 1 April 2018. The tax is designed as a tax on commercial flights and is paid for passengers travelling from a Swedish airport. The airline that carries out the flight is liable to tax. Various levels of tax (SEK 61, 255 and 408) are levied based on the final destination of the passenger. The Swedish Tax Agency is the competent tax authority.

Emission reduction obligation

An emission reduction obligation scheme was introduced 1 July 2018. The emission reduction obligation is part of a Fuel Change Reform, which also includes changes in the taxation of petrol and diesel, and puts an obligation on petrol and diesel suppliers and large consumers to reduce carbon dioxide emissions from petrol and diesel, through increased biofuel blending into these fuels. The Fuel Change makes an important contribution to the phasing out of fossil fuels in transports. The indicative target to 2030 is to reduce emissions by at least 40 percent, which equals a share of biofuels of about 50 percent.

Requirements for renewable fuels at filling stations

The availability of renewable fuels has been subject to legislation requiring that filling stations with annual sales of petrol and diesel above 1,500 m³ must supply at least one kind of renewable fuel.

Differentiated vehicle tax

There are currently two systems for light vehicle taxation in Sweden, vehicle tax rates are based on either carbon dioxide (CO₂) emissions or weight. Cars of model year 2006 or later, or cars of an earlier model year that meet the requirements for certain environmental classifications, and light trucks, light buses, and motorhomes put into service after 2010, are subject to carbon-based vehicle taxation. Other vehicles are subject to weight-based vehicle taxation.

In the carbon dioxide based system, the annual vehicle tax is differentiated based on the vehicle's carbon dioxide emissions per kilometre (CO₂/km). The tax consists of a basic rate of SEK 360 plus a carbon dioxide amount. The carbon dioxide amount is SEK 22 for each gram of CO₂ emitted above 111 grams per kilometre. For diesel cars, this sum is multiplied by 2.37, to compensate for a lower energy tax on diesel than on petrol. Diesel cars registered for the first time in 2008 or later pay an additional SEK 250 (cars registered before 2008 pay SEK 500). For alternative vehicles that can be powered by ethanol or gas other than LPG, the carbon dioxide amount is SEK 11 for every gram emitted above 111 grams per kilometre at mixed driving. . The design of vehicle taxes and bonuses for environmentally friendlier vehicles can according to the Swedish Government be important complements to fuel taxation, in order to incentivise progress towards vehicles with lower emissions.

Bonus-malus-system for new light vehicles

In July 2018, a bonus–malus-system (sometimes referred to in English as “feebate”) for new light vehicles was introduced. Vehicles with low emissions of carbon dioxide are qualified for a bonus at purchase, while vehicles with high emissions of carbon dioxide are taxed at a higher rate for the first three years. The system is also replacing the previous five- year exemption from annual vehicle tax and the super-green car rebate.

New vehicles refer to vehicles of model year 2018 or later that have become subject to taxation for the first time on 1 July 2018 or later. Light vehicles are passenger cars (class I and II), and buses and trucks with a maximum weight of 3 500 kilogram. The system does not cover motor cycles.

Vehicles with low emissions of carbon dioxide qualify for a bonus at purchase. Vehicles that emit zero carbon dioxide qualify for the maximum bonus of SEK 60 000. Vehicles that emit a maximum of 60 gram carbon dioxide qualify for the minimum bonus of SEK 10 000. Vehicles using gas qualify for a bonus of SEK 10 000.

Light vehicles using petrol or diesel with high emissions of carbon dioxide are subject to an increase in vehicle tax (malus) during the first three years. For petrol and diesel-powered vehicles, an increased carbon dioxide amount is calculated. The carbon dioxide amount is the sum of SEK 82 per gram of carbon dioxide the vehicle emits per kilometer in addition to 95 grams and up to 140 grams and SEK 107 per gram of carbon dioxide the vehicle emits at mixed driving in excess of 140 grams. (Figure 3.12)

From year 4 and beyond, the carbon dioxide amount is SEK 22 per gram of carbon a vehicle emits per kilometer in addition to 111 grams. For vehicles that can be powered by ethanol or gas other than gasol (LPG), no increased carbon dioxide amount is calculated, which means that these vehicles for all years they are in service have a carbon dioxide amount of SEK 11 per gram of carbon dioxide the vehicle emits per kilometer in excess of 111 grams at mixed driving. The vehicle tax for diesel-powered light vehicles in the bonus–malus-system is adjusted by converting the current fuel factor into a fuel surcharge

Lower benefit value on cars with advanced environmental technology

Company-registered cars represent about 50 percent of new car registrations in Sweden. Approximately 50 percent of these cars are cars that are registered in the name of a company and made available to employees for private use.

The benefits of private use of a company car are subject to personal income taxes where the value of the benefit should approximately correspond to the market value of the cost of owning the car.

Fuel provided by the employer is taxed separately. The value of the benefit corresponds to 1.2 times the market value of the cost of fuel.

To increase the incentive to purchase company cars that use environmental technologies, green cars receive relatively favourable tax treatment through the reduction of their benefit value. Typically, the

benefit value is reduced to the (lower) level of a similar model without the environmental technology of the green car. This reduction is permanent.

In addition to this reduction, the benefit value of electric cars, plug-in hybrids and cars powered by gas (other than liquefied petroleum gas) are provided an extra reduction of 40 percent, up to a maximum of SEK 10,000 applied until the end of 2020.

Electrical bus premium

Regional public transport agencies are eligible to apply for an electrical bus premium¹⁸. The premium applies for electrical busses for public transportation use. The size of the premium depends on the number of passengers and whether the bus runs on electricity only or is a hybrid. In total, SEK 350 million has been allocated for 2016–2019.

Electric vehicle premium

An ‘electric vehicle premium’ was introduced in 2018 to improve the possibilities of commuting and transportation with electric bicycles or electric scooters. The electric vehicle premium makes it possible to commute longer distances by bike and aims at making large groups less car dependent.

Charge at home-grant

The government allocates SEK 90 million annually between 2018–2020 to support households that invest in installations of charging points for electric vehicles. Private individuals receive a rebate equaling 50 percent of costs for buying and/or installing charging stations for electric vehicles in their homes. The maximum rebate is SEK 10 000. The aim of the rebate is to make it easier and cheaper for households to switch to more sustainable modes of transportation.

Fossil-free transport solutions

The government allocates SEK 1 billion 2018–2023 to a commitment to the development of fossil-free transport solutions. The investment will support the switch to an electrified transport sector and develop sustainable solutions for electric cars and other electric vehicles including batteries. The investment also refers to developments in biogas.

Coordination of the transition to a fossil-free transport sector

The Swedish Energy Agency received the task of coordinating and preparing a strategic plan for the transition to a fossil-free transport sector together with five other authorities (the Swedish National Board of Housing, Building and Planning, the Swedish Environmental Protection Agency, Transport Analysis, the Swedish Transport Administration and

¹⁸ Swedish Code of Statutes 2016:836

the Swedish Transport Agency) in 2016. The Swedish Energy Agency has received SEK 3 million per year between 2016 and 2019 for this task. The strategic plan was delivered in April 2017 and now the work proceeds to implement the plan.

Urban environment agreements

Urban environment agreements are a scheme for investments in public transport and cycling infrastructure at the regional and local level in Sweden. The scheme commenced in 2015 and will continue until 2018. Municipalities are eligible to apply for grants to cover part of the investment costs for public transport infrastructure. The investment should be coupled with other actions aiming at increasing the long-term sustainability of urban areas and the transport system. These actions can include increased accessibility through public transport, urban planning for increased cycling and walking, lower vehicle speeds, parking policies and pricing. The scheme is administered by the Swedish Transport Administration with a total budget of SEK 2.75 billion.

Consideration of climate in long-term infrastructure planning

In 2016, the Swedish Parliament decided on a new national infrastructure plan for 2018–2029, to be implemented by The Swedish Transport Administration with other actors. The Swedish Transport Administration is responsible for long-term planning of all modes of transport. Planning is undertaken in dialogue with local and regional planning bodies. Under the Planning and Building Act¹⁹, too, there is a clear requirement to take environmental and climate issues into account in planning.

Eco-bonus system for heavy transports

In order to stimulate the transfer of freight transport by road to shipping a temporary Eco-bonus system has been introduced. The aim of the system is to reduce greenhouse gas emissions from heavy transports.

Waste sector

Landfill tax

In 2000 a tax of SEK 250 per tonne landfilled waste was imposed on waste disposal to landfill²⁰. The landfill tax has been increased gradually, and is since January 2015 SEK 500 per tonne landfilled waste. From January 2019 the landfill tax will be SEK 520 per tonne landfilled waste.

Ban on landfilling combustible and organic waste and methane collection

Under the Swedish Ordinance on the Landfill of Waste²¹ a ban on landfilling combustible materials was introduced in 2002 and a similar

¹⁹ Swedish Code of Statutes 2010:900

²⁰ Swedish Code of Statutes 1999:673

²¹ Swedish Code of Statutes 2001:512

ban was imposed for organic material in 2005. The ordinance also regulates the collection and disposal of methane gas from landfills.

Extended producer responsibility

A set of ordinances mandates extended producer responsibility for producers of eight product groups. Producer responsibility promotes sorting, collection and recycling of certain waste flows²². Producer responsibility aims to incentivise producers to develop more resource- efficient products that are easier to recycle and do not contain environmentally hazardous substances. It also aims to reduce the amount of waste. The legislation on extended producer responsibility contains national targets for recycling, and has resulted in increased separated collection of waste fractions and increased recycling (apart from pharmaceuticals and radioactive products, where there are no specific targets).

The municipal waste planning requirement

Since 1991, it is required that all municipalities in Sweden must have their own municipal waste plan. A Swedish EPA regulation (NFS 2006:6) sets out the minimum requirements of what each municipality must include in its waste plan, such as a description of the current situation, recycling plants and landfills, environmental assessment, measures and monitoring. Both the national waste plan²³ and the national prevention programme²⁴ act as guidance for the municipalities in developing their local plans and deciding on prioritised actions.

Agriculture

Rural Development Programme 2014-2020

The Swedish Government decided on a new Rural Development Programme in June 2014. The programme for 2014–2020 includes investment grants for young entrepreneurs, capacity building, cooperation and innovation, support to areas with natural constraints, animal welfare subsidies, ecological farming, and environmental and climate actions.

Measures specifically contributing to climate change mitigation include those aimed at: increasing energy efficiency; production and use of renewable energy (including biogas production and establishment of perennial energy crops); conversion from fossil to renewable energy sources; improved manure handling; more efficient use of nitrogen; climate and energy advice; measures to prevent the risk of nitrogen leakage; restoration and establishment of wetlands; sustainable perennial grass ley with reduced soil tillage; and other separate projects relating to

²² Extended producer responsibility has been developed for packaging, waste paper, end of life vehicles, tyres, electrical and electronic equipment, batteries, pharmaceuticals and radioactive products.

²³ Swedish Environmental Protection Agency (2012). *From waste management to resource efficiency*. Report 6560.

²⁴ Swedish Environmental Protection Agency (2015). *Tillsammans vinner vi på ett giftfritt och resurseffektivt samhälle Sveriges program för att förebygga avfall 2014 –2017*. Report 6654.

climate and energy. The programme budget totals SEK 36 billion, of which 59 percent is financed by Sweden and the remaining 41 percent by the EU.

Rural network

The rural network complements the Swedish Rural Development Programme, the Ocean and Fishery Programme, and the programme for local leadership development in the Social fund and Regional fund. The network brings together actors at the local, regional and central levels for exchanging information and experiences. The network is intended to reinforce implementation of these programmes.

'Focus on Nutrients' advisory service

Financed by the Swedish Rural Development Programme, the Swedish Board of Agriculture offers an advisory service called 'Focus on Nutrients' together with the Federation of Swedish Farmers and the County Administrative Boards of Sweden. The service started in 2001, with an initial focus on advice for higher nutrient efficiency in order to reduce nutrient leaching. Today, it also provides advice specifically targeting GHG emission reductions and energy efficiency as reducing GHG emissions has become one of the main objectives of the service.

Support for biogas production

In January 2015, the Government introduced a support scheme for biogas production through anaerobic digestion of manure. The support aims to help increase biogas production from manure and thereby gain two-fold environmental and climate benefits through reduced methane emissions from manure and the substitution of fossil energy. The increased digestion of manure offers several environmental benefits. It reduces both emissions of greenhouse gases and eutrophication of fresh and marine waters as well as produces biogas for energy. The biogas generated can be used to generate electricity or heat, or as vehicle fuel. The subsidy amounts to a maximum of 0.40 SEK/kWh of biogas produced. Between January 2015 and September 2016, a total amount of SEK 69 million was shared among 51 biogas plants.

Land use, land-use change and forestry (LULUCF)

Forest Policy and the Forest Act

The Swedish Forestry Act (as of 1993) has two overarching, equal objectives: support production and protect the environment. The production objective means that forests and forest lands should be used effectively and responsibly so they produce sustainable yields. The direction of forest production should be given flexibility in the use of what the forests produce. The environmental objective means that the natural productive capacity of forest land should be preserved. Forests

should be managed in a manner that enables naturally occurring plant and animal species to survive in natural conditions and in viable populations.

Under the current Forestry Act, production subsidies are abolished, and forest owners have considerable freedom and responsibility to independently conduct long-term sustainable forest management. The regulations concerning timber production cover the notification of felling, the lowest age for felling, requirements for reforestation, guidelines for thinning and measures to limit damage. Special regulations apply to certain types of forests, such as subalpine forests and deciduous forests. Examples of regulations concerning nature conservation and cultural heritage include not disturbing important biotopes, buffer zones and arable land, and leaving older trees, high stumps and dead wood in situ. Sustainable forest management influences carbon dioxide removals and emissions in various ways, through the production of renewable raw materials that can replace fossil fuels and materials that generate emissions of greenhouse gases while maintaining or increasing carbon stocks in biomass, soils and harvested wood products.

Land use and the Environmental Code

The Environmental Code contains regulations on, for example, land drainage. In central parts of the southern Swedish highlands and north of the *limes norrlandicus* (the biogeographical boundary of northern Sweden), drainage – defined as drainage intending to permanently improve the suitability of a property for a certain purpose – may only be undertaken with a permit. In the rest of the country, and on sites specially protected under the RAMSAR Convention, such schemes are prohibited. Protection and restoration of peatlands with high carbon stocks can reduce emissions of carbon dioxide to the atmosphere.

Conservation efforts (site protection, nature conservation agreements and voluntary set-aside of land) not only preserve biodiversity, but also positively impact carbon stocks in forest biomass and soil carbon, by allowing them to be maintained or to continue to increase. Protected forest ecosystems, in areas where natural disturbances like forest fires are rare, have a large capacity to sequester carbon, even long after a conservation measure is implemented. There are also targets for the conservation and protection of areas containing both wetlands and forest land. Since such areas are usually excluded from felling, their stocks of carbon in biomass and soil will, in most cases, be larger than those of productive forests.

The Swedish National Forest Programme

The supply of sustainable biomass from Swedish forests has an important role to play in the continued transition to a fossil free society. In 2015 the Government initiated a comprehensive dialogue with stakeholders within the Swedish National Forest Programme. The programme contributes to

Sweden's mitigation efforts by establishing goals and actions plans to increase the national supply of bio-based alternatives.

Renewable energy

Although Sweden has no 2030 target for renewable energy, it nevertheless intends to increase the share of renewables which the policies and measures described below demonstrate.

Electricity certificate system

An electricity certificate system aiming to support electricity based on renewable energy was introduced in 2003. In 2012, Norway joined the system and the common target is 28.4 TWh by 2020 compared with the 2012. In June 2017 the Riksdag decided on a new national target by another 18 TWh by 2030.

Through the system, electricity producers are allocated a certificate for every MWh of renewable electricity produced, which can then be sold in an open market. The buyers are mainly electricity suppliers who are obliged to purchase electricity certificates corresponding to a certain share, or quota, of their electricity deliveries. The quota is gradually increased to reach the targets.

Tax relief for micro-production of renewable electricity fed into the grid

A tax reduction for households and businesses was introduced in 2015 to stimulate investment in the micro-production of renewable electricity. The income tax reduction is SEK 0.60/kWh fed into the grid during a calendar year in a connection point with a fuse size of up to 100 amperes, however no more than the amount of kilowatt hours of electricity emitted at the point of connection during that year. The tax reduction is capped at SEK 18,000 per year.

Tax exemption for micro-production of renewable electricity consumed at the place of production

Exemption from energy taxation of electricity applies to electricity not transferred to a power grid with network concession if produced in a plant in with an installed generator capacity of less than 50 kW, by a producer who possesses a total installed generator capacity of less than 50 kW.

As for generator capacity, 50 kW is defined to be equivalent of 125 kW wind or wave power, 255 kW solar power (peak power) and 50 kW for other power sources without generator. When electricity is produced from several sources, the installed effects are added together.

If the producer's total generator capacity exceeds 50 kW or equivalent, but the capacity of the individual installation does not, the energy tax is reduced to 0.5 öre per kWh if the electricity is not transferred to a power grid with network concession. The tax exemption is achieved through a

deduction for energy tax on electricity. The deduction is the first step towards an energy tax exemption for renewable power produced in small plants at the same location as where the electricity is consumed.

Support for solar power connected to the grid

A subsidy for photovoltaic systems was introduced in 2009. The budget for this support is set at SEK 1085 million year 2018 and SEK 915 million year annually for 2019 and 2020. All types of actors can obtain financial support for installing grid-connected photovoltaic and hybrid power/thermal systems, as of 2018 covering 30 percent of the costs.

Support for energy storage for produced electricity

Energy storage can contribute to increased efficiency in the energy system. In order to increase the individual customers' ability to store their own-produced electricity there is a support for energy storage for own-produced electricity. The subsidy provides financial support to individuals for the installation of storage systems ²⁵.

Exceptions from the network charge

Electricity prosumers feeding in less electricity into the grid than what they purchase on a yearly basis are exempted from the network charge for the electricity they feed in. Examples of electricity users covered by the exemption are farms with small wind turbines and buildings with solar power systems on the roof.

Specific measures for regional cooperation

Without at target for the share of renewable energy by 2030 it is not possible to estimate an excess production which could be transferred to other Member States. In relation to the Swedish target for 2020, the excess production in the reference scenario²⁶ (see chapter 4) is 38 TWh.

Information about Specific measures on financial support, including EU support and the use of EU funds, for the promotion of the production and use of energy from renewable sources in electricity, heating and cooling, and transport, see section 3.1.

Specific measures to introduce a one-stop-shop, streamline administrative procedures, provide information and training, and empower renewable self-consumers and energy communities

Initiatives for wind power

The prospects for additional wind power generation have been improved by increased experience and technical development, which have resulted in lower wind energy costs. Furthermore, different programmes have

²⁵ Förordning (2016:899) om bidrag till lagring av egenproducerad elenergi

²⁶ Refers to the case *EU reference*. In the case *Low electricity price + 18 TWh*, the excess production is estimated to 36 TWh.

promoted the dissemination of knowledge and information about wind power. An example is the research programme Vindval, which aims to collect and provide scientific knowledge about wind power's impacts on humans and on nature.

Since 2004, certain land and water areas in Sweden have been designated as areas of national interest for wind power. There are 313 such areas in Sweden, of which 284 are located onshore and 29 offshore. The most recent update was carried out in 2013 and four areas were added in 2015. The total area of these national interests for wind power is roughly 7,900 km², representing about 1.5 percent of the country's land area, including Swedish waters.²⁷

Marine plans are being developed

The Government decided in 2015 on a marine planning regulation that regulates how state-owned maritime planning is to be carried out in Sweden. According to the regulation, the seawater and water authority will draw up proposals for sea plans for the Gulf of Bothnia, the Baltic Sea and the North Sea. The marine plans shall contribute to the sustainable use of the marine resources and the development of nutrients while at the same time achieving a good marine environment. The work also includes study the potential for using marine energy in the form of offshore wind power and wave energy. In the autumn of 2016, the marine and water authority developed the first draft for maritime plans. Currently, dialogues between relevant authorities are in preparation for the consultations on marine plans scheduled to take place in early 2018.

Guidance on wind turbine disposal

There is a guide for dismantling wind turbines and restoring the site that was published in 2016. The guidance summarizes the available knowledge and provides recommendations for dismantling wind turbines and restoring the site in order to contribute to a more uniform application in the country.

Infrastructure for district heating and cooling produced from renewable energy sources

The Swedish district heating is well developed and its share of renewable energy is high. The assessment of the necessity and profitability of building new infrastructure is made by the owners.

Specific measures on the promotion of the use of energy from biomass

No specific measures are needed to promote biomass.

²⁷ <http://www.energimyndigheten.se/fornybart/riksintressen-for-energiandamal/riksintressen-for-vindbruk/>

3.1.1 Other elements of the dimension

Industrial Leap

In the budget proposal for 2018, the Government has proposed the “Industrial Leap”. Under the Industrial Leap, the government will invest SEK 300 million annually from 2018 until 2040 to support the development of technologies and processes to significantly reduce process-related greenhouse gas emissions in Swedish industry. Financial support may be provided for feasibility studies, including detailed design studies, and full-scale investments. Companies with process-related emissions are eligible to apply for financial support for particular projects along with universities and research institutes. The aim of this long-term reform is to support Swedish industry to reduce its process-related emissions to achieve Sweden’s long-term climate targets. The Industrial Leap will be administered by the Swedish Energy Agency.

Strategies, plans and measures on adaptation to climate change

Significant progress and increased awareness of the importance of adaptation have been achieved in the last few years. The Swedish Government adopted in March 2018 the country’s first National Adaptation Strategy. The strategy outlines mechanisms for coordination, monitoring, evaluation and review of adaptation to climate change.

As the work on adaptation cuts across many different disciplines, it is to a large extent guided by existing legislation, frameworks and targets, both national and international. Examples include the work on Agenda 2030 and the Swedish Environmental Quality Objectives.

Setting the ground for adaptation – coordination structure and stakeholders involvement and action plans

The Ministry of the Environment and Energy has the overall responsibility for coordinating the Government’s policy work on climate change. Monitoring and evaluation of adaptation is carried out with the assistance of the National Expert Council and the Swedish Meteorological and Hydrological Institute (SMHI).

As a result of the National Adaptation Strategy the Government gave in June 2018 the National Board on Planning, Building and Housing a coordinating role in relation to adaptation within spatial planning.

In 2012, SMHI was tasked to form the National Knowledge Centre for Adaptation, to assist municipalities, regions, authorities and other stakeholders in their adaptation efforts. In 2018, the Centre has a budget of approximately SEK 18 million.

Many Swedish authorities play an important role in adaptation work through their respective sectoral responsibilities and are working on preventive measures, building knowledge and improving resilience. To underpin the National Adaptation Strategy with specific actions the Government decided in June 2018 on an ordinance which mandates 32 national authorities and the 21 County Administrative Boards to initiate, support and follow up on adaptation within their area of responsibility, including to develop action plans. Several national authorities had already developed action plans for the sectors that fall under their responsibility. So far, sectors that have received national funds for developing such plans include forestry, human health, construction/land use and reindeer herding/sami culture.

The regional government offices (County Administrative Boards, or CABs) are responsible for coordinating the regional adaptation work and supporting local actors in their adaptation work. The CABs adopted in 2014 regional action plans on which they report annually to the Government about the actions taken to adapt to climate change. These plans cover the entire country of Sweden with nearly 800 proposed actions. The main actions proposed in the plans concern flood protection, protection of drinking water, shoreline protection, infrastructure (roads, railways), adaptation of agriculture and forestry, resilience for heatwaves and health care.

There is a National network for adaptation, promoting both vertical and horizontal cooperation, including the 21 counties, and 19 Government agencies. The secretariat for the network is provided by SMHI. There are also national networks for thematic cooperation.

Some local authorities have also developed adaptation action plans for their municipality. Significant progress and increased awareness of the importance of adaptation have been achieved in the last few years, at all levels of society. To spur the process further the Government has issued amendments to the Planning and Building Act proposed in the National Adaptation Strategy and approved by the Riksdag in June 2018. Through these amendments the municipalities now have strengthened powers to include aspects of climate change in the planning process.

Knowledge transfer and risk assessments

Rosby centre of SMHI carries out climate research and has developed climate scenarios up until the year 2100. A database of natural disasters is kept by the Civil Contingencies Agency, and the Swedish Geotechnical Institute has developed maps on geotechnical risks and support tools for climate risks. The Swedish portal for climate change adaptation provides information on possible climate impacts, tools for adaptation, good examples and information on ongoing activities.

Many of the sectoral and regional adaptation plans include risks and vulnerability assessments.

Implementation

The Government finances measures to improve knowledge about the impacts of climate change and to address these impacts, for example by implementing prevention measures against landslides and flooding. For 2018, the budget is increased to SEK 214 million. This includes funding for actions to prevent landslides in a particularly vulnerable area of Sweden.

The Government also distributes assignments related to various measures to sector agencies. Most adaptation issues are, however, multidisciplinary, meaning that work on climate adaptation is largely performed in collaboration between different actors and sectors at the national, regional and local levels.

Sweden has a well-established and functioning framework for disaster risk reduction (DRR), including work in forums for crisis preparedness. The work is coordinated by the Swedish Civil Contingencies Agency (MSB).

Cooperation is promoted on all levels and between sectors and actors working with land use planning, risk management, natural disasters and climate adaptation, in order to reduce risks and enhance preparedness.

3.2 Dimension Energy efficiency (2030 Framework target)

Sweden has so far chosen to use energy and carbon dioxide taxation, above the minimum level set out in the energy taxation directive, instead of an energy efficiency obligation scheme.

The Swedish renovation strategy includes the following measures:

Building regulations

Building regulations limit inter alia the specific energy use (kWh/m² and year), average thermal transmittance (W/m²K) and the building envelope's average air leakage (l/s m²) for new buildings and buildings that undergo changes. The specific energy use, with different climatic regions and different energy carriers given different factors, are limited to 90 kWh/m² for single-family houses, 85 kWh/m² for multi-dwelling blocks and 80 kWh/m² for non-residential premises.

Support for renovation and energy efficiency of rental apartments

In October 2016, a new support scheme was introduced to incentivise renovation and energy efficiency of rental apartments in areas with

socioeconomic challenges²⁸. The Government allocated SEK 800 million for this initiative in 2016. For 2018 about SEK 355 million is estimated to be used for the support scheme. This state aid will end after 2018. The support for energy efficiency is calculated based on the estimated level of energy efficiency after the renovation. Only cases in which the efficiency is improved by at least 20 percent are eligible to receive support.

Support for refurbishment of schools

For the period 2015–2018 there is a government grant for the refurbishment of schools (including and outdoor environments at schools), aimed at creating a better working environment and to reduce the environmental impact of the premises. For 2018, the budget is SEK 680 million.

ROT reduction

The ROT (Repairs, Conversion, Extension) reduction gives an income tax reduction on labour costs for repair, maintenance, conversions and extensions in the taxpayer's home.

Information Centre for Sustainable Building

In 2018 the Information Center for Sustainable Building was established. The Center aim to promote energy-efficient renovation and energy- efficient construction using sustainable materials and low climate impact from a life-cycle perspective. By establishing the Center, information on renovation and energy efficiency can be more easily accessible, coherent and quality assured for property owners and other relevant stakeholders in the renovation process.

Dissemination of information

To promote energy services, the Swedish Energy Agency currently operates as a point of contact for end users, providing relevant information on the website. An obstacle to the development of the energy services market has been low competence in this area among purchasers. In order to counteract this, the Swedish Energy Agency contributes by spreading information about energy services, clarifying what it means with energy services and following market developments. The Authority has published a report, *Energy Services in Sweden*, as well as providing information and support materials for buyers. For energy service providers, the Swedish Energy Agency helps in understanding the need of businesses so that offers can be customized.

Energy Efficiency Council

The Energy Efficiency Council has the task of strengthening government cooperation and facilitating coordination of implementation and follow-up of measures and instruments to meet the targets set by the Swedish

²⁸ Swedish Code of Statutes 2016:837

Parliament for energy efficiency. The Council has an important role to play in implementing the Energy Efficiency Directive. The Council is an arena where strategically important issues are raised to strengthen government cooperation and increase transparency in energy efficiency, including government procurement and measures to increase energy efficiency. The Energy Efficiency Council is advisory and meets four times a year.

Other policies measures and programmes

Apart from energy efficiency policies decided at union level and implemented in Sweden, such as the ecodesign directive, the energy labelling directive, the energy performance of buildings directive and the energy efficiency directive, the following policies and measures apply.

Sectoral strategies

The government has commissioned the Swedish Energy Agency to formulate sectoral strategies for energy efficiency together with different types of businesses. The purpose is to create a platform between the Swedish Energy Agency, businesses and relevant authorities in order to achieve Sweden's energy and climate goals, especially the new energy efficiency target.

Energy audits for large enterprises

All large companies are obliged to carry out an energy audit at least every fourth year unless they have introduced either an environment or energy management system. The audit must be conducted by a certified expert.²⁹

Energy step

Companies which have carried out their energy audits may apply for support for either projecting further energy efficiency actions or investing in energy efficiency measures identified in the audit.

Grants for small and medium-sized enterprises for energy surveys

To stimulate a more efficient use of energy, small and medium-sized enterprises³⁰ are since 2010 eligible to apply for financial support to conduct energy surveys³¹. The energy survey should include energy mapping, proposals of measures and an energy plan. The maximum support per entity is 50 percent, up to a maximum of SEK 50,000.

Energy efficiency networks for small and medium-sized enterprises

The Swedish Energy Agency initiated a network project for small and medium-sized enterprises in 2015. The goal is to operate 40 networks with a total of 400 companies, supporting them to introduce energy

²⁹ Swedish Code of Statutes 2014:266, the law is part of fulfilling the EU Energy Efficiency Directive, EED (Directive 2012/27/EU)

³⁰ Businesses using more than 300 MWh of energy annually, farms with at least 100 livestock units and economical organizations are eligible for the support.

³¹ Swedish Code of Statutes 2009:1577

management principles with the help of regional coordinators and energy experts. Sharing experiences and learning from each other within and between the networks are also important success factors. The aim of the network activities is to reduce the energy use of the participating companies by 15 percent. By doing this, the enterprises will benefit from reduced costs, strengthened competitiveness and new opportunities for growth.

Energy Performance Certificate Act

Based on the Energy Performance of Buildings Directive, Sweden has implemented a law on energy performance certificates for buildings ³². The law includes an obligation for owners of single-family and multi-dwelling buildings and of commercial premises to declare the energy use of buildings and certain parameters regarding the indoor environment. The aim is to promote efficient energy use and a healthy indoor environment by requiring property owners to learn more about which measures are cost-effective to implement for improving building energy performance.

Training programmes in building for low energy consumption

Since 2016, the Swedish Energy Agency in cooperation with other actors has been responsible for a set of capacity building programmes in the area of building for low energy consumption. The programmes target different construction stakeholders, such as architects, engineers, clients, technicians, installers, site managers and teachers in building programmes at upper secondary schools.

Measures to utilise energy efficiency potentials of gas and electricity infrastructure

The Electricity Law

Electricity Law was changed 1 June 2014 to meet the requirements of the Energy Efficiency Directive. This stipulated an explicit ban on tariffs that negatively affect the overall effectiveness of the services. In this way, they do not impede such system services or contain incentives that may inhibit the use of load management in connection with balancing services and procurement of additional services.

The regulatory model for grid operators

A new regulatory model for grid operators' revenue was introduced in 2014 to encourage energy efficiency. Operators that contribute to energy efficiency are allowed to have a greater return on the capital base, while companies operating in a way that is not compatible with an efficient use of the electricity grid are only allowed to have a smaller revenue.

³² Swedish Code of Statutes 2006:985

Financing measures, including EU support and the use of EU funds, in the area at national level

In addition to the national funding measures described above, the following EU funding is relevant:

National Regional Fund Program

A special effort to raise small and medium-sized enterprises' competence as energy service purchasers is implemented under the EU Regional Fund Program. The Swedish Energy Agency receives a total of SEK 80 million per year for the investment in energy efficiency in SMEs during the period.

EU financial support for energy efficiency in buildings

The EU promotes improvements in the energy performance of buildings through a series of financial support programs. Energy Efficiency Financing Instrument (EEFF) was established in 2011, offering instruments for loans, equity and guarantees as well as support for technical assistance for project development support.

3.3 Dimension Energy security

Policies and measures to achieve the objectives set out in 2.4

Electricity supply

Measures regarding electric power outages

The Swedish TSO, Svenska kraftnät, is Sweden's Authority of Electricity Contingency Planning and are working to ensure that electricity supply is prepared for extreme events that may pose serious strains on society.

Svenska Kraftnät makes sure that measures are taken to enhance the preparedness, that there are trained professionals and that resources are available for repair work and communication equipment. For financing measures for emergency preparedness see 3.3.

As described in 2.4, there is a requirement aimed at the network operator that outages must not last longer than 24 hours, unless caused by a factor not controlled by the operator. If an outage lasts longer than 12 hours, customers are entitled to compensation.

Moreover, measures are taken to increase public knowledge of appropriate preparedness measures at home in order to alleviate the consequences of a power outage.

Measures regarding electric energy shortages

Emergency management measures are prepared both for preventing energy shortages and for mitigating the consequences should a shortage occur. Measures include inter alia a national information campaign to encourage electricity users to voluntarily decrease their consumption and

so avoid a shortage. Should this be insufficient, there is a plan for electricity rationing ready to be launched.

Measures regarding electric power shortages

In order to maintain balance in the electricity system, the Swedish TSO Svenska kraftnät has a number of technical and commercial mechanisms available, such as strategic reserve. If these mechanisms are insufficient, the last resort is load shedding, where part of the consumption is disconnected to reduce the extent and duration of a power shortage and avoid system collapse. To alleviate the consequences for society, a method for planning the prioritisation of socially important electricity users, Styrel³³, has been developed.

Gas supply

Sweden follows the revised Gas Security of Supply Regulation, which sets operational requirements for gas supply security. Based on the Regulation and Swedish Constitution, Law (2012:273) and Regulation (2012:275) on Natural Gas Supply (which complement the Regulation), there is a National Preventive Action Plan and National Crisis Plan. In addition to these, there are also regulations and general advice developed. These include requirements for natural gas companies and large consumers of natural gas. The requirement means, among other things, that "protected customers", that is, consumers, should be able to receive gas for at least 30 days in case of disturbances or disruptions in deliveries.

Oil supply

The Swedish legislation on emergency preparedness for oil is based on Council Directive 2009/119/EC. The EC Directive has approached the IEA requirements and reporting on emergency preparedness stocks. The storage obligation is also linked to Sweden's commitments to the IEA (International Energy Agency) under the IEP agreement, which is an agreement between 29 countries on a common energy program. Among other things, the agreement requires that each Member State stores oil equivalent to 90 days net imports. The size of the oil stock for supply crises, in total and for each actor, is determined by the state once a year. The size of the storage obligation is based on how much the company has sold or consumed during the previous year. A storage year runs from 1 April to 31 March the following year.

Regional cooperation in this area

Efforts for security of supply, as well as for crisis management measures, follow the geographical distribution of markets. As the oil and fuel market is global, cooperation on crisis management measures takes place globally, including within the International Energy Agency (IEA)

³³ Regulation (2011: 931) on planning for prioritising socially important electricity users. The planning is being carried out to provide the basis for the power companies' plans for manual load shedding.

cooperation. At risk of oil and fuel shortage, the situation is analysed both in Sweden, the EU and the IEA. The IEA evaluates the degree of impact of a supply outage on the market and analyses whether emergency stocks should be put into service. The IEA can provide recommendations for actions, such as about collective action, but Sweden is responsible for decisions about possible actions.

The Swedish electricity system is connected with the Nordic neighbours, and therefore cooperation is taking place on various crisis management measures in the Nordic region, mainly within NordBER. NordBER is a collaboration that includes preparedness for the electricity supply between the Nordic energy and power emergency agencies as well as grid operators. Energy authorities and grid operators from all Nordic countries are included. From Sweden, two authorities, the Swedish Energy Agency and Svenska kraftnät, participate.

In the gas supply, regional co-operation between Sweden and Denmark has taken place before. In the EU's new natural gas regulation, regional cooperation is more formalised by Member States being divided into different regional groups to deal with common issues. The gas industry players are also working to establish a joint-balancing zone in Sweden and Denmark, which will make regional cooperation very tight.

3.4 Dimension Internal energy market

3.4.1 Electricity infrastructure

As described in 2.5, the Swedish level of interconnectivity is already well above the Union target of 15 percent. Thus, there are no policies or measures to increase the interconnectivity level, but rather the expansion of interconnections is governed by the market.

Regional cooperation in this area

The Swedish transmission system operator (TSO), Svenska kraftnät, cooperates with other transmission system operators through ENTSO-E (European Network of Transmission System Operators). Svenska kraftnät contributes to ENTSO-E's deliveries, such as the Ten Year Network Development Plan (TYNDP).

In addition, Svenska kraftnät together with the other Nordic TSOs is planning a Nordic Grid Development Plan in 2019.

3.4.2 Energy transmission infrastructure

There are no specific policies or measures since there are no national key infrastructure objectives in this area.

However, there is an ongoing effort to eliminate bottlenecks in electricity infrastructure. After an economic appraisal is conducted, frequently

recurring bottlenecks are addressed by investing in new transmission capacity. It is not, however, economically efficient to strengthen the networks to such a level that bottlenecks never occur. Eliminating bottlenecks by strengthening network capacity is a long-term measure.

The regional cooperation in this area is described in section 3.4.

Financing measures

Since 1 May 2015, a new regulation applies, which means that distribution companies can apply for so-called network reinforcement loans. The purpose is to facilitate the connection of large renewable electricity generation projects to the grid.

The net reinforcement loan is a temporary solution, which means that, under certain conditions, regional distribution companies can get a loan from Svenska kraftnät. The loan applies to the portion of network reinforcement costs that facilitate the future connection of additional power generation in the same region. Unlike previously, the first affiliated party therefore only needs to pay "its" share of the network reinforcement costs.

3.4.3 *Market integration*

Policies and measures to achieve the objectives set out in 0.

Sweden has no national objectives referred to above. The measures that contribute to these areas, although there are no set national targets, are described in more detail below.

Measures to increase flexibility are essentially governed by Commission Regulations³⁴ which Sweden implements accordingly.

Forum for Swedish Smart grid

The Forum for Swedish Smart grid³⁵ is a national forum appointed by the Swedish Ministry of the Environment and Energy. The Forum is established as a result of the recommendations from the Swedish Coordination Council for Smart Grid (active 2012–2014). The mission is to implement the action plan, set up by the Council, to further develop a store of knowledge on the website and to support Swedish export within smart grids.

³⁴ "Roll-out of intraday market coupling" in Commission Regulation (EU) 2015/122 and "Cross-border balancing markets" in Commission Regulation "establishing a guideline on electricity balancing" (not in force yet)

³⁵ <http://swedishsmartgrid.se>

Measures to ensure priority access and dispatch of electricity produced from renewable energy sources or high-efficiency cogeneration and prevent the curtailment or re-dispatch of this electricity

Sweden does not apply priority dispatch, since such a procedure distorts competition in the market. Svenska kraftnät does not prioritize electricity produced from a certain type of energy source. Svenska kraftnät aims to treat all producers equally and according to the same market model, in accordance with Swedish legislation.

Policies and measures to protect consumers

In accordance with the Electricity Market Directive, Member States should take appropriate measures to protect end consumers, particularly vulnerable customers. The Swedish government's investigation into the implementation of the Directive noted that the Swedish system is based on the responsibility of social authorities to apply the social security system in an effective manner. There is no requirement for member states to incorporate protective legislation in the electricity legislation, which Sweden has not chosen to do.

However, the Swedish Energy Markets Inspectorate (Ei) carefully considers vulnerable customers when the Authority carries out its supervisory duties. *Elpriskollen*, the only independent comparison tool, operated by Ei, is one example of protecting and empowering consumers as it enables household customers to compare electricity offers, in terms of price and contractual terms, from suppliers. To reach as many consumers as possible, *Elpriskollen* is available in 13 different languages. Moreover, consumers can contact the Authority for questions or complaints related to energy market issues.

As of 1 April 2017, a new legal provision (Law 2017:18) to the Electricity Act forces distribution system operators (DSOs) to inform customers who have not signed an electricity offer about the characteristics of the current default offer and how the customer can make an active choice. This may empower customers and hence lead to lower shares of customers with default offers.

To further protect customers from being disconnected, e.g. due to unpaid invoices, the new proposed Electricity Market Act suggests that DSOs must report all disconnections to the Authority. The designated authority may monitor these disconnections.

Description of measures to enable and develop demand response including those addressing tariffs to support dynamic pricing

The Swedish Energy Markets Inspectorate has developed an action plan in which a number of measures to achieve increased demand response are identified. The measures consist of proposals for new or amended

regulations, knowledge-enhancing efforts, government assignments and cooperation between authorities and other stakeholders to create long-term conditions and rules. The measures focus primarily on household customers as they have a high potential for demand response that is not taken advantage of today.

Svenska kraftnät also works with these issues mainly through European and Nordic cooperation projects. Among these the following can be mentioned:

- Adapting the mFRR market to better fit consumption flexibility (e.g. in terms of bid size).
- Active cooperation with Nordic TSOs to review the price signals that the regulatory framework for the balancing market and imbalance fees give to market participants.

3.4.4 Energy Poverty

Energy poverty is not treated as a part of energy policy.

3.5 Dimension Research, innovation and competitiveness

Sweden's ambition is that research and innovation in the field of energy will help to find solutions for five overall challenges:

- To create a completely renewable energy system that meets the challenge of the energy system's impact on the climate, while considering the environmental impact of renewable energy sources.
- To ensure a flexible and robust energy system that provides a secure, fully renewable energy supply for the entire community.
- To create a resource-efficient society that contributes to competitiveness, enables the transition to a renewable energy system and utilizes the available resources effectively.
- To increase efforts for innovations for jobs and climate, so that Sweden can be a pioneering country in the transition to a sustainable energy system. The transition also provides an opportunity to develop the business community.
- To enable co-operation in the energy system between different actors, sectors, rules and business models with the purpose of creating opportunities for interaction and diversity, in order for the transition to accelerate.

Based on the challenges outlined above, Sweden will implement actions under the national energy research and innovation program in the field of energy for the years 2017–2020. The program enables research and innovation efforts in nine different themes:

- The transport system
- Bioenergy
- Buildings in the energy system
- Electricity generation and power system
- Industry
- Sustainable society
- General energy systems studies
- Business development and commercialization
- International cooperation.

In addition to the national energy research and innovation programme there is also a 10-year national research programme for climate, the programme started in 2017 and Formas, the Swedish Research Council for sustainable development, is administrating it. This programme will contribute to achieving Sweden's objective to become a fossil-free society and the ambition to be a leading participant in global efforts to achieve the goals of the Paris Agreement. Reducing the climate impact of humans necessitates comprehensive transitions and adaptations in Sweden, in the EU and globally. Tackling climate challenges therefore requires research within several different subject areas, as well as interdisciplinary and intersectoral research and innovation.³⁶ During 2018 the programme disbursed approximately 75 million SEK, this figure will be approximately 130 million SEK for every year between 2019 and 2026. For examples of specific research programmes, read more in 4.6.

Cooperation with other Member States

The SET plan contains four core priorities and ten actions to accelerate the transition of the energy system. Each action area has developed or is about to set targets at EU level. In addition, efforts are being made to develop an implementation plan. Participation is voluntary, but Sweden participates in relevant and nationally prioritised areas to best link national goals to the EU goals. Sweden participates to a higher or lower degree in work in the following temporary working groups: Ocean Energy, Smart Solutions for Consumers, Smart Cities and Communities, Energy Systems, Energy Efficiency in Buildings, Energy Efficiency in Industry, Batteries and e-mobility batteries, Renewable fuels and Bioenergy, and Carbon Capture Utilization and Storage. The work involves linking parts of the national research program, i.e. our thematic and strategic research and innovation efforts, to carry out the efforts and achieve the goals that are jointly developed within the current action areas of the SET plan.

ERA-NET is an instrument of Horizon 2020 for cooperation on joint calls and project funding between research financiers in the EU. In order to supplement national initiatives within a certain area, increasing

³⁶ <http://www.formas.se/en/International/Research-Programme/>

knowledge dissemination and drawing lessons from various research and development initiatives, Sweden participates in several of these co-operations. These include bioenergy, ocean energy, solar energy, smart cities and communities, sustainable urban development, smart grids, wind power, transport and adaptation to climate change.

In addition, Sweden collaborates with the other Nordic countries on research and innovation. The main objective of the Nordic Energy Research (NEF)³⁷ is to support Nordic energy cooperation. NEF supports areas of energy research that are of common interest to Nordic stakeholders and have potential for cross-border research cooperation. NEF finances and coordinates research, as well as provides administrative expertise, networking and guidance.

Financing measures

Sweden supports the Mission Innovation³⁸ initiative and has chosen to double the funding for those initiatives in the energy research and innovation program that are stakeholder-initiated through open calls. The doubling is based on the average of the budget allocated for such operations during the period 2013-2015 and valid until 2020.

³⁷ <http://www.nordicenergy.org/>

³⁸ <http://mission-innovation.net/participating-countries/sweden/>

4 Current situation and projections with existing policies and measures

Sweden developed several energy scenarios in 2016³⁹ that are used as the basis for the climate scenarios for European climate reporting. The reference scenario, presented here unless stated otherwise, is based on the Commission's assumptions about the future prices of fossil fuels and EU ETS allowances. In that scenario, policies and measures that were valid in Sweden in 30 June 2016 have been included.

4.1 Projected evolution of main exogenous factors influencing energy system and GHG emission developments

The development of GDP is modelled in the macroeconomic model EMEC, which is the basis for the energy and climate scenarios. Table 3 presents developments from 2013 to 2050.

Table 3 Development of GDP in economic scenarios from EMEC

2013-2035	2036-2050
2.28	1.99

Population development for the period 2014–2040 is developed by Statistics Sweden and presented in Table 4.

Table 4 Population development

2014	2020	2030	2035	2040
9,747,355	10,589,867	11,480,303	11,779,103	12,039,748

In the scenarios, the four oldest nuclear reactors are taken out of service by 2020. The other six reactors are in operation for 60 years, which means that there is production from nuclear power until 2045. Of course, this can change if the owners decide to take the reactors out of operation earlier.

International fossil fuel prices used in the reference scenario come from the Commission projections and are presented below in Table 5-7.

³⁹ Energimyndigheten, Scenarier över Sveriges energisystem 2016, ER 2017:6.

Table 5 Assumed world market prices for crude oil, USD/barrel

2015	2020	2030	2040
54	87	113	124

Table 6 Assumed world market prices for coal USD/tonne

2015	2020	2030	2040
54	70	104	114

Table 7 Assumed world market prices for natural gas, USD/mmBTU

2015	2020	2030	2040
7	9	11	12

EU ETS carbon prices used in the reference scenario also come from the Commission projections and are presented in Table 8.

Table 8 Assumed price of EU ETS allowances, EUR/tonne CO₂

2015	2020	2030	2040
7.5	15	33	50

Technology cost developments

In the Swedish energy scenarios, a cost for each energy technology is assumed. The most profitable technology, based on these assumptions, is then chosen in the future energy system. The assumed technology costs do not change over time in the model, except for solar power costs because rapid cost development is expected. The assumed technology costs are presented below.

Nuclear power

Estimated costs for new nuclear power are presented in Table 9.

Table 9 Estimated costs for new nuclear power

Investment cost (SEK/kW el)	Fixed O&M (SEK/kW el)	Variable O&M and fuel cost (SEK/MWh el)	Service life (year)
50,000	550	100	50

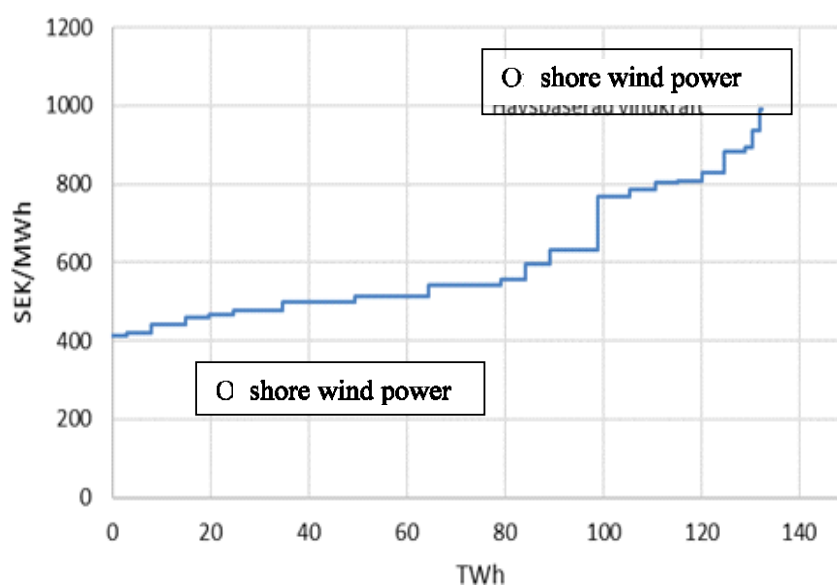
Hydropower

It is assumed that 0.5 TWh of new hydropower can be introduced in Sweden by 2020 and just over 1 TWh by 2030 at a cost of SEK 0.4-0.5/kWh depending on the type of investment.

Wind power

Cost assumptions for wind power are based on information from the Swedish Energy Agency⁴⁰, in which almost 100 TWh of land-based wind power are expected to be available for expansion. The scenario model includes 12 different land-based classes and 9 different sea-based classes for wind power production in Sweden. Together, these classes provide the supply curve (total production cost and production potential) for wind power seen in Figure 3, assuming 25 years of service life and 7percent real interest rate. The model does not include system integration costs, such as for reserve capacity and network expansion which are needed especially at very large volumes of wind power.

Figure 3 Supply curve for new wind power in Sweden, SEK/MWh electricity



Solar power

Solar power is described in the model using three different technology classes: installations on villa roofs with battery storage, installations on

⁴⁰ Energimyndigheten, Produktionskostnader för vindkraft i Sverige, ER 2016:17.

villa roofs without battery storage and large ground-mounted installations. Important assumptions for these technologies are shown below in Table 10. The cost of investment for the villa option with battery storage is typically 30 percent higher than the option without batteries but decreases over time due to relatively rapid cost reduction for batteries. A battery storage solution (solar cells plus batteries) results in a more even production throughout the day and thus a higher proportion of self-consumption. In general, however, the temporal resolution of the model specification is too low to fully reflect the various aspects of solar power production and battery storage.

In the model calculations, a tax rebate of SEK 0.6/kWh of sold electricity from micro-production is applied for the villa application. For self-use, there is no electricity tax for installations with a generation capacity less than 255 kW and no variable network fee. For the villa application in the model calculations, a ROT reduction⁴¹ is included equal to 9 percent of the investment cost. For large-scale facilities, investment aid amounts to 30 percent or maximum SEK 1.2 million. The size of such facilities is assumed to be a relevant limitation, so the percentage support is assumed to be less than 30 percent.

⁴¹ Read more about ROT in chapter 3.2.

Table 10 Estimated cost data for solar power

		2015	2030
Villa roof (without batteries)	<i>Investment (SEK/kW)</i>	15,000	9,000
	<i>O&M (SEK/kW)</i>	50	50
	<i>Service life (year)</i>	30	30
	<i>Full load hours</i>	900	900
Large plant (ground-mounted)	<i>Investment (SEK/kW)</i>	13,000	8,000
	<i>O&M (SEK/kW)</i>	50	50
	<i>Service life (year)</i>	30	30
	<i>Full load hours</i>	1,050	1,050

Biofuel power plants**Table 11 Typical data for a conventional biofuel power plant with flue gas condensation in three dimensions (certain parameters, such as efficiency and alpha value, are assumed to develop over time)**

	Investment (SEK/kW el)	Fixed O&M (SEK/kW el)	Variable O&M (SEK/MWh el)	Efficiency (%)	Alpha value	Service life (year)
Large plant (app 80 MW el)	25,500	380	80	30-32 (el)	0.38-0.41	30
Medium plant (app 30 MW el)	34,500	580	85	28-30 (el)	0.35-0.39	30
Small plant (app 10 MW el)	45,000	920	85	25-27 (el)	0.32-0.34	30

Natural gas-fired CHP plant**Table 12 Typical data for gas-based power and CHP production**

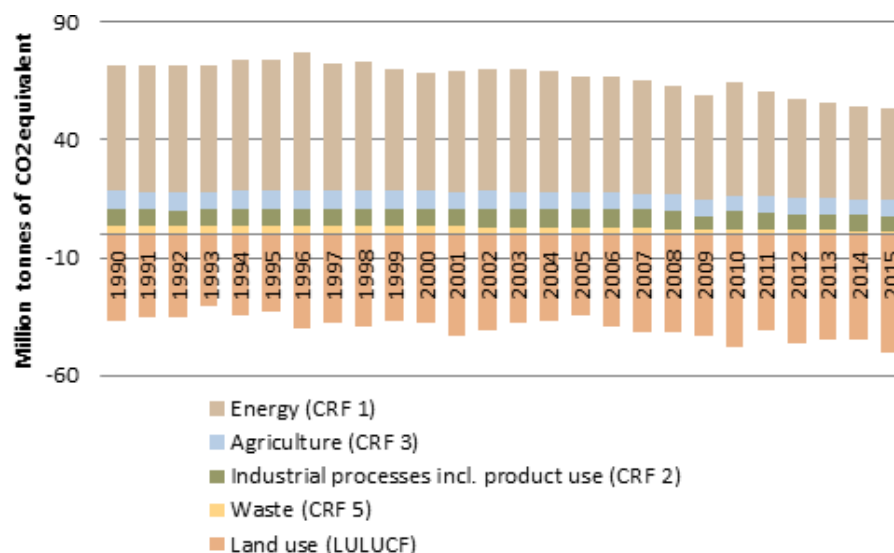
	Investment (SEK/kW el)	Fixed O&M (SEK/kW el)	Variable O&M (SEK/MWh el)	Efficiency (%)¹⁾	Alpha value	Service life (year)
Condensing power	7,000	40	15	55-62	-	30
CHP, large plant	9,500	70	20	45-50 (el)	1.1	30
CHP, small plant	12,500	120	25	45-50 (el)	1	30

4.2 Dimension Decarbonisation**4.2.1 GHG emissions and removals**

In 2015, greenhouse gas emissions (excluding LULUCF) in Sweden totalled 53.7 million tonnes of carbon dioxide equivalents (Mt CO₂-eq.), see Figure 4. Total emissions have decreased by 18.2 Mt, or 25 percent, between 1990 and 2015. Emission levels have varied between a low of 53.7 Mt CO₂-eq. in 2015 and a high of 77.3 Mt CO₂-eq. in 1996. Annual

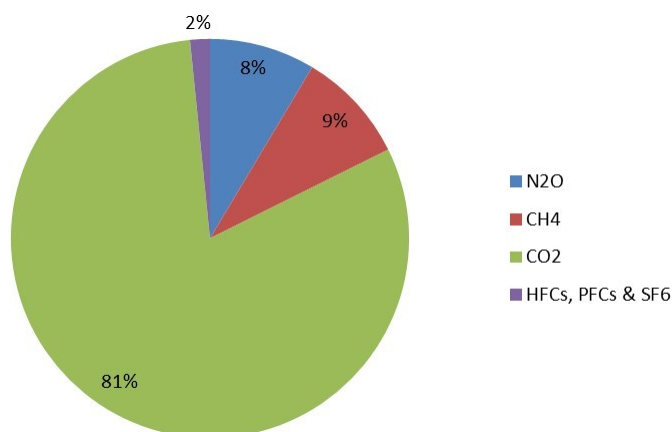
variations are largely due to fluctuations in temperature and precipitation and to the economic situation. The net sink attributable to the land use, land-use change and forestry (LULUCF) sector has varied over the period. In 2015 it amounted to 50.5 Mt CO₂-eq., which corresponds to 94 percent of total greenhouse gas emissions.

Figure 4 Total greenhouse gas emissions from different sectors.



In 2015, emissions (excl. LULUCF) of carbon dioxide (CO₂) amounted to 43.1 Mt in total, which is equivalent to 81percent of total greenhouse gas emissions, calculated as CO₂-eq. Emissions of methane (CH₄) accounted for 4.9 Mt of CO₂-eq. (about 9 percent of total emissions), emissions of nitrous oxide (N₂O) 4.6 Mt (9 percent), fluorinated greenhouse gases 0.9 Mt (2 percent), see Figure 5. The shares of the different greenhouses gases have remained stable over the period 1990 to 2015.

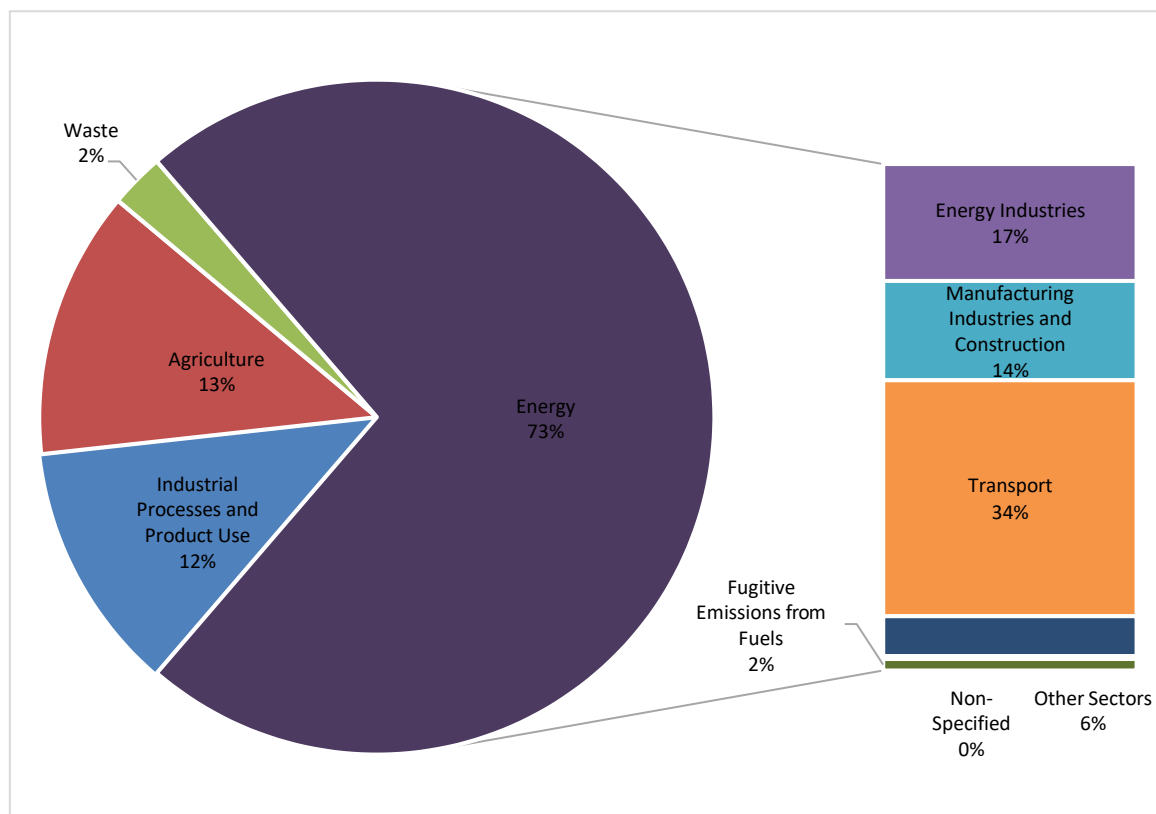
Figure 5 Greenhouse gas emissions in 2015 (excl. LULUCF) by gas, in carbon dioxide equivalent.



Emissions and removals of greenhouse gases by sector

The largest sources of emissions in 2015 was the energy sector (73 percent), agriculture (13 percent) and industrial processes and product use (12 percent), as shown in Figure 6.

Figure 6 Greenhouse gas emissions in 2015 (excl. LULUCF), by sector.



In recent years there has been a downward trend in emissions. The largest reductions in absolute terms are due to a transition from oil-fuelled heating of homes and commercial and institutional premises to electricity, e.g. heat pumps, and district heating. Increased use of biofuels in district heating generation and industry has also contributed to the reductions together with reductions in landfilling of waste. Fluctuations in production levels of manufacturing industries following changes in the economic development of specific industries have also had significant impacts on the national trend.

Projections of sectorial developments with existing national and EU policies and measures at least until 2040

Total greenhouse gas emissions in Sweden in 2015 were 53.7 Mt CO₂-eq. (excluding The Land Use, Land Use Change and Forestry sector) (National Inventory Report, Submission 2017). Total emissions decreased by 25 percent, between 1990 and 2015. The projection results point to a gradual decline in total emissions of greenhouse gases (excl. LULUCF) over the projection period. The projected emissions for 2020 are 30 percent below 1990 levels, and by 2030 total emissions are projected to

be 36 percent below 1990 levels, shown in Figure 7. Historical and projected emissions and removals of greenhouse gases divided by sector is presented in Table 13⁴².

The LULUCF sector contributed to an annual net removal of carbon dioxide in Sweden during the period 1990–2015 and is expected to continue to do so during the projection period.

Figure 7 Historical emissions of greenhouse gases and projected emissions and removals of greenhouse gases with existing measures⁴³.

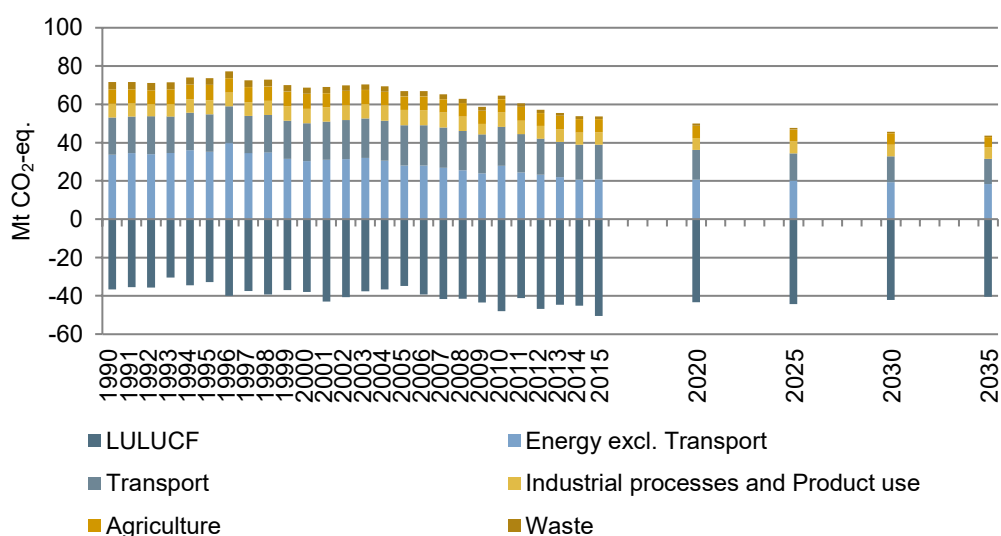


Table 13 Historical and projected emissions and removals of greenhouse gases by sector (million tonnes CO₂-equivalents)

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2030
Energy excl. transport	33.8	20.8	20.7	20.2	19.3	18.4	-39%	-43%
Transport	19.3	18.2	15.4	14.3	13.6	13.1	-20%	-30%
Industrial processes and product use	7.2	6.4	6.3	6.2	6.1	6.0	-12%	-15%
Agriculture	7.6	6.9	6.4	6.1	5.9	5.4	-17%	-23%
Waste	3.7	1.4	1.1	0.9	0.7	0.7	-72%	-81%
Total emissions	71.6	53.7	49.9	47.7	45.6	43.6	-30%	-36%
LULUCF	-36.7	-50.5	-43.3	-44.3	-42.2	-40.5	18%	15%

4.2.2 Renewable energy

Table 14 below shows the current share of renewable energy in total and for each sector, as well as developments since 2005, according to the

⁴² Ministry of the Environment. 2017. Report for Sweden on assessment of projected progress, March 2017. In accordance with articles 13 and 14 under Regulation (EU) No 525/2013 of the European parliament and of the Council Decision on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC

⁴³ Measures until 30 of June 2016

official reporting and calculation in Shares, the calculation tool for the Renewable Energy Directive.

Table 14 Percentage of renewable energy, total and per sector 2005-2015, %

	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015
Total share	40.6	42.7	44.2	45.3	48.2	47.2	48.7	51.1	52	52.4	53.9
Of which cooperation mechanisms								-0.1	-0.4	-0.7	-1
Heating and cooling	51.9	56.4	58.7	61.1	63.6	60.9	62.2	65.8	67.1	68	68.6
Electricity	50.9	51.8	53.2	53.6	58.3	56	59.9	60	61.8	63.2	65.8
Transport sector	6.2	7.1	8	8.3	8.9	9.2	11.5	14.8	19.2	21.1	24

Since Norway joined the electricity certificate system, the larger part of the renewable electricity generation has been built in Sweden, and therefore there is a statistical transfer of renewable energy from Sweden to Norway through the cooperation mechanism. In 2015, 4 TWh of renewable electricity will be transferred, corresponding to 1 percentage point of Sweden's share.

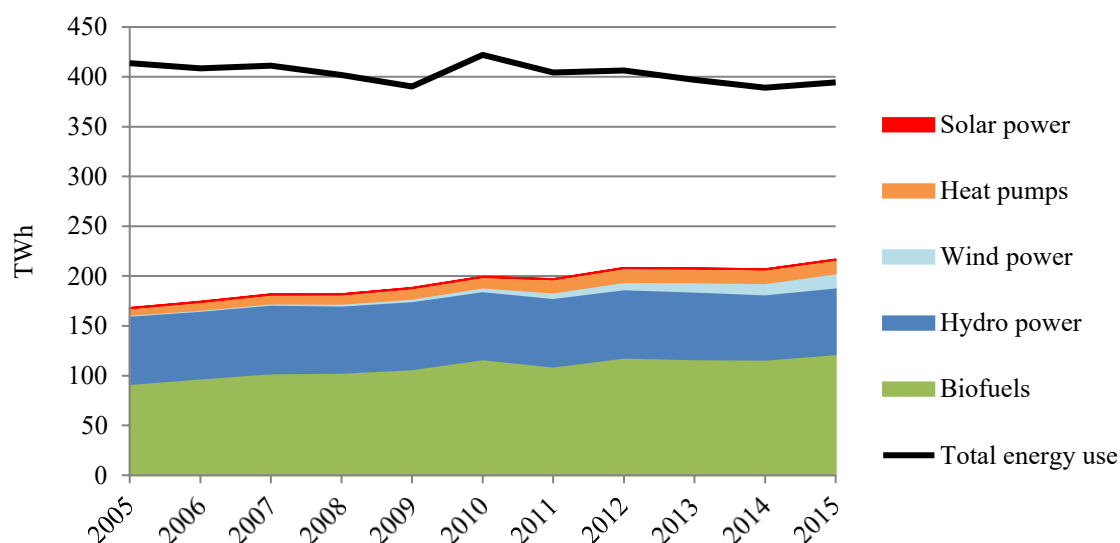
Total share renewable per technology/energy source

The current share of renewable energy in relation to gross energy use is 53.9 percent in 2015, which is 1.4 percentage points higher than in 2014. The share depends on the development of the amount of renewable energy and energy use.

The total amount of renewable energy in Sweden, according to the Renewable Energy Directive, was 217 TWh⁴⁴ in 2015, an increase of 10 TWh from the previous year. The increase is due primarily to the continued expansion of wind power and a greater use of biofuels. The largest contributions of renewable energy came from biofuels and hydropower, as can be seen in Figure 8.

⁴⁴ Since the electricity certificate system is common with Norway and more than half of the electricity production within the system is produced in Sweden, a statistical transfer of renewable energy is to be made to Norway. In 2015, 4 TWh of the 217 TWh were transferred.

Figure 8 Renewable energy and energy use according to the Renewable Energy Directive, 2005-2015, TWh

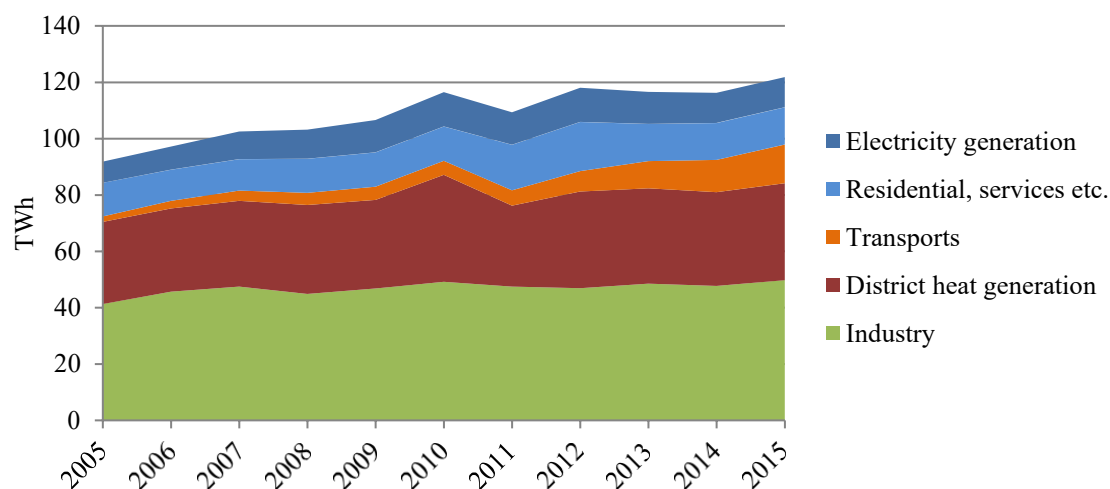


At the same time, the total energy use increased slightly between 2014 and 2015 and was 394 TWh in 2015. The increased energy use limited the increase in the share of renewable energy. Energy consumption is 20 TWh lower in 2015 than it was in 2005.

Hydropower is the second largest contribution to the high proportion of renewables and accounted for 31 percent of renewable energy. Wind power is the fastest growing energy technology, in 2015 giving the same contribution to the amount of renewable energy as heat pumps (just over 6 percent each). Solar power has so far contributed only 0.1 percent of renewable energy.

The use of biofuels contributed most to the amount of renewable energy, and accounted for 56 percent of the total amount of renewable energy included in the calculation for 2015. Figure 9 shows the sectors in which biofuels are used. The largest use is in the industry sector and for district heating. The largest increase in biofuel use has occurred in the transport sector in recent years.

Figure 9 Use of biofuel by sector, 2005-2015, TWh



Renewable share in the heating and cooling sector by technology and energy source

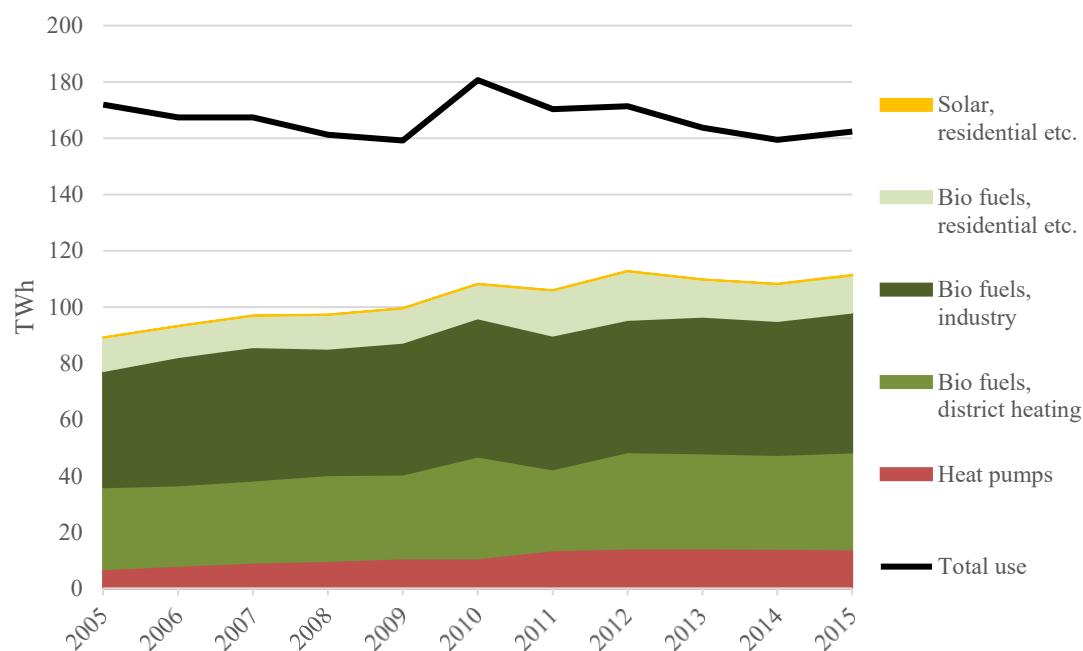
The share of renewables in the heating and cooling sector⁴⁵ relative to energy use was 68.6 percent in 2015, an increase of 0.6 percentage points from 2014. In 2005, the share was 51.9 percent. The amount of renewable energy is 111 TWh in 2015 and is larger compared to 2005 when it was 89 TWh. The development is pictured in

Figure 10. Renewable energy is primarily made up of biofuels⁴⁶ in the heating and cooling sector which accounts for 88 percent in 2015. The remainder is the contribution of heat pumps. Since 2005, total use in the sector has decreased from 172 to 162 TWh in 2015.

⁴⁵ The heating and cooling sector includes industry, residential, service and district heating, excluding electricity used in these sectors.

⁴⁶ Including a small amount of solar heat.

Figure 10 Renewable energy and energy use in the heating and cooling sector, 2005-2015, TWh



Share of renewables in the electricity sector by energy source and technology

The share of renewable electricity production in relation to total electricity consumption was 65.8 percent in 2015, an increase of 2.5 percentage points from 2014. In 2005, the share was 50.9 percent.

Renewable electricity generation⁴⁷ in 2015 amounted to 92 TWh, with 67 TWh⁴⁸ of hydropower, 14 TWh⁴⁹ of wind power and 9 TWh of biomass-based combined heat and power⁵⁰. The remaining 2 TWh is produced with solar power, the renewable part of waste and bio oils. The amount of renewable electricity was higher than in the previous year, mainly due to increased production from wind power.

The electricity use has decreased since 2005, from 151 to 137 TWh, even though population increased in Sweden, from 9.05 to 9.85 million in the same period. The decrease has mostly occurred in the industrial sector, but declines have occurred in all sectors. The fact that 2015 is a warmer year than 2005 also affects the amount of electricity used for heating.

The renewable electricity generation and electricity use 2005 –2015 is shown in Figure 11 below.

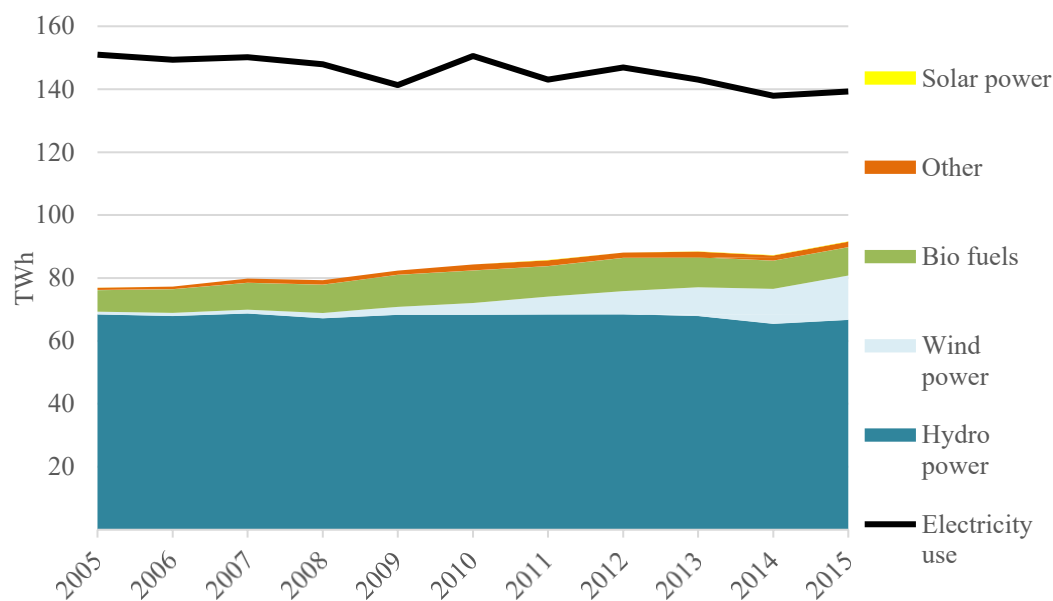
⁴⁷ With a temperature adjusted value and wind power according to the Renewable Energy Directive and renewable electricity in relation to electricity use.

⁴⁸ Temperature adjusted value. Actual production was 75 TWh.

⁴⁹ Temperature adjusted value. Actual production was 16 TWh.

⁵⁰ Including the renewable part of waste.

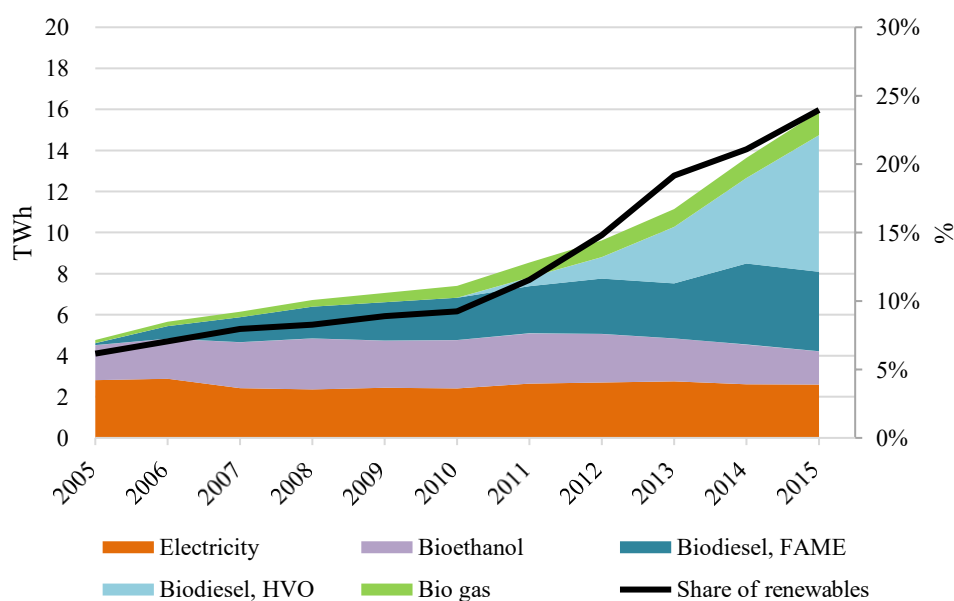
Figure 11 Renewable electricity generation and electricity use 2005-2015, TWh



Renewable share in the transport sector by energy source

By 2015, 24.0 percent of the transport sector's energy use is renewable according to the Renewable Energy Directive calculation method. The increase from the previous year was 2.9 percentage points. The share of renewable has increased rapidly in the transport sector from 6.2 percent in 2005 and is shown in Figure 12.

Figure 12 Actual use of biofuels and electricity in the transport sector (TWh) and renewables share (incl. double counts) according to the Renewable Energy Directive calculation method (%), 2005-2015



It is mainly the use of biofuels that contribute to the high share of renewable energy in the transport sector. The biofuels used in Sweden are mainly biodiesel (HVO and FAME) followed by ethanol and biogas. It is particularly HVO that has increased significantly over the last 5 years. As HVO's chemical composition is identical to that of fossil diesel, HVO can be blended with fossil diesel at high levels, and that is the main use of HVO.

In order to promote biofuels produced from waste and residues, these fuels are double counted against the ten-year goal of the Renewable Energy Directive. In Sweden, double counting affects the outcome significantly because Swedish HVO and biogas are largely produced from waste and residues.

The renewable part of the electricity used in the transport sector is promoted in the calculation method. The electricity that Sweden reports and seen in Figure 12 is used by rail traffic. Use of electricity for cars, etc. in road traffic or other modes of transport is not reported as these data are not available in the official statistics.

Between 2005 and 2015, the total energy consumption for domestic transport has decreased from 91 to 87 TWh, which contributes to the increased share of renewables. Without the Renewable Energy Directive's calculation method, where some fuels are double counted, the share of renewable energy in the transport sector was 18 percent in 2015.

4.2.3 Projections of development with existing policies and measures at least until 2040

The most recent scenarios are *Scenarios of Sweden's energy system 2016*⁵¹ and the base year of the scenarios is 2014. The reference scenario is based on the conditions given by the European Commission and on policies and measures decided before 30 June 2016, according to the conditions presented in 4.1.

In addition to the reference scenario, a low-price scenario has been performed for the electricity system. The purpose of the scenario is to model the electricity market with lower fossil prices. The low-price scenario uses lower prices for natural gas and coal as well as a lower price for EU ETS allowances according to Table 15-17 below. Since oil prices, unlike the prices of natural gas and coal, do not affect the Swedish electricity market, oil prices are the same as in the reference scenario. In this scenario, the extension and increased ambition of the electricity certificate system with 18 TWh is also added.

⁵¹ Energimyndigheten, ER 2017:6, <https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=5636>

Table 15 Assumed world market prices for coal, USD/tonne, low-price scenario

2015	2020	2030	2040
54	61	84	93

Table 16 Assumed world market prices for natural gas, USD/mmBTU, low-price scenario

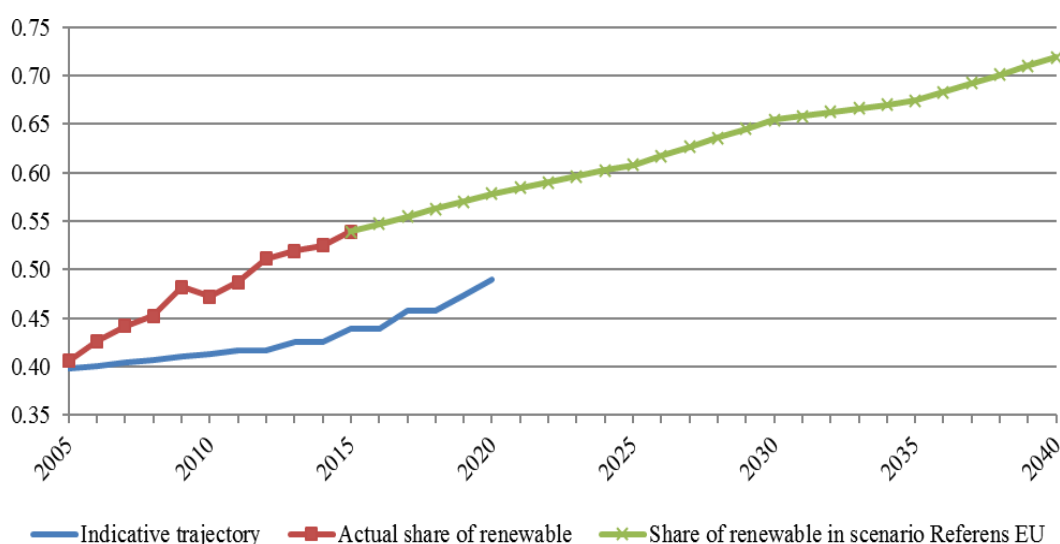
2015	2020	2030	2040
6	5	6	7

Table 17 Assumed prices for ETS allowances, EUR/tonne CO₂, low-price scenario

2015	2020	2030	2040
7.5	6	15	20

Scenarios for the total share of renewables

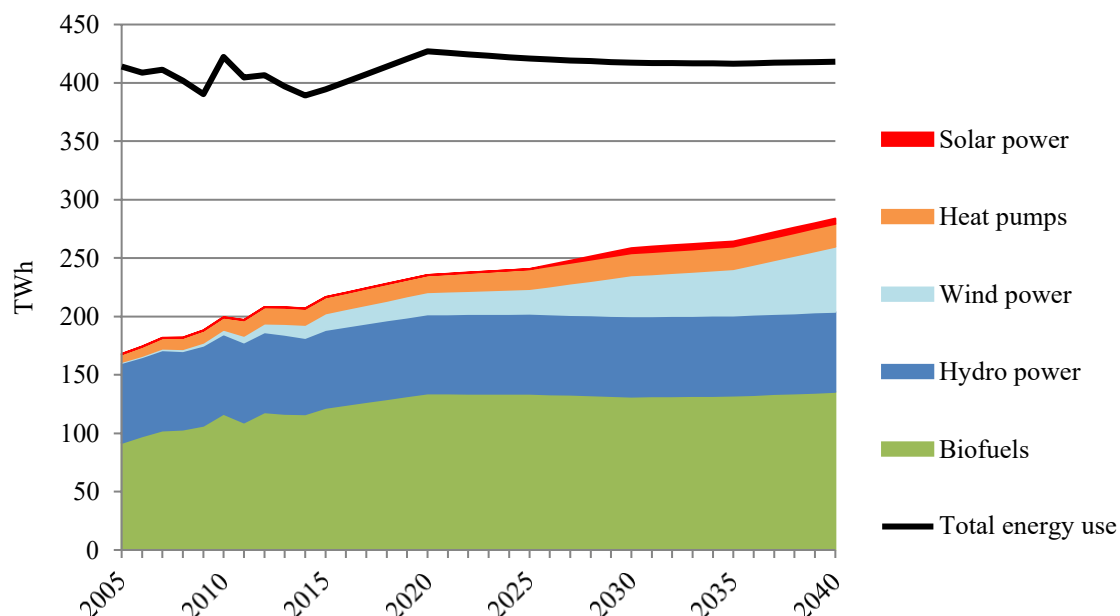
The share of renewable energy in relation to gross energy use is increasing from the 2014 share of 53 percent to 58 percent by 2020. The share continues to rise to 65 percent and 72 percent in 2030 and 2040 respectively, shown in Figure 13.

Figure 13 Renewables share in the reference scenario, 2005-2040, %

The increased share is due to the fact that the energy consumption is expected to decrease somewhat between 2020 and 2040, but above all,

that the use of renewable energy is increasing. In this scenario, it is mainly wind power that increase heavily until 2040 on the basis of current conditions, shown in Figure 14 below.

Figure 14 Renewable energy by power source and energy use in the reference scenario, 2005-2040, TWh



In the low-price scenario with prices of fossil fuels and emission allowances at a significantly lower level and with the increased ambition of the electricity certificate system by 18 TWh by 2030, the share of renewables is lower, 64 percent and 63 percent in 2030 and 2040 respectively.

Scenarios for the renewables share in the heating and cooling sector

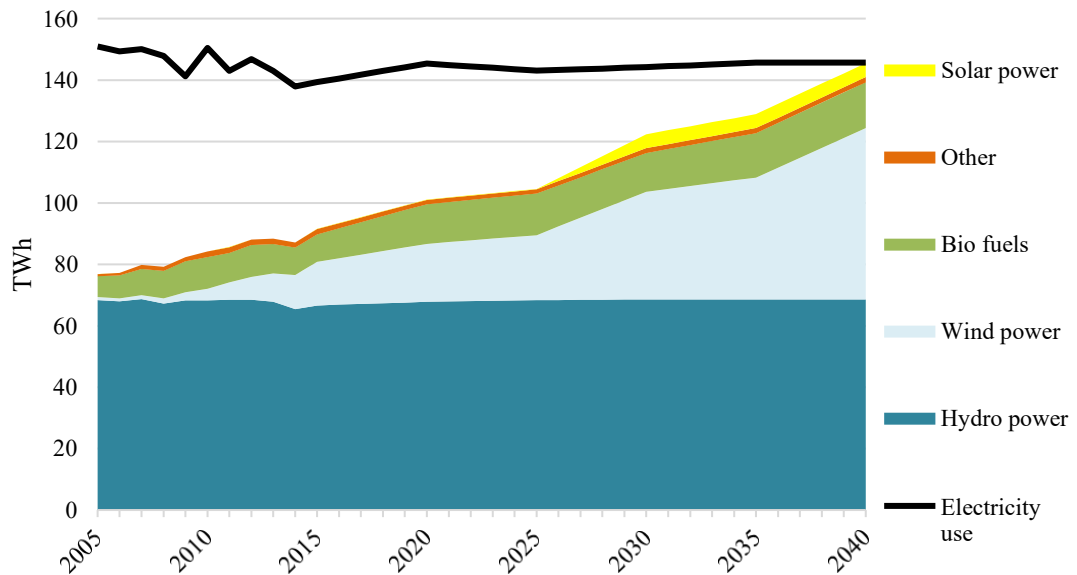
The share of renewables in the heating and cooling sector relative to the energy use is slightly increasing, from 68 percent in 2014 to 69 percent by 2030. By 2040, the share of renewables is 71 percent in the reference scenario. The energy used in the sector today is already largely renewable, but the increased share is due to a slight increase in the use of biofuels, but above all the increased use of heat pumps. In the low-price scenario, the share is the same for 2030, 69 percent, but decreases to 67 percent for 2040.

Scenarios for the renewables share in the electricity sector

The share of renewable electricity increases in the reference scenario from 63 percent in 2014 to 85 percent in 2030 and further to 100 percent in 2040, shown in Figure 15, according to the Renewable Energy Directive. If the share instead is calculated as renewable electricity

production related to the total electricity production the share will become lower in 2040, approximately 83 percent.

Figure 15 Renewable electricity production and total electricity use in the reference scenario, 2005-2040, TWh



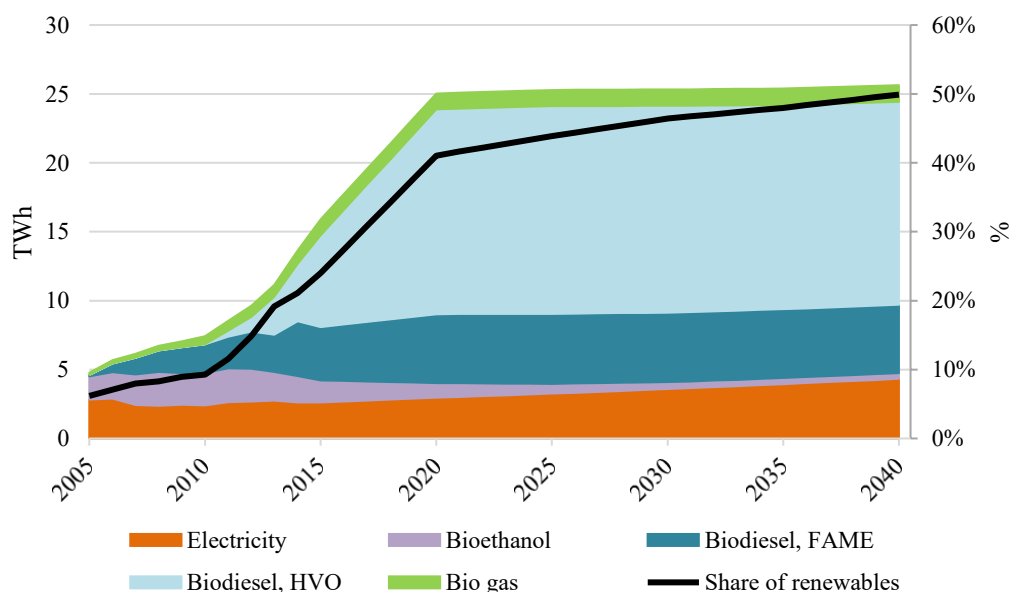
It is mainly wind power production that increases in the reference scenario, but solar power also increases around 2030. The large increase in wind power depends on the conditions under which the scenario is based and in this case, prices for fossil fuels and emission allowances are high, which leads to a sufficiently high electricity price to make wind power profitable.

In the low-price scenario, the share of renewable electricity is lower than in the reference scenario, 81 percent and 78 percent respectively in 2030 and 2040. This is explained by the fact that the natural gas in this scenario becomes profitable and increases at the expense of renewables. This means that with lower future prices for fossil fuels and above all a lower price of emission allowances, Sweden's target of 100% renewable electricity will not be reached in 2040.

Scenarios for the renewables share in the transport sector is shown in Figure 16.

The share of renewables increases from 14% in 2014 to 46% in 2030 and further to 50% by 2040, reference scenario

Figure 16 Actual and projected energy use, in the reference scenario, of biofuels and electricity in the transport sector (TWh) and renewables share (incl. double counting) according to the Renewable Energy Directive (%) 2005–2040



The share of renewables increases mainly until 2020 but the rate of increase decreases thereafter. This is because in the scenario, there are no further measures beyond 2020 to promote a continued increase in the amount of biofuels in addition to the measures currently in place. However, the fact that the share will increase slightly by 2040 is due to the fact that energy consumption is decreasing somewhat and that the share of renewable electricity is higher. It is an increased use of biodiesel (HVO) that contributes most to the increased share of renewables.

In the low-price scenario, the share of renewable energy in the transport sector is 46 percent and 48 percent in 2030 and 2040, which is only a slightly lower share for the year 2040 than in the reference scenario. The renewable share in electricity generation is lower in the low-price scenario which affects the calculation of the transport sector.

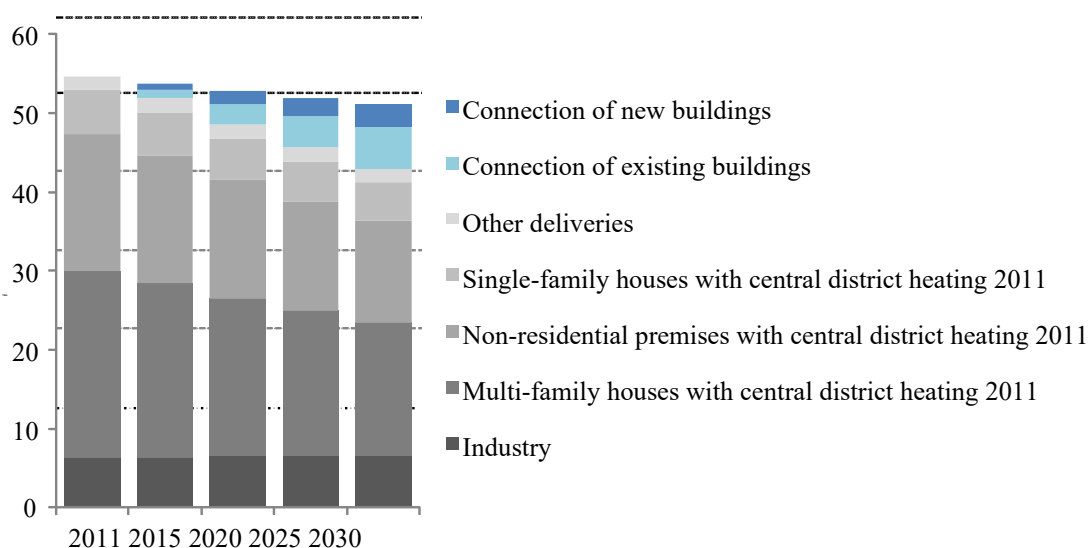
4.3 Dimension Energy efficiency

The primary and final energy consumption totally and per sector is presented in Table 18.

Table 18 Energy consumption 2015 [TWh]

	2015
Total energy consumption including non-energy use	540
Total energy consumption excluding non-energy use	505
Total energy consumption	370
<i>Industry</i>	140
<i>Residential</i>	84
<i>Services</i>	59
<i>Transport</i>	87

The numbers in this chapter are from the report *Comprehensive assessment of the potential for using high-efficiency cogeneration, district heating and district cooling, promotion of effective heat and cooling in accordance with the provisions of Article 14 (1) of the Energy Efficiency Directive - ER 2013: 24*. New connection of district heating that takes place both in existing and in new buildings does not compensate the decline that occurs at the same time in the already connected buildings due to efficiency improvements and conversions to heat pumps. In 2011, 54.7 TWh of district heating was produced, which is expected to decrease to 51 TWh in 2030, despite the fact that new connections to existing buildings and new buildings are estimated to amount to 8 TWh in 2030. The net reduction is thus estimated at approximately 4 TWh, or 12 TWh without new connections, shown in Figure 18.

Figure 17 The estimated development for Sweden's combined district heating supplies up to and including 2030, TWh

District cooling is currently around 1 TWh. For district cooling, the potential has been estimated at an additional 2 TWh by 2030.

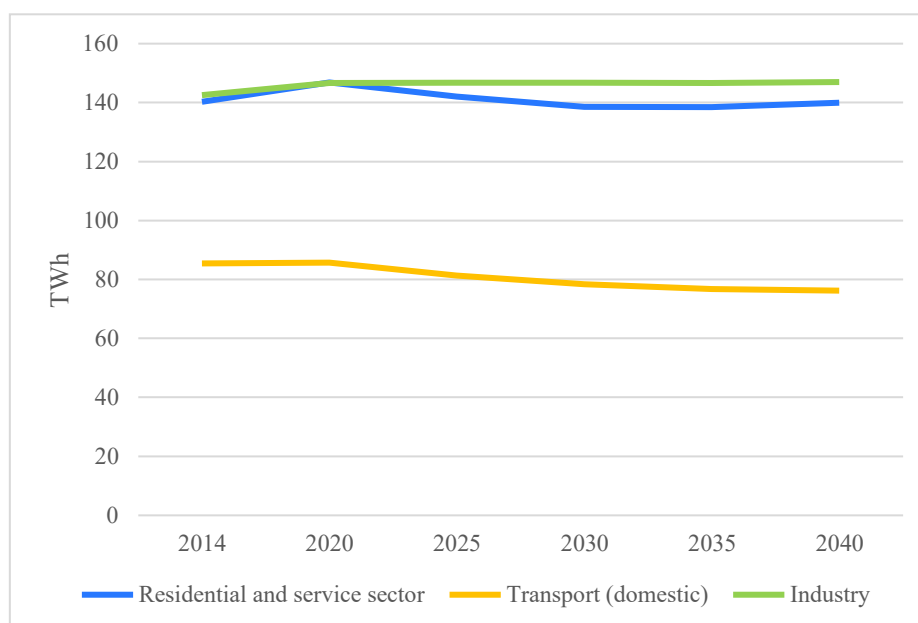
The potential of CHP

The combined heat and power potential consists of cogeneration in district heating systems and industrial cogeneration, so-called industrial back pressure. The additional potential for electricity generation from CHP is approximately 15 TWh by 2030, from 10.5 TWh in 2011. This is based on the assumption that district heating supplies will slightly decrease in the long term.

Electricity production from the industrial CHP is currently 6 TWh per year. The overall assessment of the potential of industrial back pressure is 8.8 TWh by 2030.

Figure 18 shows a projection of Sweden's final energy consumption by 2040, for each sector. The projection is based on policies and measures decided until 30 June 2016. At present, there is no projection for primary energy consumption for each sector available.

Figure 18 Projection of Sweden's energy consumption for the sectors Residential and service, Transport and Industry, 2014-2040



Cost-optimal levels for nearly zero energy buildings

In Table 19 the cost-optimal levels of levels of minimum energy performance requirements resulting from national calculations, according to Article 5 of Directive 2010/31/EU is represented. The results are represented as an interval with the applicable minimum requirements in brackets.

Table 20. Cost-optimal levels of minimum energy performance requirements

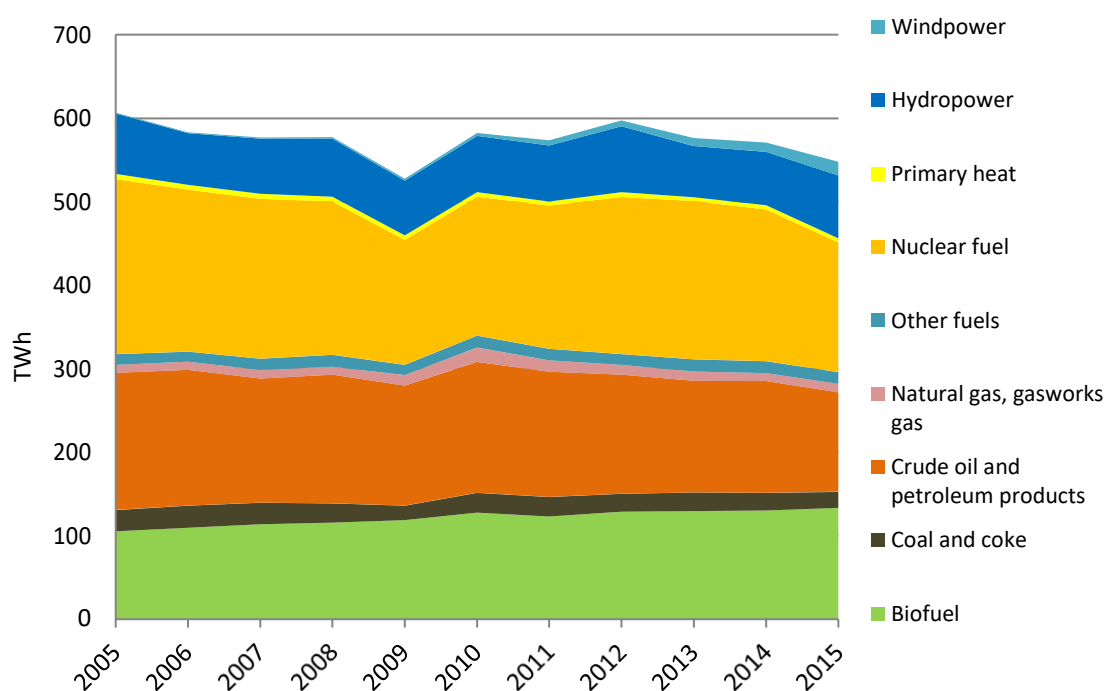
	Cost-optimal levels in primary energy (EP_{pet}) $\text{kWh/m}^2 A_{\text{temp}} \text{ year}$
One-and two-dwelling buildings	74 - 88 (90)
Multi-dwelling	50 - 80 (85)
Non-residential premises	53 - 70 (80)

4.4 Dimension Energy security

The Swedish energy system is partly based on domestic sources of renewable energy such as water, wind and biofuel. The biofuel represented 25 percent of the primary energy in 2015. In addition, a large proportion of the energy supplied is dependent on imports, such as nuclear fuel for electricity production in nuclear reactors and fossil fuels, such as oil and natural gas for the transport system. The fossil fuels represented 28 percent of the primary energy in 2015. The development of total energy supply 2005-2015 is shown in Figure 19.

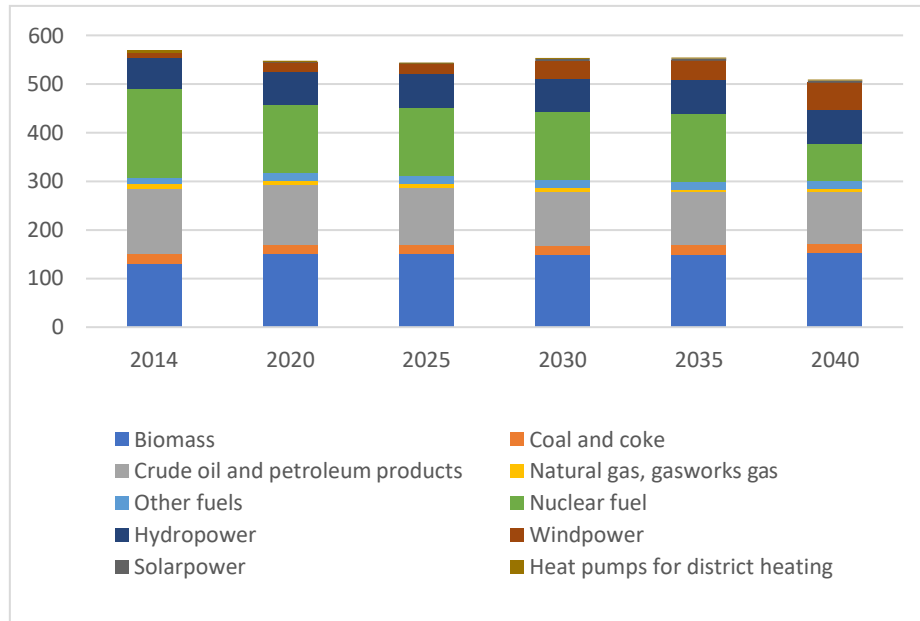
The Swedish electricity production is based mostly on hydropower and nuclear power, 47 percent and 34 percent in 2015. The expansion of wind power is steadily increasing and in 2015 it produced 10 percent of total electricity production. The use of biofuel for electricity and heat production is also increasing.

Figure 19 Total energy supply by energy commodity, TWh, 2005-2015



The projection of the energy mix in the reference scenario for 2040 is presented in Figure 20 below.

Figure 20 Total energy supply by energy commodity, TWh, 2014-2040



In 2040 the nuclear production will decrease because several reactors are old and projected to shut down. The nuclear production is nearly halved in 2040 compared to 2020. The Swedish electricity system and especially electricity generation are facing major changes. The owners of nuclear power plants have taken decisions in the last year that will affect the importance of nuclear power. There are discussions about whether the operation of the market provides sufficiently good conditions for long-term secure electricity generation in Sweden. This affects the future risk of both power and electricity diversity and requires different types of analyses and measures in both the short and long term.

The production of wind power will increase to 2040. In 2040, wind power production is over 50 TWh compared to 19 TWh in 2020. In 2030, solar power is also increasing and in 2040 it is almost 5 TWh in the energy system. An electricity system with a large share of variable electricity, such as wind and solar power, will bring several challenges in terms of power control. Without any other power source that replaces nuclear power, there is an increased risk of power failure situations occurring more often in the future. Two key issues regarding the future power balance will be to determine which level of energy security to apply and how to ensure the availability of electricity power.

Other energy sources and fuels, such as biomass and fossil fuels, is approximately at the same level between 2020 and 2040.

The export of electricity will increase and between 2030 and 2040 the export is more than 30 TWh yearly.

The development towards decentralized energy systems and smart networks means that more and smaller players will be involved in the energy market in the future. This means an increase in information management but also in the use of information technology. Thus, there is a risk that future energy supply will become more vulnerable to IT-related threats. The rising age of the infrastructure and low investment rate may also be a clear and immediate threat to security of energy supply in the future. Systematic monitoring and analysis are therefore the key to ensuring the necessary ability to prevent and deal with disturbances in the energy supply – today and in the future.

Work on defence planning will in the future bring special needs for robustness and enhancement in all aspects of energy supply. Security and, in particular, information security are considered to be areas that need further treatment.

4.5 Dimension Internal energy market

There are no projections regarding the electricity infrastructure and interconnections after 2027. Planning and projections are performed on a 10-year period by the Swedish TSO, Svenska kraftnät.

4.5.1 Electricity interconnectivity

Sweden has at the end of 2017 an interconnection level of 26 percent. Total import capacity is 10 250 MW and installed production capacity is 39 799 MW. Actual interconnectors are shown in Table 21 below.

Table 21 Actual interconnectors

From	Type	Name	MW
Finland	AC		1,100
Finland	HVDC	Fennoskan 1&2	1,200
Lithuania	HVDC	Nordbalt	700
Poland	HVDC	SvePol link	600
Germany	HVDC	Baltic cable	615
Denmark	HVDC		740
Denmark	AC		1,700
Norway	AC		3,595
Total			10,250

By 2027, the following interconnections will be expected, which will change the interconnection level to 28%, shown in Table 22

Table 22.

Table 22 Additional interconnectors until 2027

From	Type	Name	MW
Finland	AC		900
Finland	HVDC	Fennoskan 1 ⁵²	-400
Finland	HVDC		800
Germany	HVDC	Hansa Powerbridge	700
Total			2,000

⁵² Fennoskan 1 is planned to shut down when the new HVDC 800 MW between Sweden and Finland is built.

4.5.2 Energy transmission infrastructure

Infrastructure for electricity

Hydropower in the north of Sweden together with hydropower in Norway are the most important regulatory resources for the entire Nordic power system. Sweden is an elongate country with the bulk of electricity consumption in south and most of the hydropower in the north. The task of the transmission grids is thus to transfer production from north to south.

During certain hours when there are large electricity flows through Sweden, the transmission capacity is not always sufficient. Sweden is divided into bidding zones based on today's structural bottlenecks.

Infrastructure for gas

The Swedish natural gas system is small compared to most other natural gas networks in Europe. There are just over 30 of Sweden's 290 municipalities that have access to natural gas. The gas comes to Sweden via a pipeline from the Danish Dragør. In Sweden, the transmission network is owned and operated by Swedegas, which also holds the system balance responsibility. A few very large consumers are connected directly to the transmission network.

There is also an urban and vehicle gas network in the Stockholm area, owned by Gasnätet Stockholm AB. The production and supply of gas to the urban gas grid mainly takes place from a gasification plant in Stockholm, where both biogas and LNG are delivered.

There are also a number of small local gas networks around Sweden. Many of the small local networks are mainly used to transport biogas for vehicles from a production plant to gas stations.

Infrastructure for electricity

Svenska kraftnät has no network development plan that extends to 2040. An analysis can, however, be made given certain assumptions and scenarios. The result is, in such cases, a consequence of the various assumptions and scenarios and not Svenska kraftnät's projections. The current network development plan from Svenska kraftnät extends to 2027⁵³.

There are two types of plans for networks expansion. The first one is the National Network Development Plan, which extends 10 years ahead and is made every two years (odd). The second one is the European network

⁵³ <https://www.svk.se/siteassets/om-oss/rapporter/2017/svenska-kraftnats-systemutvecklingsplan-2018-2027.pdf>

development plan, TYNDP (Ten Year Network Development Plan), which is being developed within ENTSO-E every two years (even).

The national plan includes all national planned projects, while the ENTSO-E plan (TYNDP) indicates current and future networking projects of European interest and compiles the latest available information. It provides the basis for consultation with external stakeholders on the development of the European electricity grid. In addition, the plan is an important part of reporting the work on the integration of renewable energy required to achieve the EU's climate and energy goals. Network project of importance is listed in TYNDP 2016⁵⁴.

Infrastructure for gas

There are no projections for the development for the Swedish natural gas system at the present time.

4.5.3 Electricity and gas markets, energy prices

Electricity market

The electricity market is composed of a wholesale and a retail market. In the wholesale market, generators, retailers and other major electricity users are trading with electricity. Sweden's electricity market is linked to Denmark, Norway, Finland, Germany, Poland and Lithuania and indirectly throughout Europe. The main marketplace for the wholesale market is the spot market at Nord Pool. It is a day-ahead market and today it is primarily an instrument for power companies' production planning for the next coming day. Trading takes place through an auction process which also includes transmission capacity in the power grid between the four different bidding zones.

The cost of electricity for an end user consists of electricity price, energy tax and VAT. In addition to the above costs, a number of retailers charge a fixed annual fee (not to be confused with the so-called subscription fee on the network side). The annual fee usually varies between 100 and 500 SEK. All these costs are subject to VAT.

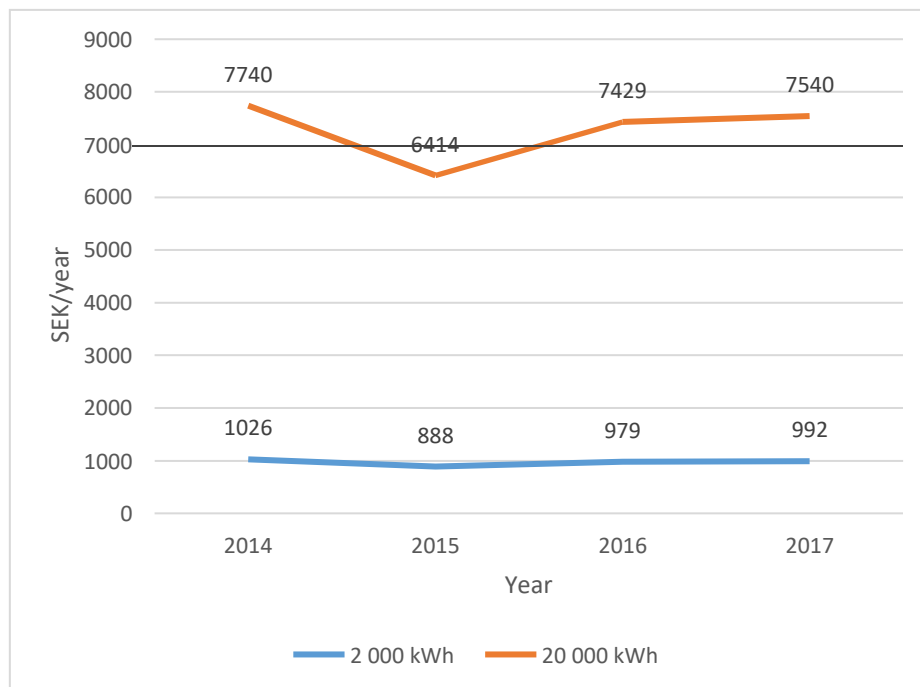
As described in section 3.1 electricity retailers are obliged to purchase electricity certificates corresponding to a quota of their customers' consumption. For fixed electricity price agreements, the electricity certificate fee is included in the electricity price. For variable electricity price contracts, the electricity certificate fee is specified separately.

The Figure 21 below is based on typical customers of 2 000 and 20 000 kWh, with a variable electricity price for bidding zone 3. Prices are at the 2017 price level and indicate the median. Electricity price include annual

⁵⁴ <http://tyndp.entsoe.eu/>

fee and possibly green electricity surcharge. VAT and energy tax are excluded.

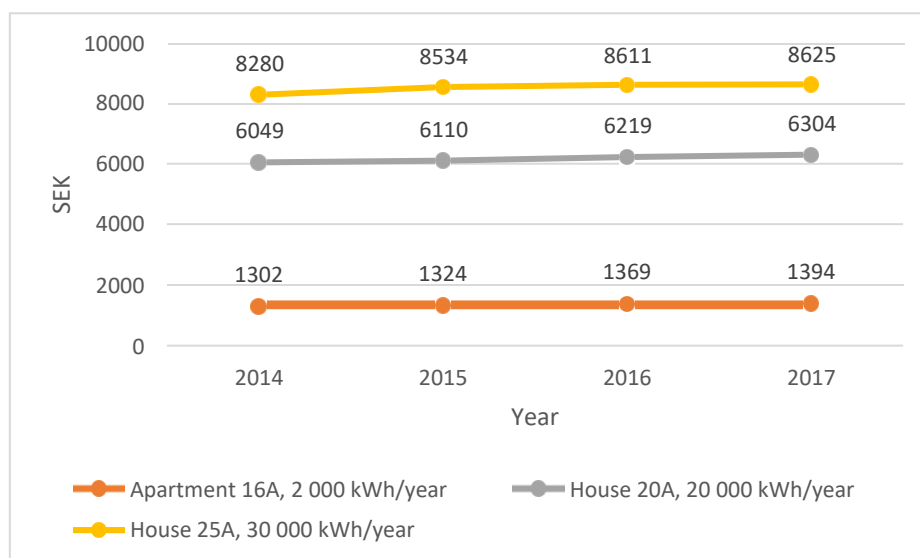
Figure 21 Retail prices inclusive yearly fee, excl. VAT & tax



The costs of the electricity grid consist of a fixed cost, subscription fee and a variable cost (transfer fee). VAT is payable on the fixed subscription fee and on the variable transfer fee.

The costs for the three most common household customers for network charges are shown in Figure 22 below.

Figure 22 Tariff reports household customers 2014-2017



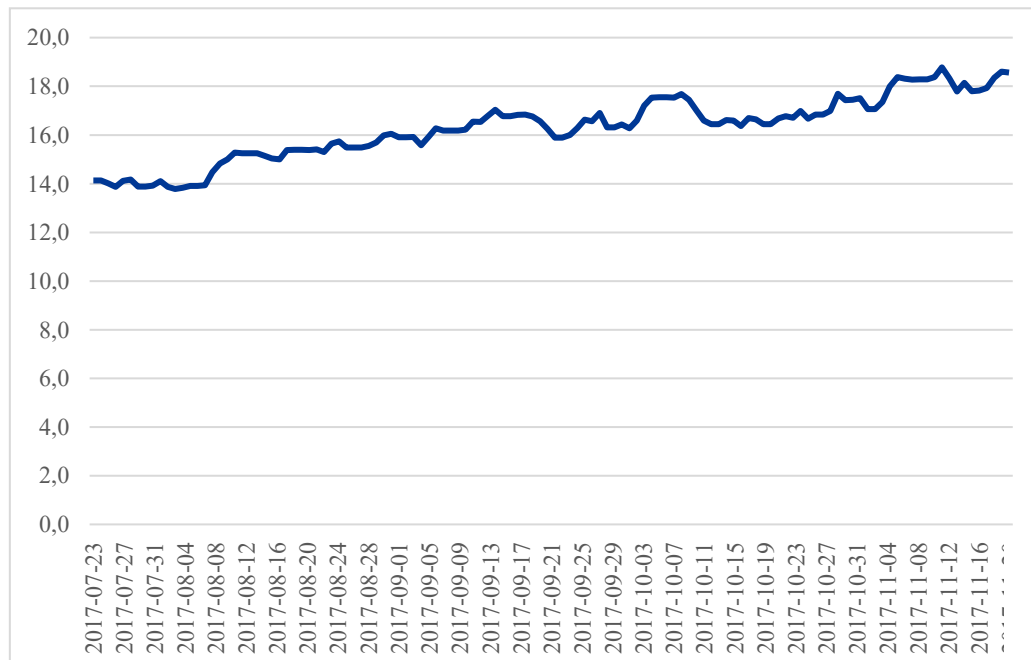
Gas market

Sweden does not produce any natural gas (except small-scale biogas). The natural gas consumed in Sweden comes mainly from the Danish gas fields in the North Sea through the connection from Dragör. Due to the Swedish network's design, the Swedish natural gas market is closely linked to the Danish. The balancing actors in the Swedish natural gas system are also active in the Danish gas market, especially Gaspoint Nordic, which since 24 November 2016 is part of the pan-European gas pump PEGAS. Therefore, competition, price development and transparency depend largely on the development in Denmark.

All trading on Gaspoint Nordic/PEGAS takes place with physical delivery and the operators must have an agreement with the Danish transmission network operator Energinet.dk. At Gaspoint Nordic/PEGAS, an operator can trade gas for delivery during the day, the day before, before the weekend and next month. Energinet.dk uses Gaspoint Nordics/PEGAS intraday trading to manage the balance of the Danish natural gas network.

The price of Gaspoint Nordic/PEGAS is based on supply and demand and is also the basis for the so-called balance base price used by Energinet.dk to settle imbalances between players. The price for three months from 2017 is presented in Figure 23.

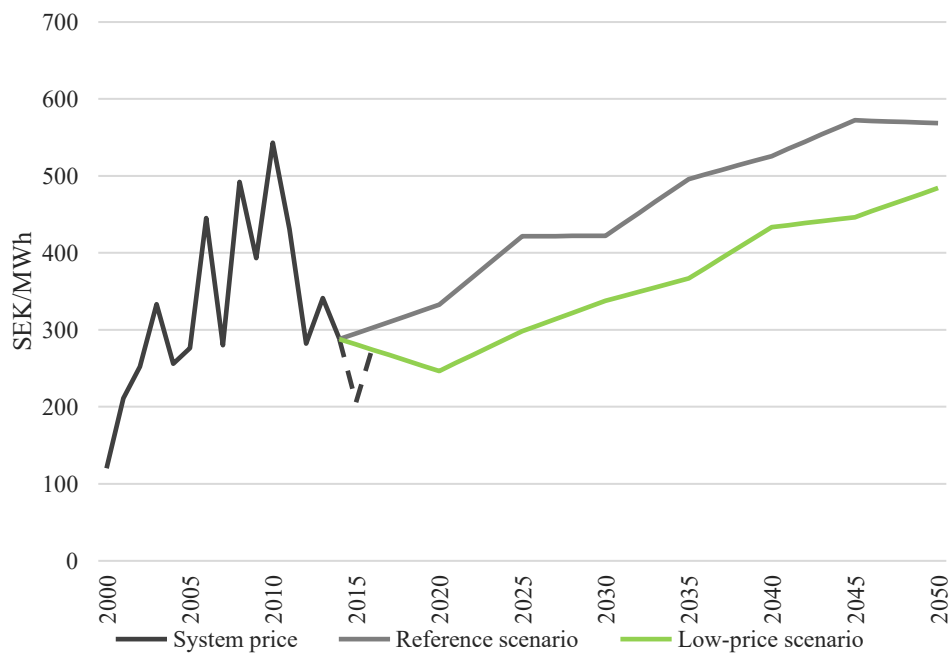
Figure 23 Gaspoint Nordic Spot Index (EUR/MWh)



Swedish energy policy is to secure the supply of electricity and other energy on competitive terms in the short and long term. In terms of energy prices in the electricity market, the development is fully market-driven. For price developments, there are no political strategies other than to secure a well-functioning market.

There are no projections for the electricity price. However, two different levels of electricity prices have been used in the scenarios (reference and low-price scenario) which are presented in Figure 24 below.

Figure 24 System price of electricity in bidding zone 3, 2000-2016, and in performed scenarios until 2050, SEK/MWh (nominal prices)



Projections for the gas price, as given by the Commission, are presented in 4.1.

4.6 Dimension Research, innovation and competitiveness

Sweden is prominent in several areas of research and innovation and the area of low carbon technologies and internationally in the forefront in the areas exemplified below.

Research and innovation

Carbon dioxide efficient biofuels and energy transition

Sweden is internationally leading in biofuels and waste based combined heat and power production. Research has played an important part in the development of efficient and environmentally friendly biofuel and waste based heat and power plants.

Forestry and bioenergy

Forest carbon sequestration and the efficient use of bioenergy resources is a strong research area in Sweden. The project Cost effective and sustainable primary harvest of forest fuel aims at improving the cost efficiency in 1) harvesting of small trees 2) forwarding of forest biomass, and 3) biomass storage at landing.

Resource optimization, energy efficiency and carbon neutrality in industry

Sweden is at the forefront of research making parts of energy intensive industry more energy and resource efficient and ultimately free of carbon dioxide emissions. Through HYBRIT (HYdrogen BReakthrough Ironmaking Technology) research that could deliver a breakthrough is ongoing for a fossil-free production of steel from iron ore in Sweden.

A feasibility study for the project was granted SEK 7.7 million and in February 2017 a resolution was passed to finance a 4-year long research project under The Swedish Energy research and innovation programme (Government Bill 2016/17:66). The research project will investigate processes such as fossil fuel-free pellet manufacturing, hydrogen-based direct reduction, and the use of sponge iron in electric arc furnaces, along with providing an electrical power supply source for hydrogen manufacturing and storage. The research project has been allocated SEK 99 million, where SEK 54 million of this amount is financing from the Government and SEK 45 million is financed from private sector.

Transition to a renewable electricity system and the use of smart grids

Research areas of wind solar and energy are a priority in the Swedish energy research and there are several ongoing projects. Among them is the High-efficiency multijunction solar cells on silicon.

The Forum for Swedish Smart grid is a national forum appointed by the Swedish Ministry of the Environment and Energy, described in 3.4.3. There are also a number of national centers and research and innovation programmes for smart grids, for example the national research programme SamspEL, Swedish Centre for Smart Grids and Energy Storage (SweGRIDS) and KTH ACCESS Linnaeus Centre.

Research and demonstration in the transport sector

Swedish agencies are financing several large research projects covering the entire chain from cultivation of raw materials for bio-based motor fuels to the use of new fuels. These include:

- FFI – Strategic vehicle research and innovation
- F3 – Collaboration program for renewable fuels and systems

- SFC – Research on biomass gasification
- Battery funding programme
- Energy efficiency in the transport sector programme
- Demonstration programme for electric vehicles
- Innovations for a sustainable society

Sweden is also involved in the EU Renfuel project, which aims to develop strategies for introducing cost-effective alternative vehicle fuels. The project is also investigating potential effects on stationary installations using biofuels.

Energy-related research

As a sectoral authority, the Swedish Energy Agency has a main and coordinating responsibility for energy-related building research. In addition to the Swedish Energy Agency, Formas and Vinnova also finance projects in the area. In addition, the Swedish Consumer Agency, the Swedish National Board of Housing, Building and Planning and the Swedish Environmental Protection Agency have energy-related commitments in the area of construction.

The energy-related research activities are characterized by a system vision, with the vision of achieving resource and energy-efficient housing. This is mainly done through collaboration. The Swedish Energy Agency is focusing on energy efficiency through a number of programs, including *Research and Innovation for Energy Efficient Construction and Housing*, *Energy Efficiency in Cultural Historical Buildings*, *Save and Preserve*, and *the Energy Efficiency Program in the Lighting Area*.

From research to market

Sweden has supported several successful companies taking their research and innovation to the market. In solar energy, for example Exeger (Heffa Solar - a new cost efficient Grätzel solar cell). In ocean energy, for example CORPOWER OCEAN (high efficiency Wave Energy Converter (WEC)), Minesto, Waves4Power and Ocean Harvesting Technologies.

Pilot and demonstration collaborations between public and private actors

Sweden has also supported successful projects in pilot and demonstrations, with public and private cooperation, in the areas of:

Zero Emission Transportation: VOLVO, SCANIA electric-/hybrid electric buses and construction equipment, as well as electric roads.

Smart Grids: several demonstrations in Stockholm Royal Seaport⁵⁵, Hyllie Smart City⁵⁶ and Smart Grid Gotland.⁵⁷

Biofuels: RenFuel, -a chain-link from black-liquor to green petrol and diesel. By catalytic transformation of lignin to Lignol, oil refineries can convert diesel and petrol to a green substitute for petroleum based gas oil.

In addition, Sweden is by the European Innovation Scoreboard 2017 named innovation leader, followed by Denmark, Finland, the Netherlands and Germany.⁵⁸

Public and private research and innovation spending on low-carbon-technologies, current number of patents, and current number of researchers

Public and private expenses

Granted funds in the national energy research and innovation program in the energy sector 2013-2015 amounted to SEK 6,365 billion. Business financed 43 percent of these funds, i.e. SEK 2.737 billion. Other private expenses are difficult to assess.

Number of patents

During the period 2010-2012, there were 629 domestic and 732 international energy-related Swedish patent applications.

Number of researchers

During the period 2013–2015, approximately 1,100 graduate students and senior researchers were employed within projects that to at least 20% were financed by the National Energy Research Program.

Energy costs including in the international context

Energy costs in Sweden compared with other countries are shown in the Commission's *Energy Prices and Costs in Europe report*. Sweden has the lowest electricity price in the EU (including taxes and charges) for the industrial sector, while gas prices for major industries are the second highest. However, the industry's gas use is marginal (3 percent) compared with electricity consumption (34 percent), so the relatively high gas prices for the industry do not outweigh the low electricity prices. Beyond electricity, biofuels are the largest energy carrier for the industrial sector, but these are not included in the above-mentioned report. Energy costs for households, which are not primarily of interest from a competitiveness perspective, are described under 4.5.3. In terms of petrol prices, Sweden is roughly at the EU average.

⁵⁵ <http://stockholmroyalseaport.com/>

⁵⁶ <https://www.con.se/samhaelle---utveckling/hallbara-stader/smarta-nat-i-hyllie.html>

⁵⁷ <http://www.smartgridgotland.se/>

⁵⁸ http://ec.europa.eu/growth/industry/innovation/facts-figures/scoreboards_sv

As for energy costs, see 4.5.3 As for the other questions, it is difficult to know in advance which lines of research will be fruitful. Considering this difficulty, Sweden has not found it meaningful to make projections for the development of research and innovation.

5 IMPACT ASSESSMENT OF PLANNED POLICIES AND MEASURES

This chapter will be included in the final plan