

## Country Reports

IEA Bioenergy: 09 2018

This report was prepared from the 2018 OECD/IEA World Energy Balances, combined with data and information provided by the IEA Bioenergy Executive Committee and Task members. Reference is also made to Eurostat. All individual country reports were reviewed by the national delegates to the IEA Bioenergy Executive Committee, who have approved the content. General background on the approach and definitions can be found in the central introductory report<sup>1</sup> for all country reports.

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## NATIONAL POLICY FRAMEWORK IN SWEDEN

Already in 2012 the share of renewable energy in Sweden surpassed the target for the EU Renewable Energy Directive (2009/28EC) of 49%, as well as the Swedish parliament national overall renewable energy target of 50%. In addition the binding national target for transport of 10% (all EU Member States have this transport target) was already met in 2011. Sweden opted not to divide the renewable energy target into further targets per sector, but projections per sector were made in the NREAP as displayed in the table below.

*Table 1: Sweden's 2020 renewable energy targets as stated in the NREAP*

Sector	Share in gross final consumption per sector
<b>Overall target</b>	50.2%
<b>Heating and cooling</b>	62.1%
<b>Electricity</b>	62.9%
<b>Transport</b>	13.8% <sup>2</sup>

Source: National Renewable Energy Action Plan (NREAP) of Sweden (2010)<sup>3</sup>

In the Swedish progress report 2015 the reported shares for year 2014 was 52.6 % overall and 19.2 %

<sup>1</sup> Available at <https://www.ieabioenergy.com/iea-publications/country-reports/2018-country-reports/>

<sup>2</sup> For reaching the transport target, the Renewable Energy Directive allows to apply multiplication factors for several types of options (advanced/waste based biofuels, renewable electricity in road vehicles).

<sup>3</sup> <https://ec.europa.eu/energy/en/topics/renewable-energy/national-action-plans>

for transport (including double counting of advanced biofuels). In 2016, the renewable share in transport was even higher, 30.8% with EU calculation method, including double-counting. The real share was 18.8 %.

Apart from the targets set by the EU Directive, Sweden has no specific targets for bioenergy. However, general policy stated an aim of a Fossil Free Society 2050, and the new government in 2014 declared that Sweden shall be a "fossil free welfare state". In 2016 the framework agreement on energy with five out of eight in the parliament stated that "At the latest in the year 2045, Sweden shall have no net emissions of greenhouse gases to the atmosphere, and will thereafter achieve negative emissions". In addition, The Swedish parliament decided in 2009 that Sweden shall have a fossil independent vehicle fleet by 2030.<sup>4</sup>

Sweden`s policies regarding bioenergy have been rather stable for a long period of time. The development of biomass as a renewable energy source for heat was promoted from the late 1970s to decrease Sweden`s dependence on imported oil, mainly by taxation of oil, and investment grants for heat plants using biomass. In 1991 a carbon tax was introduced, and this tax has since then been raised multiple times, mainly on the heating and service sector, and lately also on industries which are not part of emission trading (ETS). Beside the carbon tax there are also variable energy taxes and fees on sulphur and nitrous oxide emissions. The most important incentives and tax measures were:

- 1970s to present: energy taxes to diversify energy use and decrease dependence on oil
- 1977: Law on municipal energy planning
- 1991: introduction of a carbon tax, high on heat, lower on industry.
- 1991 – 1995, 1997 – 2003: investment grants to build biomass fuelled CHPs.
- 2000 – 2004: green tax shift. The carbon tax was increased while labour taxes were lowered.
- 1998-2012 LIP & KLIMP: Local investment programmes for municipalities
- 2002: landfill ban for combustible waste
- 2003: Green certificate scheme to promote new renewable electricity production,
- 2005: landfill ban for organic waste
- 2007: Tax exemptions for biofuels for transport to be used to 2013. Annual prolongation since then with some major adjustments
- 2012: Electricity Certificates Act. Together with Norway, a common electricity certificate market was installed in order to increase the production of renewable electricity by 26.4 TWh by 2020. In 2016 the goal was raised to 30 TWh.
- 2016: Framework agreement on energy and climate: Net zero emissions to the atmosphere by 2045<sup>5</sup>

However, the higher oil prices during the last few years in combination with reduced prices of traditional biofuels has resulted in an "overcompensation" of biofuels relative to fossil transport fuels, which is not allowed by EU state aid regulations. Moreover, the revision of the EU state aid regulation for energy 2014-2020 also limits Sweden`s possibilities to exempt biofuels from energy and CO<sub>2</sub> tax, since it contains limitation on giving tax exemptions to "food crop based" biofuels. Therefore the Swedish government launched a proposal in 2017 that will be executed on 1 July 2018. In brief, the structure of the system builds on a gradual increase in reduction of greenhouse gas emissions by addition of biofuels in gasoline and diesel. The system shall reduce emissions from diesel with 19.2% and 2.6% in gasoline

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<sup>4</sup> Personal communication (Olle Olsson): This should be interpreted as a 70% reduction of emissions from land transport by 2030 compared to 2010.

<sup>5</sup> Personal communication (Olle Olsson): This should be interpreted as a 85% reduction of domestic GHG emissions

from 1 July 2018. The decrease shall than increase over time with specific control stations with the goal of 40% decrease in greenhouse gas emissions by 2030. The system aims at creating a more stable long term rules for producers and distributors.

The Swedish support scheme for renewables has mainly been based on general incentives and technology neutrality, like the carbon tax and the green certificates. The carbon tax is based on PPP, the polluter pays principle, whereby the fossil fuels pay for their long-term environmental damage and cost and direct subsidies for any renewable alternative have in general been avoided. Bioenergy has thus not had any direct subsidies but has been benefited because its greenhouse gas emissions are estimated to zero.

A link is provided to the respective detailed description of all fiscal and non-fiscal supports for bioenergy development: <http://www.iea.org/policiesandmeasures/renewableenergy/?country=Sweden>

Swedish energy statistics can be found at

[http://www.energimyndigheten.se/globalassets/nyheter/2015/energy-in-sweden-2015\\_150826.xlsx](http://www.energimyndigheten.se/globalassets/nyheter/2015/energy-in-sweden-2015_150826.xlsx)

## TOTAL PRIMARY ENERGY SUPPLY (TPES) AND THE CONTRIBUTION OF BIOENERGY

The total primary energy supply of Sweden in 2016 amounted to 2,061 petajoule (PJ) with an export surplus of electricity of 42 PJ (2% of Swedish TPES). Less than one third comes from fossil fuels, over one third from renewables and one third from nuclear energy. Fossil fuels include 490 PJ oil products, 80 PJ coal products (almost exclusively used in heavy industry), 34 PJ natural gas and 7 PJ peat products. Renewable energy sources have a share of 36.9% or 746 PJ – 23.1% bioenergy and 13.8% other renewable energy sources. The statistic also features 33.9% or 688 PJ of nuclear energy in nuclear power stations (which produce 40% of national electricity). However, this reflects total primary energy supply; due to the high thermal losses in nuclear energy, the share of nuclear is lower in final energy consumption, and the share of renewable energy is higher.

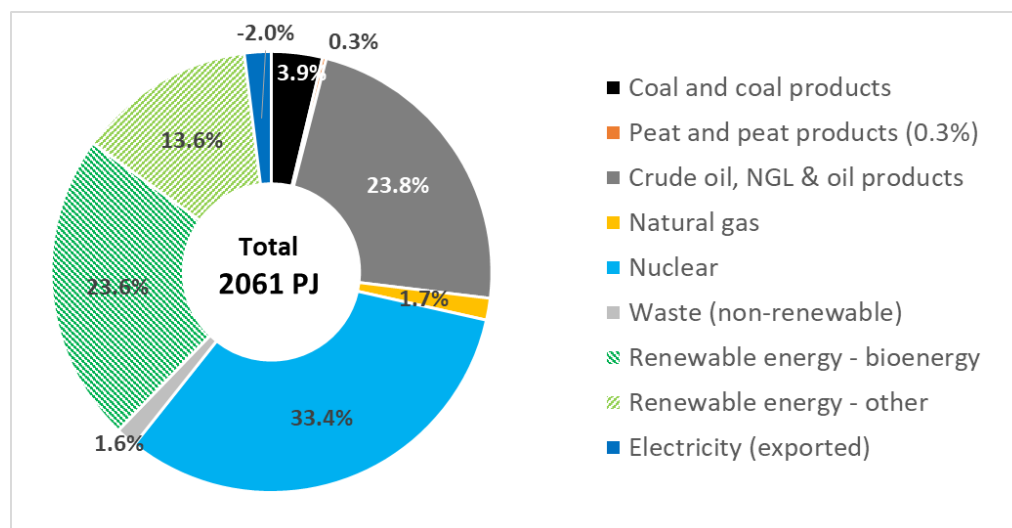


Figure 1: Total primary energy supply<sup>6</sup> in Sweden in 2016 (Source: World Energy Balances © OECD/IEA 2018)

Compared to 5 years earlier (2011) the shares of all fossil fuels have gone down, with oil products from 27.7% to 23.8%, coal products from 4.4% to 3.9%, peat products from 0.7% to 0.3% and natural gas from 2.3% to 1.7%. In the same period the share of renewable energy increased from 32.9% to 37.2%,

<sup>6</sup> TPES underestimates the actual role of pure electricity sources like PV, wind or hydro energy, and overestimates the role of resources producing electricity with a high share of unused waste heat (like nuclear, coal).

but also nuclear energy increased from 31.8% to 33.4% and exported electricity from 1.3% to 2.0%.

Bioenergy represents 63% of total primary energy supply from renewable energy sources with 485 PJ, followed by hydropower (222 PJ) and wind energy (56 PJ). The role of solar energy is marginal.

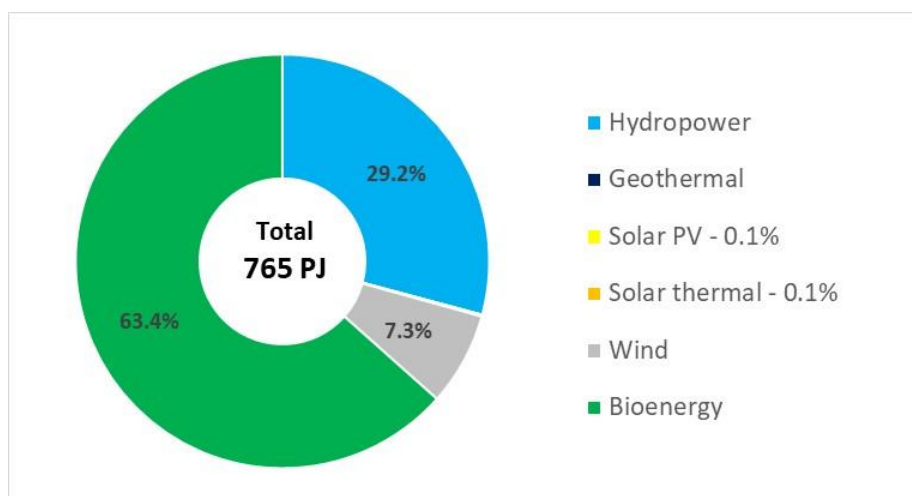


Figure 2: Total primary energy supply of Renewable Energy Sources in Sweden in 2016 (Source: World Energy Balances © OECD/IEA 2018)

With a share of 81% (394 PJ), bioenergy in Sweden is predominantly from solid biomass, mostly in forest based industries (chips, bark, sawdust) and pulp and paper industries (black liquor), where it is used for the production of process heat and electricity. It should be mentioned that black liquor (158 PJ) is counted in the category of solid biofuels. Around 38 PJ of solid biomass is used in the residential sector. Apart from solid biomass, the next item is biodiesel (41 PJ), followed by renewable MSW (35 PJ) and smaller shares of biogas (7.3 PJ), biogasoline<sup>7</sup> (4.7 PJ) and other liquid biofuels (3.1 PJ).

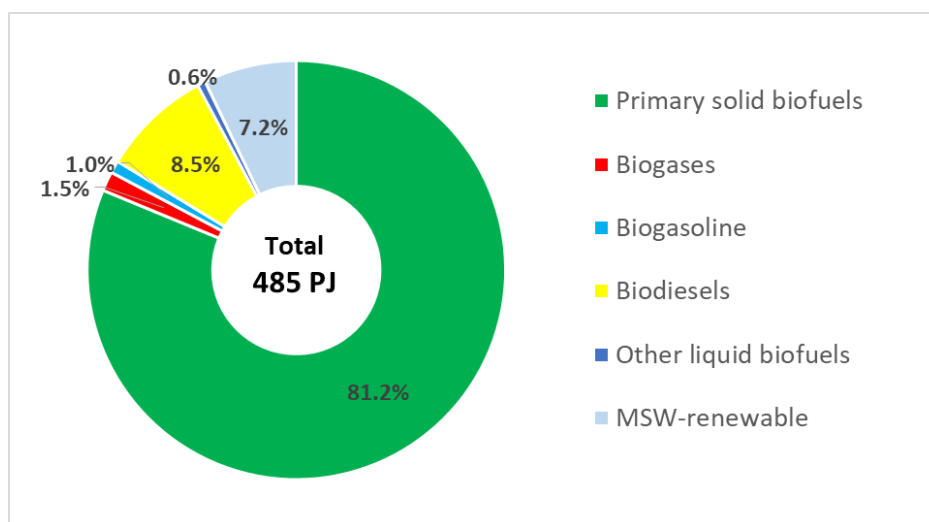


Figure 3: Total primary energy supply from bioenergy in Sweden in 2016 (Source: World Energy Balances © OECD/IEA 2018)

<sup>7</sup> Predominantly bio-ethanol (see IEA definitions)

Bioenergy consumption in Sweden increased steadily from 1990 to 2010, from 11% of TPES in 1990 to 22% in 2010. In 1990 bioenergy merely came from *solid (forest) biomass* and accounted for 216 PJ. After a continuous growth up to 400 PJ in 2010, the use of solid biomass stabilized after 2010 at around 380-400 PJ. *Liquid biofuels* increased from 9 PJ in 2005 to 26 PJ in 2010; after a small drop in 2011, its share continued to grow further to 49 PJ in 2016. While until 2010 bio-ethanol was the most important liquid biofuel, it has lost market share since then. Biodiesel overtook bioethanol after 2011 and continued to grow fast (from 7.4 PJ in 2010 to 42.7 PJ in 2016). Swedish consumption of liquid biofuels is primarily based on imports, with about 10-15% supplied by domestic production. *Biogas* saw a continuous growth from 1.2 PJ in 2005 up to 7.3 PJ in 2016. *Renewable MSW* had its main growth between 2005 and 2010 (from 12 PJ to 30 PJ), and continued at a somewhat smaller growth rate of around 3% per year afterwards, reaching 38 PJ in 2015.

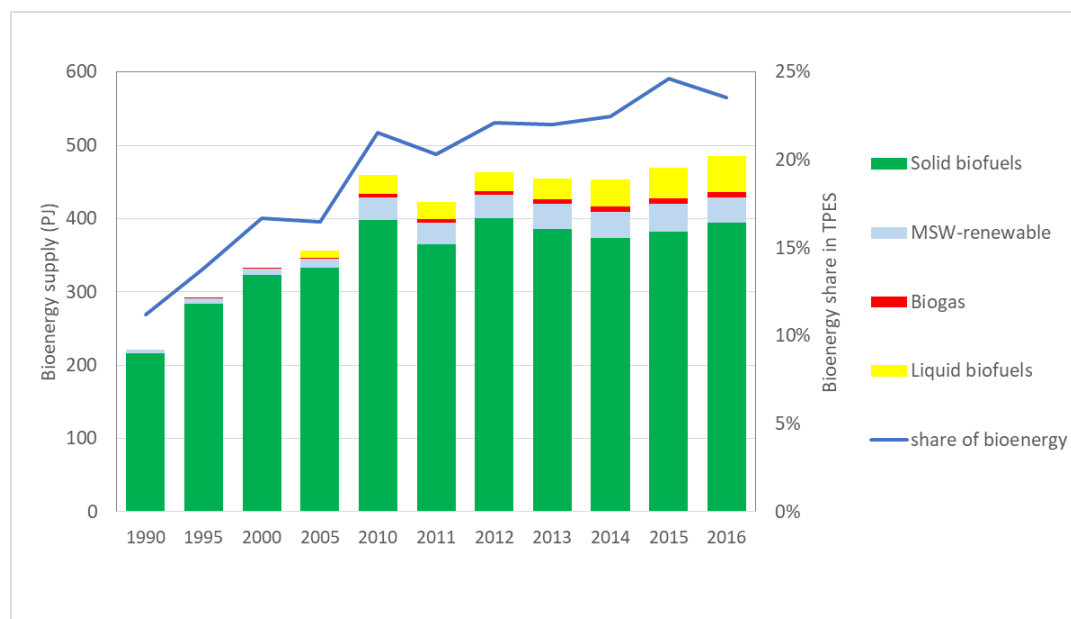


Figure 4: Development of total primary energy supply from bioenergy in Sweden 1990 – 2016 (Source: World Energy Balances © OECD/IEA 2018)

Table 2 expresses the 2016 TPES figures per capita, considering Sweden’s population of 9.92 million people. Compared to the other 22 member countries of IEA Bioenergy (expressed per capita), Sweden ranks highest for biofuels, 2<sup>nd</sup> for solid biomass (after Finland) and for renewable MSW (after Denmark). For biogas, Sweden ranks halfway compared to the other IEA Bioenergy members.

Table 2: Total primary energy supply per capita in 2016

	GJ/capita
<b>Total energy</b>	207.8
<b>Bioenergy</b>	48.9
<b>Solid biofuels</b>	39.8
<b>Renewable MSW</b>	3.5
<b>Biogas</b>	0.7
<b>Liquid biofuels</b>	4.9

Source: World Energy Balances © OECD/IEA 2018

## Role of bioenergy in different sectors

Sweden has a relatively high share of renewable electricity, of which 70% is related to hydropower and the rest divided between wind and biomass.

The share of biofuels for transport amounts more than 16% in 2016, which is much higher than European average.

Overall, the direct share of biomass for heating in the different sectors is around 45%. Heat output generated and sold by CHP plants and heat plants represents around 35% of fuel/heat provided, of which on average 70% is produced from biomass (another 10% from the non-renewable part of waste). In the residential sector direct use of biomass represents about 27% of fuel/heat consumption, another 72% is provided through district heating (which is largely based on biomass).<sup>8</sup> Mind that heat pumps or direct use of electricity for heat are not included in these figures of fuel/heat consumption.

**Table 3:** Role of bioenergy and renewable energy in electricity production, transport and heat production/consumption in 2016

Sector	Share of bioenergy	Share of renewable energy	Overall production/consumption
<b>Electricity production</b>	7.4%	57.2% (38.8% hydro)	156 TWh (561 PJ)
<b>Transport energy (final consumption)</b>	16.1%	17.7%	342 PJ
<b>Overall fuel and heat consumption<sup>9</sup></b>	Direct biomass: 44.3% Biobased heat: 24.3%	68.7%	513 PJ

Source: World Energy Balances © OECD/IEA 2018

According to Eurostat<sup>10</sup>, the following renewable energy shares in gross final energy consumption were reached in Sweden in 2016:

- Overall share: 53.8%
- In heating and cooling: 68.6%
- In electricity: 64.9%
- In transport: 30.3%

Both the overall share and the individual sectors have exceeded the renewable energy targets for 2020 (see Table 1). Mind that some of these figures can differ from the IEA derived data because of different accounting rules. This is particularly the case for transport biofuels, e.g. where cellulose or residue/waste based biofuels are double-counted towards the EU target.

<sup>8</sup> Personal communication Olle Olsson: Space heating in Sweden is about 55% district heating, 35% heat pumps & direct electricity, 7% biomass and the rest heating oil & natural gas.

<sup>9</sup> This includes final consumption of fuels and heat in industry, the residential sector, commercial and public services and agriculture/forestry. Transport fuels are excluded. Energy used for transformation and for own use of energy producing industries is also excluded.

<sup>10</sup> [http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg\\_ind\\_335a&lang=en](http://appsso.eurostat.ec.europa.eu/nui/show.do?dataset=nrg_ind_335a&lang=en)

## RESEARCH FOCUS RELATED TO BIOENERGY

Sweden has a very high proportion of renewable energy production, due to long-standing utilisation of bioenergy and hydroelectric installations and recent advances in the deployment of wind power.

Various funding programmes are dedicated to research on hydropower, wind power, solar cells, sustainable biomass production and conversion into district heating as well as CHP plants. Bioenergy has been given high priority in the R&D portfolio. Over the years, Swedish energy R&D has covered the main economically and environmentally relevant bioenergy topics. The three most ambitious projects up to 2017 in Sweden's overall energy R&D portfolio all concern development of new bioenergy technologies and processes: gasification of black liquor, fermentation of woody cellulose, and synthesis of liquid fuels via gasification. These technologies have all been considered central for advancing the current use of bioenergy. In summer 2018 the Swedish Energy Agency announced a large project, contributing 50 million € to set up a pilot plant to do tests on hydrogen-based steel production. The biomass component in this project is relatively small.

Mainly the energy research programs in Sweden are managed by the Swedish Energy Agency (SEA). In 2017 the Energy RD&D programme covered some 60 active sub-programmes and 1600 projects. For a detailed description on current R&D programmes please see the webpage of the energy agency (<http://www.energimyndigheten.se/>). During 2017- 2020 the research aims at solving five challenges for the future sustainable energy system. The challenges are closely linked and are: a total renewable energy system, a resource-efficient energy system, a robust and stable energy system, interaction (team play) in the system, as well as innovation as a tool for jobs and climate.

## RECENT MAJOR BIOENERGY DEVELOPMENTS

The first bio-SNG plant at industrial scale in the world, GoBiGas in Gothenburg, was taken into operation in 2014. The plant provided 20 MW (160 GWh) of bio-methane to the gas grid. The outcome from the demonstration is that the technology is ready for large scale deployment, applying commercially mature components, for which the production cost will be in the range of 0.55 € per litre gasoline equivalent (feedstock 35% of cost) at present feedstock price of woody biomass in the region. The demonstration was finalized in March 2018 and the plant is at present conserved to be able to be recommissioned if the right markets condition come in place.

Forest biomass by-products such as tall oil and lignin are co-processed, or piloted to be co-processed, respectively, in a fossil refinery. Tall oil is used on a commercial scale by Sunpine in a new factory in Piteå to produce HVO biodiesel (100 000 tonnes/year).

Preem and Vattenfall recently published plans to use electrolysis to produce the hydrogen gas used for HVO biodiesel.<sup>11</sup>

Preem and RenFuel are assessing, in collaboration with Rottneros, the construction of the world's first lignin plant for biofuels, at a pulp mill in Vallvik, Söderhamn. The plant is expected to produce an annual volume of 25,000-30,000 tonnes of lignin, and will be completed in 2021.<sup>12</sup>

The world's largest biomass CHP was inaugurated in May 2016 in Stockholm, owned by Fortum and the City of Stockholm. The plant is located in central Stockholm and is entirely supplied with woodchips (2.5

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<sup>11</sup> <http://news.cision.com/vattenfall/r/swedish-energy-agency-supports-preem-and-vattenfall-s-planned-hydrogen-gas-plant-in-gothenburg,c2567838>

<sup>12</sup> <http://news.cision.com/rottneros-ab/r/preem-and-renfuel-to-create-the-world-s-first-lignin-plant-for-biofuels,c2530611>

TWh/y) and supplies district heat to 190 000 households.

New CHPs using biomass and waste have been built in the last years also in Västerås, Linköping, Norrköping, Växjö, Jönköping, Gävle, Karlstad, Lund, and a number of other cities – a total investment of 30 billion SEK.

The use of fossil fuels in the forest industry, which is the biggest energy user in Swedish industry, has decreased by 73% in the last ten years. Oil has been substituted with pellets and bio-oils, mainly in recovery boilers in the pulp industry.

The carbon tax has been increased in recent years in industries and other businesses outside ETS. This increase is promoting conversion from fossil fuels to wood fuels, bio-oils and district heating in breweries, dairies, asphalt preparation, etc. The Swedish greenhouses have in general switched from oil and gas to biomass and industrial waste heat.

Biofuels for transport has expanded quickly on the transport fuel market in recent years and in 2016 Biofuels accounted for 18.8 % of all sold transport fuels compared to 5.1% in 2011. The largest share was HVO that accounted for two thirds of all biofuels, equalling 25% of all diesel sold. HVO is based on feedstocks like tall oil, animal fats, and recovered vegetable oils.

## LINKS TO SOURCES OF INFORMATION

The following websites provide useful information and data on national Swedish bioenergy policy, production and consumption.

- National Renewable Energy Action Plan (NREAP): [http://ec.europa.eu/energy/renewables/action\\_plan\\_en.htm](http://ec.europa.eu/energy/renewables/action_plan_en.htm)
- Swedish Energy Agency statistics: <https://www.energimyndigheten.se>
- Sweden. The framework: energy policy and climate change: [http://www.iea.org/textbase/nppdf/free/2013/sweden2013\\_excerpt.pdf](http://www.iea.org/textbase/nppdf/free/2013/sweden2013_excerpt.pdf)
- An integrated climate and energy policy framework: "A sustainable energy and climate policy for the environment, competitiveness and long-term stability"
- Energy Efficiency Policies and Measures in Sweden: <http://www.odyssee-mure.eu/publications/national-reports/energy-efficiency-sweden.pdf>
- The Swedish Climate Strategy: <http://www.government.se/contentassets/32e5a14843804c07a22c874b7418f79f/the-swedish-climate-strategy-a-summary>
- Swedish board of forestry: [www.skogsstyrelsen.se](http://www.skogsstyrelsen.se)
- Sweden large forest research programme: [www.futureforests.se](http://www.futureforests.se)
- The forest research institute: [www.Skogforsk.se](http://www.Skogforsk.se)

Relevant ministries in Sweden are:

- Ministry of Enterprise and Innovation: <http://www.government.se/government-of-sweden/ministry-of-enterprise-and-innovation/>
- Ministry of Education and Research: <http://www.government.se/government-of-sweden/ministry-of-education-and-research/>
- Ministry of Environment and Energy: <http://www.government.se/government-of->



[sweden/ministry-of-the-environment/](http://www.svebudsjetten.se/engelska/2014-01-29/2014-01-29-sweden/ministry-of-the-environment/)

- Ministry of Finance: <http://www.government.se/government-of-sweden/ministry-of-finance/>

Relevant stakeholders in academia and industry:

- Swedish Environmental Protection Agency: <http://www.swedishepa.se>
- IVL Swedish Environmental Research Institute: <http://www.ivl.se>

Funding organizations at national level:

- Swedish Energy Agency (SEA): <https://www.energimyndigheten.se/en>
- Swedish Government Agency for Innovation Systems (Vinnova): <http://www.vinnova.se/en>
- Swedish Research Council (Vetenskapsrådet): <http://www.vr.se>
- Swedish Research Council for Environment, Agricultural Sciences and Spatial Planning (FORMAS): <http://www.formas.se/en>

Programmes and initiatives: Competence Centres

- Biogas Research Centre (BRC): <http://www.liu.se>
- Competence Center Combustion Processes (KCFP): <http://www.lth.se/kcfc/english/>
- Swedish Center of Excellence in Electrical Power Engineering (EKC<sup>2</sup>): <http://researchprojects.kth.se>
- Competence Centre for Catalysis (KCK): <http://www.kck.chalmers.se>
- High Temperature Corrosion Centre (HTC): <http://www.htc.chalmers.se>
- Combustion Engine Research Center (CERC): <http://www.chalmers.se>
- Competence Center for Gas Exchange (CCGEx): <http://www.kth.se/en/itm/inst/mmk/forskning/centra/ccgex-competence-center-for-gas-exchange-1.279297>
- Swedish Gasification Centre: <http://www.ltu.se/centres/Svenskt-forgasningscentrum-SFC>
- The Swedish Knowledge centre for renewable transportation fuels: <http://www.f3center.se/>
- ETC Energy Technology Center: [www.sp.se/Etc](http://www.sp.se/Etc)