Sweden’s long-term strategy for reducing greenhouse gas emissions

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Government Offices of Sweden
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Index

Summary

Purpose
Long term strategies shall contribute to fulfilling Parties commitments under the UNFCCC and the Paris Agreement to reduce anthropogenic greenhouse gas emissions and enhance removals by sinks, and to promote increased carbon sequestration. Reporting concerns national long-term objectives for territorial emissions. This document constitutes Sweden's reporting and derives from Sweden's existing targets, and policy instruments and actions decided on in the field of energy and climate. The strategy is largely based on the national climate policy framework and Government Bill[1] En samlad politik för klimatet – klimatpolitisk handlingsplan (A coherent policy for the climate – climate policy action plan).

The Swedish Climate Policy Framework
Under the Paris Agreement, all countries are to contribute towards holding the increase in the global average temperature to well below 2 °C and pursuing efforts to limit the temperature increase to 1.5 °C. This demands wide-ranging action to reduce greenhouse gas emissions and also demands that every sector of society plays a part in the climate transition. In 2017, the Swedish Parliament (Riksdag) adopted a climate policy framework with (1) national climate goals, (2) a Climate Act and (3) a Climate Policy Council.

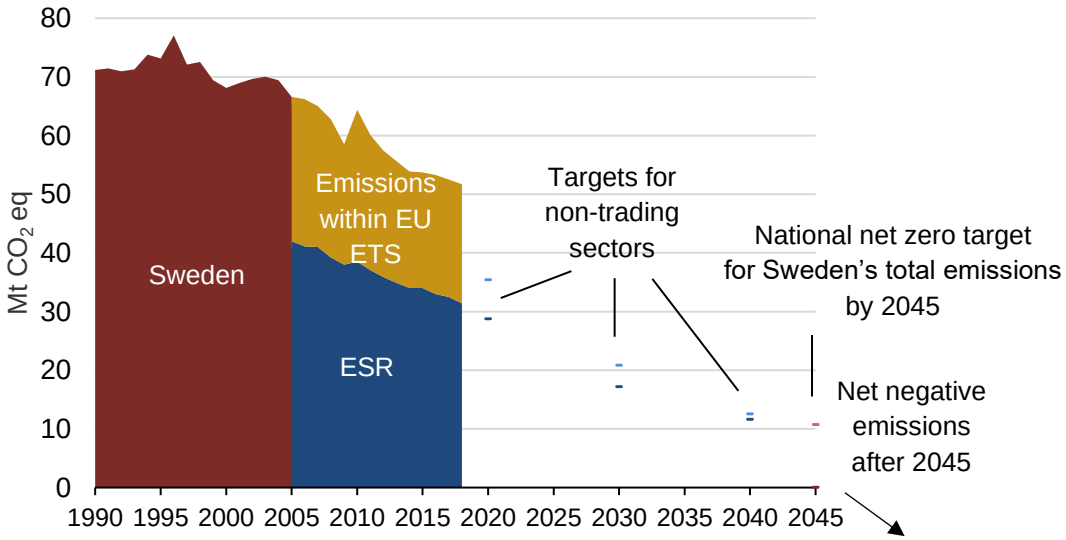
The climate policy framework's long-term climate goal establishes that, by 2045 at the latest, Sweden is to have zero net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions. By 2045, greenhouse gas emissions from Swedish territory are to be at least 85 per cent lower than emissions in 1990. To achieve net zero emissions, supplementary measures may be counted in line with rules decided at international level. Supplementary measures may be (1) increased net removal of carbon dioxide in forests and land, (2) verified emission reductions from investments in other countries, and (3) negative emission technologies such as capture and storage of biogenic carbon dioxide (BECCS).

Milestone targets for Swedish territorial emissions in the sectors covered by the EU's Effort Sharing Regulation have been adopted for 2020, 2030 and 2040, see Figure 1. Emissions from domestic transport, excluding domestic

[1] Prop 2019/20:65

aviation which is included in the EU ETS, are to be reduced by at least 70 per cent by 2030 compared with 2010.

Figure 1. Sweden's climate targets (with and without the opportunity to use supplementary measures) and historical emissions



Sweden's Climate Act imposes an obligation on current and future governments to pursue a policy based on the national climate goals. The Act contains elements that ensure that the policy is planned and followed up.

Sweden's Climate Policy Council is an independent expert body tasked with evaluating whether the overall policy decided by the Government is compatible with the climate goals.

The EU's climate policy has a major impact on how Swedish policy can be conducted. The EU's current climate target is to cut greenhouse gas emissions by at least 40 per cent in the EU by 2030 compared to 1990. In September 2020 the European Commission presented its 2030 Climate Target Plan which proposed to increase the target to at least 55 per cent. The EU's heads of state and government are expected to endorse such an enhanced target at the end of 2020.

The emissions covered are territorial and do not include the emissions that the EU causes outside the EU's borders. A number of policy instruments at EU level, including emission standards for vehicles and emissions trading are very important to Sweden's possibility to meet its own national targets.

Sweden uses a number of national and EU-wide policy instruments to meet the national climate goals. Emissions pricing forms the basis of governance and is supplemented by targeted initiatives. The policy instruments in Sweden and the EU span all sectors of society. It is estimated that they will help to achieve the targets but that further measures will be needed to fully attain them. Areas of possible actions to attain the long-term climate target have been identified in the respective sectors. Government spending on climate related initiatives has increased substantially in recent years.

Table 1. Overview of key policy instruments and measures impacting on the national climate targets (EU instruments are marked with an asterisk)

Transport	**Industry**	**Electricity and district heating**	**Homes and premises**	**Non-road mobile machinery**	**Waste**	**Agriculture**	**LULUCF**
Energy and carbon tax	Energy and carbon tax	Energy and carbon tax	Energy and carbon tax	Energy and carbon tax	Ban on combustible and organic waste in landfill	CAP*	Forestry Act
Emission reduction targets for new vehicles*	EU ETS*	EU ETS*	Eco-design Directive*	Reduction obligation	Collection of methane from landfill	Aid for manure gas	Environmental Code rules on land drainage
Reduction obligation	Industrikliv et (the Industrial Leap)	The Electricity Certificate System	Energy Labelling Directive*	Procurement requirements	Waste hierarchy in the Environmental Code		Protecting forest and land in the Environmental Code and nature conservation agreements
Bonus-malus system	Energy and climate coaches	Promoting wind power	Building regulations		Landfill tax		The National Forest Programme
Tax reduction for eco-friendly cars	Energy surveys for companies	Support for solar energy	Training programme for low energy buildings		Producer responsibility		Advice and training
Carbon dioxide-based vehicle tax	Energistegt (energy efficiency grants for industry)	Tax reduction for microproduction of renewable energy	Energy and climate advice		Municipal waste planning		
Klimatkliv et (local investment grants)	Energy efficiency networks		Energy declarations*				
Climate premium	Klimatklivet (lthe Climate Leap)		Market launch, technology development, innovation clusters				
Act on the Obligation to Supply Renewable Fuels	Environmental Code						
	EU Regulation on fluorinated		Information centre for sustainable				

Urban environment agreements	greenhouse gases	construction
Long-term infrastructure planning		
Eco bonus for shipping		
Tax on air travel		
EU ETS (aviation)*		

The costs related to climate change and the cost of *failing to act* will be very high. Several reports[2] have shown that the costs of not taking action widely exceed the costs of doing so.

The economic consequences of national policy to attain Sweden's national climate goals are hard to calculate. Many of the consequences will depend on *how* Sweden reaches the goals and under which conditions. In recent decades, Sweden has succeeded in combining reduced emissions with strong economic development.

A long-term and stable climate policy is needed if Sweden is to lead the way on a global transition. A broad parliamentary majority backs the decision made in 2017 on the climate policy framework. It is also vital that Sweden involves a broad range of groups in producing and implementing the policy and that different actors in society are given every opportunity to play their part in the climate transition. Several large actors in Sweden have already shown that they have the desire, ambition, conditions and opportunity to make their operations climate-friendly while retaining competitiveness. In the initiative for a Fossil Free Sweden instigated by the Swedish Government, a considerable number of sectors and industries have themselves drawn up roadmaps towards very low or zero emissions. The initiative is an important platform for dialogue and cooperation between key actors for a competitive climate transition.

[2] See for example UNEP, 2019, "Changing Course". https://www.unepfi.org/wordpress/wp-content/uploads/2019/05/TCFD-Changing-Course-Oct-19.pdf

1 Introduction

Sweden is pleased to submit its long-term strategy in accordance with article 4.19 of the Paris Agreement, complementing the submission by Croatia and the European Commission dated 6 March 2020. The Swedish long-term strategy builds on our submission to the European Commission in response to Regulation (EU) 2018/1999.

Climate developments are deeply concerning. The IPCC's special report from October 2018 on the impacts of a global warming of 1.5 °C shows very far-reaching consequences of a temperature rise of two degrees. Global warming is proceeding at such a pace that ecosystems are unable to adapt in time. Humans depend on well-functioning ecosystems, making climate change one of the greatest threats of our age. The decisions we make today are vital for the planet and for future generations.

Through the Paris Agreement, the countries of the world have committed to limiting global warming to less than 2 °C above pre-industrial levels and pursuing efforts to limit the increase to 1.5 °C. The average global temperature has already increased by approximately 1,1 °C compared with pre-industrial levels and is continuing to rise by around 0,2 degrees per decade.

Though the issue of climate change is now prioritized on the global agenda and investments in fossil-free technology are hitting record heights in Sweden and across the globe, we have not yet seen a clear and persistent turnaround in the upward trend in emissions. In Sweden, territorial emissions have been reduced over time, but progress is too slow. Additional measures are needed if Sweden is to be able to live up to the commitments made in the Paris Agreement, to reach its national emission targets and to attain the Government's ambition of becoming the world's first fossil-free welfare nation.

The climate goals must be met. Several major climate measures, such as the Klimatklivet initiative (the Climate Leap), the reduction obligation, a bonus–malus-system for new light vehicles, the urban environment agreements, and the industrial green investment aid programme Industriklivet (the Industrial Leap) are now in place. These reforms pave the way for the transition that Sweden has begun and entail us to take important steps towards a society that is not dependent on fossil fuels.

More ambitious policy instruments are needed, and the climate transition needs to be made in such a way that everyone has an opportunity to be part of the solution. All sectors of society at all levels (local, regional, national and international) need to play their part in the transition towards sustainable, fossil-free development. For this to happen, climate policy needs to be integrated into all relevant policy areas and at all levels in society. Sweden has taken some important steps on this route already. The Government decides the rate of emission mitigation and whether they need to increase for the climate targets to be met through existing instruments and new measures.

More than 400 actors from the business community, municipalities, regions, research institutions and civil society organisations are working together in the Fossil Free Sweden initiative to achieve this aim. 22 sectors have so far produced and submitted roadmaps for fossil-free competitiveness to the Government. This includes large emitting sectors such as steel, cement, mining and minerals and the automotive sector.

The roadmaps contain proposals for how the sectors intend to bring about the transition to fossil-free operation and what the Government can do to facilitate this.

Sweden is one of the countries in the world that has the capacity to lead the way and show that a fossil-free society is possible. Besides the Swedish Climate Act and ambitious emission targets, there is a broad consensus behind the climate transition among the Swedish people and in the Swedish business community. Swedish companies lie at the forefront in offering innovative solutions. The Government is determined to meet the national climate goals and to fulfil Sweden's commitments under the Paris Agreement.

2 Sweden's climate policy framework

Under the Paris Agreement, all countries are to contribute towards holding the increase in the global average temperature to well below 2 °C and pursue efforts to limit it to 1.5 °C. This demands wide-ranging action to reduce greenhouse gas emissions and that every sector of society plays a part in the climate transition. The climate perspective needs to be integrated in all policy areas and at all levels in society.

In 2017, the Swedish Parliament (Riksdag) adopted a climate policy framework for Sweden. The framework was supported by a broad parliamentary majority and comprises of three parts: *national climate goals*, *a Climate Act* and a *Climate Policy Council*. The climate policy framework brings stability to climate policy and sets long-term conditions for business and society. The framework is a key component in Sweden's efforts to comply with the Paris Agreement.

2.1 Sweden's national climate goals

There are four main aspects to Sweden's national climate goals:

- An overarching environmental quality objective linked to reducing the average global temperature increase (with no time frame).
- A long-term emissions target for Sweden for 2045.
- Milestone targets for Swedish emissions covered by the EU's effort sharing regulation (i.e. outside the EU Emissions Trading System) for 2020, 2030 and 2040.
- A milestone target for domestic transport (aviation excluded) for 2030.

2.1.1 The Swedish environmental quality objective – *Reduced Climate Impact*

To provide a clear structure for environmental efforts in Sweden, the Parliament already in 1999 adopted 16 environmental quality objectives. One of these, the Reduced Climate Impact, underlies Sweden's action in combatting climate change and that Sweden will work internationally for global efforts to be directed towards achieving the temperature goal of the Paris Agreement.

2.1.2 A long-term emission target for 2045

By 2045 at the latest, Sweden is to have no net emissions of greenhouse gases to the atmosphere, after which negative emissions are to be attained. The target means that by 2045 at the latest, greenhouse gas emissions from Swedish territory are to be at least 85 per cent lower than emissions in 1990. To achieve this aim, the capture and storage of carbon dioxide emanating from fossil fuels may be counted as a measure where no other viable alternatives exist. Emissions from fuels used for international aviation and maritime transport are not included in the target. Emissions and removals from land use, land use change and forestry are not included directly.

To achieve net zero emissions, supplementary measures may be counted in line with rules decided at international level. Supplementary measures may be (1) increased net removal of carbon dioxide in forests and land, (2) verified emission reductions from investments in other countries, and (3) capture and storage of biogenic carbon dioxide (BECCS).

Emissions are calculated in line with Sweden's international reporting of greenhouse gases.

2.1.3 Milestone targets for 2020, 2030 and 2040

The Swedish Parliament has decided on three milestone targets to limit cumulative emissions and ensure a course that is feasible. The milestone targets apply to emissions outside the EU ETS[3] in the ESR sector[4]. The targets are as follows:

- In 2020, greenhouse gas emissions in Sweden in the ESR sector are to be 40 per cent lower than in 1990. The Government's ambition is to reach the target with national measures.

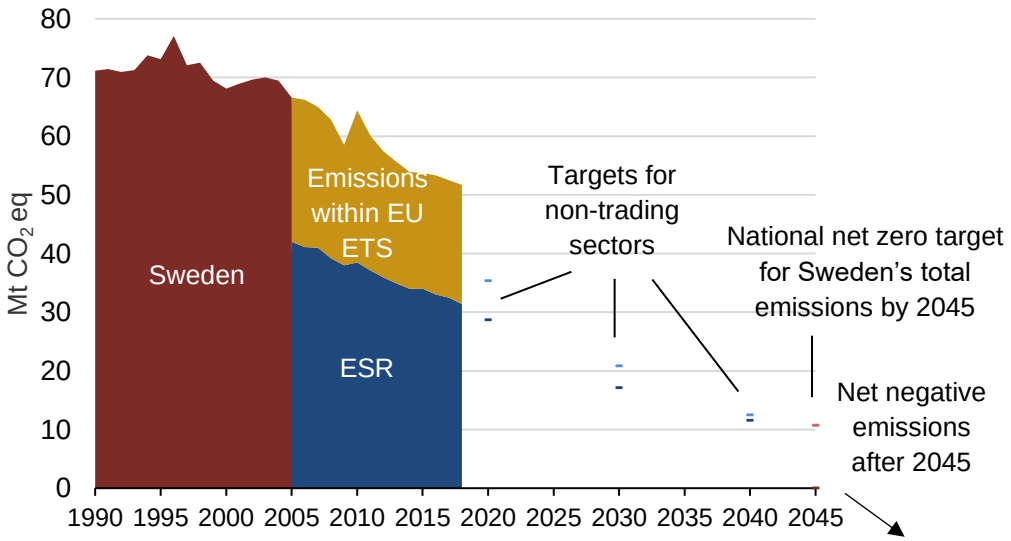
- By 2030 at the latest, greenhouse gas emissions in Sweden in the ESR sector are to be at least **63** per cent lower than emissions in 1990. A maximum of 8 percentage points of the reduction in emissions may be achieved through supplementary measures.

- By 2040 at the latest, emissions in Sweden in the ESR sector should be at least 75 per cent lower than emissions in 1990. A maximum of 2 percentage points of the reduction in emissions may be achieved through supplementary measures.

[3] The EU Emissions Trading System

[4] ESR stands for the Effort Sharing Regulation which regulates national emissions in EU Member States. Between 2013 and 2020 this is termed the ESD, Effort Sharing Decision.

Figure 2. Sweden's climate targets (with and without the opportunity to use supplementary measures) and historical emissions



Facts: What is covered by the EU ETS and the ESR sector?
The EU Emissions Trading System covers emissions of carbon dioxide, nitrous oxide and perfluorocarbons from combustion installations and energy-intensive sectors (mineral oil refineries, coke ovens, the iron and steel industry, the pulp and paper industry and the mining industry). Carbon dioxide emissions from aviation in the EEA are also part of the EU ETS.

ESR stands for the Effort Sharing Regulation and includes emissions that are not included in the EU ETS (domestic transport (apart from aviation), agriculture, non-road mobile machinery, waste, houses and premises, fluorinated greenhouse gases (F-gases), use of solvents, and emissions from industry and energy supply facilities not covered by the EU ETS).

2.1.4 A milestone target for domestic transport

The transport sector currently accounts for almost a third of Sweden's greenhouse gas emissions. However, there are major opportunities to reduce emissions in the sector. The Parliament has decided on a separate milestone target for domestic transport:

- Emissions from domestic transport (excluding domestic aviation, which is part of the EU ETS) are to be reduced by at least 70 per cent by 2030 compared with 2010.

2.1.5 Supplementary measures to meet the targets for 2030, 2040 and 2045

To achieve the long-term target by 2045 at the latest and the milestone targets, supplementary measures may be counted in line with rules decided at international level. Supplementary measures primarily include net removals

in forest and land, verified emission reductions through investment in other countries and bioenergy with carbon capture and storage (bio-CSS). The supplementary measures need to increase after 2045 to attain net negative emissions.

2.1.6 Consumption-based emissions

Sweden's long-term emissions targets and milestone targets for 2020, 2030 and 2040 follow the UN's and the EU's reporting methods and refer to emissions and removals of greenhouse gases within Sweden's borders, known as territorial emissions and removals. Consumption-based emissions give additional information to territorial emissions by reflecting the total climate impact of the Swedish population, including emissions from goods and services produced in other countries and used in Sweden as well as emissions arising from travel abroad. Calculations from Statistics Sweden (SCB) show that emissions arising as a result of Swedish consumption of goods and services amounted to around 90 million tonnes of carbon dioxide equivalents in 2017. Since 2008, consumption-based emissions have decreased by around 10 per cent, but they have increased again in the latest years.

2.2 Sweden's Climate Act

The Climate Act imposes an obligation on current and future governments to pursue a policy based on the national climate goals, to regularly report to Parliament on developments and to present a Climate Policy action plan every four years. Statutory regulation makes it difficult for a government to act in a way that counteracts with the climate goals or to pursue a policy that is insufficient to attain them. One key starting point for the Climate Act is enabling climate policy and budget policy objectives to interact with each other.

Under the Climate Act, the Government is to present a *climate report* in the Budget Bill each year. The report makes it easier to monitor and evaluate the combined climate effects of all policy areas and must contain a description of emission trends in relation to the targets. The report is also to describe the most important decisions made during the year and the effects of these on the development of reducing greenhouse gas emissions and have to contain an evaluation of whether there is a need for further measures.

The Climate Act also states that the Government must produce a *climate policy action plan* every four years. The purpose of the action plan is to show

how the Government's combined policy in all relevant expenditure areas as a whole is contributing to attaining the milestone targets by 2030 and 2040 and the long-term emission target by 2045. If the Government finds that the targets decided cannot be attained with the current policy instruments, the action plan is to contain an account of the reasons for this and the additional measures the Government intends to take. The plan is also to contain a report on how other decisions and measures, both at national and at international level affect Sweden's ability to attain the climate targets. The Government presented the first climate policy action plan in line with the Climate Act in December 2019

2.3 A Climate Policy Council

The Swedish *Climate Policy Council* began its work in 2018. The Council is a cross-sectoral expert body tasked with assisting the Government with an independent evaluation of whether the combined policy decided by the Government is compatible with the climate targets. The role of the Council is based on the complexity of climate policy and the fundamental importance of all policy areas taking concerted and integrated responsibility. The Council comprises of members with a high level of scientific expertise in the fields of climate, climate policy, economics, political science and behavioural science.

In particular, the Climate Policy Council is to:

1. evaluate whether the direction of various relevant policy areas is contributing to or counteracting opportunities to attain the climate goals,
2. shed light on the impacts of decided and proposed policy instruments from a broad societal perspective,
3. identify policy areas where additional measures are needed,
4. analyse how the goals can be attained in a cost-effective manner in the short and in the long term, and
5. evaluate the knowledge basis and the models on which the Government is building its policy.

The Climate Policy Council is to submit a report to the Government by the end of March each year containing an assessment of how climate efforts and trends in emissions are progressing, an assessment of whether the Government's policy is compatible with the climate goals together with other analyses and assessments conducted by the Council.

In addition, three months after the Government has submitted its climate policy action plan in line with the Climate Act, the Council is to submit a report to the Government evaluating the action plan.

The Climate Policy Council is also to foster greater discussion about climate policy in society.

3 Sweden's current conditions and emissions

3.1 National situation

Sweden's emissions and removals of greenhouse gases are affected, among other things, by factors such as population size, Sweden's climate, energy and transport systems, construction, consumption, industrial structure and the economy in general.

Sweden's population is just above 10 million and the majority of people live in towns and cities. Sweden is the fifth largest country in Europe in terms of land area and has a low population density with an average of 25 inhabitants per km^2. The majority of the population live in the south of the country, and the population density varies between the counties from 3 inhabitants per km^2 in the northernmost county of Norrbotten to 360 inhabitants per km^2 in the county of Stockholm.

Sweden's land area covers approximately 408 000 km^2. Productive forest land is the dominant land cover type, followed by wetlands, mountains and agricultural land. Settlements account for 3 per cent of the total land area and inland water systems cover 9 per cent of this area.

Despite its northern latitudes, much of Sweden has a temperate climate with four distinct seasons and mild temperatures throughout the year. The northern parts of the country, however, have a sub-arctic climate with long, cold, snowy winters. In the period 1961–90 the average temperature in January was 0 °C in southernmost Sweden, while the coldest valleys in the north registered an average temperature of −17 °C. The highest average temperature in July was approximately 17 °C in southern Sweden and just over 10 °C in the northern part of the country.

The average temperature in Sweden has increased considerably in past decades. Since 1988, every year apart from 1996 and 2010 has been warmer or much warmer than the average for 1961–1990. The increase in Sweden's average temperature is now approaching 2 degrees above pre-industrial levels. The equivalent figure for the global average is 1 degree. The much higher increase in Sweden's average temperature is linked to the higher temperature rise in the Arctic.

Sweden is an open economy in which exports account for almost half of the gross national product (GNP). Natural resources, such as forest and iron ore, form the basis of Sweden's industrial production and have, together with the technology industry, laid the foundations for a predominantly export-oriented economy. The service sector is important, both for the industry and in its own right.

The Swedish energy system is partly based on domestic sources of renewable energy, such as hydroelectric power, wind power and biofuel. Moreover, a large proportion of energy 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. Swedish electricity production is largely based on hydroelectric power and nuclear power, but both the installed capacity and annual electricity production from wind power are increasing steadily, as the use of bioenergy in combined heat and power plants. In 2019, hydroelectric power accounted for 39 per cent of total electricity production, nuclear power for 39 per cent and wind power for 12 per cent, while biofuels and fossil-based production made up the remaining 10 per cent. Solar power has increased exponentially in recent years but accounts for only 0,4 per cent of the electricity production.

Between 1970 and 2016 the Swedish economy grew by 164 per cent while total energy consumption only increased by 29 per cent and final energy consumption remained unchanged. For example, the value of industrial production almost doubled, but industrial energy consumption dropped by 7 per cent. The housing and service sector cut its energy consumption, while the total heated area in households and commercial and institutional premises increased. Overall, the total energy intensity in the economy more than halved in this period.

Emissions from domestic transport are dominated by road traffic emissions. Road traffic emitted 15.0 million tonnes of carbon dioxide equivalents in 2018, accounting for 91 per cent of emissions in the transport sector. Of that proportion, cars account for 67 per cent of emissions while heavy goods transport makes up 21 per cent. Other emissions come from light goods vehicles (10 per cent), buses (1 per cent) and mopeds (0.5 per cent). The high emissions from road transport are due to the fact that road traffic is the dominant form of transportation and because the vast majority of vehicles mainly run on petrol and diesel. According to official statistics, shipping only accounts for 4.5 per cent of domestic transport emissions. Rail transport accounts for 0.3 per cent of greenhouse gas emissions from domestic

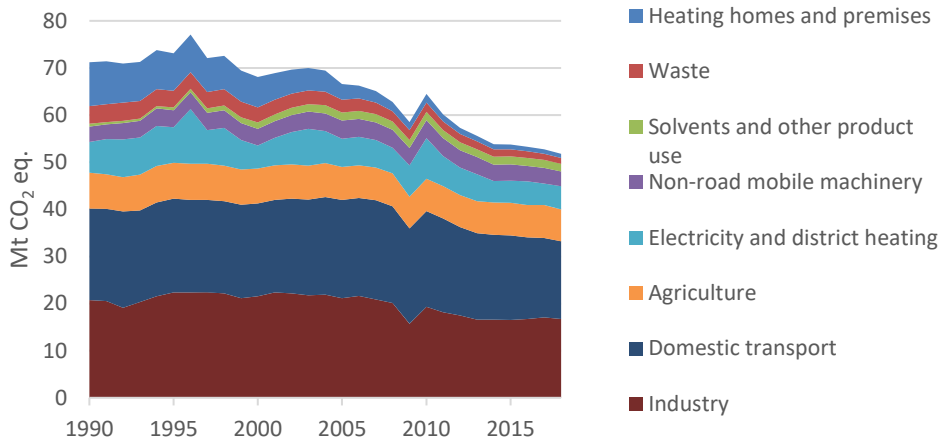
transport, and this is declining over time. Domestic aviation stands for 3 per cent of emissions from domestic transport.

3.2 Sweden's greenhouse gas emissions and removals

Sweden has a high gross national product (GNP) per person, a large industry, long transport distances and cold winters. However, while these factors are generally associated with high greenhouse gas emissions, Sweden's domestic greenhouse gas emissions (also known as *territorial emissions)* are relatively low. Sweden's territorial emissions are equivalent to 5.1 tonnes per person (2018), which is lower than the EU's average of approximately 8.8 tonnes per person and the global average of 6.4 tonnes per person (2017).

Emissions of greenhouse gases within Sweden's borders amounted to 51.8 million tonnes of carbon dioxide equivalents in 2018, excluding the land use sector. Territorial emissions, excluding the land use sector, have fallen by 27 per cent between 1990 and 2018, or 1.8 per cent compared to 2017. The recently published statistics emphasise that the rate of reduction is not sufficient and that there is a need for additional measures to meet the national climate goals. Initiatives are needed both to mitigate emissions covered by the EU ETS and for the activities covered by the EU ESD/ESR. In addition, supplementary measures are needed to attain net zero emissions and negative emissions after 2045. Swedish forests and land removes carbon dioxide and the total removals remain at a high level and in 2018, net removals stood at just under 41 million tonnes of carbon dioxide equivalents.

Figure 3. National greenhouse gas emissions per sector in 1990–2018, millions of tonnes of carbon dioxide equivalents



3.2.1 Historical development of greenhouse gas emissions per sector

Domestic transport

In 2018, greenhouse gas emissions from domestic transport accounted for well under 17 million tonnes of carbon dioxide equivalents, 32 per cent of Sweden's territorial emissions. The transport sector's emissions increased between 1990 and 2007 but has since then seen a decrease over time. Total emissions from the sector have fallen by 15 per cent between 1990 and 2018. The majority, 92 per cent, of the emissions originates from road traffic, while aviation, shipping and rail transport are responsible for a smaller proportion. In terms of road transport, cars and heavy goods vehicles account for the majority of emissions. The lower emissions level is due to an increase in the proportion of biofuels used and the introduction of more energy-efficient technology.

Industry

In 2018, industrial greenhouse gas emissions accounted for just under 17 million tonnes of carbon dioxide equivalents, or 32 per cent of Sweden's total emissions. The highest amounts of emissions come from the iron and steel industry (34%), the minerals industry (19%) and refineries (18%). Emissions in the industry sector have fallen by 19 per cent since 1990. The sectors that have cut emissions the most are the pulp and paper industry (-59%), by switching from fossil fuels to biofuels and electricity in conjunction with a reduction in production, and the food industry (-66%) through reduced use of fossil fuels, mainly oil products but also coal and coke.

Emissions have increased the most in refineries (+33%) due to a rise in production over this period.

Agriculture

In 2018, total greenhouse gas emissions from the agricultural sector amounted to 6.8 million tonnes of carbon dioxide equivalents, or 13 per cent of Sweden's total greenhouse gas emissions. Emissions from the agricultural sector fell by 11 per cent between 1990 and 2018. The most distinct drivers behind the trend are a reduction in the number of livestock and a lowered usage of mineral fertiliser.

Electricity and district heating

In 2018, total greenhouse gas emissions from electricity and district heating production amounted to 4.9 million tonnes of carbon dioxide equivalents, equating to 9 per cent of total territorial greenhouse gas emissions in Sweden. Emissions from electricity and district heating fell by 24 per cent between 1990 and 2018. This reduction is mainly due to biofuel and waste having been substituted for fossil fuels in electricity and district heating production.

Non-road mobile machinery

Greenhouse gas emissions from non-road mobile machinery amounted to 3.1 million tonnes of carbon dioxide equivalents in 2018, equating to approximately 6 per cent of Sweden's territorial emissions. The sector's emissions have risen by 6 per cent since 1990. These emissions come from fuel-powered non-road machinery, including tractors diggers, lawnmowers and snowmobiles as well as tools such as chainsaws. These are used in a variety of sectors such as construction and maintenance of roads, households, services, industry, agriculture and forestry.

Solvents and other product use

In 2018, greenhouse gas emissions from product use had increased by 190 per cent since 1990. Emissions amounted to approximately 1.6 million tonnes of carbon dioxide equivalents in 2018, which equates to approximately 3 per cent of Sweden's territorial emissions. In product use, F-gases[5] account for 64 per cent of emissions. Emissions of F-gases soared up until 2008, as at that point these gases were replacing substances that

[5] F-gases is an umbrella term for a group of greenhouse gases that contain fluorine (F). These gases are used, e.g. for cooling and freezing and have a much more powerful greenhouse gas effect than carbon dioxide.

depleted the ozone layer. In recent years, however, these emissions have been regulated and have started to decrease.

Waste

In 2018, greenhouse gas emissions from waste treatment amounted to 1.3 million tonnes, equivalent to about 2 per cent of Sweden's total greenhouse gas emissions. Emissions have fallen by about 67 per cent compared with 1990. Emissions from the waste sector mainly come from landfills and their emissions of methane, but also from treating wastewater, from biological treatment of solid waste and from non-energy generating waste incineration.

Heating homes and premises

Emissions in this sector amounted to 0.9 million tonnes of carbon dioxide equivalents in 2018, accounting for almost 2 per cent of Sweden's total greenhouse gas emissions. Emissions have fallen by 90 per cent since 1990. The reduction is mainly due to heating with oil being replaced by district heating and heat pumps. This sector covers greenhouse gas emissions from own burning of fuels for heating buildings and producing hot water in homes and premises, including premises in agriculture and forestry. Emissions caused by district heating and electricity used in the sector are not covered here but instead included under electricity and district heating production.

The construction and civil engineering sector

Sweden has a growing population, which brings with it a need for long-term housing construction. Increased housing construction opens up opportunities to make the transition to more flourishing, climate-smart communities. The construction and civil engineering sector accounts for 8 per cent of Sweden's territorial emissions of greenhouse gases. This construction work has a significant impact on emissions in several other sectors (e.g. industry, energy and transport) and in other countries through imports of construction products. Sweden's National Board of Housing, Building and Planning reports on a number of environmental indicators for the sector with the aim of highlighting and monitoring the environmental and climate impact of construction from a lifecycle perspective. Increasing the number of lifecycle analyses of the climate impact of newly constructed buildings also show that the product and construction production phases account for an increasing proportion of the climate impact of buildings.

Forestry and other land use (LULUCF)

This sector includes emissions and removals of greenhouse gases from forest land, arable land, and other land in line with reporting under the UN Climate

Convention. The sector is not included in Sweden's national targets but is, however, included in Sweden's undertakings under the Kyoto Protocol until 2020, and from 2021 onwards will be included in Sweden's commitments to the EU for 2030.

In the period 1990–2018 net removals have increased somewhat to just under 42 million tonnes of carbon dioxide equivalents, but uncertainties in the data are higher for this sector compared with other emission sectors. The size of net removal is mainly affected by annual growth in the forest, harvesting volumes and different types of disruption, such as forest fires and storms. The Swedish forest demonstrates net growth, which means that growth is higher than the amount harvested.

3.2.2 Measures that have reduced greenhouse gas emissions

Measures that have affected emission trends have been carried out over a long period and in some cases started even before 1990. These include:

- expansion of carbon dioxide-free electricity production (hydroelectric power and nuclear power, and, more recently, bio-energy and wind power),
- Expansion of the district heating network and increased use of biofuels and waste fuels in district heating production,
- a shift from oil-fired boilers in domestic heating to electricity including hat-pumps and district heating,
- fuel shift in industry, plus
- reducing landfill of organic waste.

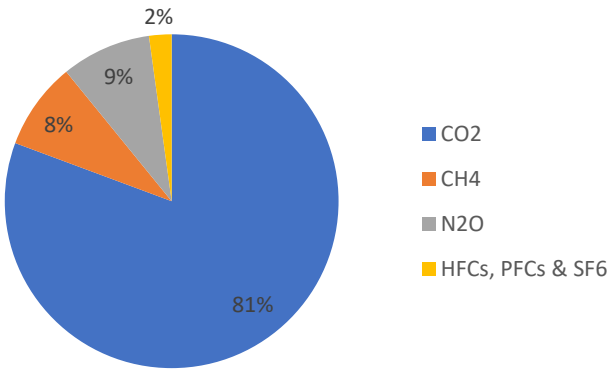
Industry is affected by the economic cycle, which has had a major impact on emissions for particular years and for longer periods in specific sectors.

3.2.3 Total greenhouse gas emissions by gas

In 2018, emissions (excluding LULUCF) of carbon dioxide (CO_2) of fossil origin amounted to 41.8 million tonnes, equating to 81 per cent of total greenhouse gas emissions calculated as carbon dioxide equivalents. The energy sector, including transport, is the largest source of carbon dioxide emissions in Sweden. Methane (CH_4) emissions amounted to 4.4 million tonnes of carbon dioxide equivalents in 2018, equating to approximately 8 per cent of total greenhouse gas emissions. Methane emissions mainly come from agriculture, landfill and combustion of fossil fuels in the energy sector. Total emissions of nitrous oxide (N_2O) in 2018 amounted to 4.5 million tonnes of carbon dioxide equivalents, equating to approximately 9 per cent of total emissions. Emissions of nitrous oxide mainly stem from the

agricultural sector. Total emissions of fluorinated greenhouse gases (PFCs, HFCs and SF6)[6] were 1.1 million tonnes of carbon dioxide equivalents in 2018, equating to 2 per cent of total emissions. A significant proportion of emissions are due to the replacement of ozone-depleting substances with fluorinated gases, HFCs. The split between different greenhouse gases has remained virtually the same across the entire timeframe from 1990 to 2018.

Figure 4. Total emissions (excluding LULUCF) in 2018 by greenhouse gas, shown as carbon dioxide equivalents.



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

In Sweden there are significant net removals[7] in the land use, land use change and forestry (LULUCF), below termed the land use sector. In the period 1990–2018 net removals amounted to an average of approximately 40 million tonnes of carbon dioxide equivalents per year, but major variation is seen between the years. Total net removals amounted to just under 42 million tonnes of carbon dioxide equivalents in 2018, equivalent to approximately 80 per cent of total emissions in all other sectors. The highest net removals come from forest land, which is the dominant land category, see

Figure 5, and in the carbon pool of living biomass.

In the sector, annual changes in carbon stocks are calculated[8] for the categories:

- forest land,

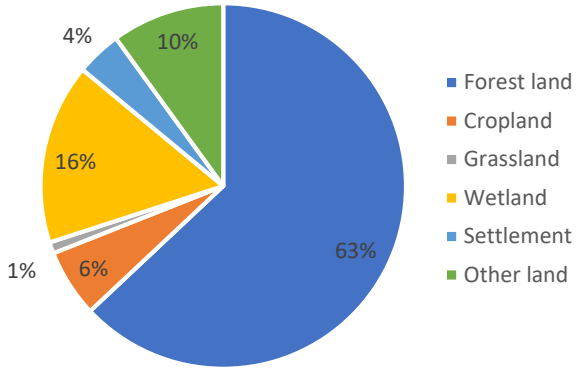
[6] No emissions of NF_3 have been found in Sweden.

[7] Removal of carbon dioxide minus emissions of carbon dioxide, nitrogen oxide and methane

[8] The carbon stored in all carbon pools, living biomass, dead organic material, soil carbon and harvested wood products.

- arable land,
- pasture,
- settlements,
- wetlands (with peat production),
- harvested wood products (HWP), and
- other land (only the area is reported).

Figure 5. Distribution of land (proportion of Sweden's total land area) between the different land use categories



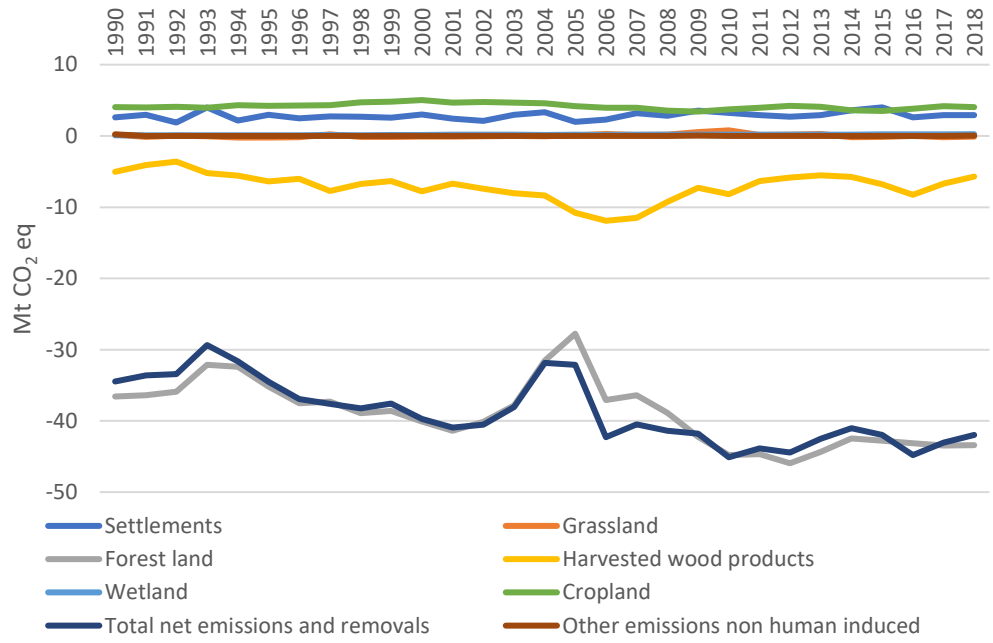
Source: Swedish University of Agricultural Sciences

The carbon flows for each carbon pool are calculated in each category as follows:

- living biomass,
- dead organic matter,
- soil carbon (mineral soil and peatlands), and
- harvested wood products (HWP).

The change in the carbon stock (changes in removal and release for all carbon pools) is calculated for all categories considered to be managed, in other words, not for the unmanaged categories of other land (non-productive land) or wetlands. The net change per category and total net removal is shown below in Figure 6. The total net removal in the land use sector has increased between 1990 and 2018. In 1990, net removals amounted to 34 million tonnes of carbon dioxide equivalents and in 2017 net removals amounted to 42 million tonnes of carbon dioxide equivalents.

Figure 6. Net emissions and net removals in the land use sector.



Source: Swedish Environmental Protection Agency

The greatest carbon flows are seen in the category forest land, where large net amounts of carbon dioxide are removed in both living biomass and mineral soil. Significant removal also occurs in the carbon pool of harvested wood products (HWP)[9]. Net emissions, unlike net removals, in the sector mainly take place in the categories arable land (apart from 2015), settlements and peat production.

3.2.5 Scenarios for Sweden's greenhouse gas emissions and removals with existing management

Scenarios indicate that with existing policy instruments, total emissions of greenhouse gases will continue to fall before subsequently stabilising after 2030. In 2050, emissions are estimated to be approximately 36 per cent below 1990 levels, see Figure 7. Historic emissions and scenarios by sector are presented in Table 2 Historical emissions and removals of greenhouse gases and scenarios per sector (millions of tonnes of carbon dioxide equivalents). Governance needs to be strengthened to attain the national climate goals. The climate policy framework, requiring

[9] Harvested wood products are calculated as a category under the Climate Convention but are accounted for as a carbon pool under the category forest land under the Kyoto Protocol.

action plans, reports and audits, seek to ensure that governance develops in such a way that the goals are attained.

The LULUCF sector has contributed to an annual net sink in Sweden in the period 1990–2018 and is estimated to continue contributing to a net sink during the scenario period.

Figure 7 Historical emissions and removal of greenhouse gases and scenarios with decided policy instruments[10] (millions of tonnes of carbon dioxide equivalents).

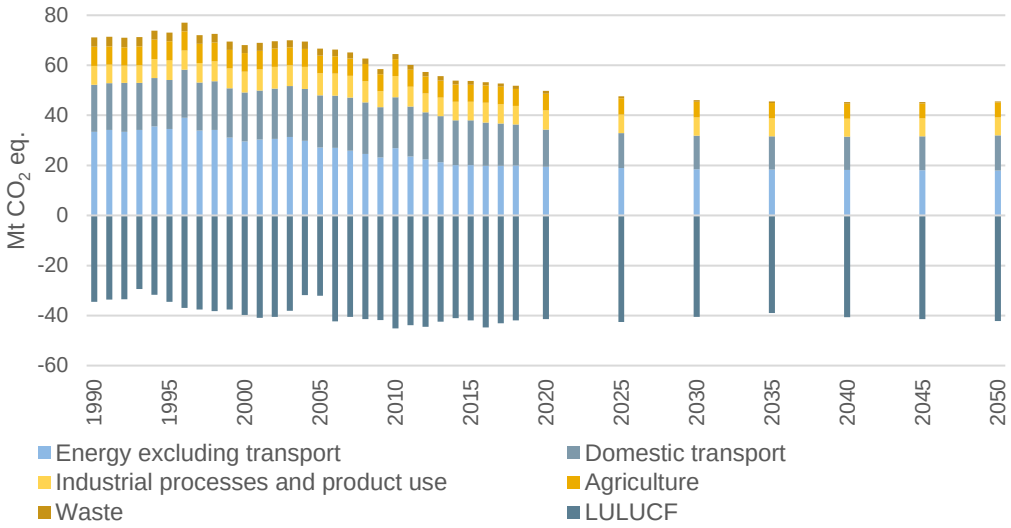


Table 2 Historical emissions and removals of greenhouse gases and scenarios per sector (millions of tonnes of carbon dioxide equivalents)

	1990	2018	2020	2030	2040	2050	1990–2030	1990–2050
Energy excluding transport	33.3	19.9	19.5	18.5	18.2	17.9	-44%	-46%
Domestic transport	19.0	16.5	14.8	13.4	13.3	14.2	-30%	-26%
Industrial processes and product use	7.6	7.3	7.7	7.3	7.1	7.2	-4%	-6%
Agriculture	7.7	6.8	6.7	6.2	6.1	5.9	-19%	-23%
Waste	3.7	1.2	1.1	0.7	0.6	0.5	-81%	-87%
Total emissions	**71.3**	**51.8**	**49.7**	**46.1**	**45.3**	**45.6**	**-35%**	**-36%**
LULUCF	34.4	-42.0	-41.4	-40.6	-40.6	-42.2	18%	23%

3.3 Energy

3.3.1 Overarching energy policy

The overarching objective of Swedish energy policy is to build on the same three fundamental pillars as energy co-operation in the EU, which seeks to unite security of supply, competitiveness and sustainable development.

[10] Policy instruments to 30 June 2018

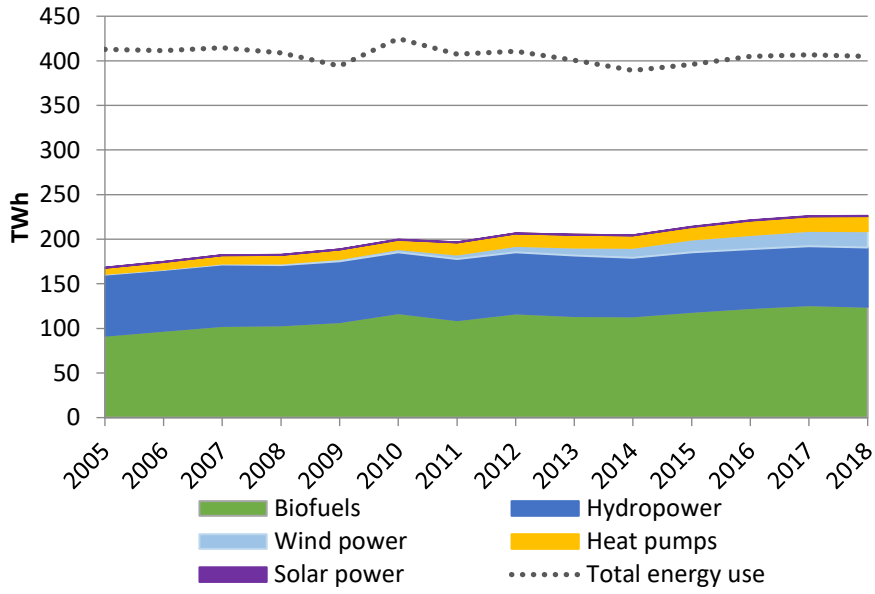
Energy policy is thus to create conditions for effective and sustainable energy consumption and a cost-effective energy supply with low negative impact on health, the environment and climate, and ease the transition to an ecologically sustainable society.

Besides the target of net zero emissions of greenhouse gases into the atmosphere by 2045, energy policy targets addressing renewable energy and energy efficiency have been set. The target for 2040 is 100 per cent renewable electricity production. This is a target, not an end date that prohibits nuclear power, nor does it mean shutting down nuclear power by means of political decisions. In addition, Sweden's energy consumption is to be 50 per cent more efficient by 2030 compared with 2005, expressed in terms of energy supplied in relation to gross national product (GNP).

3.3.2 Renewable energy

The target of net zero emissions by 2045 demands a major reduction in the use of fossil fuels. Sweden already has a high proportion of renewable energy, mainly due to favourable conditions for wind and hydroelectric power and sizeable biomass assets. The proportion of total energy use made up by renewables has increased over time, as can be seen in Figure 8. The largest contribution made by renewable energy comes from biofuels, followed by hydroelectric power.

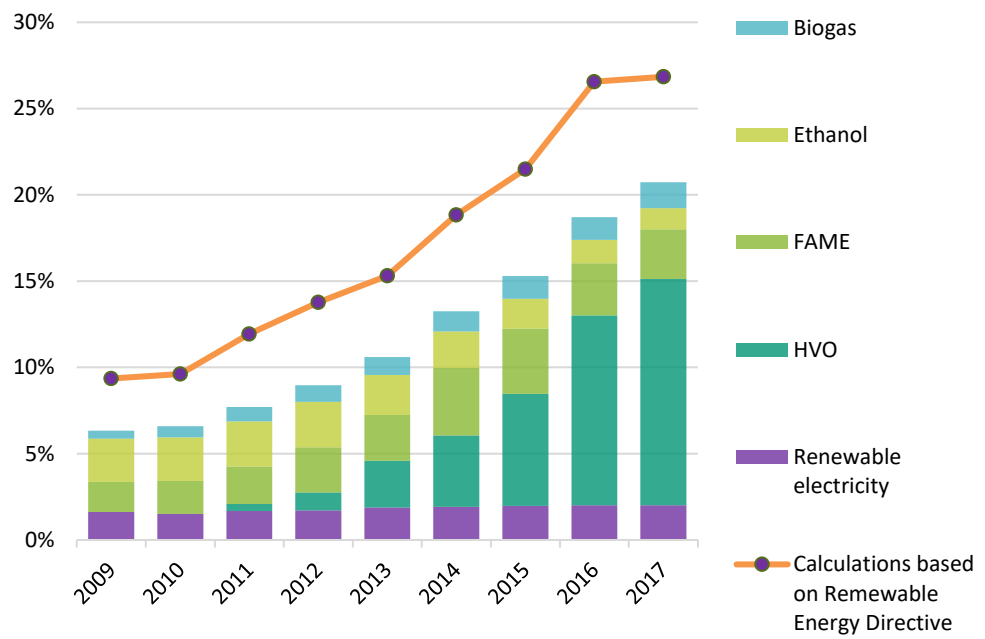
Figure 8 Renewable energy and energy use under the Renewable Energy Directive, 2005–2018, TWh



Source: Swedish Energy Agency and Eurostat

Today, renewable energy accounts for the largest proportion of energy production and only a few per cent is of fossil origin, with remaining production originating from nuclear power. Wind power is undergoing extensive expansion which is estimated to continue and will make up a significant proportion of the future electricity system. In terms of district heating production, the transition to renewable energy has come a long way, and here the majority of the input fuels are biofuels. Looking at industrial energy consumption, the main energy carriers are electricity and biofuel, which together account for three-quarters of energy consumption. Extensive work towards a fossil-free society is in progress in the industrial sector, see section 4.4. For housing, the vast majority of energy consumption comprise of electricity and district heating, plus a certain proportion of biofuel in single-family dwellings. Direct use of fossil fuels in homes is currently very low at only approximately 2 per cent. It is in the transport sector that the highest proportion of fossil fuels is found, but this is also the sector in which renewable alternatives are showing the highest growth, see Figure 9. The increase in the transport sector so far is mainly due to a major increase in HVO (Hydrogenated vegetable oil).

Figure 9 Proportion of renewable energy in domestic transport, 2009–2018, per cent



Source: Swedish Energy Agency

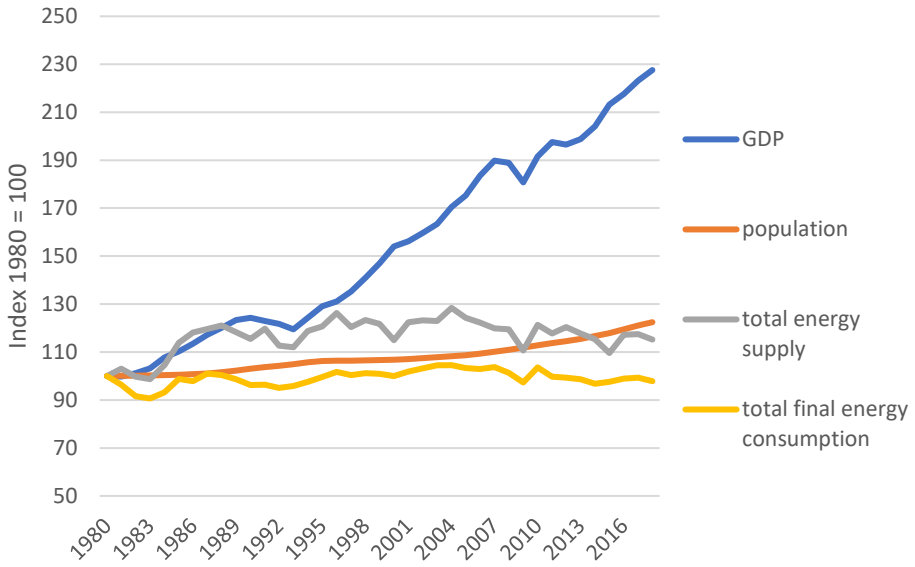
In the transport sector, renewable alternatives are favoured through a reduction obligation scheme, which consists of an obligation for suppliers of

gasoline and diesel to gradually reduce the climate impact of the delivered fuels by blending in more biofuels. Policy instruments such as the electricity certificate system, support to research, etc. are other reasons that explain the growing proportion of renewable energy in the transport sector.

3.3.3 Energy efficiency improvements

Since the 1970s, the trend has moved towards a relative decoupling of energy consumption from economic growth and population. Efficiency improvements, structural changes in the economy, behavioural changes in society and better use of waste energy have countered other factors pushing towards a higher energy consumption.

Figure 10. Index-linked energy consumption, GDP (fixed prices as at 2015) and population growth 1980–2018



Source: Statistics Sweden and the Swedish Energy Agency

In terms of energy consumption in different sectors, the greatest impact factor for industry is economic development, while structural changes also have an effect. In housing and services, etc. heating and hot water make up a large proportion of the sector's energy consumption. This means that the energy requirement varies hugely depending on the outdoor temperature. Household finances, fuel prices and demography, i.e. the size and composition of the population, are important impact factors for personal transport, while business developments and trade with other countries are important factors for goods transport. Technological development of

vehicles, improving the efficiency of fuel consumption and introducing renewable fuels are other factors affecting the transport sector.

Sweden has many policy instruments and measures to encourage improvements in energy efficiency. Sectoral strategies are one such example, where the aim is to facilitate a dialogue between the industry and agencies on appropriate guiding objectives and measures in each sector to cost-effectively contribute to the target of 50 per cent more efficient energy consumption in 2030.

3.3.4 Energy markets

Sweden's energy markets are largely competitive and increasingly international. The price signal, i.e. the economic driver, is an important incentive for behaviours and investments that bring greater user flexibility and energy efficiency. Pricing is also considerably affected by political governance. Carbon pricing forms the basis of Swedish governance in this area. There are taxes on fuels, and a charge on nitrogen monoxide emissions. Fuel taxation consists of an energy tax, carbon tax and sulphur tax. The taxes vary depending on whether the fuel is used for heating or powering a vehicle. There are also variations depending on whether the energy carriers are used by households, by industry or in the energy conversion sector. There is also an energy tax on the use of electricity. Besides energy and carbon taxes, Sweden has a number of supplementary national and EU-wide instruments and targeted initiatives.

In many ways, the electricity market is the most important energy market, as a large proportion of energy consumption takes the form of electricity consumption. The use of electricity is expected to increase as the electricity system expands into new sectors and functions, especially the transport sector and some industrial processes. Technological development and instruments alike mean rising demand for electric vehicles. Electrification of the vehicle fleet may also bring about energy efficiency improvements, provided that electricity production itself is sufficiently efficient. In industry, for example, electrochemical and electrolytic processes are being developed to replace the use of fossil fuels and raw materials.

The most important factor in greater demand flexibility is that it is given a value and that this reaches the customer so that they can benefit from using their flexibility. There is also a need for a range of smart services, e.g. through automation, contracts for customers that want to be flexible, offered by actors such as aggregators, energy service companies, electricity

companies and electricity trading companies[11]. In a future electricity system with more renewable, variable power and less thermal power production, price volatility is likely to increase, providing greater incentives for flexibility both on the user and on the production side[12].

Another trend that can be observed is that there is greater awareness and commitment from actors in society to play their part in the energy transition.

3.4 Digitalisation

In 2017, the Government decided on a strategy on how digitalisation policy is to contribute towards socially and environmentally sustainable development. The overarching objective is for Sweden to be the best in the world at using the opportunities offered by digitalisation. To attain this overarching objective, five objectives have been set up: digital competence, digital security, digital innovation, digital management and digital infrastructure.

Digitalisation offers great potential to further contribute towards innovative and effective solutions for the benefit of society in all sectors and can play a part in attaining the Swedish climate goals by products being replaced with services, certain use intensifying or is becoming easier to reuse or share. Digital services can increase resource efficiency, through for example smart electricity networks for heating and domestic electricity or for cutting food waste. In the transport sector, digitalisation has the potential to contribute to cost efficiency improvements, foster changes in behaviour and optimise traffic levels, resulting in a reduced environmental and climate footprint.

3.5 Climate change adaptation

3.5.1 Strategies, plans and measures to adapt to a changing climate

Significant progress has been made in adapting to climate change in Sweden in recent years and awareness of the importance of adapting has increased. In March 2018, the Swedish Government adopted the first national climate adaptation strategy (Govt. Bill 2017/18:163). The strategy includes mechanisms for coordination, follow-up, evaluation and auditing climate

[11] Swedish Energy Markets Inspectorate (2016), Åtgärder för ökad efterfrågeflexibilitet i det svenska elsystemet, Ei R2016:15

[12] Swedish Energy Agency (2019), 100 procent förnybar el, Delrapport 2 – Scenarier, vägval och utmaningar, ER 2019:06

adaptation efforts. Drawing on the predicted consequences for society, seven particularly urgent areas are identified for continued efforts in adapting to climate change. This work should be conducted based on a number of guiding principles. The Government's objective for the adaptation of society to a change in climate is to develop a long-term sustainable and robust society that actively addresses climate change by reducing vulnerabilities and leveraging opportunities.

As climate adaptation work covers many different areas, it is largely steered by existing regulations, frameworks and objectives, both national and international. Examples include the 2030 Sustainable Development Agenda and the Planning and Building Act (2010:900).

3.5.2 Create conditions for adapting to climate change – collaborative structures, involvement of stakeholders and action plans

The Ministry of the Environment is responsible for coordinating the Government's policy work on climate change. Following up and evaluating adaptation to climate change is supported by the National Expert Council for Climate Adaptation (Nationella expertrådet för klimatanpassning) and the Swedish Meteorological and Hydrological Institute (SMHI).

As a result of the national climate adaptation strategy, in June 2018, the Swedish National Board of Housing, Building and Planning (Boverket) was tasked with coordinating efforts in the construction industry to adapt to climate change.

In 2012, SMHI was tasked with forming a National Knowledge Centre for Climate Change Adaptation to assist municipalities, regions, agencies and other stakeholders with their climate adaptation efforts. In 2019 the centre had a budget of approximately SEK 20 million.

Many Swedish agencies have an important role to play in adapting to climate change through their respective sectoral responsibilities. They work preventively by increasing knowledge and improving resilience. Implementation of the national climate adaptation strategy began in June 2018 with an ordinance in which the Government tasks 32 national agencies and the 21 county administrative boards with initiating, supporting and following up climate adaptation in their respective area of responsibility, including by producing action plans. Several national agencies had already ahead of this ordinance drawn up action plans for their sector. Some were produced with the support of national funding, e.g. action plans for forestry,

people's health, cultural heritage, sustainable construction and Sami businesses and Sami culture.

The county administrative boards (Länsstyrelser) have responsibility for coordinating regional work to adapt to climate change and for supporting local actors. In 2014, the county administrative boards adopted regional action plans. Work on the measures to adapt to climate change identified in these is reported to the Government on an annual basis. The plans cover the whole of Sweden with almost 800 proposed measures. The majority of the measures concern flood protection, protecting drinking water, protecting shorelines, infrastructure (roads and railways), adapting agriculture and forestry, resilience in heatwaves and healthcare.

The national agency network for adaptation is comprised of the 21 county administrative boards and 19 national agencies. The network is responsible for coordination and knowledge exchange and its secretariat is provided by the agency SMHI. There are also thematic networks for national collaboration.

Some local agencies have also developed action plans for their municipality. Significant progress has been made, and awareness of the importance of adapting to climate change has increased in recent years across the whole of society. To encourage further progress, the Government has implemented changes to the Planning and Building Act, proposed in the national adaptation strategy and adopted by the Parliament in June 2018. These amendments have given the municipalities greater opportunities to incorporate climate change adaptation aspects in the municipal planning process.

3.5.3 Knowledge transfer and risk assessment

The Rossby Center at SMHI conducts climate research and has produced national and regional climate scenarios up to 2100. A flood portal containing information from flood mapping, geographical data in line with the ordinance on flood risks and a database of natural disasters is under supervision of the Swedish Civil Contingencies Agency. The Swedish Geotechnical Institute (SGI) has worked in partnership with seven other agencies to produce joint maps of geotechnical risks and tools to assess climate risks.

The climate change adaptation portal provides information on how society will be affected by a changing climate, climate adaptation tools and examples of climate adaptation measures carried out and information on relevant

activities. Many of the sectoral and regional adaptation plans include risk and vulnerability analyses.

3.5.4 Implementation

The Government finances measures to increase knowledge of the effects of a changing climate and to address these effects, e.g. by putting preventive measures against landslides, rockfalls and flooding in place.

The Government also makes decisions on mandates to sectoral agencies relating to different measures. However, adapting to climate change is a multi-sectoral effort, which means that work is usually carried out in collaboration between several actors and sectors at national, regional and local level.

Sweden has a well-established and well-functioning framework for disaster risk reduction, including work in civil contingency groups. This work is coordinated by the Swedish Civil Contingencies Agency.

Collaboration is encouraged at all levels and between sectors and actors working on land use planning, risk management, natural disasters and climate change adaptation to reduce risks and improve preparedness.

Several collaborative forums are now active in Sweden, where sectoral agencies and other stakeholders can share experiences and plan important action. These forums include the agency network for coastal erosion, the Swedish committee for design flood determination, the delegation for landslides and rockfalls, and the national drinking water network.

Swedish municipalities are tasked with conducting risk and vulnerability analyses as part of their readiness to tackle extraordinary events and disasters. Such analyses also cover events affected by a changing climate. Municipalities can apply for government funding for measures to prevent natural disasters. SEK 75 million is earmarked for this each year in the period 2017–2020. The grant is administered by the Swedish Civil Contingencies Agency at a rate of up to 60 per cent of costs or a maximum of 60 per cent of the value of the item under threat. Here, natural disasters mainly involve landslides, rockfalls and flooding.

3.5.5 Evaluation and audit

The national climate change adaptation strategy has a five-year follow-up cycle. The first step is a vulnerability analysis, follow-up and evaluation of implementation of the strategy and proposals for auditing the strategy,

followed by an updated strategy for 2023. The Government has established a national expert group for climate adaptation at SMHI in line with proposals in the strategy. The group is responsible for evaluating progress on adapting to climate change and presenting proposals for a revised national adaptation strategy which will be presented in 2023.

4 Action areas and instruments

4.1 Instruments work together to attain Sweden's climate goals

Sweden uses a number of national and EU-wide policy measures to attain the national climate goals. These instruments can be divided into four main categories:

- *economic,* e.g. energy and carbon taxes, emissions trading and grants such as the Climate leap and subsidies to low emission vehicles.
- *administrative* (normative), e.g. the reduction obligation, the Planning and Building Act and requirements on carbon dioxide emissions from new vehicles
- *informative,* e.g. energy and climate advice
- *research and market launches,* e.g. support for research programmes and the Industry Leap's industrial green investment grants programme.

Since the early 1990s, pricing of emissions has formed the basis of Swedish climate policy governance. The carbon tax with exemptions for biofuels and the EU Emissions Trading System have been cornerstones of this strategy. These broad instruments have been supplemented by targeted sectoral initiatives. In addition, the design of societal planning has been of major significance for the impact of the governance by providing actors with alternatives. The decisions on expanding the district heating network, public transport systems and carbon-free energy production have been particularly important. Sweden has also long invested in conducting climate and energy-related research and launching new technologies on the market.

The instruments in the EU and Sweden cover all sectors of society, and it is estimated that the emission target for 2030, as set out in the Climate Policy Framework, is within reach but that additional measures and instruments will be needed to go all the way. Additional measures are also needed for emission targets beyond 2030. The following sections (4.2–4.10) set out the action areas in the respective sector together with the existing policy instruments of most significance.

4.1.1 Fundamental starting points for Sweden's climate instruments

One starting point when introducing policy instruments in Sweden is that they must be as cost-effective as possible. Cost-efficiency means that instruments should be general and not promote a particular solution, and that they should give all actors the same incentives to reduce their environmental footprint. Economic instruments, such as a price on carbon, are therefore the most cost-effective in theory. A price on emissions is also compatible with the polluter pays principle, a fundamental international principle.

Furthermore, in Sweden's experience, a combination of instruments can improve the feasibility of attaining the goals, with instruments mutually supporting each other. Sweden has supplemented carbon pricing with other policy instruments for targeted interventions and to tackle related problems on the market, such as a lack of knowledge and insufficient technological development. Instruments that overlap, on the other hand, have been avoided to the greatest possible extent, as this reduces flexibility and can lead to higher administrative costs.

In practice, there are factors that prevent or limit the opportunity to introduce certain instruments, e.g. measuring problems, high administrative costs or risk of carbon dioxide leakage, i.e. emissions moving geographically to countries with weaker climate policy or lower carbon pricing. Practical difficulties, unwanted side-effects and conflicts of interest in implementing the theoretically most effective governance may also arise. This means that what in theory might be the second-best instrument may be the one that is the most effective in practice. In addition, it is recognised that policy instruments can produce positive and negative side-effects on other societal goals, e.g. air quality and energy security, which affects their socio-economic effectiveness. Taking a holistic approach to policy and instruments is therefore important for identifying appropriate instruments.

4.2 Cross-sectoral, overarching policy instruments

In Sweden, a number of general cross-sectoral policy instruments are applied, at national level and at EU level. A description of Sweden's most important overarching instruments is provided below.

4.2.1 Energy tax and carbon tax

The Swedish energy taxation system is based on a combination of a carbon tax, an energy tax on fuel and an energy tax on electricity.13 The most important taxes that affect greenhouse gas emissions in Sweden are the carbon tax and the energy tax on fuels. This is described in general terms below and in more detail under the respective sector.

Carbon tax

The carbon tax, based on the fossil content of the fuel, was introduced in Sweden in 1991 and seeks to reduce carbon dioxide emissions. The tax has been increased in several stages since it was first introduced. In total, the tax has increased from SEK 0.25 per kg carbon dioxide (1991) to SEK 1.20 per kg (2020). The tax rates on different fuels are calculated in proportion to the content of fossil carbon in the fuel. Besides specific tax increases decided by the Parliament following proposals in government bills, the tax rates are increased annually on an index-linked basis pursuant to previously decided statutory rules. A carbon tax is not charged on biofuels that are not used as part of the reduction obligation for petrol and diesel (see section 4.3.2 *Policy instruments in the transport sector*). Due to the risk of carbon leakage, i.e. operations and their emissions moving outside the country's borders, a reduced tax or tax exemptions apply in certain sectors.

Energy tax

Sweden has long applied taxes on energy. Energy taxes on petrol and diesel were introduced in 1924 and 1937 respectively. An energy tax was imposed on fuels used for heating in the 1950s. The purpose of the energy tax was initially purely fiscal. In recent years, the aim has also been to steer energy consumption in line with Sweden's goal of energy efficiency and increase in renewables14. The energy tax on motor fuels such as petrol and diesel also seek to internalise external costs of traffic, such as road wear and noise. The energy tax on fuel varies depending on whether it is used as motor fuel or for heating. The tax rate for heating fuels also varies between households, industries and the energy supply sector. There is also an energy tax on the use of electricity.

[13] Tax on energy is a collective term for duty on fuel and electricity and is regulated by the Act (1994:1776) on Excise Duties on Energy.

[14] The energy efficiency target and the renewables target for 2020 are part of Govt. Bill 2008/09:162 and 163.

4.2.2 The EU Emissions Trading System

The EU Emissions Trading System (EU ETS) is the EU's most important instrument for reducing greenhouse gas emissions. It was introduced in 2005 and since then, it has gradually been expanded to cover more sectors and greenhouse gases. The amount of emissions permitted in the system is limited by a ceiling, which is lowered every year. Approximately half of the emission rights are allocated free of charge and the rest are auctioned off. There is no free allocation for emissions from electricity production. The EU ETS includes emissions of carbon dioxide from combustion installations and energy-intensive industry (mineral oil refineries, coke ovens, the iron and steel industry, the pulp and paper industry and the minerals industry). The system includes approximately 760 Swedish facilities. Since 2012, the system has also included emissions from aviation, flights within the EU. For the period 2013–2020, emissions in the EU ETS are to be reduced by 21 per cent compared with 2005. For the period 2021–2030 the annual linear reduction factor will be raised, which means that emissions from the EU ETS are to fall by 34 per cent up to 2030 compared with 2005.

4.2.3 Fossil Free Sweden

The Government initiative *Fossil Free Sweden,* launched in 2016, has a clear mandate to increase the Government's dialogue with industry, municipalities, other public sector actors and civil society and to create roadmaps to eradicate obstacles and facilitate more rapid reductions in emissions. The initiative is an important platform for dialogue and cooperation between key actors for a competitive climate transition.

Today the initiative brings together more than 400 actors and is open to everyone who signs up to the declaration produced. The actors involved in the initiative share the view that the world must become fossil free and that Sweden should lead the way in these efforts. In the declaration, the actors also undertake to demonstrate tangible measures to mitigate emissions.

The sector-specific roadmaps are drawn up to highlight commercial opportunities for companies and sectors to become fossil free. As of October 2020, 22 roadmaps have been submitted to the Government[15]. The roadmaps constitute a good basis for constructive interaction between the Government and other actors in society on the path towards the shared climate goals.

[15] http://fossilfritt-sverige.se/in-english/roadmaps-for-fossil-free-competitiveness/

4.2.4 The Climate Leap (Klimatklivet)

To further encourage cuts in greenhouse gas emissions, a government co-funding programme was introduced in 2015 for local climate investments, known as the Climate Leap. The investments cover all sectors, apart from those included in the EU ETS[16], and all types of organisations can apply for grants. The selection of the investment granted is based on the estimated reduction in greenhouse gas emissions in relation to cost. Examples of investments that have been entitled to funding are charging infrastructure for electric vehicles, biogas production and processing plants, switching from oil to biofuel or district heating, expanding small district heating networks and cycling infrastructure.

To further reduce emissions throughout the Swedish society and contribute to a green recovery, the government proposes that Klimatklivet will be extended to 2026. Since 2015, this investment support has financed climate projects around Sweden that have reduced emissions by a total of 29 million tonnes and created more than 4,000 new jobs. The government also proposes that an additional SEK 100 million be added to the programme in 2021 and that the Swedish Environmental Protection Agency is provided with the financial framework needed to support larger climate projects.

4.2.5 Information and increased knowledge

Swedish agencies have many years of experience of using communication as an instrument for the public sector, the business community and citizens. Some examples of this:

The Swedish Environmental Protection Agency website is a hub for statistics and facts about emissions that is a popular resource for politicians, the media, companies, organisations and researchers.[17]

The Swedish Meteorological and Hydrological Institute (SMHI) develops and distributes information about changes in weather, water and climate. The National Knowledge Centre for Climate Change Adaptation, established by SMHI, has launched a Swedish climate change portal with facts and guidance on adapting to a warmer climate.[18]

[16] Investments in sectors included in the EU ETS may qualify for grants if these result in greater use of waste heat.

[17] http://www.swedishepa.se/

[18] https://www.smhi.se/en

The Swedish Energy Agency is responsible for giving citizens and companies information and advice on more effective energy use and is responsible for an informative website and support for local energy advisory services (see more under Section 4.2.6 "Energy and climate advisory services" below).[19]

The Swedish Forest Agency[20] and *the Swedish Board of Agriculture*[21] offers e-services and digital information for forest owners, forestry workers and farmers and guidance for mitigation and adaptation measures for forestry and agriculture.

The Swedish Transport Administration is tasked by the Government with using information and awareness-raising measures to help to ensure that the milestone target for domestic transport is reached and to create the preconditions to see Sweden reach net zero emissions by 2045 at the latest.[22]

In addition, in January 2020, the Government tasked the Swedish Environmental Protection Agency to investigate and account for Sweden's possibilities and conditions for the implementation of Article 12 of the Paris Agreement. The agency has reported recommendations to the Government on how the work on Article 12 can be strengthened and contribute to the achievement of national climate goals and which authorities, organizations and higher education institutions that play an important role in the implementation of Article 12.

4.2.6 Energy and climate advisory services

The Swedish Energy Agency allocates government funding to municipalities to provide local advice on energy and climate to citizens and small businesses. The local climate and energy advisors, a post at almost all Swedish municipalities, provide objective and locally adapted information and advice on energy efficiency measures, energy consumption and climate-related questions regarding buildings and households.

The Swedish Energy Agency also awards funding to 15 regional energy offices that 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 associations and other organisations. The offices work regionally in

[19] http://www.energimyndigheten.se/en/

[20] https://www.skogsstyrelsen.se/

[21] https://jordbruksverket.se/

[22] https://www.trafikverket.se/en/startpage/

partnership with companies, county administrative boards, municipalities and others, e.g. on plans and strategies.

Municipalities are entitled to apply for the cost of a part-time (50%) climate and energy coach position (SFS 2016:385). The coaches offer targeted advisory services to small and medium-sized companies with an annual energy consumption below 300 MWh. The coaching seeks to increase energy efficiency and reduce greenhouse gas emissions. Doing this will enable companies to benefit from lower costs and boost competitiveness.

4.2.7 The Environmental Code and the Planning and Building Act

The Environmental Code23 (Miljöbalken), with its overarching goal to promote sustainable development, brings together Sweden's comprehensive legislation on the environment. When applying the Code, Sweden's environmental quality objectives, including Reduced Climate Impact (see section 2.1.1) are to have a guiding role. The Code includes general rules on taking the environment into account that must be observed in all operations and measures. It also incorporates requirements to use the best available technology. Permits must be obtained for large, environmentally hazardous operations. The permit application procedure includes an assessment of direct and indirect environmental impacts and energy management and, for the facilities that are not included in the EU ETS, it also includes greenhouse gas emissions. Emission value requirements for carbon dioxide may not be imposed on operations covered by the EU ETS.

The Government is working on reviewing the environmental permit application procedure to make the processes more efficient and less long-winded, which is important in enabling industry to make the transition, so aiding progress in line with the roadmaps produced as part of the Fossil Free Sweden initiative.

Urban planning is governed by the Planning and Building Act24, but several measures, such as infrastructure projects, also fall under the Environmental Code. The Planning and Building Act requires that environmental and climate aspects are taken into consideration in planning.

[23] SFS 1998:808

[24] SFS 2010:900

4.2.8 Regional climate and energy plans

The county administrative boards coordinate regional climate and energy initiatives and support regional actors, e.g. by gathering and distributing information. Regional climate and energy strategies are shaped in partnership with other regional and local actors to foster effective measures and find synergies. Furthermore, the county administrative boards are involved in work on environmental assessments and environmental monitoring, local and regional spatial planning, regional development and growth policy, and infrastructure planning.

4.2.9 Grants for market launch, technological development and innovation clusters

Technological development is an instrument designed to initiate a transformation of the market and spread new, more efficient technologies and methods, such as new products, systems and processes. Network-based procurement for developing technology is a methodology that spans the entire decision-making process, from pilot study and purchaser group to specification of requirements and dissemination, plus further development of more energy efficient technologies. It is used in areas such as heating and control, ventilation and lighting. The Swedish Energy Agency coordinates innovation clusters for homes (BeBo), commercial and public premises (BeLok), manufacturers of single-family dwellings (BeSmå), public sector bodies that lease premises (HyLok) and food distribution (BeLivs).

4.2.10 Research and development

Public financing of climate-related research and development seeks to create better underlying conditions for attaining the national climate targets. Swedish climate-related research spans a broad spectrum, from the natural sciences to the humanities, but with an emphasis on research and development in technology and science. The three key areas focused on are energy, transport and industry, on which the Government is involved through high levels of funding.

Energy and climate issues are closely linked and the solutions to the challenges of climate change are largely energy related. The overarching aim of research and innovation in the field of energy in Sweden is to strive towards reaching national energy and climate goals.

4.2.11 Gender Equality and Climate Change

Sweden's feminist foreign policies, which means to always adopts a gender equality approach to international relations, also include specific international and regional work. Sweden's domestic policy and foreign policy on gender equality are closely linked, as with the EU cooperation. Sweden promotes gender equality work within the EU, the UN and other international organisations. Work is ongoing nationally to meet the international gender equality commitments and obligations, including those under the Beijing Platform and the UN's Convention on the Elimination of all Forms of Discrimination against Women (CEDAW).

The feminist foreign policy is set out in an action plan, which includes specific targets for gender equality. Sweden has campaigned for many years for gender equality to be integrated into all relevant EU processes with the aims to ensure that all women and men have the same power and opportunities to shape society and their own lives. At the Government's request, the Swedish Environmental Protection Agency has submitted a proposal for further integration of gender equality in the implementation of the Paris Agreement.[25]

4.3 Transport

4.3.1 Action areas to cut greenhouse gas emissions in the transport sector

Domestic transport accounts for a third of Swedish greenhouse gas emissions. Road traffic, mainly cars and heavy goods vehicles, accounts for the majority of emissions. Significantly reducing greenhouse gas emissions from the transport sector requires initiatives predominantly in three areas:

- a transport-efficient society,

- sustainable renewable fuels and infrastructure for alternative fuels including electrification, and

- energy-efficient and climate-smart vehicles and ships.

The degree of electrification, energy efficiency improvements, the proportion of sustainable renewable fuels and traffic development are the

[25] http://www.naturvardsverket.se/Miljoarbete-i-samhallet/Miljoarbete-i-Sverige/Regeringsuppdrag/Utveckla-arbetet-med-jamstalldhetsintegrering/

factors of greatest significance for how greenhouse gas emissions from the transport sector will evolve by 2030 and 2045.

Transport efficiency has several advantages. Measures such as route optimisation and coordination of goods transport can cut goods transport costs and increase competitiveness in the business community. There are also significant gains to be made for taxpayers and society by using the transport system more efficiently. Accessibility in cities and towns will increase for more groups in society, if e.g. provision of well-adapted and usable public transport increases and walking and cycling are made easier.

For the milestone target for domestic transport by 2030 and the net zero target by 2045 to be met, there will also be a need for extensive electrification of the transport system and a switch to the use of renewable sustainable fuels. Both an extensive electrification and a fast transition to the use of renewable sustainable fuels need to take place in the immediate future for transport by road and eventually also for transport by sea and air, also recognizing that especially ships take a long time to build and have a long life span. Over time, competition of renewable sustainable fuels will increase, but the need for these fuels will also be affected by the way in which electrification and traffic develop over the longer term.

In a longer perspective road transport should mainly be electrified. This will make sustainable renewable fuels available for use in aviation and shipping, where electrification is expected to take longer time.

Transport-efficient society

In a transport-efficient society, the transports that takes place is as efficient as possible from energy, environmental and economic perspectives respectively to achieve accessibility, sustainability and competitiveness. Development towards a more transport-efficient society therefore means that traffic, and thus emissions and other environmental impacts, can be reduced without impairing accessibility.

A more transport-efficient society will be achieved through measures including urban planning, access to efficient, punctual and reliable public transport, coordinated goods transport, a shift to less energy-intensive means of transport and vehicles, higher use of vehicle capacity, greater opportunities for longer and heavier trains, greater opportunities for longer and heavier trucks where switching to rail and sea is not a realistic option, route optimisation, greater use of digital solutions, and innovative local and

regional transport and mobility solutions. In some cases, journeys can be shortened or replaced entirely. Developing and using technological infrastructure for virtual meetings and remote working are additional examples of how traffic can be reduced without impairing accessibility.

A more transport-efficient society demands measures in several sectors and by different actors. The location of homes, services and workplaces is important, as it affects the distances and transportation between them. A large proportion of Sweden's urban planning, e.g. planning homes, businesses and public transport, takes place at local and regional level. Creating long-term sustainable and robust structures capable of increasing transport efficiency will mean local, regional and national levels will need to coordinate their planning processes to a greater extent.

Densely populated areas offer better opportunities for walking, cycling and using public transport instead of travelling by car, while the car will continue to be important in sparsely populated areas. On the other hand, rural areas have an important role to play in the transition as suppliers of climate-smart energy and renewable resources

Sustainable Renewable fuels

Gradually increasing the use of biofuels and electricity in the transport sector will reduce emissions of greenhouse gases. The extent to which renewable fuels are able to contribute to reduced emissions depends on a number of aspects: opportunities to produce biofuels that meet sustainability requirements at a reasonable cost; how biofuels and electricity distribution systems are developed; access to charging infrastructure for electric vehicles, and fuel quality requirements for blending biofuels in petrol and diesel for use in conventional combustion engines.

In the longer term, use of renewable fuels in aviation[26] and shipping must replace the fossil alternatives to a greater extent. This will increase competition for renewable fuels in the road sector, while the need for liquid renewable fuels in the road sector is expected to fall in the long term as electrification takes on a greater role. Sweden has good access to biomass and thus the potential to produce biofuels from domestic raw materials. Swedish production of biofuels may provide additional added value in the

[26] The report *Biojet för flyget* (Bio-jets for aviation) (SOU 2019:11) was submitted to the Government in March 2019. The inquiry proposes that a reduction obligation be introduced, requiring blending sustainable biofuels in aviation fuel, starting from 2021. According to the proposal, such a reduction obligation is to be introduced for fuel suppliers. The biofuels used to meet this obligation must fulfil the sustainability criteria implemented in Swedish legislation. The Government is currently preparing the inquiry's proposals on a reduction obligation for aviation fuel.

form of fuel security, export of knowledge and technology to other countries, effects on employment and regional development.

Energy efficient and fossil-free vehicles

Energy-efficient and fossil-free vehicles reduces emissions and the need for fossil fuels. Much of the technology required to lower emissions is already available, and the range of energy-efficient and fossil-free vehicles is increasing at an even faster pace. Today the share of chargeable cars is 30 percent of the sales of new cars in Sweden, a duplication compared to the year before. But the conversion of the vehicle fleet will take time, as it will take time to fully phase out the older vehicles.

4.3.2 Policy instruments in the transport sector

In the transport sector, Sweden applies a number of different instruments adopted at national and EU level. As the range of low-emission vehicles largely depends on a market beyond Sweden's borders, the EU's governance of emission restrictions is crucial. To provide further incentives for energy-efficient vehicles and renewable sustainable fuels, national policy instruments have been introduced in the form of pricing and subsidies. To make alternative fuels accessible, certain regulations for the sale of cars is applied. Grants are also available to expand the charging infrastructure and for the production of alternative fuels.

In summary, Sweden has implemented instruments in three main action areas: (1) a transport-efficient society, (2) sustainable renewable fuels and infrastructure for renewable fuels, and (3) energy-efficient and fossil-free vehicles.

Table 3. Summary of the most significant instruments for transport

Overarching instruments	**Transport-efficient society**	**Sustainable renewable fuels**	**Energy efficient and fossil-free vehicles**
Energy and carbon tax Klimatklivet (the Climate Leap) Research and development funding Procurement rules	Urban environment agreements Infrastructure planning Environment compensation for rail transports Eco-bonus system for shipping Tax on air travel (aviation)	The Fuel Change – Emission Reduction obligation Exemption from energy and carbon taxes for biofuels Climate premium Electrified road systems	Emission reduction targets for new vehicles (EU) Bonus-malus system Carbon dioxide-based vehicle tax Tax reduction for eco-friendly cars Market introduction support for electric busses, electric

	Planning and Building Act EU ETS (aviation)	Act on the Obligation to Supply Renewable Fuels Environmental information about fuel	working machines and low emission heavy trucks.

Overarching policy instruments in the transport sector

Energy tax and carbon tax in the transport sector

Both petrol and diesel are subject to an energy and a carbon tax on fuel used for road vehicles, non-road mobile machinery and private vessels and aircrafts. The energy and carbon taxes on fuel are adjusted in relation to changes in the consumer price index to take inflation into account. Since 2017 the tax rates for petrol and diesel have also been adjusted to reflect the expected development of the GDP[27].

In specific cases, Sweden applies tax exemptions for sustainable biofuels. The reduction depends on the type of biofuel and the blend proportion. All high-blend sustainable biofuels are exempt from energy tax and carbon tax. Low-blend biofuels are instead covered by the reduction obligation system (see below). These biofuels are subject to carbon and energy taxes on the level of their fossil equivalent.

The Climate Leap (Klimatklivet)

The Climate Leap is a cross-sectoral policy instrument, but it is specifically important for the transport sector. Important measures supported by this instrument are installing charging points for electric vehicles and investing in biogas plants. The investment aid programme eases the transition to a fossil-free vehicle fleet (more information on The Climate Leap is provided in section 4.2 on cross-sectoral policy instruments).

Transport-efficient society

Urban environment agreements

Urban environment agreements are a programme for investment in public transport, cycling infrastructure and sustainable goods transport solutions in urban environments. Municipalities can apply for grants to cover part of the infrastructure investment costs. The investment is often combined with

[27] This is attained by an increase of 2 percentage points per year, in addition to adjustment in line with changes in the consumer price index. However, the total change (increase) in the rates of carbon and energy tax is only added to the energy tax (in other words the level of carbon tax is only directly affected by index-linking in line with changes in the consumer price index). For the years 2021 and 2022 no GDP related adjustment of the taxes for petrol and diesel will be made.

other measures seeking greater long-term sustainability in urban environments or transport systems. These measures may cover greater accessibility through public transport, urban planning to encourage more cycling and walking, lower vehicle speeds, and parking regulations and pricing. Financing has been in place for urban environment agreements since 2015 and from 2018 onwards has been part of the economic framework for developing the transport system, amounting to SEK 1 billion a year in 2018–2029.

Long-term infrastructure planning

In May 2018, the Government decided on a new national plan for transport infrastructure in the period 2018–2029 across all modes of transport. The Swedish Transport Administration is responsible for long-term planning for all modes of transport and is responsible for implementing the plan. Planning is conducted in dialogue with municipalities and regions, among others.

Electric roads

Electric roads are infrastructure for dynamic charging, i.e. charging while in motion. Depending on the technologies chosen, electrified roads can be used by trucks, buses and cars. Demonstration projects are in progress on the E16 motorway outside Sandviken (heavy goods vehicles) and at Arlanda airport (heavy goods vehicles and cars). In April 2019, the Swedish Transport Administration decided on two further demonstration projects that are being set up in Lund (public transport) and on Gotland (heavy goods vehicles and public transport). The demonstration project on Gotland uses inductive technology, i.e. there is no need for a permanent connection from the vehicle, while other demonstration projects are conductive, i.e. a physical connection is needed to transfer electricity to the vehicle. At the same time, the Swedish Transport Administration is preparing to build the first permanent electrified road.

Electric roads can help to improve the efficiency of goods transport and cut greenhouse gas emissions. The Government therefore intends to produce a long-term plan for building and expanding electrified roads. Important goods routes and links to key ports should be prioritised. The need for additional technologies for electrical power outside the electrified road network, e.g. rapid charging for heavy goods vehicles, should be taken into account in efforts going forward.

Eco-bonus system for shipping

Since 2018, the Government has allocated funding for an eco-bonus system to stimulate switching goods traffic from road to sea transport. The purpose of the system is to mitigate greenhouse gas emissions from goods transport. The Government is budgeting SEK 50 million a year for the system in the period up to 2022.

Tax on air travel

On 1 April 2018, Sweden introduced a tax on air travel with the aim to help reduce the climate impact of aviation[28]. The tax is designed as a tax on commercial flights and is paid for passengers travelling from an airport in Sweden. The airline that carries out the flight is liable to the tax. Different amounts are to be paid depending on the final destination of the passenger.

Policy instruments for energy-efficient vehicles and Sustainable renewable fuels

Emission reduction obligation for petrol and diesel (Fuel change)

An emission reduction obligation on petrol and diesel was introduced on 1 July 2018 to encourage the use of biofuels. This means that all fuel suppliers must reduce greenhouse gas emissions from petrol and diesel by a certain percentage each year. This can be done by blending increased proportions of biofuels in petrol or diesel over time, see Table 4. The reduction obligation makes an important contribution to phasing out fossil fuels in the transport system.

Table 4. Reduction levels 2018–2020 in line with the Act (2017:1201) on reduction of greenhouse gas emissions by mixing of biofuels in petrol and diesel fuels[29]. Reduction levels between 2020-2030 are announced but not formally decided.

Year	2018	2019	2020	2030*
Diesel	19.3%	20%	21%	66%
Petrol	2.6%	2.6%	4.2%	28%

In 2020, the Government announced that the emission reduction levels will be gradually increased by 2030, aiming at levels of 28 per cent for petrol and 66 per cent for diesel by 2030, with a control station in 2022.

Emission reduction targets for new vehicles

Manufacturers that sell vehicles in the EU are covered by an EU Regulation[30] that sets average emission reduction targets for new cars and

[28] SFS 2017:1200

[29] Act (2017:1201) on reduction of greenhouse gas emissions by mixing of biofuels in petrol and diesel fuels

[30] No. 443/2009, 333/2014, 510/2011 and 253/2014

vans. From 2021, phased in from 2020, the EU fleet-wide average emission target for new cars will be 95 g CO2/km and 147g CO_2/km for new vans. These requirements have a major impact on emissions in Sweden, as they considerably affect the composition of the vehicle fleet.

Bonus–malus-system for new light vehicles

A bonus–malus-system has been applied in Sweden since July 2018. Under this system, vehicles with low carbon dioxide emissions can qualify for a bonus on purchase, while vehicles with high carbon dioxide emissions in their first three years have a higher vehicle tax. From year four onwards, the ordinary vehicle tax is applied based on carbon dioxide emissions (see below). The system covers all new passenger cars and vans. Since 1 January 2020, the new cars and vans are taxed on WLTP values (Worldwide Harmonised Light Vehicle Test Procedure). In general, the WLTP has led to higher emission values and thus contributed to make the rules stricter.

Carbon dioxide-based vehicle tax

To provide incentives to car buyers to choose cars, vans and caravans with low greenhouse gas emissions, Sweden applies a differentiated annual vehicle tax based on the vehicle's carbon dioxide emissions per kilometre. Accordingly, vehicles with lower carbon dioxide emissions are taxed lower than vehicles with higher emissions. This tax applies to vehicles bought before the bonus–malus-system was implemented in July 2018 (see above) and will continue to apply to vehicles that "exit" the bonus-malus system three years after purchase.

Tax reduction on eco-friendly company cars

Company cars account for a large part of new vehicles registered in Sweden, and a large proportion of these can be used privately by the employees who drive them. The benefit of using a vehicle provided by one's employer for private journeys is, as a rule, taxable, and the value of the benefit is calculated according to a particular formula. To encourage the introduction of new eco-friendly cars on the market, the taxable value of eco-friendly cars is set at a lower level, equivalent to the price of the nearest comparable car without environmental technology. For electric cars, plug-in hybrids and cars run on gas (apart from liquefied petroleum gas - LPG), the taxable value of the company car benefit may be further reduced. From 1 January 2021 the further reduction will be abolished.

Climate premium
Regional public transport authorities, municipalities and companies to which the regional public transport authorities have outsourced the right to enter into agreements on public transport, and traffic companies that are public transport operators can apply for an electric bus premium. The premium applies to electric buses, charging hybrid buses, trolleybuses and fuel cell buses for public transport[31]. The size of the premium depends on the number of passengers and whether the bus is solely powered by electricity or if it is a hybrid. The premium seeks to support the introduction of electric buses on the market. The budget for the electric bus premium is SEK 80 million for 2019.

From 2020 onwards, the electric bus premium will be converted into a climate premium. This means that besides electric buses, it will also be possible to apply for funding for electric lorries and other eco-friendly lorries, as well as non-road mobile machinery powered by electricity, which combined with the continuing funding for electric buses seeks to encourage the introduction of these vehicles to the market.

Act on the Obligation to Supply Renewable Fuels[32]
To make renewable fuels available, there is legislation in Sweden that requires that filling stations with sales of more than 1,500 m^3 of petrol or diesel must offer at least one renewable fuel.

4.4 Industry

4.4.1 Action areas – industry

Emissions from combustions plants and industrial processes accounted for approximately a third of total emissions in Sweden in 2018. A large proportion of the direct emissions from industry come from some specific energy and carbon dioxide-intensive sectors in what can be termed the "basic materials industry": the iron, steel, minerals, refinery and chemicals industry. A number of other industrial sectors have considerably lower carbon dioxide emissions. Achieving long-term emissions targets close to zero demands several major changes that directly and indirectly affect the basic materials industry.

[31] SFS 2016:836

[32] Act (2005:1248) on the Obligation to Supply Renewable Fuels

The refinery and chemicals industries use high amounts of fossil fuels as raw materials for the process, making them relatively difficult to replace. These industries need funding and conditions in place to enable them to develop bio-based substitutes for fossil-based inputs.

Solutions to cutting emissions from cement and steel manufacture to zero span the entire chain, from raw material to end use. Lowering emissions to such an extent means reducing emissions from the basic process itself, improving the efficiency of the whole stream from raw material to end use, and increasing recycling of material. In rough terms, there are four major opportunities to reduce emissions:

(i) a transition from fossil raw materials and energy to renewable raw materials and energy carriers,
(ii) improve the efficiency of the process and increase material efficiency,
(iii) transition the basic process entirely, e.g. through electrification,
(iv) introduce technologies for carbon capture and storage (CCS), capable of reducing both fuel-related and process-related emissions.

In the cement industry, a combination of a transition to bioenergy and CCS is currently seen as the most realistic alternative for reducing emissions from the basic process itself in the long term. CCS technology is also an alternative for steel manufacturing if blast furnaces are retained, but there are several other feasible solutions here. Looking towards 2035, for example, direct reduction of iron ore using hydrogen (produced from renewable electricity or bioenergy) is an option. Since 2016, the private initiative HYBRIT (Hydrogen Breakthrough Ironmaking Technology) has begun to commercialize the concept. Moreover, there are other ways of reducing iron ore that have proved to work on a laboratory scale, e.g. electrolysis (known as electrowinning), which may also be a solution in the long term.

Improving process efficiency and downstream efficiency of material flows will also be necessary and justified in terms of cost and resource efficiency. Increased recycling of material is an important strategy today but can be expanded even further. The Government has therefor adopted a national strategy for a circular economy that sets out the direction and ambition for a long-term and sustainable transition of Swedish society.

Lowering emissions from the mining industry when mining iron ore also requires technological development which can be linked to developments in the iron and steel industry. The oxygen in the ore produced by the mining industry could be reduced by processing the iron ore at the mine

immediately after it has been mined, with the help of renewably produced methane or hydrogen, so reducing the need for reducing agents (carbon and coke) downstream in steel manufacture. Emissions in the aluminium industry and smelting works could be reduced with additional technological development. As far as the aluminium industry is concerned, this may involve developing what are termed inert anodes that do not give off carbon dioxide.

Reducing emissions in other areas of industry is easier. It is assumed that energy consumption for heating premises and for different types of industrial heating need (industrial emissions from incineration) could be reduced to low levels in all sectors through a combination of energy and material efficiency improvements, higher use of renewable fuels, and energy carriers such as electricity and hydrogen.

4.4.2 Policy instruments in industry

Sweden's policy instruments in the industry sector incentivise the use of renewable energy, improving efficiency and a transition in the basic process entirely. There is also certain governance for the introduction of carbon capture and storage (CCS). The policy instruments are directed towards large and smaller actors alike. Much of Sweden's industry has signed up to the Fossil Free Sweden initiative (see section 4.2.3) and work on the initiative serves as an important driving force in the sector. With regards to F-gases, governance mainly takes the form of regulation in the EU and at national level.

Table 5. Summary of the most significant instruments for industry

Renewable energy	**Efficiency improvements**	**Transition the basic process**	**Introduction of CCS**
EU ETS Industriklivet (industrial investment grants) Energy and carbon tax Energy and climate coaches Klimatklivet (local investment grants)	EU ETS Energy and carbon tax Environmental Code Energy surveys for companies Energisteget (energy efficiency grants for industry) Energy efficiency networks for SMEs Energy and climate coaches	EU ETS Industriklivet (industrial investment grants)	Industriklivet (industrial investment grants)

Below is a description of the most important existing instruments in the sector in addition to the EU ETS.

Carbon tax and energy tax in industry

Industry has certain energy and carbon tax reductions and exemptions, basically as a result of the fact that most of the manufacturing industry is already covered by the EU ETS. The manufacturing industry that falls under the EU ETS pays 30 per cent of the general energy tax and is entirely exempt from carbon tax. The manufacturing industry not included in the EU ETS also pays 30 per cent of the energy tax on fuel used in the manufacturing process. Previously, this part of industry had significant reductions in carbon tax but in recent years, the tax has gradually been raised. The tax reduction was removed entirely in 2018 and the full carbon tax is now levied. Furthermore, the Swedish Government has announced that the energy taxation reduction will be proposed to be abolished as from 1 January 2022.

Until 31 July 2019, diesel used in vehicles in the manufacturing process in mining industry operations, known as mining diesel, was subject to an energy tax and carbon tax levied at 11 per cent and 60 per cent respectively of the general tax levels. This reduction in energy and carbon taxes was abolished from 1 August 2019.

The Industry Leap (Industriklivet)

The Industry Leap is a long-term government programme, that supports the development of technology and processes to reduce process-related greenhouse gas emissions in the Swedish industry sector. The grant scheme initiated in 2018 is planned to run until 2040. Financial support can be given to research, preliminary trials, testing, pilot and demonstration projects, detailed planning studies and investments in measures to reduce emissions as well as for measures that seek to attain negative emissions, for example bio-energy CCS (BECCS). The target group for this funding is industries with process-related emissions as well as universities and research institutions. In 2020, the Government budgeted SEK 600 million for the programme. In its budget bill for 2021 the Government has proposed to extend and broaden the scheme.

One highly significant project part-funded by the Industry Leap is HYBRIT (Hydrogen Breakthrough Ironmaking Technology). The companies SSAB, LKAB and Vattenfall launched the project with the aim of producing

technical solutions to significantly cut carbon emissions from the steel industry. During 2018, with financial support from the Industry Leap, work started on the construction of a pilot plant for fossil-free steel production in Luleå, Sweden. The goal is to have a solution for fossil-free steel by 2035. If successful, HYBRIT can reduce Sweden's CO2 emissions by 10% and Finland's by 7%.

Energy survey and Energisteget grants

The Energy Audits Act[33] requires that large companies conduct an energy audit at least every four years, including information about their total energy consumption and proposals for cost-effective measures to improve energy efficiency. Companies covered by the Act that have conducted an energy audit have an opportunity to apply via the Energisteget programme for grants for in-depth planning of measures and for the additional cost of energy efficiency investments. Small and medium-sized enterprises are not covered by the Act but can apply for financial support for conducting energy audits.[34] The audit is to cover the energy audit, proposed measures and an energy plan.

Energy and climate coaches for SMEs

Municipalities can apply for compensation for the cost of a climate and energy coach employed at 50 per cent of a full-time post[35] who provides specific advice to SMEs. See also section 4.2.

Energy efficiency networks for SMEs

In 2015, the Swedish Energy Agency launched a network project for small and medium-sized enterprises. The energy efficiency networks are regional networks of companies where SMEs gain help and support in their work to cut energy consumption at their company. The networks consist of 8–16 companies with energy consumption exceeding one gigawatt hour (GWh). Sweden has 40 networks in place with about 300 participating companies. A network coordinator appointed by the Swedish Energy Agency leads the networks and has an affiliated energy expert providing support and advice. Sharing experiences and learning from each other within and across the networks are also important success factors. The purpose of the network activities is to reduce the energy consumption of participating companies by

[33] SFS 2014:266

[34] SFS 2009:1577

[35] SFS 2016:385

15 per cent over a four-year period. This enables companies to benefit from lowered costs, higher competitiveness and new growth opportunities.

4.4.3 Directives and provisions regulating emissions of fluorinated greenhouse gases

EU Regulation and Swedish Ordinance on fluorinated greenhouse gases

The EU Regulation on fluorinated greenhouse gases (F-gases)[36] seeks to cut emissions by two-thirds by 2030 compared with 2015. It contains provisions on the use, reuse and destruction of F-gases and sets conditions for placing on the market specific products and equipment that contain, or whose function relies upon, F-gases. Above all, the provisions include a mechanism for quantified emission reductions of substances that contain hydrofluorocarbons (HFCs), with a gradually lowered ceiling for total HFC emissions.

The Swedish Ordinance on fluorinated greenhouse gases[37] supplements the EU Regulation. The Ordinance sets out specific terms on cooling, air conditioning and heat pump equipment to ensure that leakage of F-gases is avoided.

The Industrial Emissions Directive (IED) and Best Available Techniques reference documents (BREF)

Under the Industrial Emissions Directive (IED), in 2016 the EU adopted a reference document on best available techniques (BREF) for the non-ferrous metals industries. The BAT (best available techniques) conclusions must be implemented within four years. These can significantly reduce emissions from aluminium production.

4.5 Electricity and district heating

4.5.1 Action areas – electricity and district heating

Sweden has a low proportion of fossil fuels in its electricity and heating production. The production of district heating has risen by approximately 50 per cent since 1990. At the same time, emissions from this sector have remained relatively stable, as expansion has largely been attained through

[36] Regulation (EU) no 517/2014 of the European Parliament and of the Council

[37] SFS 2016:1128

higher use of biofuels and wind power, while oil and coal consumption have decreased.

In a long-term perspective, however, since emissions in principle need to come down to close to zero, a number of challenges still remain. Two key challenges are how peak loads can be handled and how emissions from incineration of waste of fossil origin can be reduced. Furthermore, non-fossil electricity and biomass will continue to play an important role in substituting fossil fuels.

Phasing out fossil fuels in the transport sector and industry brings challenges and opportunities for the energy system

Greater electrification of the transport sector and industry can lead to a higher demand for electricity. Relative to total electricity consumption, electrification of the vehicle fleet is not estimated to lead to a major increase in Sweden. Complete electrification of the vehicle fleet could lead to an estimated increase in demand of 13 TWh[38]. Depending on charging patterns, a higher proportion of electric vehicles can bring both challenges and opportunities for the electricity system. On the one hand, it may bring challenges if there is a very high demand for power at certain times of the day. On the other hand, the fleet of electric vehicles can be a resource for the electricity system, helping to even out load over the course of the day, if charging is steered towards times of day where this is most beneficial to the system as a whole.

Future changes in energy carrier and the introduction of new technology in specific parts of the basic materials industry can have consequences for blast furnace gases delivered from the iron and steel industry to local electricity and heating producers. The potential electrification of processes in the steel industry may result in the disappearance of blast furnace gases, and the introduction of more energy-efficient technologies may affect the amount of waste heat available. In terms of increased electricity consumption in basic industry, the potential electrification of parts of the steel industry could mean an increase in electricity consumption of approximately 15–20 TWh, while large-scale expansion of CCS could be equivalent to 2–5 TWh[39].

The need for action to cut emissions from incineration of waste of fossil origin and for greater resource-efficiency

[38] IVA (2016) *Framtidens elanvändning – en delrapport* (Electricity consumption in the future – an interim report)

[39] Ibid.

From a systems perspective, waste incineration for electricity and heat production is efficient in many respects. Burning waste recovers the energy and cuts methane emissions from landfill. The Swedish plants have effective waste incineration technology, and Sweden has a well-developed district heating network. However, incineration of waste of fossil origin is problematic from a climate viewpoint. To combat a trend towards growing emissions from waste incineration, there is a need for measures to increase material recovery, and for incentives such as product requirements for more renewable raw materials in plastics manufacture. Amounts of waste have increased in Sweden and studies point towards continued growing amounts of waste, making waste prevention measures extremely important. Higher resource efficiency and promoting a circular economy is of the utmost importance for this reason.

4.5.2 Policy instruments on electricity and district heating

Policy instruments on electricity and district heating seek to replace fossil fuels with renewables and are geared towards electricity and district heating producers, electricity suppliers and other actors. Policy instruments targeting district heating producers seek to use price setting to incentivise substitution of fossil fuels with renewable alternatives. Price setting occurs both via taxes and via the EU ETS.

The fuels used for electricity production are not subject to price setting via taxation. On the other hand, the major electricity producers are covered by the EU ETS. The electricity suppliers are also obliged, via an electricity certificate system with a quota obligation, to demand renewable electricity from the producers. To make it easier to establish renewable energy production, measures are also implemented seeking to provide good conditions for expanding renewable electricity production, including identifying suitable areas for such establishment.

Policy instruments targeted at other actors seek, through financial support, to incentivise the installation of production of renewable electricity that can also be distributed on the national grid. The support contributes towards encouraging an increase in the total production of renewable electricity and the commercial development of new technology.

Table 6. Summary of the most significant policy instruments for electricity and district heating

Substituting fossil fuels with renewables for heat production	**Production of renewable electricity**
EU ETS Energy and carbon tax	EU ETS The electricity certificate system Promoting wind power Support for solar energy Tax reduction for microproduction of renewable energy

Below is a description of the most important existing policy instruments in the sector in addition to the EU ETS.

Carbon tax and energy tax for heating and electricity production

An energy and a carbon tax are applied to fuels used in heat production. Most biofuels are exempt from energy and carbon taxes. Fuels used to produce heating in combined heat and power plants (CHP) and other heat plants within the EU ETS are subject to a 91 per cent carbon tax and full energy tax. This is a significant increase for the CHP plants since 1 August 2019, as these fuels were previously only subject to an 11 per cent carbon tax and a 30 per cent energy tax. CHP plants that are not included in the EU ETS pay full energy tax and full carbon tax on fuel used to produce heat. This too is an increase, as before 1 August 2019, these fuels were subject to tax cuts and only paid an energy tax of 30 per cent.

Fuels used for electricity production are exempt from both the energy and the carbon tax, but the use of electricity is generally subject to energy tax.

The Electricity Certificate System

An electricity certificate system that seeks to increase the proportion of renewable electricity production was introduced in 2003. Sweden and Norway have had a joint electricity certificate market with shared targets since 2012 and the Riksdag has adopted sub-targets for the system to 2020 and 2030. The electricity suppliers have a statutory obligation to buy electricity certificates equivalent to a specific proportion, or quota, of the electricity they supply. The quotas gradually increase year after year. The electricity producers are allocated a certificate for each megawatt hour (MWh) of renewable electricity they produce. The producers sell the certificates on an open market where the price is set by sellers and buyers.

The certificates thus produce extra income for producers of renewable electricity. As the sub-targets are expected to be achieved in the near future, ten years before schedule, a deadline for allocating new electricity certificates has been recently introduced and that the electricity certificate system be ended by the end of 2035, ten years earlier than what was stated in the previous agreement.

Promoting wind power
Since 2004, certain land and water areas have been designated areas of national interest for wind power. There are more than 300 such areas in Sweden, on land and at sea. The total area covered by these national wind power interests is approximately 8,000 km^2, equivalent to approximately 1.5 per cent of Sweden's land area including Swedish waters.

Since 2018 funding has also been available to municipalities to make it easier to build wind farms[40].

Support for solar energy
A subsidy for installing solar panels was introduced in 2009. The budget for these grants is approximately SEK 4.5 billion for the period 2016–2021. All types of actors can receive financial support for installing solar panels and hybrid solar systems connected to the electricity grid. The investment grants help to transform the energy sector and aid commercial development of the market for solar energy technology.

Tax reduction for microproduction of renewable energy
A tax reduction for households and companies was introduced in 2015 to stimulate investment in microproduction of renewable electricity. An income tax reduction is granted in relation to the amount of renewable electricity fed into the national grid and amounts to a maximum SEK 18,000 per year per connection point.

4.6 Households and services

4.6.1 Action areas – households and services

Greenhouse gas emissions from heating households and services[41] in Sweden have plummeted since 1990, mainly due to private heating using fossil fuels being replaced with district heating or electricity. Energy and

[40] SFS 2017:1338

[41] Refers to heating excluding district heating.

carbon taxes, the oil price, the technology available for fossil fuel substitution and the expansion of district heating infrastructure have had a major impact on this trend. Emissions are equivalent to approximately 2 per cent of Sweden's total greenhouse gas emissions.

Challenge to build large amounts of housing quickly with climate considerations paramount

Boverket, Sweden's National Board of Housing, Building and Planning, has estimated that there is a need to build over 700,000 homes in the ten-year period 2015–2025, which is a very high rate relative to Sweden's existing housing stock. The rapidly increasing need for housing is leading to higher pressure on municipalities to rapidly produce a large number of affordable homes. There is a certain risk that such an urgent situation will lead to solutions in which not every aspect of sustainability is sufficiently addressed in planning and construction, and it is thereby important to ensure long-term solutions as construction increases.

Lower energy consumption can contribute towards resource efficiency

Direct emissions of greenhouse gases from this sector is low and is estimated to fall up to 2045. Total energy consumption in homes and premises, on the other hand, accounts for a large proportion of Sweden's energy use. Policy instruments targeting energy consumption in homes and premises currently mainly tackle emissions in electricity and district heating production. The trend in emissions in the electricity and district heating sector is also downward, which means that energy efficiency measures in the housing sector are making less of an impact in terms of lowering greenhouse gas emissions. That said, cost-effective measures to improve the efficiency of energy consumption help to lower the costs of climate policy through more efficient use of resources. Improved energy efficiency reduces the total need for energy and consequently the negative impacts that energy supply has on other environmental quality objectives and other objectives of society.

A large proportion of Sweden's housing stock is more than 50 years old, and the need to renovate estates including the "million programme" developments of the 1960s and 1970s is an urgent and demanding task. Renovating these buildings offers an opportunity to also improve their energy performance. The major challenge in reducing energy consumption in the housing sector therefore lies in renovating and improving the energy efficiency of existing housing and premises with a lower energy performance, with sufficient attention paid to their value as part of Sweden's cultural heritage.

Besides measures to reduce energy consumption in existing and new buildings, buildings have the potential to become "plus energy" buildings. In energy-efficient buildings, more small-scale electricity and heating producers will be able to produce heating and electricity to partly cover their own needs and sell any surplus to the national grid.

Improved energy storage opportunities, such as batteries in electric vehicles and smart grids will improve the underlying conditions for these "plus energy" buildings. Technological developments in renewable energy also offer greater opportunities for buildings to become plus energy buildings, e.g. through increased efficiency of solar panels or thin film solar panels that enable the use of more surfaces for electricity production.

Emissions in the housing production phase

The operational phase has long been the focus of emissions in the housing sector. However, while emissions from using homes and premises accounts for a small proportion of emissions today, the phase in which the buildings are produced accounts for approximately 21 per cent of Sweden's total greenhouse gas emissions[42]. This can include emissions from machinery and goods transport during construction, and emissions in producing materials, e.g. cement and steel. These emissions do not count as emissions in the housing sector and the emissions can arise both inside and outside Sweden's borders.

4.6.2 Policy instruments on households and services

Because the sector has largely made the transition to fossil-free, policy instruments expected to be of the most importance in the future are focused on increasing energy efficiency incentives. This is important, not least to make fossil-free energy available to other sectors. Governance uses a combination of policy instruments. Regulation imposes minimum requirements on producers while pricing in the form of taxes targets consumers. Requirements that producers provide product information also mean that consumers receive information on the energy efficiency of energy-related products, increasing opportunities for the consumer to make an informed choice. Promotional initiatives, such as training for actors in the construction industry, are also carried out to make the market better at providing energy-efficient buildings both in the construction phase and the usage phase.

[42] Boverket (2019) *Utsläpp av växthusgaser från bygg- och fastighetssektorn* (Greenhouse gas emissions from the construction and property sector)

Governance on housing and premises is thus geared towards: production of energy-efficient buildings and products, users' choice of buildings and energy-related products, users' energy consumption and improving the energy efficiency of the existing housing stock.

Table 7. Summary of the most significant policy instruments for homes and premises

Production of energy-efficient buildings and products	**Users' choice of more energy-efficient buildings and energy-related products**	**Users' energy consumption**	**Improving energy efficiency of the existing housing stock**
Ecodesign Directive Energy Labelling Regulation Building regulations Training programme for low energy buildings Grants for market launch, technological development and innovation clusters	Ecodesign Directive Energy Labelling Regulation Climate and energy advice	Energy and carbon tax Energy Declaration of Buildings Act Climate and energy advice	Climate and energy advice Building regulations Training programme for low energy buildings Grants for market launch, technological development and innovation clusters

Below is a description of the most important existing policy instruments in the sector besides carbon and energy taxes, climate and energy advice and support for market launch, technology development and innovation clusters as described in section 4.2.

The Energy Labelling Regulation and the Ecodesign Directive

Energy labelling is compulsory for the product groups regulated under the Energy Labelling Regulation and applies across all EU Member States. Energy labelling makes the product's energy consumption visible, making it easier for consumers to make energy-smart choices.

The Ecodesign Directive is intended to improve the environmental performance of products throughout their lifecycle. The requirements act as a floor for banning and removing the most energy intense products on the market. In principle, these rules can be applied to all energy-related products (apart from transport) and cover all energy sources. In Sweden, the Directive has been implemented by the Ecodesign Act[43].

[43] SFS 2008:112

The construction and civil engineering industry

The Planning and Building Act (PBL)[44] sets requirements for buildings. The rules apply to newbuilds and renovation. Boverket's building regulations (BBR)[45] contain provisions applying the Planning and Building Act in the form of rules on housing design, accessibility and usability, fire protection, hygiene, health, the environment, water and waste management, noise protection, safety during use and energy management.

The building regulations include energy efficiency requirements, setting out limits for the highest permitted energy consumption in buildings. One requirement covers limit values for the energy consumption of the building (primary energy factor) expressed as kWh per square metre of floor area per year. The requirement covers energy for heating, air conditioning, hot tap water and property energy and is stated for normal use of the building. The requirements for primary energy factors are currently 90 kWh/m^2 for single-family housing, 85 kWh/m^2 for apartment blocks and 80 kWh/m^2 for non-residential premises.

The milestone target in the environmental objectives system for higher resource efficiency in the construction sector means that measures are to be taken so that, by 2020 at the latest, at least 70 per cent by weight of non-hazardous construction and demolition waste is prepared for reuse, recycling and other material recovery.

The Swedish Transport Administration's experience of setting requirements to cut the climate impact of major civil engineering projects has shown how public procurement can create incentives for reduction measures, such as climate-smart concrete, and scope for new, innovative solutions.

Support for renovation and energy efficiency improvements

A grant aimed at encouraging renovation and energy-efficiency improvements to rented homes in areas facing socioeconomic challenges was introduced in 2016[46]. The renovation grant covers 20 per cent of the renovation costs and this proportion of the grant is paid directly to the tenant in the form of a rate rebate for seven years. However, in conjunction with its decision on the national budget for 2019, the Parliament has decided

[44] Planning and Building Act (2010:900)

[45] Boverket's code of statutes (BFS 2011:6, including amendments up to and including BFS 2018:15)

[46] Ordinance (2016:837) on grants for renovation and energy-efficiency improvements in certain residential areas.

not to allocate any funding for grants for renovation and energy efficiency improvements in certain residential areas in 2019[47].

The income tax reduction known as "rotavdraget" was introduced in 2008. It is a tax reduction, which means that the taxpayer's final tax is reduced for covered services. The services covered are maintenance, repair, extension and rebuilding of e.g. a house or an apartment. Some of the services covered also contribute towards more efficient energy consumption. One natural effect of the deduction is to create incentives for property owners to carry out more renovation work and energy-efficiency improvements.

Training programme for low energy buildings
Since 2016, the Swedish Energy Agency, in partnership with other actors, has been responsible for a number of capacity expansion programmes in the field of low energy buildings. The programmes are especially intended for different actors in the construction industry such as architects, engineers, clients, technicians, fitters, site managers and teachers of upper secondary school construction programmes.

Energy Declaration of Buildings Act
Based on the EU's Energy Performance of Buildings Directive, Sweden has implemented the Energy Declaration of Buildings Act[48]. The Act entails an obligation for owners of single-family and multi-family buildings and of commercial premises to declare the energy consumption of the buildings and certain parameters regarding the indoor climate. The aim is to encourage efficient use of energy and a healthy indoor environment by requiring owners to learn more about the measures that are cost-effective to implement for improved energy performance in buildings.

4.7 Non-road mobile machinery

4.7.1 Action areas – non-road mobile machinery

Non-road mobile machinery accounts for approximately 6 per cent of Sweden's greenhouse gas emissions. Non-road mobile machinery used in industry, agriculture, forestry and in other sectors of society released 3.1 million tonnes of carbon dioxide equivalents in 2018. Emissions from non-

[47] Owners of single-family dwellings are entitled to a tax reduction for boring and installing geothermal heating, and replacing windows, doors and taps, additional insulation, plus fitting and replacing ventilation. For individual tenant-owners, only such renovation work carried out in the apartment is eligible for a tax rebate (www.skatteverket.se).

[48] SFS 2006:985

road mobile machinery are 6 per cent higher than they were in 1990 and 5 per cent lower than in 2017. Non-road mobile machinery in industry accounts for just over a third of emissions from non-road mobile machinery, while such machinery in agriculture and forestry combined accounts for about a third, with other sectors of society making up the remainder. The calculation of emissions from non-road mobile machinery is so far entirely model-based.

Non-road mobile machinery covers a large number of types of machinery in different sectors, such as tools, tractors, cranes and diggers, but also smaller machines such as lawnmowers. This heterogeneity means that there is wide variation in capacity to take measures to reduce emissions. Greenhouse gas emissions from non-road mobile machinery amount to approximately 3.5 million tonnes per year. Unlike emissions from the transport sector, the trend in emissions from non-road mobile machinery has increased since 1990.

4.7.2 Policy instruments on non-road mobile machinery

Emissions from non-road mobile machinery are mainly governed by price-setting in the form of energy and carbon taxes, see section 4.2, and lower energy and carbon dioxide tax on biofuels, see section 4.3.2. The reduction obligation also has a bearing on emissions from non-road mobile machinery, see section 4.3.2. The public sector has additional opportunities to set requirements on machinery emissions in public procurement.

Reduction obligation

The use of petrol and diesel in non-road mobile machinery is covered by the reduction obligation. A higher blend of bio-based fuels makes it possible to reduce greenhouse gas emissions directly without having to replace each piece of machinery. The Swedish Environmental Protection Agency calculates that the effect of a reduction obligation of 40 per cent by 2030 would mean a potential reduction in emissions from non-road mobile machinery of up to 1 million tonnes of carbon dioxide equivalents. Existing tax cuts on high-blend biofuels also encourages increased use of biofuels in machinery.

Climate premium

An introductory grant will be needed to increase the proportion of electrified non-road mobile machinery in Sweden. In the 2020 Budget Bill, the Government therefore proposed a new premium for electric lorries and other eco-friendly lorries, as well as non-road mobile machinery powered by

electricity, which, combined with the continuing funding for electric buses, seeks to encourage the introduction of these vehicles to the market.

Procurement requirements
Environmental requirements on the environmental performance and energy consumption of non-road mobile machinery are set at varying levels in different public procurements of contracting services. The National Agency for Public Procurement is tasked with providing support to actors engaged in procurement and to suppliers to develop criteria for environmental considerations. The Swedish Transport Administration has worked with the three largest municipalities to develop joint requirements[49] on the environmental performance of non-road mobile machinery and on the proportion of renewable fuel use.

4.8 Waste

4.8.1 Action areas – waste

The volume of waste has constantly increased in Sweden. In addition, waste is imported for treatment and energy recovery. Despite the increasing amount of waste, emissions from the sector have fallen considerably, mainly in the form of methane emissions from landfill. The factors behind this reduction are increased material recovery from landfill and small landfill sites of organic material, combined with higher material recovery and waste incineration with energy recovery. These measures are a consequence of a series of policy instruments at national level and in the EU. Demand for waste as fuel for district heating has also had an impact on the switch from landfill to incineration.

Waste incineration for electricity and heating production is effective in many respects from a systems perspective, but incineration of waste of fossil origin is problematic from a climate aspect, see section 4.5.1.

To attain the climate goals, resources need to be used effectively and emissions from the entire lifecycle of products be taken into account when action and policy instruments are developed. The linear economy builds on a virgin natural resource being extracted, used and then becoming waste. This resource may be of fossil origin and its use thus means net emissions of greenhouse gases. For resources that are not of fossil origin, large amounts of energy are required – in global terms today, these too are often fossil in

[49] Swedish Transport Administration (2018) Environmental requirements for contractors

origin – to produce new products from virgin raw materials compared with reusing or recovering the energy from the products already created.

In a circular economy, waste is seen to a greater extent as a resource that can be returned to a new phase of production, and fossil inputs are replaced with sustainably produced bio raw materials and waste products.

The transition from a linear to a circular economy demands changing the entire value chain, with the development of innovative production methods, recovery technologies and circular business models. New goods also need to be designed and produced from the very start to enable them to be recovered and reintroduced in a circular flow to a greater extent.

4.8.2 Policy instruments on waste

Policy instruments in the waste sector seek to reduce methane emissions from landfill, increase material recovery and reduce the amount of waste.

Table 8. Summary of the most significant instruments for waste

Reduce methane emissions from landfill	**Increase material recovery**	**Reduce the amount of waste**
Ban on combustible and organic waste in landfill Regulation of collection and management of methane from landfill	Waste hierarchy in the Environmental Code Producer responsibility Measures for a circular and resource-efficient economy	Waste hierarchy in the Environmental Code Landfill tax Producer responsibility Municipal waste planning Measures for a circular and resource-efficient economy

A description of the most important existing policy instruments in the sector is provided below.

Ban on placing combustible and organic material in landfill and collection of methane

In line with the Swedish Landfill Ordinance[50], there is a ban on landfilling combustible and organic material. The ordinance also regulates the collection and management of methane gas from landfill.

[50] SFS 2001:512

Producer responsibility

Legislation on producer responsibility contains national targets for recovery, and a total of eight product groups[51] are covered under a number of ordinances. Producer responsibility encourages sorting, collection and recycling of waste flows. Producer liability seeks to provide incentives for producers and develop more resource-efficient products that are easier to recycle and no longer contain environmentally hazardous substances.

The Government has appointed an inquiry to submit a proposal on producer responsibility for textiles. The purpose of producer responsibility is to achieve environmental benefit through increased collection of textiles for reuse and of textile waste for recycling, primarily for preparation for reuse and material recovery. The purpose is also that responsibility for waste management and recycling of textiles is to be placed on the producers to achieve the polluter pays principle.

Waste hierarchy in the Environmental Code

The waste hierarchy in the EU Waste Framework Directive (Directive 2008/98/EU) sets out an order of priority in legislation and policy in Member States. The waste hierarchy is incorporated in Chapter 2 and Chapter 15 of the Swedish Environmental Code and means that waste prevention measures are to be taken in the first instance. This means policy instruments leading to a reduction in amounts of waste, a reduction in the amount of hazardous substances in the material and products, and a reduction in the negative consequences of the waste that arises. When selecting the waste treatment method, the starting point is that preparing for re-use is to be the first choice option. The second option is recycling and the third is other recovery (including energy recovery). Disposal is the final option.

When applying the waste hierarchy, Member States shall take measures to encourage the options that deliver the best overall environmental outcome. This may require specific waste streams departing from the hierarchy where this is justified by life cycle thinking regarding the overall impacts of the generation and management of such waste.

[51] Producer responsibility has been developed for packaging, waste paper, end-of-life vehicles, tyres, electrical and electronic equipment, batteries, pharmaceuticals and radioactive products.

Landfill tax

A tax on landfilled waste was introduced in 2000.[52] This tax has gradually been raised and since 2015 has amounted to SEK 500 per tonne of landfilled waste. The tax will be index-linked from 2019 onwards. In 2020 the tax is SEK 540 per tonne of waste.

Municipal waste planning

In line with the Environmental Code, all municipalities must have a waste plan that covers all types of waste and steps to manage the waste in a manner that is environmentally and resource-efficiently appropriate. The waste plan is to include measures to reduce the amount of waste and its hazardousness.

Measures for a circular and resource-efficient economy

Development towards a circular economy is vital if Sweden is to be the world's first fossil-free welfare nation, and contribute to the environmental and climate goals and several of the UN's Sustainable Development Goals in the 2030 Agenda.

There are major environmental and climate benefits to be gained from preventing waste arising and from material recovery. For example, there are major energy benefits to be attained from recovering materials rather than extracting new ones. For aluminium, the energy gain is as high as 90 per cent, which also means environment and climate gains from more energy-efficient waste management on top of the resource efficiency that is also attained. Extending product lifespan to replace new production makes the gains even greater. Key areas for the circular economy are to do with how material and products are viewed and dealt with to minimise environmental impact and extend their value. Production and consumption need to change to achieve this. In a circular economy, it is vital that hazardous substances do not enter the ecocycle. Non-toxic material is part of the transition to a circular economy.

The Government presented its national strategy for a circular economy 2020 and will conduct a broad overview of the regulations on recycling and managing waste and waste products to encourage innovation and enterprise in the circular economy.

In April 2018, the Government decided to set up a circular economy delegation. The aim is to boost the transition to a resource-efficient, circular

[52] SFS 1999:673

and bio-based economy, nationally and regionally. The tasks of the delegation are to provide advice to the Government, identify obstacles and act as a catalyst, and to be a knowledge centre and a coordinating force for transition.

If the circular, resource-efficient economy is to achieve its full potential, there is also a need for broader and deeper collaboration in the EU. For example, common, higher standards on recycling of plastics, textiles and batteries in the EU are important for facilitating trade in recyclable materials and to be able to control the quality.

4.9 Agriculture

4.9.1 Action areas – agriculture

Greenhouse gas emissions from Swedish agriculture have fallen compared with 1990, but still account for 13 per cent of Sweden's emissions. Swedish agriculture contributes to emissions of greenhouse gases in the form of methane from livestock's enteric fermentation as well as nitrous oxide and methane from agriculture soil and manure management. Other emissions are reported elsewhere, i.e. emissions from non-road agricultural machinery (see section 4.7.2) building heating (see section 4.6.2), as well as emissions and removals of greenhouse gas emissions from agricultural land (see section 4.10.1).

In the objectives of the Food Strategy, the Swedish Parliament has decided that Swedish food production is to increase. This means that some agricultural emissions are likely to remain even after 2045.[53] These remaining emissions will need to be compensated for with supplementary measures. It is nevertheless essential to work to ensure that these remaining emissions are as small as possible.

Agricultural emissions can be reduced by taking action that reduce emissions from production, e.g. through manure management measures and more efficient nitrogen use in arable farming. The most important action areas are described below.

Methane and nitrous oxide from storing manure

Actions that can reduce emissions from storing manure are, for example, a switch to slurry, acidification of slurry, covering of slurry pits and anaerobic

[53] Swedish Board of Agriculture. 2012. Ett klimatvänligt jordbruk 2050. Swedish Board of Agriculture (2018), Hur kan den svenska jordbrukssektorn bidra till att vi når det svenska klimatmålet?, Report 2018:1.

digestion of animal manure. The latter is estimated to have the greatest potential for emission reductions.

Anaerobic digestion of manure reduces the emissions from storage because the methane produced is managed rather than being emitted, and the storage of the digested residues produces lower emissions than non-anaerobically digested manure. Emissions of nitrous oxide from agricultural land is reducing as access to nitrogen increases in digested manure compared with non-aerobically digested manure, reducing the need for mineral fertiliser. Furthermore, greenhouse gas emissions in other sectors fall if the biogas (methane) replaces fossil fuel.

Nitrous oxide from agricultural land

Emissions of nitrous oxide from agricultural land can be reduced if fertiliser inputs are adapted to the expected nutrient needs, harvest levels of the crops and the expected nitrogen delivery of the land. Therefore, measures to increase nitrogen effectiveness by optimising fertiliser spreading in terms of the amount and time of spreading are important. With precision fertiliser spreading, nitrogen can be spread out according to how nitrogen need varies over the field instead of providing average inputs.

Additional measures that have the potential to reduce emissions are the use of nitrification inhibitors and incorporating fertiliser in the soil when spreading. Anaerobic digestion of manure increases the proportion of plant-available nitrogen and produces lower nitrous oxide emissions. Rewetting of peatlands, which is mainly a measure to reduce carbon dioxide emissions, can also reduce nitrous oxide emissions.

Methane from livestock digestion

Increased resource-efficiency and higher productivity reduce emissions of methane per produced unit. Through better breeding, animal health and more effective feed utilisation, Swedish productivity has risen over the years. The potential for further productivity increases in Sweden is therefore somewhat lower in the years ahead.

Composition of livestock feed can affect methane release. Feed additives can also be used to reduce emissions. However, the potential for this is considered to be relatively low.

4.9.2 Policy instruments in agriculture

Policy instruments in the agricultural sector seek to improve manure management and increase resource efficiency and productivity. Governance

takes place in the form of economic support and advice. Several agricultural initiatives are co-financed by the EU and Sweden via the Rural Development Programme, e.g. investment grants for biogas.

A description of the most important existing policy instruments in the sector is provided below.

The EU's Common Agricultural Policy, CAP

The EU's Common Agricultural Policy (CAP) seeks to increase productivity in the agriculture sector, secure the food supply, stabilise the markets, and guarantee farmers a reasonable standard of living and consumers reasonable prices. The CAP is divided into two pillars. Pillar I contains direct aid, while pillar II comprises rural development programmes in the Member States. Pillar I contains cross-compliance and greening payments, where greening is linked to measures that could increase the storage of carbon in agricultural land.

Rural Development Programme 2014–2020

The Rural Development Programme for 2014–2020 covers investment support, start-up grants for young entrepreneurs, skills development, collaboration and innovation, support for organic farming, land-based environment and climate measures and support for animal welfare. Measures that particularly contribute to reducing greenhouse gas emissions are those targeting increased energy efficiency, production and use of renewable energy (including biogas production and establishing multi-annual energy crops), switch from fossil fuels to renewable energy sources, improved fertiliser management, more effective use of nitrogen, climate and energy advice, measures to prevent risks of nitrogen leakage, restoration and establishment of wetlands, promotion of set-aside and capture crops in arable land, preserving natural grazing and other separate projects related to the climate and energy. The programme's budget amounts to SEK 36 billion throughout the programme period, 56 per cent of which is funded by Sweden and the remaining 44 per cent by the EU.

Swedish Rural Network

The Swedish Rural Network supplements and is funded through Sweden's rural development programme. The network gathers actors at local, regional and central level to swap information and experiences. The network is intended to reinforce the implementation of EU-related programmes. The Swedish Board of Agriculture has been tasked by the Government with ensuring that the Swedish Rural Network works.

Advice on plant nutrients – "Greppa näringen"
The Swedish Board of Agriculture offers an advisory service called "Greppa näringen" together with the Federation of Swedish Farmers and the county administrative boards. The service is funded by the Rural Development Programme and since its launch in 2001 has focused on advice for higher nutrient effectiveness to reduce nutrient leakage. The service also includes advice specifically aimed at cutting emissions of greenhouse gases and energy efficiency, because reducing greenhouse gas emissions has become one of the main aims of the service.

Aid for manure gas [54]
Since 2015 there has been a support system for biogas production through anaerobic digestion of manure. The funding seeks to increase biogas production from manure and thus double the environmental and climate benefits through reduced methane emissions from manure and substitution of fossil energy. Increased breakdown of manure generates several environmental benefits. This reduces both emissions of greenhouse gases and eutrophication of fresh and marine water, and produces biogas that can be used as energy. The biogas generated can be used to generate electricity or heating or be used as fuel for vehicles. The funding amounts to a maximum SEK 0.40 per kWh of biogas produced. Between January 2015 and September 2018, a total of SEK 176 million was distributed between 66 biogas plants. Funding to investments in new biogas facilities can also be granted through the Rural Development Programme.

4.10 Land use, land use change and forestry, LULUCF

4.10.1 Action areas – land use and forestry, LULUCF

In land use, land use change and forestry, Sweden has net removals, in other words removals of carbon dioxide mainly through growth in the forest being higher than emissions of carbon dioxide, nitrous oxide and methane. Total net removals in the sector were just under 42 million tonnes of carbon dioxide equivalents in 2018. The highest removals are seen in living biomass on forest land and in 2018, net removals (growth minus harvesting and natural breakdown) were just under 36 million tonnes of carbon dioxide equivalents. Net removal also takes place in harvested wood products and in 2018, this amounted to just under 6 million tonnes of carbon dioxide

[54] Ordinance (2014:1528) on government funding for biogas production

equivalents. The highest net emissions in the sector occur in organogenic land and in 2018 this amounted to just under 9 million tonnes of carbon dioxide equivalents.

A larger use of residue-based bioenergy has been crucial in Sweden in order to cut the use of fossil fuels in several industries. In the future, the demand for bioenergy is expecting to continue to be important so that the emission targets can be met. Wood products can also replace fossil-based materials in construction, biofuels replacing fossil fuels and biomaterial can replace fossil-intensive materials in clothing. The Government's inquiry on negative emissions (M 2018:07) whose mandate includes estimating the technical and realisable potential of increasing carbon sinks and proposing incentives to increase them submitted its report in January 2020. The Government has also appointed an inquiry on forests, looking at revised forms of protection and compensation when protecting forest land, and how international commitments on biodiversity could be made compatible with a growing circular bioeconomy.

In May 2018, the Government decided on a strategy for Sweden's National Forest Programme. The National Forest Programme will be developed to further promote a growing forest industry and sustainable forestry.

The Government also intends to produce a Swedish bioeconomy strategy together with the green industries that contribute towards greater access to biomass and employment throughout Sweden and create environmental and climate benefit.

Potential obstacles and uncertainties in increasing removals in the sector

A changing climate brings about both opportunities and obstacles for increasing carbon sinks. According to some studies, a warmer climate will mean higher forest growth and carbon storage in forest biomass in Sweden. On the other hand, natural disasters such as drought, fires, storms and pests could become more common in a changed climate, which could result in that the previously stored carbon returns into the atmosphere. Therefore, it is important to adapt Swedish forests to a fast-changing climate in order to harness the potentially positive effects of climate change and counteract the potentially negative effects.

4.10.2 Policy instruments in land use and forestry, LULUCF

Larger carbon removals, and reduced emissions, can contribute to net negative emissions in the long term and, as a supplementary measure, can

contribute to attaining the milestone emission targets as set within the climate policy framework. At the same time, bio-based fuels and bio-based materials that can replace materials based upon fossil raw materials are of great value to a society undergoing a climate transition. Sweden is well placed to combine active forestry with high environmental requirements as well as maintaining a significant carbon sink.

The Swedish Forestry Act has two overarching objectives: production and protection of the environment. The production objective means that forests and forest land must be used efficiently and responsibly so that they deliver a sustainable profit. The focus is that flexibility is to be given in terms of what the forests produce and how it is used. The environmental objective means that the natural productive capacity of forest land must be preserved. Biodiversity and the genetic diversity in the forests must be safeguarded. Forests must be managed in a way that enables naturally occurring plant and animal species to survive in natural conditions and populations that enable them to thrive. Endangered species and habitats as well as heritage forests and their aesthetic and societal values must be protected.

Applicable legislation affects indirectly the development of removals or emissions of carbon dioxide in different ways, mainly through provisions on forest management in the Forestry Act, provisions on land drainage in the Environmental Code and protection of areas and nature conservation agreements. A description of the most important existing policy instruments in the sector is provided below.

Under the Forestry Act, forest owners have freedom and responsibility for long-term sustainable forest management. The regulations cover obligation to report planned harvesting, minimum age for harvesting, regeneration requirements, thinning guidelines, provisions for consideration to soil, biodiversity, water and measures to limit forest damage. Examples of provisions on nature conservation and cultural heritage include not disturbing important biotopes, buffer zones and arable land, and leaving gatherings of old trees and dead wood in place. The forestry Act is also applicable for continuous cover forest management. Special rules apply to certain types of forest such as mountain forests and deciduous forests as well as reindeer herding areas.

Rewetting of drained wetlands

In 2021, a new scheme will be established in order to rewet previously drained wetlands and thereby reduce greenhouse gas emissions while

contributing to other significant environmental goals such as preserving biodiversity.

Rules on land drainage, Environmental Code, Chapter 11

The Environmental Code contains rules on land drainage which implies that oxygenation of organogenic land by drainage is prevented. Land drainage is a measure carried out by removing water or protecting land from flooding. In order for land drainage to be acceptable in the sense of the Environmental Code, the purpose of the measures must be to increase the long-term suitability of the land for a particular purpose, such as cultivation, construction, peatland, road construction or golf courses.

Since 1986, a permit is required for land drainage under the Environmental Code. In line with Chapter 11, section 14, the Government may prohibit land drainage in areas where the conservation of wetlands is particularly desirable. The provision further states that the county administrative boards may grant exemptions from such prohibitions. The Government has used its authorisation by pointing out areas where a ban on land drainage applies in Ordinance (1998:1388) on water operations. For land drainage to be able to be permitted in such an area, the county administrative board must find that the conditions for the dispensation are met, and the permit must be applied for and granted.

Nature reserves[55], Chapter 7 of the Environmental Code

In Sweden and in many other countries, nature reserves are one of the most common ways of protecting valuable natural environments. There are currently almost 5,000 nature reserves in Sweden, covering a total area of 4,808,590 hectares (2018). Chapter 7 of the Environmental Code contains the regulations for setting up nature reserves. Work to set up nature reserves is headed by the Swedish Environmental Protection Agency.

Nature conservation agreements

Nature conservation agreements[56] are agreements in civil law. The property owner and the State or a municipality agree on a certain amount of financial compensation for the property owner in return for the owner not carrying out forestry, for example. The Swedish Forest Agency and the Swedish Environmental Protection Agency together provide guidance.

[55] http://www.swedishepa.seEnjoying-nature/Protected-areas/Nature-reserve/

[56] http://www.naturvardsverket.se/Stod-i-miljoarbetet/Vagledningar/Skyddad-natur/Naturvardsavtal/

Sweden's National Forest Programme

The strategy for Sweden's National Forest Programme was decided by the Government on 17 May 2018. Further work within the National Forest Programme's strategy is guided by the programme's vision: "Forests – our 'green gold' – will contribute to creating jobs and sustainable growth throughout the country, and to the development of a growing bioeconomy." An action plan has been drawn up for the strategy containing concrete measures based on the Forest Programme's vision and objectives. Access to sustainable biomass from Swedish forests has an important role to play in the ongoing transition to a fossil-free society. The action plan contributes to Sweden's climate efforts by setting goals and measures aimed at increasing national access to bio-based alternatives.

Advice and training on forest management

The Swedish Forest Agency provides information and guidance to forest owners on adaptation and mitigation measures. The Swedish Forest Agency also provides tools and guidance on how best to manage and administer their forests with the owner's specific objectives in mind.

The EU's Common Agricultural Policy, *CAP*

One important policy instrument influencing production in the agricultural sector, and emissions and removal of greenhouse gases from the agricultural sector and its land use, is the EU's Common Agricultural Policy, CAP. The CAP also applies to the LULUCF sector, as emissions and removals of greenhouse gases on arable land and pasture are allocated to this sector. Read more about the CAP in section 4.9.2 on policy instruments in agriculture.

5 Consequences of Sweden's goals and actions

5.1 Consequences of failing to meet the climate targets

An important number of reports have shown that the costs of climate change to society can be substantial. Several reports, including the Stern Review, state that if we do not act preventively, the long-term total costs and risks of climate change will be equivalent to a significant loss of global GDP per year for a long time to come. Moreover, the Stern Review estimates that the costs of not taking action widely exceed the costs of acting. The World Economic Forum judges that failure of climate-change mitigation and adaptation as well as extreme weather events are the two greatest and most likely risks to the global economy[57].

Temperature is estimated to rise twice as rapidly in Sweden compared to the global average, which could bring, for example[58]:

Positive impacts such as a longer growing season, lower heating costs and higher hydroelectric power potential.

Negative impacts such as higher death rates due to heatwaves, greater spread of infectious diseases, shorter snow seasons, higher risks for flooding, landslides, rockfalls and erosion, lower quality drinking water and a higher risk of drought, forest fires and insect infestation.

The summer weather of 2018 – with high temperatures over a long period, severe drought, low drinking water levels and insect damage to trees – can be seen as an illustration of Sweden's vulnerability even now.

In general, other regions in the world are expected to be harder hit by the effects of climate change than Sweden. However, with an open economy, Sweden is vulnerable to indirect impacts when other countries suffer storms, fires and floods, etc. The effects may include increased migration, a higher

[57] http://www3.weforum.org/docs/WEF_Global_Risks_Report_2019.pdf

[58] https://www.regeringen.se/49bbac/contentassets/94b5ab7c66604cd0b8842fd6510b42c9/sverige-infor-klimatforandringarna---hot-och-mojligheter-missiv-kapitel-1-3-sou-200760

risk of violent conflict, impaired food supply and a need for more extensive work on combatting poverty[59].

These effects may also be considerably greater if certain irrevocable thresholds in the climate system are passed. For example, this would involve a serious rise in sea level following the collapse of the West Antarctic ice cover, high methane emissions from melting of the permafrost or major regional temperature changes from the stopping of the Gulf Stream. Effects of such events are very hard to predict.

5.2 Consequences of Swedish policy to attain the climate goals

5.2.1 The costs of transition are estimated to be small but uncertain

The total costs for Sweden of reaching net zero emissions by 2045 at the latest are estimated by today's models, both in Swedish and international studies, to be minor: only a few percentage points of GDP, either positively or negatively[60]. However, there are considerable uncertainties in forecasts reaching over 25 years in the future. There are examples of previous future forecasts, both in the field of economics and in the field of energy, that were no longer relevant only a few years after they were published. This is due to large uncertainties in many modelling assumptions, such as discounting rates, economic growth, behavioural change or technical development.

In addition, GDP is an incomplete measurement of prosperity, so the models currently used are limited in their scope. Both the IPCC and The New Climate Economy therefore emphasise the value of a multi criteria decision analysis, i.e. strategies that are favourable for the climate and several other goals of society at the same time.

5.2.2 Synergies and conflicts with other environmental and societal goals

The total number of potential synergies between cutting emissions and other goals of society generally exceeds the number of conflicts, but the net impact depends on the policy pursued in practice and the rate and size of the

[59] https://www.ipcc.ch/site/assets/uploads/2018/02/ar5_wgII_spm_en.pdf

[60] http://www.sou.gov.se/wp-content/uploads/2016/03/SOU_2016_21_webb.pdf
General equilibrium models usually show higher costs than energy system models.

change[61]. Favouring synergies and reducing conflicts between emission reductions and other societal goals reduces the cost of a broader transition towards sustainable development.

These side-effects are often difficult to quantify but can be very significant. Energy efficiency improvements and electrification of cars as well as a greater use of public transport, cycling and walking can for example lead to a better urban environment and lower particle emissions, whose health effects are estimated to claim 7,600 lives every year and cost about 1.2 per cent of Sweden's GNP[62]. More physical exercise can also reduce the risk for premature death, cardiovascular disease and type 2 diabetes[63]. Cutting down on red meat and charcuterie products is also considered to reduce the risk of a number of cases of cancer[64].

Biomass harvests need to be done in a way that is compatible with efforts to attain other environmental and social goals and with attention paid to the consequences for carbon sinks over time. Therefore, the bioeconomy needs to be based on effective use of resources, where the resource of the forests can be used to the full within the sustainability parameters set by other environmental and societal goals while retaining or improving the long-term carbon sink in the forest over time.

In the transition, it is also important to take into account distributional and regional effects, as different households have different opportunities to adapt to new instruments. Other sustainability aspects such as increasing gender equality and social cohesion can help to encourage reducing emissions[65].

5.2.3 Risks and opportunities of the transition for industry

If policy instruments are only unilaterally introduced in Sweden, there is a risk of job losses, for example, in carbon-intensive industries and sectors that operate on an international market. In such cases, there would be a risk of carbon leakage, i.e. the policy pursued resulting in emissions occurring in

[61] https://www.ipcc.ch/site/assets/uploads/sites/2/2019/05/SR15_SPM_version_report_LR.pdf

[62] https://www.ivl.se/download/18.2aa26978160972788071cafe/1529073450199/C317%20Quantification%20of%20population%20exposure%202015.pdf

[63] http://gih.diva-portal.org/smash/get/diva2:849879/FULLTEXT03.pdf

[64] https://apps.who.int/iris/bitstream/handle/10665/278948/WHO-NMH-NHD-18.12-eng.pdf?ua=1

[65] https://www.naturvardsverket.se/Documents/publikationer6400/978-91-620-6458-7.pdf

other countries instead. Such a development would run counter to the generational goal adopted by the Parliament[66].

Major technological leaps are needed to enable the most carbon-intensive industry in Sweden to make the transition, and here it is important that risks are shared between the business community and the Government.

Transitioning the Swedish economy to net zero emissions by 2045 means that parts of the economy that are strongly dependent on fossil fuels, or otherwise give rise to major greenhouse gas emissions, will be affected more than the sectors that are not as emission-intensive. For example, basic industry, heavy goods transport and the agricultural sector may be particularly vulnerable in the transition, at least in the short term.

The long-term rules that form part of the climate policy framework as well as industries' own roadmaps within the Fossil Free Sweden initiative create predictability and opportunities for the financial sector to make long-term investments in new technology and new services, and refrain from investments in potentially stranded or depreciated fossil assets.

A certain degree of flexibility is also important when designing climate policy, such that policies can be adapted to prevailing circumstances and encourage cost-efficiency. This is achieved by not setting milestone targets and emission paths for sectors and sub-sectors at an overly detailed level, and by allowing the use of supplementary measures in meeting the targets.

However, the starting point for Sweden's climate strategy is that the rest of the world, including the EU, acts forcefully to keep the average global temperature rise to far below two degrees and aim for 1.5 degrees, in line with the Paris Agreement. In this transition, more than 400 organisations and 22 sectors are part of the Fossil Free Sweden initiative.[67]

This can be explained by the fact that Sweden has certain comparative advantages in the climate transition seen from an international perspective due to an almost fossil-free electricity and district heating production, biomass, water and wind resources, high climate awareness, a high trust in institutions and a long history of innovation and entrepreneurship.

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[66] The generational goal reads: "The overall goal of Swedish environmental policy is to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders."

[67] http://fossilfritt-sverige.se/in-english/roadmaps-for-fossil-free-competitiveness/

6 Buy-in and realisation – Sweden's path to goals and measures

When the decision on the climate policy framework was reached, it was emphasised that Sweden has a strong tradition of political agreements on issues that are important and fundamental to society. A long-term climate policy that has broad support across party boundaries and in the Parliament is needed if Sweden is to lead the way on a global climate transition.[68] It is also central to Sweden's strategy to involve broad groups when implementing the policy, and that different actors in society are given every opportunity to include climate aspects in the strategic planning of their operations.

The Swedish climate goals adopted in 2017 are the result of long-term efforts and part of the overarching objective of Swedish environmental policy. In 1999 the Swedish Parliament decided on a generational goal that sets out the direction of the transformation of society that needs to take place within a generation. The overarching objective of Swedish environmental policy is to hand over to the next generation a society in which the major environmental problems in Sweden have been solved, without increasing environmental and health problems outside Sweden's borders. This generational goal is linked to 16 environmental quality objectives, including Reduced Climate Impact, which states that in accordance with the UN Framework Convention on Climate Change (UNFCCC), concentrations of greenhouse gases in the atmosphere must be stabilised at a level that will prevent dangerous anthropogenic interference with the climate system.

Since 1999, the Swedish climate goals have been updated and developed further. The climate policy decisions of 2002 and 2009 adopted national goals that were more ambitious than Sweden's commitments under the first and second commitment periods of the Kyoto Protocol and in line with the EU's effort sharing decision (ESD).

In 2010, the Swedish Government appointed a parliamentary committee, *the Cross-Party Committee on Environmental Objectives*, tasked with proposing how Sweden's environmental quality objectives and the generational goal could

[68] Government Bill 2016/17:146, A climate policy framework for Sweden

be attained. In December 2014, the Cross-Party Committee on Environmental Objectives received a specific mandate from the Government, which firstly resulted in the climate policy framework and a long-term target for 2045, and secondly a proposal for a long-term climate and air quality strategy including the milestone targets for 2030 and 2040. The work of the committee was conducted in close cooperation with public and private actors. Thirty experts in different categories were assigned to the Committee: government agencies, business representatives, researchers, environmental organisations and unions. Central issues discussed in this context were the level of ambition and the timing set for the long-term target. At these meetings, representatives of research and environmental organisations asserted the importance of the target being net zero and that this needed to happen within a short timeframe to be in line with the IPCC's conclusions. Furthermore, the experts had opportunities to react to assumptions of the potential of the measures made in the scenarios that were part of the basis for producing the levels in the milestone targets for 2030 and 2040 (see annex 1 "Modelling").

Two reference groups were also attached to the Cross-Party Committee on Environmental Objectives, one with expertise in political science and law and one with expertise in climate economics. Moreover, six external dialogue groups were appointed with leading representatives from academia, the business community and civil society to discuss the development of areas identified as central to climate policy. The dialogue groups together presented what the challenges of the sectors looked like, the opportunities for action and the governance needed. The text constituted part of the underlying data for the climate and air strategy.

Once the mandate of the Cross-Party Committee on Environmental Objectives had been fulfilled and its report submitted to the Government, the proposal on a climate policy framework and a long-term target for 2045 was circulated to approximately 200 consultation bodies for comment over a three-month period[69]. A similar consultation procedure was also carried out for the long-term climate and air quality strategy[70]. The consultation bodies included voluntary organisations (NGOs), industry organisations, think tanks, universities and higher education institutions and government

[69] https://www.regeringen.se/remisser/2016/03/remiss-av-delbetankande-fran-miljomalsberedningen-med-forslag-om-ett-klimatpolitiskt-ramverk-inklusive-langsiktigt-klimatmal/
[70] https://www.regeringen.se/remisser/2016/06/remiss-av-delbetankande-fran-miljomalsberedningen-med-forslag-om-en-klimat--och-luftvardsstrategi-for-sverige/

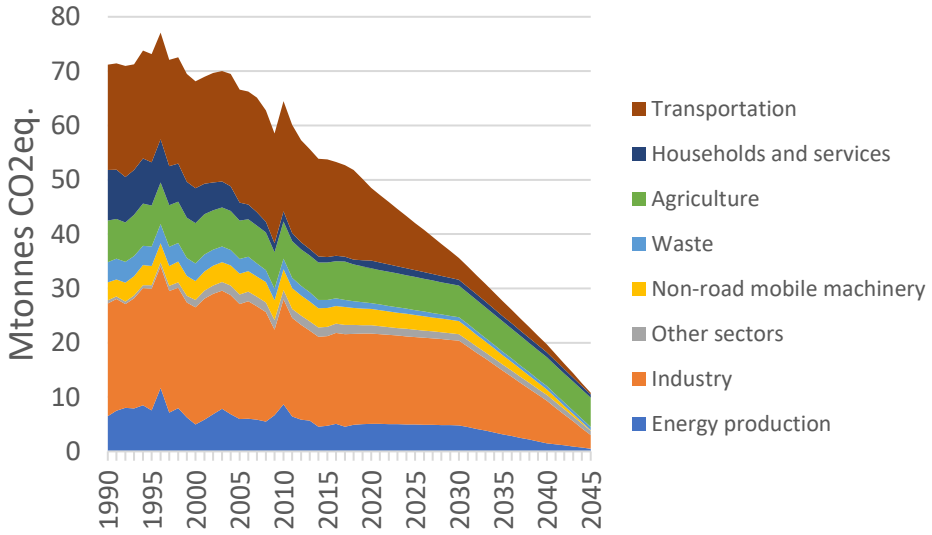
agencies. The consultations showed that there was largely broad-based support for the climate policy framework and the climate goals.

Seven out of eight political parties with more than 85 per cent of the votes in the Parliament supported the new goals of the climate policy and the framework when these were decided in June 2017. Since then, a Climate Policy Council has been set up and submits its annual reports to the Government. Audits of the Government's climate efforts have been presented each year. The Government presented its first climate policy action plan in line with the Climate Act in December 2019.

Annex 1 Modelling

Results from scenario analyses were used as part of the underlying material for discussion in producing the milestone targets for 2030 and 2040 for the non-trading sector, and for the long-term target of net zero emissions. The underlying data from the Swedish Environmental Protection Agency in 2012, in which five agencies worked together, formed the main basis of the scenarios. In line with this Government mandate, the agencies produced scenarios for different sectors to attain net zero emissions by 2050. The participating agencies were the Swedish Environmental Protection Agency, the Swedish Energy Agency, the Swedish Board of Agriculture, the Swedish Forest Agency and the Swedish Transport Administration. Universities and an energy system modelling consultant were hired to produce parts of the data for the scenarios. In this context, a "bottom-up" method was used in which potential measures in the respective sector were identified. Calculations of how high cuts in emissions the respective measure was capable of contributing and expert assessments on when these measures might be able to be put in place were combined and described in scenarios.

Figure 1. Results of the target scenario work underlying the discussion on target levels for 2030, 2040 and 2045.



The scenarios from the mandate in 2012 were developed further and updated in conjunction with the negotiations of the Cross-Party Committee on Environmental Objectives, see Figure 1. The starting point was assessments from research, environmental organisations and government agencies on the need for rapid action, together with different aspects of technical

feasibility. Scenarios and proposed target levels were discussed in the Cross-Party Committee on Environmental Objectives.

One important basis for the work on scenarios was the knowledge Sweden has on greenhouse gas emissions in the country and the scenarios that were constantly produced to evaluate emissions looking ahead in time with existing governance.

To supplement the work on scenarios, the National Institute of Economic Research produced a model calculation to roughly estimate the economic consequences by 2030; see section 6, *Consequences of Sweden's goals and actions*. Luleå University of Technology also completed a model analysis, TIMES Sweden, to shed light on cross-sectoral energy system consequences.