Sweden's Eighth National Communication on Climate Change

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Preface

Climate change remains the greatest challenge of our times with immense consequences for societies, health, and security for people across the globe. We need to transition towards sustainable societies and circular economies. It is a challenging task, but Sweden also recognises the opportunities the transformation provides. New industries and business opportunities are developing in Sweden as part of the efforts to combat climate change.

The objective of the Paris agreement is clear, and governments are responsible for setting societies on a path to achieve it. Sweden is willing to lead the way and has long worked to achieve a transformation of all sectors towards a sustainable society. By 2045 at the latest Sweden is to have net zero emissions of greenhouse gases into the atmosphere, by 2030 emissions from domestic transport, excluding domestic aviation, shall be reduced by 70 % and emissions from sectors outside of the EU emissions trading scheme should be at least 63 % lower in 2030 and at least 75 % lower in 2040 as compared to 1990.

But our efforts and commitments does not stop at 2045. Beyond 2045 we must continue working until we reach all the way to zero emissions and combine it with carbon removal to minimise the negative impacts of climate change. Therefore, we are working towards both reducing emissions in the short term and creating the necessary conditions for a sustainable society.

Sweden is committed to achieving these ambitious goals and we are continuously working to achieve the necessary transformation of our society. We encourage all countries to do the same so that we can achieve the goals of the Paris agreement together.

In this eighth National Communication and the fifth Biennial Report to the United Nations Framework Convention on Climate Change (UNFCCC), a comprehensive summary of Sweden's efforts to combat climate change is provided. Emissions and removals of greenhouse gases are reported for each sector and adopted and planned policy measures and their impact on emissions are described. The report contains projections for emissions up to 2030 and 2040. According to these projections emissions will continue to decrease, but further reductions are needed in order to reach Sweden's climate goals.

The National Communication and also describes Sweden's vulnerability and efforts to adapt to climate change. Sweden's contributions to climate finance are presented, as are research and development. Finally, a description is provided of Sweden's work on education, training and public awareness regarding climate change.

The material on which the National Communication and the Biennial Report is based has been obtained through extensive activity and input from around ten government agencies, led by the Swedish Environmental Protection Agency.

Stockholm, 2023.

Romina Pourmokhtari

Minister for Climate and Enterprise

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1. Executive summary

1.1 Introduction

This is Sweden's Eighth National Communication (NC8), which summarises the progress Sweden has made to meet its obligations under the United Nations Framework Convention on Climate Change (UNFCCC) and the Kyoto Protocol. Emissions of greenhouse gases in Sweden, excluding emissions and removals from land use, land use change and forestry (LULUCF), have decreased with 35 % over the period 1990–2020 and are expected to continue to decrease.

As part of the EU, Sweden takes on a quantified, economy-wide emission reduction target jointly with all other Member States both under UNFCCC and the Kyoto Protocol for the period 2013–2020. For the EU, the Kyoto commitment is the same as the Convention target except that it also includes LULUCF and excludes aviation emissions. The Swedish commitment under the Kyoto Protocol is the Member State share of the EU Effort Sharing Decision (ESD), where Sweden has committed to reducing emissions in sectors covered by the ESD by 17 % compared with 2005 emissions. For the LULUCF sector under the Kyoto Protocol, Sweden will account for the mandatory activities: afforestation, reforestation, deforestation and forest management.

1.2 National circumstances

Factors affecting a country's current and future levels of greenhouse gas emissions and removals include population, climate, energy and transport systems, industrial structure, and the economy. Sweden extends in a south-south-westerly/north-north-easterly direction from latitudes 55 to 69 degrees north and from longitudes 11 to 23 degrees east, with a land area of 406,550 km2. Urban land make up 3 % of the land area, while productive forest land account for 58 %, farmland 8 %, wetlands 12 %, alpine areas, subalpine woodlands and rock surface, 17%, and other land 2%[1] (Swedish University of Agricultural Sciences, 2021). Inland water systems total more than 40,000 km2, or more than 9% of Sweden's total area. Southern Sweden is low-lying, with agricultural land predominating in the far south. The only

[1] Five year average 2018.

real mountain chain, with peaks rising to over 2,000 m above sea level, is along the Norwegian border in the north-west.

Sweden's proximity to the North Atlantic and prevailing south-westerly to westerly winds result in a climate that, for the latitude, is mild in the winter months. The northernmost part of the country, however, has a sub-Arctic climate with long, cold and snowy winters. In the period 1961–90 the mean temperature in January was 0 °C in southernmost Sweden, while the coldest northern valleys had −17 °C. The daily mean July temperature was approximately 17 °C in south-eastern Sweden and just over 10 °C in the north. The mean temperature was about 1° higher in the years 1991–2020 than in 1961–90. The largest rise, over 2°, took place in the northern parts of Sweden in winter. Overall, owing to the rise in temperature, the densely populated areas (including Greater Stockholm) have undergone a shift from a cold-temperate to a warm-temperate climate.

Sweden has an open, trade-oriented economy. In 2020, the nation's gross domestic production (GDP) was SEK 4.98 trillion or close to SEK 481,000 per capita. Natural resources, such as forest and iron ore, are a basis for industrial production and, along with the engineering industry, have brought about a strongly export-oriented economy. Since 1990, exports have grown faster than imports and the trade balance has been positive. In 2019, exports accounted for 47 % of GDP. Main export industries are machines, vehicles, pharmaceuticals and chemicals, wood products, electronics and minerals.

The Swedish energy system is partly based on domestic sources of renewable energy such as water, wind and biofuel. In addition, a large proportion of the energy supplied is dependent on imports such as nuclear fuel for electricity production in nuclear reactors and fossil fuels like oil and natural gas for the transport system. Swedish electricity production is based largely on hydropower and nuclear power, but the expansion of wind power is steadily increasing as well as the use of biofuel for electricity and heat production. Total final energy use has increased by 20 % since 1970 and has been stable at approximately 520-560 TWh for the past ten years. Of total electricity production in 2019, hydropower accounted for 39%, nuclear power also 39% and wind power 12 %, while biofuels and fossil-based Combined Heat and Power production made up the remaining 10%.

Sweden has a mixed industry, characteristically based more on raw materials than many other countries. For example, the extensive forest industry (wood products, paper, and pulp) and the iron and steel industry are based on domestic natural resources. Indeed, the forest industry and iron and steel industry, together with the chemical industry, have long been an important part of the Swedish industry, and today contribute significantly to the nation's exports. The manufacturing sector is important to the economy, accounting for nearly 20 % of GDP in terms of value added in the private sector in 2019.

Domestic transport is dominated by road traffic. Several factors affect greenhouse gas emissions from traffic, especially transport volume and the technology used. Transport activity for passengers and goods alike has increased since 1970. Vehicle kilometers travelled has increased for passenger vehicles, lorries and motorcycles since 1990, whilst buses/coaches have remained relatively stable. In terms of greenhouse gas emissions, the rapid rise in passenger travel has been offset by more energy- efficient cars and increased use of renewable fuels, which have resulted in a decrease in emissions per passenger-kilometer. The efficiency of freight transport also improved in the 1990s, but this trend has since leveled off. In 2019, fossil fuels accounted for 77 % of the energy used by domestic transport, while the remainder consisted of biofuels and electricity.

Sweden's forest land amounts to 27.9 million hectares hectares (ha). Of the total forest area, 23,5 million ha is regarded as productive forest, corresponding to 58 % of the total land area. Accordingly, there is also 4.4 million ha of unproductive forests (11 % of total land area). It is for the total forest area that greenhouse gas emissions and removals in forests are reported.

1.3 Greenhouse gas inventory

In 2020, total greenhouse gas emissions (excluding LULUCF) in Sweden was 46.3 million tonnes of carbon dioxide equivalents (Mt CO2-eq.). Between 2019 and 2020 the total greenhouse gas emissions decreased by 9 %, largely due to the COVID-19-pandemic. Total emissions have decreased by 25.1 Mt CO2-eq, or 35 %, between 1990 and 2020. Emission levels have varied between a low of 46.3 Mt CO2-eq. in 2020 and a high of 77.3 Mt CO2-eq. in 1996. The net sink attributable to the land use, land-use change and forestry

(LULUCF) sector has varied over the period but has generated annual net removals in Sweden during the whole period 1990-2020. In 2020 total net removal from the sector was estimated to 40 Mt CO2-eq.

In 2020, emissions (excl. LULUCF) of carbon dioxide (CO2) amounted to 36.5 Mt CO2 in total, which is equivalent to 79 % of total greenhouse gas emissions, calculated as CO2-eq. Emissions of methane (CH4) accounted for 4.1 Mt of CO2-eq. (about 9 % of total emissions), emissions of nitrous oxide (N2O) 4.6 Mt (9 %), fluorinated greenhouse gases (HFCs, PFCs and SF6) 1 Mt (2 %).

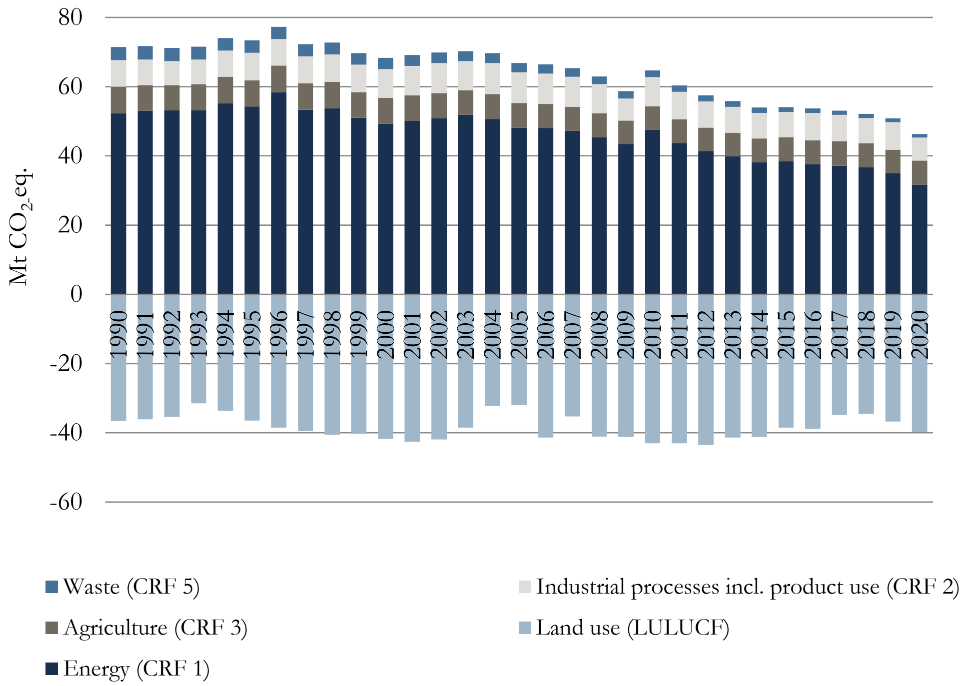

Figure 1.1 Total greenhouse gas emissions and removals in Sweden 1990-2020

Since the late nineties there has been a decreasing trend in Sweden's greenhouse gas emissions. The largest reductions in absolute terms are due to a transition from oil-fuelled heating of homes and commercial and institutional premises to electricity, e.g. heat pumps and district heating.

Increased use of biofuels in district heating generation and industry has also contributed to the reductions together with reductions in landfilling of waste. Fluctuations in production levels of manufacturing industries following changes in the economic development of specific industries have also had significant impacts on the national trend.

1.4 Policies and measures

Sweden's climate strategy has progressively developed since the late 1980s. To provide a clear structure for environmental efforts in Sweden, the Riksdag (the Swedish Parliament) has adopted 16 environmental quality objectives. One of these, Reduced Climate Impact, forms the basis for climate change action in the country. The interpretation of the objective is "Holding the increase in the global average temperature to well below 2°C above pre-industrial levels and pursuing efforts to limit the temperature increase to 1.5°C above pre-industrial levels. Sweden will work internationally towards global efforts to address this goal."

In 2017, the Riksdag adopted a national climate policy framework for Sweden. The climate policy framework consists of a Climate Act, national climate targets and a climate policy council. The climate policy framework is the most important climate reform in Sweden's history. It creates order and stability in climate policy and sets long-term conditions for the business sector and society at large. The Act imposes responsibility on the current Government, and on future governments, to pursue a climate policy that is based on the national climate targets and to provide clear feedback on the progress. As a result Sweden now have long-term climate targets (see Figure 1.2) and a council that independently reviews climate policy. The reform is a key component of Sweden's efforts to live up to the Paris Agreement.

	Historical emissions	Climate target	Climate targets in the Climate Policy Framework	
Swedish emissions in total	- 35 % 1990-2020		Net zero by 2045 Max 15 % supplementary measures	
Emissions from sectors outside the EU ETS	- 36 % 1990-2020	-40 % by 2020 Max 13 % supplementary measures	-63 % by 2030 Max 8 % supplementary measures	-75 % by 2040 Max 2 % supplementary measures
Emissions from domestic transportation	-27 % 2010-2020 Excl. domestic aviation		-70 % by 2030 Compared to 2010	

Figure 1.2 Sweden's historical missions and climate targets in the Climate Policy Framework

The climate policy is also set out in two previous Government Bills, entitled *An Integrated Climate and Energy Policy*, passed by the Riksdag in 2009. The first of these Bills sets a national milestone target for climate, calling for a 40 % reduction in emissions by 2020 compared with 1990. The target applied to activities not included in the EU Emissions Trading System (EU ETS) and wasmore ambitious than Sweden's commitment under the Effort Sharing Decision (ESD) implementing the EU Climate and Energy Package.

Sweden has introduced a range of policies and measures directly or indirectly affecting greenhouse gas emissions. The emphasis in the country's climate strategy is on the use of general economic instruments. However, many instruments which interact with carbon dioxide tax and emissions trading have also been adopted to achieve other policy goals than the climate objective, such as energy policy objectives.

Since the early 1990s, two key instruments in reducing Swedish emissions have been the energy and carbon taxes. These taxes have been supplemented with other instruments, such as an electricity certificates system, technology procurement, public information campaigns, a differentiated annual vehicle tax and investment grants. Legislation including bans, standards and urban planning also plays a part in curbing emissions. EU-wide policy instruments, in particular CO_2 emission performance standards for new vehicles and the EU ETS, are also important in Sweden.

In the budget proposal for 2022 (Govt. Bill 2021/22:1), the Government proposed measures to ensure that Swedish industry will retain its leading position in the climate transition, to contribute to infrastructure that leads to a more sustainable society and to accelerate work to transition to a more circular economy and a greener everyday life. At the same time, developments in recent decades have been defined by a framework for spatial planning and other long-established instruments in Sweden. Of particular importance are investments from earlier decades in expanding district heating networks, public transport systems and the carbon-free production of electricity.

1.4.1 Cross-sectoral policy instruments

Alongside the energy and carbon dioxide taxes, a set of other cross-sectorial policy instruments are applied in Sweden, such as grants (local climate investment program), climate communication, and research and development. A local climate investment program was introduced in 2015 and has since been scaled up. In total, SEK 7.7 billion has been granted for investments within the program (as of November 2021). Examples of investments that can be granted support are charging infrastructure for electric vehicles, biogas plants, infrastructure for biofuel and changes from fossil oil to biofuel or district heating.

In order to achieve net zero emissions by 2045, and enable negative emissions thereafter, a national center for carbon dioxide capture and storage has been established at the Swedish Energy Agency.

The government has decided on a national strategy for electrification. The strategy will contribute to a fast, smart, and economically efficient electrification. In the strategy, the government takes a holistic approach to the conditions in the energy sector, including a plan on how to tackle obstacles, to enable increased electrification. Means has been allocated to enable the implementation of the strategy to meet society's needs and expectations. Among other things, the Government intends to set up an electrification council to support the implementation of the electrification strategy.

The Swedish Government has adopted the objective to make Sweden one of the world’s first fossil-free welfare states. This ambition requires a mobilisation of the entire society, not least municipalities, cities and business. To that end the government has launched the Fossil-Free Sweden initiative which mobilises and supports key actors in their climate efforts by providing a platform for dialogue, cooperation and inspiration between themselves and the Government. A national coordinator, appointed by the government, is the link between the actors and the government in efforts to remove obstacles and create conditions to speed up the reduction of greenhouse gas emissions.

Public investment in climate-related research and development has increased in recent years and aims at creating better prerequisites for achieving the substantial longer-term emissions reduction required. Swedish climate-related research covers a broad spectrum, from natural sciences to humanities, but places an emphasis on technical and scientific research and development. Three important research areas are energy, transport, and industry, for which the Government has decided to grant extensive funding.

1.4.2 Energy sector

The production of district heating has risen approximately 50% since 1990. At the same time, emissions from this source have been signicantly reduced, as the expansion largely has been achieved by the increased use of biofuels. The carbon tax is one of the main factors behind this trend - the aggregate level of taxes on fossil fuel use in the sector has risen steadily since 1990 - but the electricity certificate system has also been important in phasing out fossil fuels in the sector. Since 2005, most combustion installations for power and heat production have been included in the EU ETS, which also is a key policy instrument for the sector. Since 2020 incineration of waste is taxed. The tax has gradually been increased and is from 2022 SEK 125 per ton.

Several policy instruments are available that target energy use in homes and commercial and institutional premises. These include building regulations, energy performance certificates, the EU Energy Labelling Directive, Energy Efficiency Directive and the Ecodesign Directive, which results in energy savings by helping to eliminate the least energy-efficient products There are several initiatives for wind power examsion as well as suport for instalations of solar power systems and systems for storage of self-produced electricity. With the aim to reduce greenhouse gas emissions private

individuals are, since 1 January 2021, eligible to a tax
deduction for installation of green technology including solar cells, systems for storage of self-produced electricity and at home charging stations.

1.4.3 Industrial sector

Total emissions from combustion in manufacturing industries as well as from industrial processes are trending downward. Iinstruments primarily affecting combustion emissions from the industrial sector include the EU ETS, energy and carbon dioxide taxes, the electricity certificates system and the Environmental Code.

Greenhouse gas emissions from industrial processes show an overall decreasing trend since 2006. These processes are regulated by the Environmental Code’s requirement to use the best available technology. Other instruments affecting process related emissions include the EU ETS, the Energy Step, Energy Audits and the Industrial Leap.. The Industrial Leap is a long-term reform which began in 2018 and continues until 2040. It consists of a government scheme that aims to support development of technology and processes to reduce the process-related greenhouse gas emissions in Swedish industry.

The Government is introducing a reversed auction where the winning company (the company offering the most cost efficient solution) will receive operating aid to operate a BECCS (Bio-Energy with Carbon Capture and Storage) facility. A first such auction is planned for 2022. In 2021 a state green credit guarantee was introduced to facilitate major industrial investments that contribute to achieving the goals in the Environmental quality objectives system and the Climate Policy Framework.

1.4.4 Transport sector

Emissions from domestic transport, where road transport dominates, increased after 1990, reaching a peak in 2007. They have been declining since then, but this decline has slowed since 2013. The decrease in emissions since 2007 can be attributed to policy instruments introduced both nationally and at the EU level. The most significant ones include carbon dioxide emission EU performance standards for new vehicles, vehicle taxes and vehicle fuel taxes and more recently, a greenhouse gas emission reduction obligation for petrol and diesel. These have resulted in more energy-efficient vehicles and a greater use of renewable fuels.

Several policies and measures aimed at the transport sector has been or is in operation. These include climate investment program granting support for infrastructure for the introduction of electrical vehicles, a bonus–malus system for light-duty vehicles, and a tax on air travel and a reduction obligation scheme for aviation with the aim to reduce the climate impact of aviation. Companies and municipalities are also eligible to apply for climate premiums for electric and other low-emission heavy-duty vehicles. In 2018 an environmental compensation scheme was introduced to stimulate railway transports of goods.

Greenhouse gas emissions from domestic transport (excluding domestic flights) amounted to 15 million tonnes of CO2 equivalent in 2020, which is a decrease of 10% compared to 2019. Road traffic accounts for by far the largest share (about 95%) of emissions from transport in the country, of which passenger cars account for about 63% and heavy and light trucks account for about 30 %. Compared to 1990, emissions from domestic transport (excluding domestic flights) have decreased by 21%. The reduction in emissions is mainly a result of an increase in the share of biofuels while at the same time making vehicles more energy efficient.

The emission reduction obligation, implemented in 2018, establishes an obligation on petrol and diesel suppliers to reduce life-cycle carbon dioxide emissions, by gradually increasing blending with sustainable biofuels. The reduction obligation scheme contributes to reduction of fossil fuels in road transport.

When it comes to the rate of electrification of cars the latest statistics show a significant increase in sales of electric cars (+105 % in 2021) and plug-in hybrids (+18 % in 2021) in Sweden. In 2020, the share of electric cars and plug-in hybrids sold in Sweden was about 31 percent of sales of passenger cars. In 2021, the share had risen to 45 percent of new car sales, which is the highest share among EU member states. When the bonus–malus system was introduced in 2018, the proportion was eight percent.

1.4.5 Waste

Methane emissions from landfill sites have declined significantly since 1990 and are expected to continue falling sharply over the next ten years. According to preliminary statistics from the Swedish Environmental Protection Agency, emissions from waste have decreased by 4.6 per cent in 2020 compared to the previous year. Behind this development are the landfill bans and taxation of landfilling of waste, which were introduced in the early 2000:s. Demand for waste as a fuel for district heating has also strongly encouraged diversion from landfill to incineration.

An analysis of the combined effect of policy instruments influencing methane emissions from landfill sites showed that, in a scenario based on instruments decided on at the time of the analysis, emissions would end up around 1.9 Mt CO_2 eq. lower in 2020 than in a scenario based on 1990 instruments.

1.4.6 Agriculture and forestry

According to the Strategic plan for the implementation of the common agricultural policy in Sweden 2023-2027 “climate-impacting emissions from the agricultural sector can be reduced but not completely removed”. Measures, mentioned in the Strategic plan, where agriculture can contribute to reduced climate impact include becoming more resource efficient per unit produced, increasing carbon storage in soil and contributing to increased production of renewable energy. Greenhouse gas emissions from Swedish agriculture have fallen since 1990. As yet, there are relatively few economic policy instruments directly targeting greenhouse gas emissions in this sector.

However, the Government has taken several initiatives to reduce fossil fuel use in farming, and to increase awareness and encourage the use of measures to curb emissions of greenhouse gases from manure and fertiliser management and from land use. An Official Report of the Swedish Government (SOU 2021:67 Vägen mot fossiloberoende jordbruk) was published in 2021 with proposals on how to reduce the agriculture sector’s dependence on fossil fuels. Apart from using CAP2-funding, investments in the agricultural sector have been granted funds from the Local Climate Investment Program (described in chapter 4). In 2021 the European Parliament, the Council of the EU and the European Commission agreed on the reform of the CAP. The new CAP for the period 2023-2027 aims to support the transition towards sustainable agriculture and forestry in the EU and to contribute to the goals of the European Green Deal. 40% of the CAP budget will have to be climate relevant (European Commission 2021)[2]

In 2020 the Government decided on a new support scheme for re-wetting previously drained wetlands, which aims at providing climate benefits while also strengthening biodiversity, balance water flows, increase the addition to ground water and reduce eutrophication. The investment in re-wetting measures is estimated to contribute to an emission reduction of 0.08-0.18 million tonnes of CO2-equivalents per year, depending on which land is re-wetted.

1.4.7 Flexible mechanisms under the Kyoto Protocol

The role of the Swedish Program for International Climate initiatives has been to support developing countries to achieve a reduction in greenhouse gas emissions. Throughout the program, Sweden has supported over 90 bilateral projects through CDM and JI and has participated in 11 multilateral carbon funds. By the end of 2020, 91 bilateral projects and 11 multilateral funds[3] had generated emission reductions equivalent to approximately 31 Mt CO2 -eq. In total, SEK 1,8 billion had been granted by the end of 2020. The number of active initiatives is steadily decreasing. The program is expected to close by 2025 with final payments in 2022.

All projects are carried out in developing countries, and priority has been given to projects in least developed countries (LDCs), small island developing states (SIDS) and in Sub-Saharan Africa. Overall, the program supports climate projects in more than 50 developing countries. A majority of the projects are in renewable energy, energy efficiency and waste management.

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[2] Common Agricultural Policy https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en

[3] Future Carbon Fund (FCF), Asia Pacific Carbon Fund (APCF), Transformative Carbon Asset Facility (TCAF), Carbon Initiative for Development (Ci-Dev), Carbon Partnership Facility (CPF), Pilot Auction Facility for Methane and Climate Change Mitigation (PAF), Umbrella Carbon Facility Tranche 2 (UCF T2), Prototype Carbon Fund (PCF), Multilateral Carbon Credit Fund (MCCF), Testing Ground Facility (TGF) and Partnership for Market Readiness (PMR).

Sweden has decided to cancel all emission reductions received up until 2020. The cancelled international credits have not been used to fulfil commitments under the Kyoto Protocol.

1.5 Projections and the total effects of policies and measures

The projections with existing measures are based on the policies and measures currently adopted by the EU and the Riksdag (the Swedish Parliament) together with an assessment of future trends. The projection results indicate a gradual decline in total emissions of greenhouse gases (excluding LULUCF) over the projection period. By 2030 and 2040, aggregate emissions are projected to be 39 % and 46 % lower respectively, than in 1990. The LULUCF sector contributed to an annual net removal of carbon dioxide in Sweden during the period 1990–2019 and is expected to continue to do so during the projection period.

Table 1.1 Historical and projected emissions and removals of greenhouse gases by sector (million tonnes CO_2-equivalents).

	1990	2019	2025	2030	2035	2040	1990-2030	1990-2040
Energy excl. transport	33.1	18.5	18.3	17.4	16.6	16.3	16.2	-50%
Transport	19.0	16.4	15.6	15.2	13.6	12.0	10.7	-28%
Industrial processes and product use	7.7	7.9	6.9	7.2	6.1	6.0	6.0	-20%
Agriculture	7.7	6.9	6.8	6.3	6.1	6.0	5.9	-20%
Waste	3.7	1.1	1.1	0.9	0.8	0.7	0.6	-79%
Total emissions	**71.2**	**50.9**	**48.8**	**47.0**	**43.2**	**41.0**	**39.4**	**-39%**
LULUCF	-36.5	-35.5	-35.9	-39.3	-37.4	-38.4	-40.4	2%

Over the projection period, the emissions from energy, transport, industrial processes and product use, agriculture and waste are expected to decrease until 2040.

Emissions from the energy industries (electricity and heat production, refineries and manufacture of solid fuels) are projected to decrease until 2040. Until 2040, production of electricity is assumed to grow more than consumption, resulting in a projected export of about 40 TWh by 2040.

The emissions from households and premises and from combustion in the agricultural, forestry and fishing sectors are projected to continue to decrease. The decline is mainly due to a continuing replacement of individual oil-fuelled boilers for heating and hot water purposes in households and premises with district heating, electric heating, heat pumps and biomass.

Combustion emissions from manufacturing industries are projected to decrease until 2040, because the use of biofuel and electricity is expected to increase more than the use of fossil fuels. The industrial processes and product use sector contributes greenhouse gas emissions from the materials used in industrial processes and the use of solvents, fluorinated greenhouse gases and other products. These emissions are projected to decrease slightly until 2035. The decrease is caused by the decrease in emissions of fluorinated greenhouse gases due to a ban on their use that resulted from EU regulations.

Emissions from domestic transport, especially from road transport, are projected to decrease until 2040 for several reasons. One is an assumed continuous improvement in the energy efficiency of the vehicle fleet due to EU CO_2 requirements that limit emissions from new cars and light-duty vehicles. Another reason for the decrease is a greater use of biofuels.

Methane emissions from landfills are projected to decrease until 2040. This decrease is mainly due to the ban on depositing combustible materials in landfills and on depositing organic materials in landfills.

Emissions from agriculture are estimated to decrease until 2040 as a result of a continuously declining cattle population. The reduced numbers of dairy cows are primarily a result of increased productivity, product pricing mechanisms and continuous adaptation to EU agricultural policy regulations.

The net removals for LULUCF are expected to increase until 2040, mainly due to a increase in removals from forest land.

1.5.1 Progress towards meetings Sweden's commitment under the Kyotoprotocol

Under the EU Climate and Energy Package, greenhouse gas emissions from the EU are to be reduced by 20% compared with 1990 by 2020. Emissions from installations included in the EU Emissions Trading System (EU ETS) are to fall by 21% between 2005 and 2020 for the EU as a whole. For Sweden, emissions not covered by the trading system are to be reduced by 17% between 2005 and 2020.

For the years 2013-2020, Sweden's ESD-emissions were lower than the ESD-targets. The surplus amount of AEAs was over 5 million per year compared to the Swedish ESD target. The surplus for 2013-2018 were deleted and the government has proposed to the Swedish Parliament that also the surplus for 2020 should be deleted. Compliance for 2020 is planned to be performed in 2023.

1.6 Vulnerability assessment, climate change impacts and adaptation measure

In Sweden, extensive research is carried out on climate change and its current and potential future effects. Information from government authorities is freely available and open to all. Although it is not always easy to use or understand for the uninitiated user, efforts are underway to ensure that citizens and stakeholders receive relevant and useable information to enable further adaptation activities.

The temperature rise will vary depending on location, with the most significant rise in temperature expected in the northern part of Sweden. The increase will be more substantial in winter than in summer, which will result in milder winters with decreasing snow cover. Average annual temperatures in Sweden already rise approximately twice as fast as the global average. Climate change will also result in changing precipitation patterns, with an expected increase in precipitation by 0–30 % by 2100, varying by location and scenario. The most pronounced increase will be during winter. During summer, rainfall in southern Sweden is expected to decrease, and increasing evaporation may lead to a shortage of drinking water in certain areas, especially in southeastern Sweden.

Natural and human systems in Sweden will be affected by climate change in a number of ways. Heavy rainfall and cloudbursts are already causing significant economic damage, and deaths have occurred. The occurrence of extreme weather events is expected to increase. Climate change affects human health in various ways, but the magnitude of impacts on health is difficult to predict and varies with local preconditions and the vulnerability of the population.

Climate disruption also has important impacts on agriculture, cultural heritage, forestry, housing, infrastructure, the natural environment and ecosystems, reindeer husbandry and many other aspects of Swedish society.

Efforts are being made to improve adaptive capacity, with several national authorities developing adaptation plans for their areas of responsibility. Adaptation plans are also in place at the regional level, and in many municipalities. Significant progress and increased awareness of the importance of adaptation have been achieved over the last few years.

Adaptation to climate change spans many different sectors. Thus, it is important to consider adaptation measures with multiple and cross-sectoral benefits as well as those involving conflicting targets.

1.7 Financial Resources and transfer technology

Climate change is the defining issue of our time and a top priority for the Swedish Government. Sweden has a long history of support for work on climate change issues in developing countries, in an array of sectors and on a long-term basis, but has raised its ambitions further since the adoption of the Paris Agreement. In 2020, total Swedish official development assistance was 7316 MSEK (794 MUSD). Total climate finance channeled through multilateral organizations wereas climate specific support were 3004 MSEK. Total bilateral finance in 2020[4] support was 4313 MSEK (924 MSEK for bilateral mitigation, 1667 MSEK for bilateral adaptation and 1721 MSEK for Cross-cutting). See

[4] In 2017, total bilateral climate finance support was 2929 MSEK (831 MSEK for bilateral mitigation, 1159 MSEK for bilateral adaptation and 939 MSEK for Cross-cutting. In 2018, total bilateral climate finance support was 3746 MSEK (872 MSEK for bilateral mitigation, 1810 MSEK for bilateral adaptation and 1063 MSEK for Cross-cutting. In 2019, total bilateral climate finance support was 4756 MSEK (1190 MSEK for bilateral mitigation, 2041 MSEK for bilateral adaptation and 1526 MSEK for Cross-cutting.

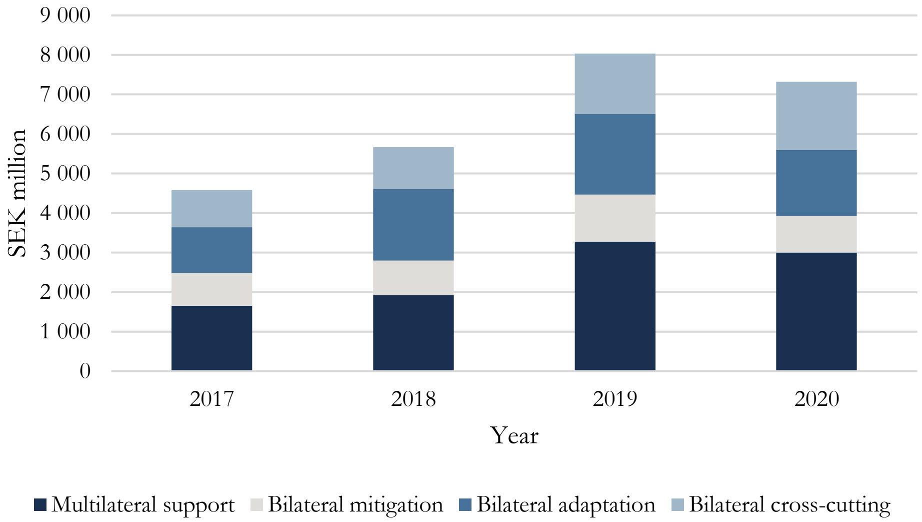

Figure 1.3 Total Swedish climate finance, 2017-2020. Multilateral support in this report refer to climate share of core contribution to multilateral organizations with reference to OECD DAC imputed climate shares. Sida performed quality assurance spot-checks of reported data for 2017 and 2018, and a number of adjustments were made during Sweden's in country review 2023. These concerned primarily broad framework agreements with Swedish civil society organisations, as well as a couple of humanitarian contributions. The adjustments resulted in a decrease in Sida's climate finance for 2017-2018. In addition, Sida has updated the climate finance reporting for 2020, following feedback from OECD/DAC on Sweden's official development finance reporting.

A large number of Swedish actors, such as ministries, government agencies, state-owned companies, non-governmental organisations, universities and the private sector assist in climate change-related cooperative actions and activities such as providing grants and innovative finance, technology transfer, research and various forms of capacity development. There are a number of different forms of cooperation, policy instruments and support, including efforts to mobilise additional private finance.

Environment and climate change constitute one of the key areas of the policy, one of three top priorities of the Government, and in addition an environment and climate change perspective shall be integrated in all Swedish development cooperation. The policy highlights that Sweden will support low and middle-income countries' accession to and implementation of commitments under the climate convention, and the implementation of their Nationally Determined Contributions under the Paris Agreement.

Sweden is one of the largest per capita donor in the world to the financial mechanism under the UN Framework Convention on Climate Change – the Green Climate Fund (GCF) and the Global Environment Facility (GEF) –

as well as to other key multilateral climate funds, such as the Adaptation Fund. Sweden is one of few OECD DAC members to have met, and even far exceeded, the UN international development aid goal of 0.7 % of gross national income (GNI). There is broad Parliamentary support, to continue delivering 1 % of Sweden's GNI to Official Development Assistance (ODA).

Capacity-building and institutional development is central for development, and is a fundamental entry point in all of Sweden's development cooperation. Sweden provides extensive support to climate change capacity building, with different approaches and in cooperation with different type of actors. This diversity is needed to respond to different partner countries' or organisations' specific needs and contexts. The majority of the climate finance support that Sweden provides through Sida therefore has capacity building integrated into the core of its operations.

1.8 Research and systematic observation

The societal impacts of the COVID-19-pandemic have resulted in a reduction in private-sector investment in Research and Development (R&D). The Swedish government has consequently decided to significantly increase public R&D funding as part of the government's latest Research and Innovation bill for the period 2021-2024 "Research, Freedom, Future – knowledge and innovation for Sweden". The bill proposes to strengthen the seven national ten-year research programmes, including the national research programme for the climate.

Sweden participates in several international research projects and initiatives. Regionally, Sweden collaborates within the framework of the Nordic Council of Ministers (NCM) in which Nordic countries work together in areas related to environment and climate. In January 2019, the Nordic Prime Ministers issued a joint commitment to work towards a carbon-neutral Nordic region and to demonstrate leadership in the fight against global warming. This joint effort underpins much of the Nordic collaboration in research initiatives. The NCM action plan for Vision 2030, running from 2021 to 2024, focuses on carbon neutrality and climate adaptation; sustainable production; sustainable consumption; and international co-operation on climate change and the environment.

On the European level, Sweden participates in the EU Research and Innovation programme Horizon Europe (2021 - 2027), the world's largest research and innovation initiative with a total budget of around €100 billion. Horizon Europe aims to strengthen green growth and competitiveness, and has clear global objectives to combat climate change and contribute to sustainable development. In 2020, Forte, Formas, the Swedish National Space Agency, the Swedish Energy Agency, the Swedish Research Council and Vinnova were asked to develop a strategy for how Sweden should strengthen its participation in Horizon Europe.

Sweden participates in the European Strategy Forum on Research Infrastructure (ESFRI), European Polar Board, European Incoherent Scatter Scientific Association – Tromsö (EISCAT) and several EU projects via various funders and providers. Within the context of climate research, Sweden participates in the Joint Programming Initiative JPI Climate, where Swedish funding agencies and researchers actively contribute to a common strategic research agenda. Via Stockholm University, Sweden leads the EU-funded Horizon 2020 project FORCeS (2019-2023). FORCeS aims to study the magnitude of aerosol radiative forcing caused by anthropogenic emissions, which is crucial in order to increase confidence in climate projections.

Regarding global collaborations, Sweden has been an active supporter of the Intergovernmental Panel on Climate Change (IPCC) from its start. Swedish researchers and organisations are participants or partners in global research activities and organisations. These include the World Climate Research Program (WCRP), International Science Council (ISC), International Arctic Science Committee (IASC), Science Committee on Antarctic Research (SCAR), International Ocean Discovery/Drilling Program (IODP), Global Biodiversity Information Facility (GBIF), US National Science Foundation, Future Earth, Science Europe, Global Research Council (GRC) and International Institute for Applied Systems Analysis (IIASA). Within the Arctic Council, Sweden is active in most of the assessments that are produced by the Arctic Monitoring Assessment Program (AMAP) in collaboration with the Arctic countries.

1.8.1 Systematic observation

Systematic climate observation includes various measurements in meteorology, hydrology, terrestrial aspects and oceanography. SMHI operates networks for these on a national level in Sweden. In addition, other monitoring research infrastructures exist that can contribute to more systematic and coherent information on the changes in marine and land-based systems. National infrastructure includes the Integrated Carbon Observing System (ICOS) and The Swedish Infrastructure for Ecosystem Science (SITES)

Through the Swedish Research Council, Sweden participates in several international research infrastructures related to climate, such as ICOS - European Research Infrastructure (ICOS-ERIC), GBIF, the Integrated Ocean Drilling Program, (IODP), International Continental Scientific Drilling Program (ICDP) and Life Watch.

Sweden also participates in coordinating observations in the Arctic and Antarctic through the organisations Inter-Agency Standing Committee (IASC) and the Scientific Committee on Antarctic Research (SCAR). SMHI and SU participates in the Integrated Arctic Observation System (INTAROS), which seeks to extend, improve and unify existing observation systems across the Arctic.

1.9 Education, training and public awareness

Achieving the goals of the Paris Agreement will require major structural changes and the participation of the whole of society in climate change transition. This presupposes that there is a strong commitment and a broad understanding of the climate issue among the public. It also presupposes that people from all parts of society are enabled to contribute. The possibility of achieving the goals of the Paris Agreement is therefore strongly linked to increased awareness and participation in issues related to climate change.

In the year 2020 the Swedish government made a national stocktake of opportunities and conditions for Sweden's implementation of Article 12 of the Paris Agreement. The stocktake was performed in line with the UNFCCC ACE Guidelines. Some conclusions of Swedens opportunities and conditions are:

Education and learning play a key role in strengthening society's preparedness and ability to act in the face of climate change. Sustainable development is well integrated into syllables and curricula for preschool, primary school and upper secondary school. There is strong support for sustainability issues including climate issues in the governing documents. Many schools work with the issues and that education materials hold a good standard. Both training programmes and education material are offered both on a national, regional and local level.

The higher education institutions' assignments for education and practical learning in climate related issues are partly expressed in the Higher Education Act and the Higher Education Ordinance, which state that they must promote sustainable development in their activities, and that sustainable development must be part of various educations. Several higher education institutions have also adopted their own governing documents, for example on how climate related issues are being included as part of compulsory or elective courses in programs.

Awareness of climate change is generally very high in Sweden. A vast majority of the Swedish public also state that is very or quite important to take societal actions to reduce the impacts of climate change. The Swedish people are interested in information about climate change, and they want the information to come from authorities, researchers or news media. A large majority of the Swedish public also state that they themselves can act to reduce climate change.

Many government agencies have an articulated task to provide information around climate change within their areas to the public. Several of them work actively with websites, social media, webinars and digital tools to enhance public access to information and public participation. The principle of openness is central to the Swedish legal system. It means that the public, both individuals and representatives of the media, have the right to insight into and access to information about the state's and municipalities' activities. The Swedish government har regular interactions with the civil society, and supports the civil society in various ways, for example financially and through cooperations like Drive for Democracy[5].

[5] https://www.government.se/articles/2019/11/drive-for-democracy-takes-shape/

2. National circumstances

2.1 Government structure

Sweden is a parliamentary, representative democracy that is ruled by a government headed by a prime minister. The Government is appointed by a popularly elected parliament, the Riksdag, which is elected every four years. As the national legislature, the Riksdag controls the Government and government agencies, and must approve political decisions such as Swedish climate and energy policies. The Government implements Riksdag decisions, submits new proposals (Bills) to the Riksdag, directs state administration and represents Sweden in the European Union.

Swedish public administration is organised at central, regional and local levels. The central level consists of a number of agencies[6] serving as the Government's expert bodies and implementing the policies adopted by the Riksdag and Government. For regional and local public administration, there are 21 county administrative boards and 290 municipalities, and some central government agencies have regional offices. Swedish municipalities are autonomous, with boards and councils elected by their respective citizens in separate elections.

As for fulfilling commitments under the United Nations Framework Convention on Climate Change and the Kyoto Protocol, it is the Riksdag that decides (on the basis of Government Bills) and the Government and its agencies that are responsible for implementing the decisions. County administrative boards and municipalities play a key role in climate policy, since they shape and implement plans for e.g. land use, energy management, transport and waste. Many Swedish municipalities are actively engaged in pursuing targets and following action plans to limit greenhouse gas emissions and adapt society to climate change.

2.2 Population profile

The population of Sweden at the end of 2020 was 10.4 million, with 21 % aged up to 17 and 20 % 65 and over (Table 2.1). Since 1990, the mean annual growth rate has been 0.6 % and by 2030 the population is expected to reach 10.9 million. Average population density is 25.5 inhabitants per km^2,

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[6] In 2021 there were 346 government agencies in Sweden (Statistics Sweden 2021c). There are also local authorities and various companies that exercise public authority.

ranging amongst Swedish counties from under 3 per km² in northern Sweden to 127 per km² in the south. Stockholm's county has a population density of 367 inhabitants per km² (Statistics Sweden 2021a, 2021b).

Table 2.2.1 Sweden's population profile, with projections (Statistics Sweden 2021a, 2021b).

	1990	2000	2010	2018	2019	2020	Annual increase, 1990 – 2020 (%)	Annual increase, 2009 – 2020 (%)	2030	2040
Population (million)	8.59	8.88	9.42	10.23	10.33	10.38	0.6	1.0	10.85	11.30
Aged up to 17 years (% of population)	21.9	21.8	20.4	21.1	21.1	21.1			19.7	19.0
Aged 65+ years (%of population)	17.8	17.2	18.5	19.9	20.0	20.1			22.0	23.4
Population density (inhabitants/km²)	21.0	21.6	22.9	25.1	25.4	25.5			26.6	27.8

2.3 Geographic profile

Sweden extends in a south-south-westerly/north-north-easterly direction from latitudes 55 to 69 degrees north and from longitudes 11 to 23 degrees east, with a land area of 406,550 km². Urban land make up 3 % of the land area, while productive forest land account for 58 %, farmland 8 %, wetlands 12 %, alpine areas, subalpine woodlands and rock surface, 17%, and other land 2%[7] (Swedish University of Agricultural Sciences, 2021). Inland water systems total more than 40,000 km², or more than 9% of Sweden's total area (including sea water, SCB 2021d). Southern Sweden is low-lying, with agricultural land predominating in the far south. The only real mountain chain, with peaks rising to over 2,000 m above sea level, is along the Norwegian border in the north-west.

Land rise (postglacial rebound) is taking place in most of Sweden because of the melting of land ice after the last ice age, but has ceased in the far south (see Fig. 2.1).

[7] Five year average 2018

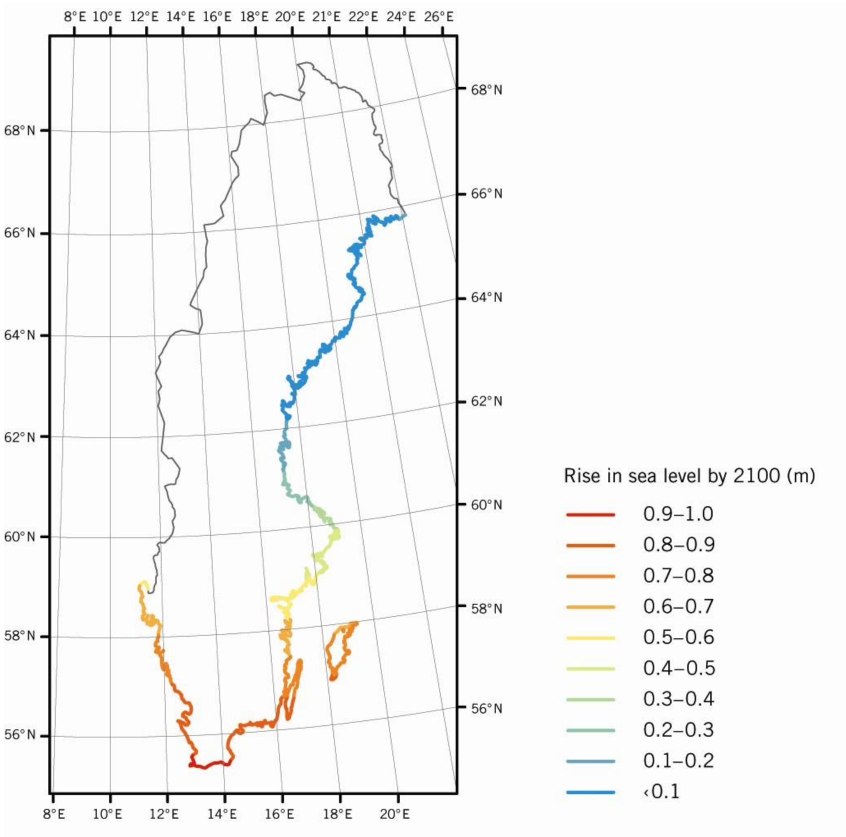


Figure 2.1 Net effect of rise in sea level (minus land rise) in Sweden, assuming a global sea level rise of 1 metre in 100 years. The land rise estimates are based on the Swedish National Land Survey's model NKG2005LU (Ågren & Svensson 2007).

Rising sea levels are causing substantial erosion along the south coast, which is characterised by easily eroded soils. Climate change due to future increases in atmospheric temperature will accelerate erosion through rising sea levels.

Forest land is an important natural resource that provides scope for biobased energy supply. In the past 50 years, farmland has successively given way to other land uses, mainly forest land. This has resulted in reduced emissions from agriculture and increased carbon sequestration in forest biomass. Besides forests, another key natural resource is iron ore, a pillar of Swedish industrial production. Abundant flowing watercourses are a significant resource for hydropower production.

2.4 Climate profile

Sweden's proximity to the North Atlantic and prevailing south-westerly to westerly winds result in a climate that, for the latitude, is mild in the winter months. The northernmost part of the country, however, has a sub-Arctic climate with long, cold and snowy winters. In the period 1961–90 the mean temperature in January was 0 °C in southernmost Sweden, while the coldest northern valleys had −17 °C. The maximum daily mean July temperature was approximately 17 °C in south-eastern Sweden and just over 10 °C in the north.

Passing low-pressure systems bring precipitation that is fairly copious all year round, but heaviest in the summer and autumn. Annual precipitation is some 500-1,000 mm. Since most low-pressure systems move in across the country from the west or south-west, the western parts of Sweden receive the most precipitation. Locally, in the mountains near the Norwegian border, precipitation reaches 1,500–2,000 mm a year. The lowest annual precipitation, just under 400 mm, falls along the eastern coasts.

The mean temperature was about 1° higher in the years 1991–2020 than in 1961–90. The largest rise, over 2°, took place in the northern parts of Sweden in winter. Overall, owing to the rise in temperature, the densely populated areas (including Greater Stockholm) have undergone a shift from a cold-temperate to a warm-temperate climate. In the long term, this should entail a reduced incidence of winters with heavy snowfall. However, there may still be major variations from year to year. Winter 2019/20 was the warmest of all winters since 1860 followed by that of 2007/08, while those of 2009/10 and 2010/11 were the coldest since the late 1980s. Precipitation has increased slightly in most of the country. The differences in temperature and precipitation between the periods 1961–90 and 2020 are illustrated in Figs. 2.2 to 2.4 (SMHI 2021).

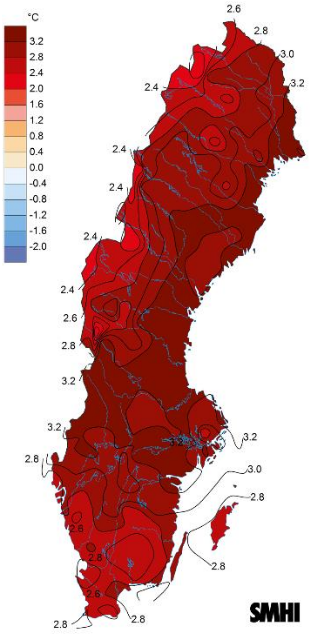


Figure 2.2 Difference in annual mean temperature between 2020 and 1961–90 (°C).

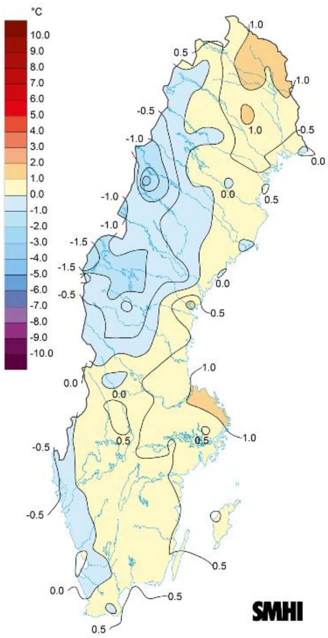


Figure 2.3 Difference in mean winter temperature between 2020/2021 and 1961–90 (°C).

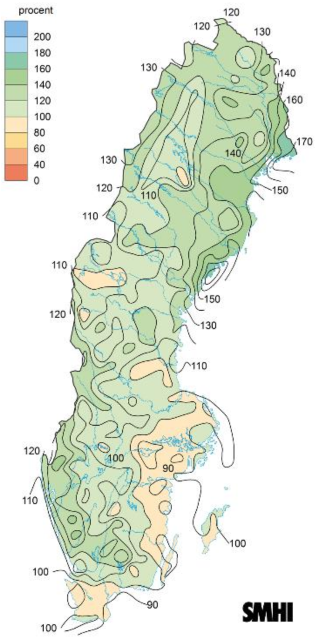


Figure 2.4 Difference in annual precipitation between 2020 and 1961–90 (%).

Extremely severe storms with widespread windthrow (uprooting of trees) are rare, and trends are difficult to identify. In January 2005, however, there was a storm with hurricane-force winds in the south of Sweden, with by far the most extensive windthrow for 100 years. Just two years later, southern Sweden was hit by another violent storm. These storms cause a temporary reduction in carbon sequestration in forest biomass.

The relatively cold climate entails high energy requirements to heat buildings for most of the year. Heating requirements are dependent on outdoor temperature, wind conditions and insulation, and vary from one year to the next. Fossil fuels in district heating have been gradually replaced by, for example, biofuels. However, fossil fuels still serve as a complementary fuel source which can lead to increased emissions during colder winters. The average temperature in Sweden in 2020 was the highest since measurements began. This combined with a phase-out of fossil fuels led to a decrease of greenhouse gas emissions within the heating and power sector by 46% percent compared with 1990.

Annual precipitation and run-off to the large rivers in north-west Sweden have a major bearing on the water inflow volume for Swedish hydropower production. Hydropower accounts for nearly half of Sweden's electricity production, varying between 50 and 80 TWh per year (Swedish Energy Agency 2021a).

2.5 Economic profile

Sweden has an open, trade-oriented economy. In 2020, the nation's gross domestic production (GDP) was SEK 4.98 trillion or close to SEK 481,000 per capita, placing the nation among the richest countries in the world.

From 1990 to 2019, the economy grew by an average of 2.2 % per year (see table 2.2). Since 1990, the economy has suffered from four recessions. In the early 1990s, GDP fell three consecutive years as a result of a combined crisis in finance and real estate. Ten years later the economy suffered when the dot-com bubble burst. In 2008, the global financial crisis hit Sweden. In 2009, the economy shrunk more than 5 %, only to bounce back up again in the following year. Finally, the COVID-19 pandemic in 2020 caused a reduction in GDP of 2.8%. In the lead up to the pandemic, between 2017 and 2019, the average GDP growth rate was 2.0 %.

Natural resources, such as forest and iron ore, are a basis for industrial production and, along with the engineering industry, have brought about a strongly export-oriented economy. Since 1990, exports have grown faster than imports and the trade balance has been positive. In 2019, exports accounted for 47 % of GDP. Main export industries are machines, vehicles, pharmaceuticals and chemicals, wood products, electronics and minerals.

Table 2.2.2 GDP by expenditure, at constant prices, reference year 2015 (Statistics Sweden 2021e, World Bank 2021)

	1990	1995	2000	2005	2010	2015	2018	2019	Growth, 1990– (%/year)	Growth, 2017-19 (%/year)
GDP (SEK m)	2482998	2579685	3076995	3502765	3826205	4260470	4547336	4637655	2,20	3,33
GDP per capita (SEK)	289036	291902	346400	387142	406370	432490	444502	449055	1,62	2,22
GDP per capita (PPP, USD 2017)	34 157	34 234	40 625	45 440	47 791	50 929	52 349	52 851	3,57	2,43
Imports (SEK m)	611280	694596	1059082	1216289	1397605	1702358	1933770	1974941	4,39	5,15
Exports (SEK m)	536781	734956	1143753	1444767	1582295	1864670	2072751	2196577	5,20	4,74

Private consumption (SEK m)	1189153	1171236	1393371	1549898	1754421	1961665	2097193	2112297	1,92	2,36
Public consumption (SEK m)	839586	890600	927610	953510	1022388	1095716	1147301	1150364	1,17	2,38

On the production side, just over 70% of Swedish GDP stems from the private sector, whereas the public sector contributes under 30%. Within the private sector, services dominate with 68% of the value added, manufacturing industries 18%, construction 8%, utilities 3%. Value added from primary production (agriculture, forestry, fishing and mineral extraction) is 2% (Statistics Sweden 2021e).

2.6 Energy

The Swedish energy system is partly based on domestic sources of renewable energy such as water, wind and biofuel. In addition, a large proportion of the energy supplied is dependent on imports such as nuclear fuel for electricity production in nuclear reactors and fossil fuels like oil and natural gas for the transport system. Swedish electricity production is based largely on hydropower and nuclear power, but the expansion of wind power is steadily increasing as well as the use of biofuel for electricity and heat production.

Sweden's final energy use can be divided into three user sectors. In the industrial sector, energy is used to operate processes. This sector primarily uses biofuels and electricity. The transportation of people or goods within the country requires energy in the form of various fuels or electricity. Energy use within transportation is dominated by oil products in the form of petrol, diesel and aviation fuel. The residential and service sector mainly uses energy in the form of district heating, electricity, oil or biofuels (see Fig 2.5, Swedish Energy Agency 2021a).

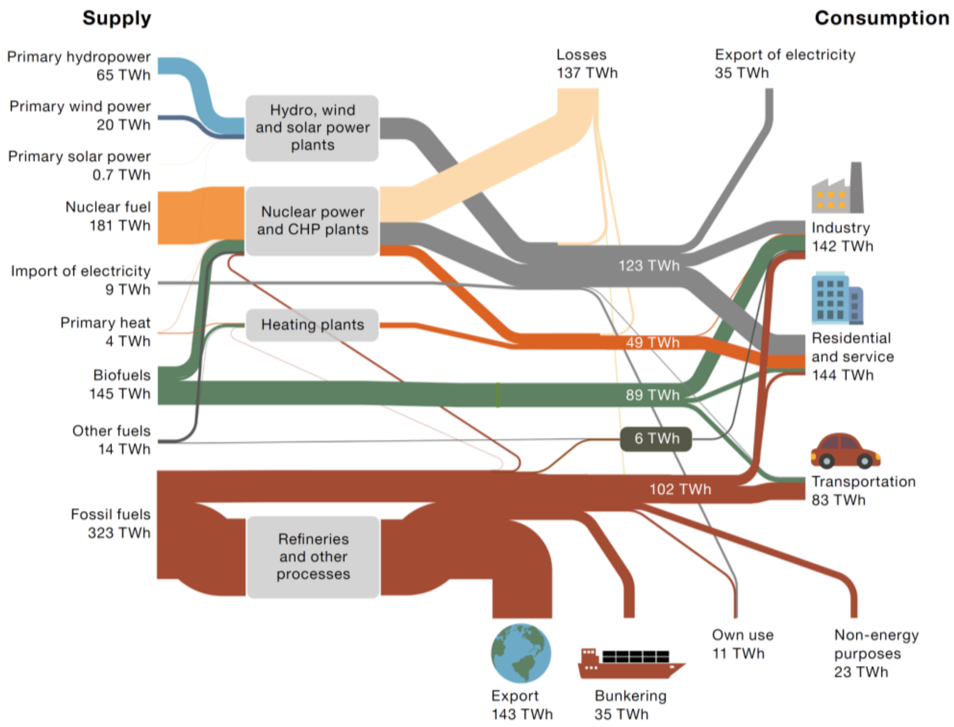


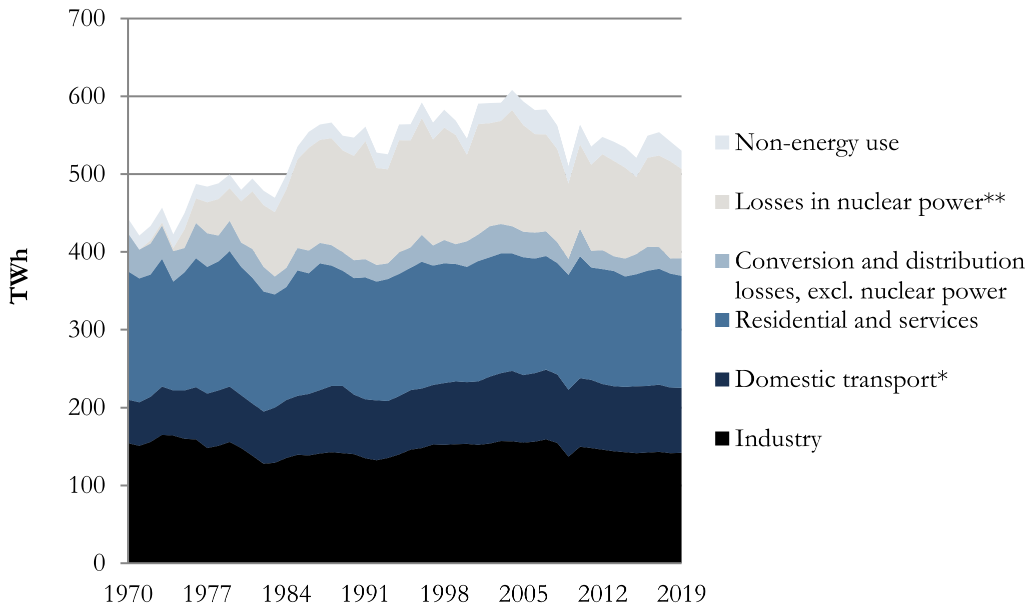
Figure 2.5 Sweden's energy system (Swedish Energy Agency 2021a).

2.6.1 Energy supply and use

Total energy supplied in Sweden has shown a rising trend since 1970, from some 450 TWh to about 500-600 TWh from the mid-1990s (see Table 2.3). A high proportion of this increase represents conversion and distribution losses associated mainly with nuclear power production, and the remainder goes to final use. The composition of the energy supply in this period has been transformed, with crude oil largely being superseded by nuclear power and biofuels.

	1990	1995	2000	2005	2010	2015	2016	2017	2018	2019
TPES (TWh)	553	578	551	595	581	525	561	562	561	548
TPES (MWh) per capita	64	65	62	66	62	53	56	56	55	53

Total final energy use has increased by 20 % since 1970, and has been stable at approximately 520-560 TWh for the past ten years. The increase corresponds to an increase in nuclear power losses as nuclear power has played a larger role in the energy system. Excluding these losses, total final energy use has been relatively stable during this period. However, there has been differing trends amongst remaining sectors. Industry and residential property and services have seen a decrease in energy use of 8 and 13 percent respectively. This is despite growing industrial production and an increase in aggregate heated floor space of homes and commercial and institutional premises, pointing to energy efficiency increases in both sectors. Energy use from domestic transport on the other hand has increased by nearly 50% during this period (see Fig 2.6, Swedish Energy Agency 2021a).

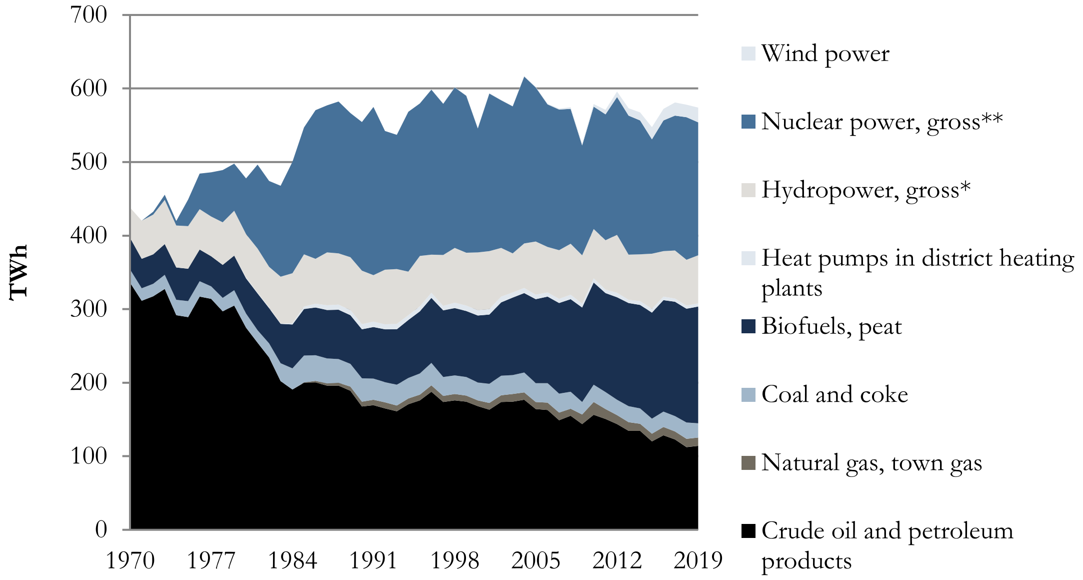


* Data up to and including 1989 include international flights.
** According to the method used by the United Nations Economic Commission for Europe (UNECE) to estimate supply from nuclear power.

Figure 2.6 Sweden's TPES in 1970–2019, including conversion and distribution losses (Swedish Energy Agency 2021a).

Sweden's total primary energy supply (TPES) is based on domestic supply of energy from biofuels, hydropower and, to a lesser extent, ambient heat from heat pumps, and on imported energy carriers such as uranium, oil, natural gas, coal and biofuels (see Fig. 2.7).

In the early 1970s, an energy policy was introduced to reduce Sweden's dependence on oil. Over 65 % of petroleum products have now been largely superseded by non-fossil energy sources, and with national incentives, the share of bioenergy in Sweden's TPES has risen to nearly 30%.



* Incl. wind power up to and including 1996.
** According to the method used by UNECE to estimate supply from nuclear power.

Figure 2.7 Sweden's energy supply in 1970–2019, excl. net electricity exports (Swedish Energy Agency 2021a).

A major shift has taken place in energy supply to homes and to commercial and institutional premises. A consistent, sustained policy to extend infrastructure for district heating production and distribution was pursued from the late 1960s to the mid-1990s. The main motive for this investment, which involved replacing numerous small heating plants with large, centralised installations to heat buildings, was to improve air quality in urban areas. The infrastructure for district heating was a precondition for environmentally sound heating of buildings based on biofuels. It was also essential to enable the national policy instruments for renewable energy to bring about the extensive phase-out of fossil fuels to heat buildings that has been achieved.

By 2019, production of district heating had risen by over 300% since 1970 and 45% since 1990 (see Fig. 2.8). At the same time, the share of biofuels (including waste and peat) in production had grown from 2% to 25% and 79% in 1970–90 and 1970–2019 respectively.

In addition to the extensive changeover from heating of individual buildings to district heating and from fossil energy to bioenergy for district heating production, there has been a switch from oil to heat pumps or pellets in remaining homes and non-residential premises that are individually heated.

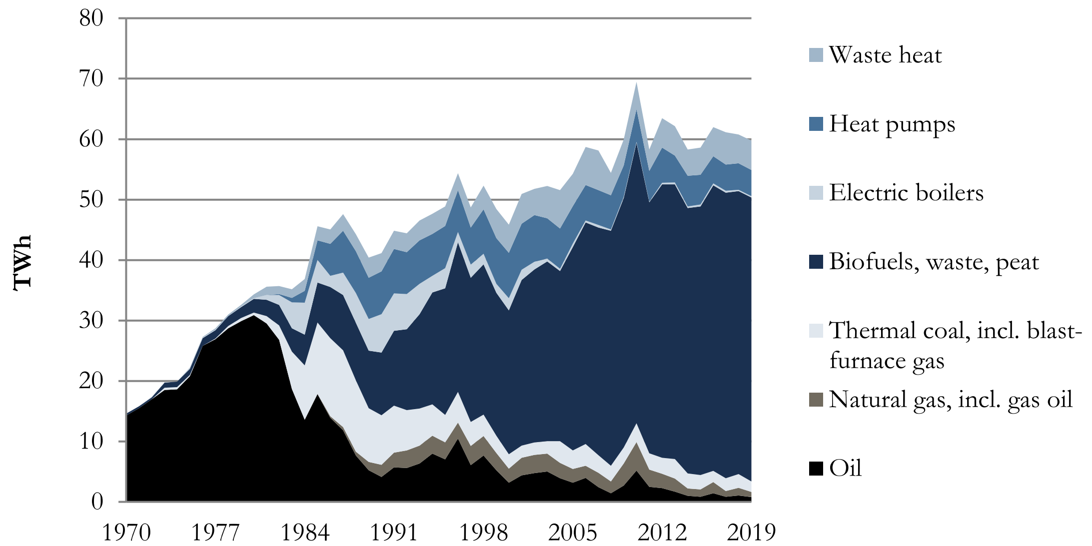


Figure 2.8 Energy supply for district heating, 1970–2019 (Swedish Energy Agency 2021a).

Between 1990 and 2019, the share of renewable energy in Sweden rose by 23 percentage points to 56% (see Fig. 2.9). The renewable energy sources contributing to this trend were hydropower, wind power, by-products used in the paper and pulp industry, and biofuels for district heating production.

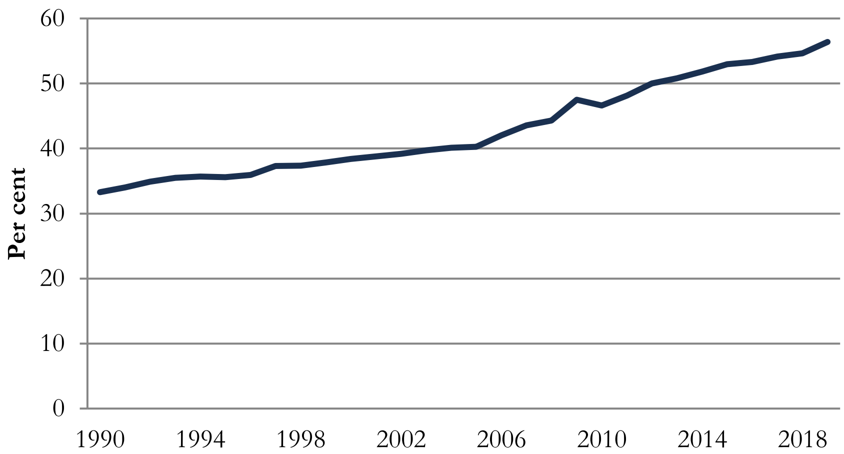


Figure 2.9 Share of renewable energy used in Sweden, 1990–2019 (Swedish Energy Agency 2021a).

Between 2000 and 2019, the price of light fuel oil rose by 178 % and heavy fuel oil rose by 187 % while that of wood chips remained relatively stable at a low level (see Fig. 2.10)[8]. Carbon dioxide and energy taxes had a substantial impact on fossil fuel prices, which helped to make biofuels competitive for heat production in district heating and for heating individual buildings.

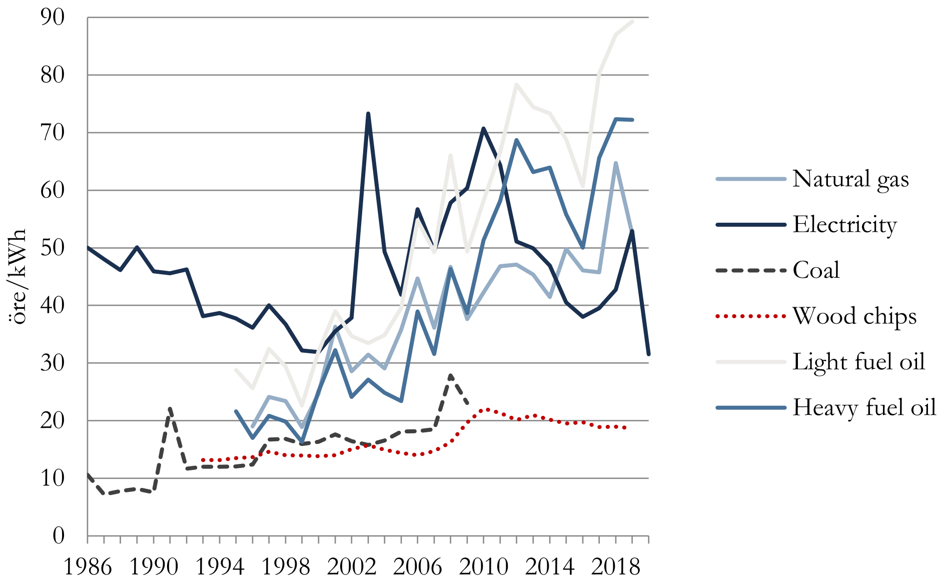


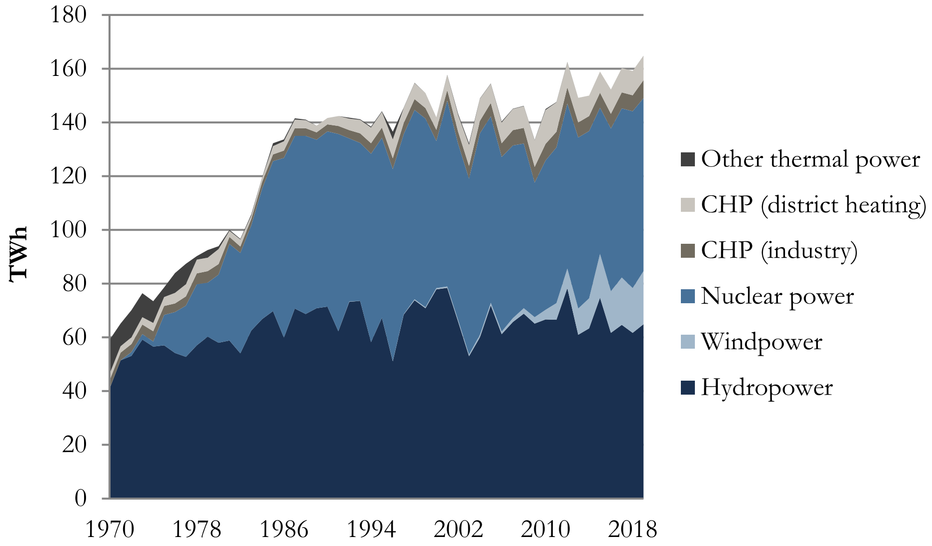
Figure 2.10 Real energy prices for industry in Sweden, including energy taxes, 1986–2020, expressed in SEK/kWh, 2019 prices (Swedish Energy Agency 2021a).

2.6.2 Electricity supply

Of total electricity production in 2019, hydropower accounted for 39%, nuclear power also 39% and wind power 12 %, while biofuels and fossil-based (CHP) production made up the remaining 10% (see Fig. 2.11). In the early 1970s hydropower, supplemented by oil-condensing power, dominated production. The expansion of nuclear and to some extent hydropower up to 1985 largely eliminated oil-fired power generation. Since then, the use of oil for electricity production has continued to decrease, except in 1996 – a cold year with extremely low water inflow for hydropower production – when decommissioned oil-condensing power plants were temporarily restarted. Ample natural watercourses for hydropower production, combined with national energy policy and investments in non-fossil-fuel-based power

[8] Light fuel oil is used for heating purposes, while heavy fuel oil is mainly used in larger heating plants and ships.

production such as nuclear power, have enabled Sweden to produce electricity by almost entirely fossil-free means.



* Wind power and hydropower are reported in the same category up to and including 1996.

Figure 2.11 Sweden's electricity production by power source, 1970–2019 (Swedish Energy Agency 2021a).

Between 1970 and 1987, electricity use rose by 7 % a year. The rise then slowed to an annual average of 0.5 % until 2000. In the subsequent decades, the figure fluctuated between 135 and 150 TWh. The Swedish electricity system is linked with the other Nordic systems, making efficient use of the Nordic countries' power plants possible. Consequently, Sweden's annual electricity balance alternates between net imports and net exports (see Fig. 2.12). In years of low precipitation and thus low hydropower production, and when nuclear power cannot be produced at normal capacity, the deficit is offset by electricity imports; and when Sweden has an ample supply of hydro and nuclear power, this country's electricity is exported to neighboring countries. In the 1990s, oil-based condensing power was used to compensate for hydro and nuclear power deficits.

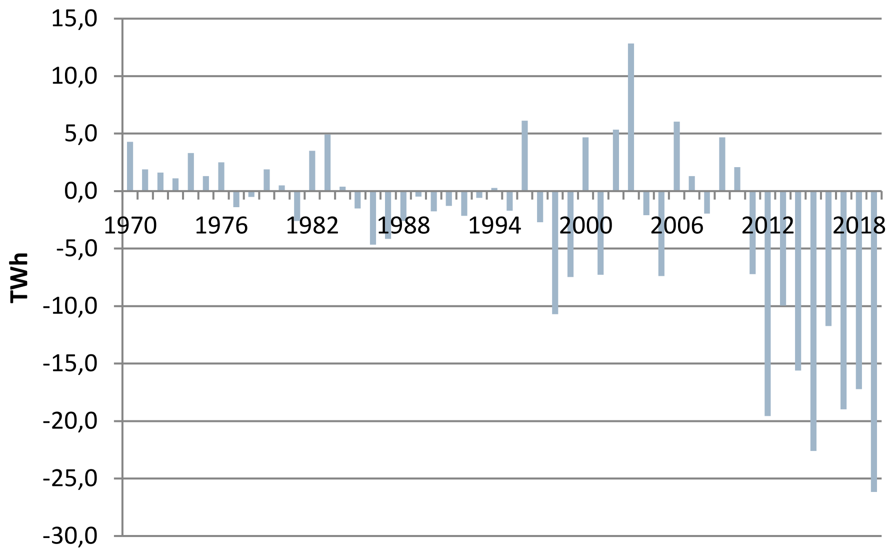


Figure 2.12 Sweden's annual net imports (+) and net exports (−) of electricity, 1970–2019 (Swedish Energy Agency 2021a).

2.7 Building stock and urban structure

2.7.1 Building stock and residential floor area

In 2020, there were 2,104,946 single-family houses for year-round occupation and 2,585,221 apartments in multi-dwelling buildings. Of the current stock of apartments, 73 % were built during or before 1980. Average floor space in single-family houses is 122 m^2. For multi-dwelling buildings, floor area is on average 68 m^2 (Statistics Sweden 2021f).

A 10.8% increase in the number of apartments and a 5.2% increase in the number of single-family houses took place between 2013 and 2020. Prior to 2013, the calculation of these two definitions were carried out differently and hence the numbers cannot be compared (Statistics Sweden 2021f). In 2020, average living space was 42m^2 per capita (Statistics Sweden 2017g). In 2021, industrial buildings contained floor space of 137 million m^2 (Statistics Sweden 2021h).

2.7.2 Energy use in buildings

Final energy use in residential and service-sector buildings, in which energy for heating predominates, decreased by 24% between 1990 and 2020 even after weather correction of energy use (Swedish Energy Agency 2021b). On the other hand, use of electricity for non-heating purposes in the residential and services sector increased slightly during this period for both domestic and business electricity usages (see Fig 2.13, Swedish Energy Agency 2021a).

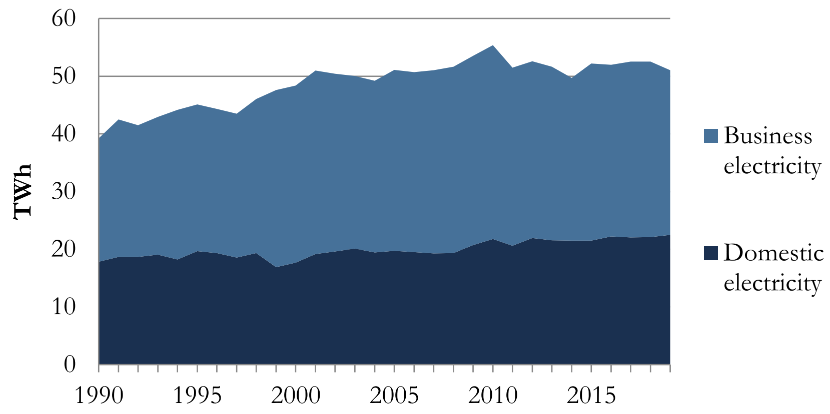


Figure 2.13 Electricity use in the residential and services sector 1990-2019. (Swedish Energy Agency 2021a).

The use of energy for heating and hot water has changed since 1990. As Fig. 2.14 shows, the use of oil has decreased sharply in single-family houses, in favor of district heating, biofuels and electric heating.

For multi-dwelling buildings, too, there has been a marked decrease in oil and increase in district heating (see Fig. 2.15). In this type of housing, district heating accounted for more than 90 % of energy use for heating and hot water in 2019 (Swedish Energy Agency 2021b). For commercial and institutional premises, the proportion of district heating was 78 % in 2019 (Swedish Energy Agency 2021b).

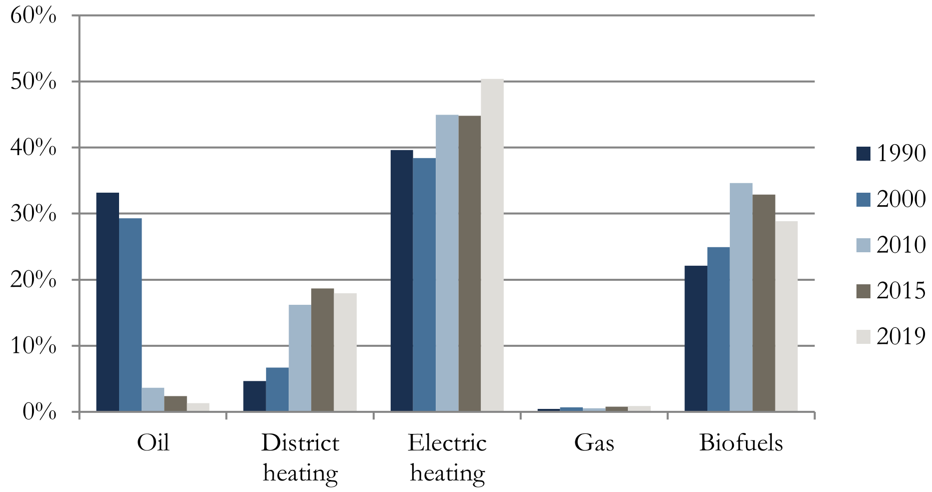


Figure 2.14 Use of energy for heating in single-family houses in 1990, 2000, 2010, 2015 and 2019 (Swedish Energy Agency 2021b).

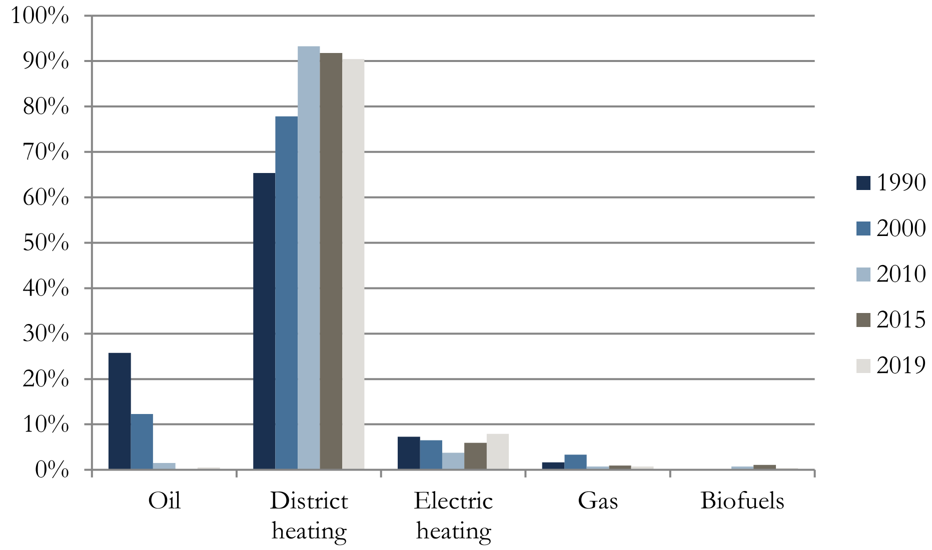


Figure 2.15 Use of energy for heating in multi-dwelling buildings in 1990, 2000, 2010, 2015, 2019 (Swedish Energy Agency 2021b).

2.7.3 Urban structure

In Sweden, as in other countries, migration from rural to urban areas is under way. In 2020, 88 % of the population lived in towns and cities. Urban areas amounted to 617,000 ha, which was 2% of Sweden's land area (Statistics Sweden 2021d). Between 1960 and 2005, the urban area increased by 54 % and the urban population by 47 %. From 2005 to 2020 these increases were 21% and 19% meaning that population density within urban areas decreased slightly. The increasing size of urban areas means that more land per capita is used for housing, infrastructure and services (Statistics Sweden 2021i)

2.8 Industry

Sweden has a mixed industry, characteristically based more on raw materials than many other countries. For example, the extensive forest industry (wood products, paper and pulp) and also the iron and steel industry are based on domestic natural resources. Indeed, the forest industry and iron and steel industry, together with the chemical industry, have long been an important part of the Swedish industry, and today contribute significantly to the nation's exports.

The manufacturing sector is important to the economy, accounting for nearly 20 % of GDP in terms of value added in the private sector in 2019 (Statistics Sweden 2021e). Following manufacturing, other sectors which contribute most to GDP in terms of value added are retail, real estate and construction. Sectors with the most significant growth respectively since 1993 are manufacture of coke and refined petroleum products (although decreased by over 70% since 2011 peak), telecommunications, IT, electronics and vehicles. Different industries' contributions to the value added in the manufacturing sector in 2019 is shown in **Error! Reference s ource not found.**.

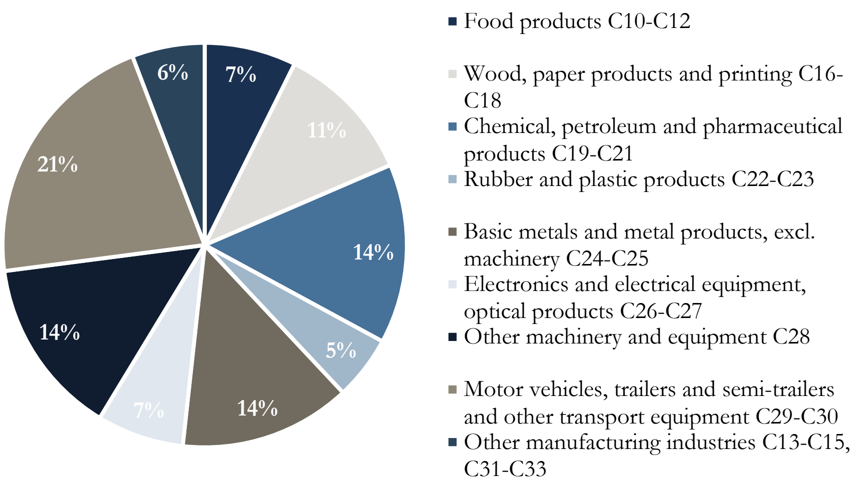


Figure 2.16 Distribution of value added in manufacturing industry, 2019. Swedish Standard Industrial Classification (SNI) designations in brackets (Statistics Sweden, 2021e).

In the industry sector, the GHG emission trends are strongly linked to a few major emission sources within production of basic material in Sweden. During 2021, 15 of the largest plants were responsible for approximately 75 percent of the total emissions from industry (energy and process emissions). About one third of the total emissions from industry are process emissions from iron- and steel making or cement calcination, another third of the emissions is process-related and is energy emissions that are closely linked to the raw material, for example within the chemical sector and refineries. The last third is emissions related to energy use.

The emissions related to energy use has decreased more historically than the emissions from processes. The emissions from processes varies with production and is closely linked to the economy. The energy emissions have decreased due to fuel change and efficiency measures. One example of a sector where energy emissions has decreased a lot is within the pulp and paper industry. There has been a substantial shift from fossil fuels to biogenic energy and electrification, resulting in emission reductions of about 65% in 2021 compared to 1990.

2.9 Transport

Domestic transport is dominated by road traffic. Several factors affect greenhouse gas emissions from traffic, especially transport volume and the technology used. Transport activity for passengers and goods alike has increased since 1970 (Transport Analysis 2021). Vehicle kilometres travelled has increased for passenger vehicles, lorries and motorcycles since 1990, whilst buses/coaches have remained relatively stable (see Figure 2.18, 2.19). There has been a substitution from lorries 3.5-26 tonnes towards lorries under 3.5 tonnes and over 26 tonnes. All vehicle types except motorcycles have seen a reduction in vehicle kilometres in 2020 as a result of the COVID-19-pandemic.

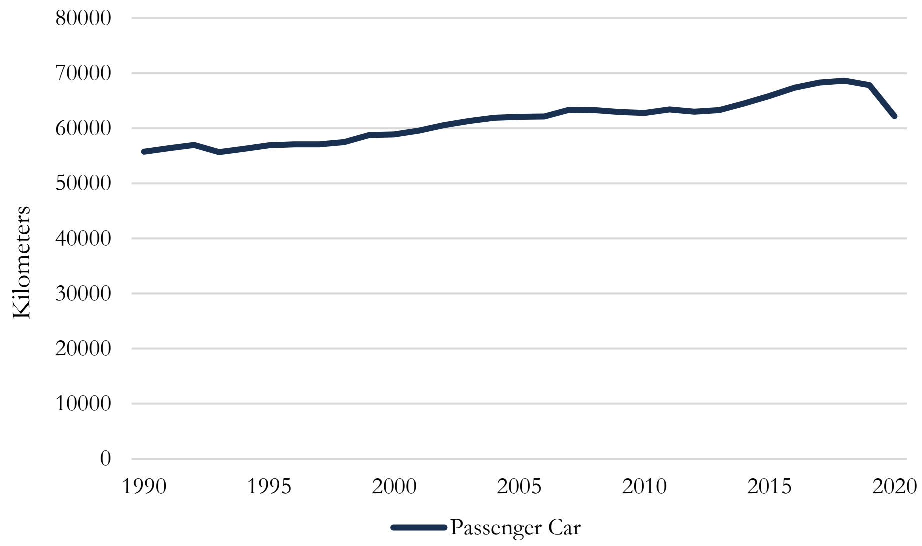


Figure 2.17 Vehicle kilometres on Swedish roads 1990-2020 for passenger cars (Transport Analysis 2021).

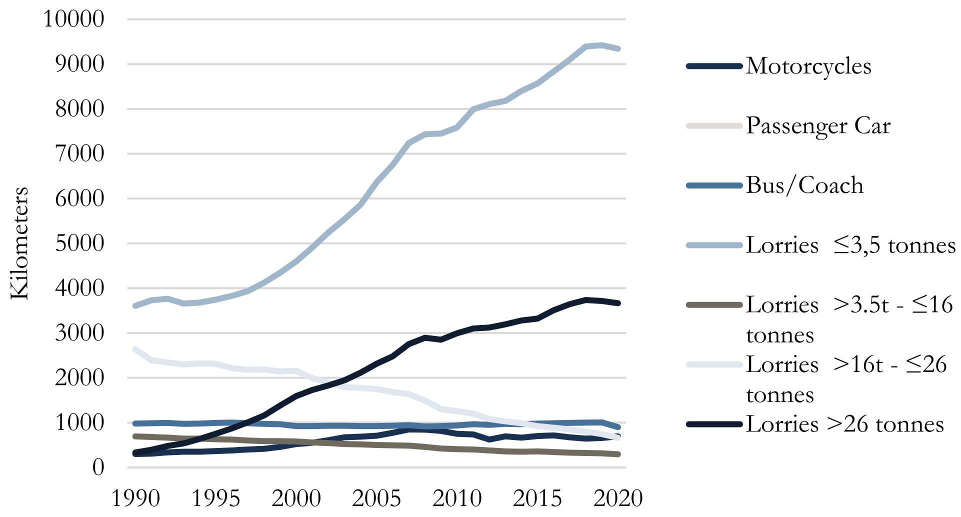


Figure 2.18 Vehicle kilometres on Swedish roads 1990-2020, lorries, bus/coach and motorcycles (Transport Analysis 2021).

In terms of greenhouse gas emissions, the rapid rise in passenger travel has been offset by more energy-efficient cars and increased use of renewable fuels, which have resulted in a decrease in emissions per passenger-kilometer. The efficiency of freight transport also improved in the 1990s, but this trend has since leveled off.

In 2019, fossil fuels accounted for 77 % of the energy used by domestic transport, while the remainder consisted of biofuels and electricity (see Fig. 2.19). Use of petrol has been decreasing since 2002, partly owing to the blending of 5 % ethanol in the fuel, but also because of greater energy efficiency and the growing market share of diesel vehicles in relation to petrol-driven ones. More diesel vehicles and increased goods transport have, on the other hand, brought about a rise in the use of diesel as fuel.

Use of biofuels – biogas, pure and low-blend FAME (fatty acid methyl ester), ethanol and pure and low-blend HVO (hydrotreated vegetable oil) – amounted to 20 % of energy use by road transport in 2019. The rise has been rapid since 2000, initially owing to low blends of ethanol in petrol and subsequently to a rise in the sale of E85 (containing 85 % ethanol) for flexible-fuel ethanol vehicles. Since 2005, there has been an increased blending of biodiesel in diesel fuel with a sharp increase in the use of low blended and pure HVO during the last few years.

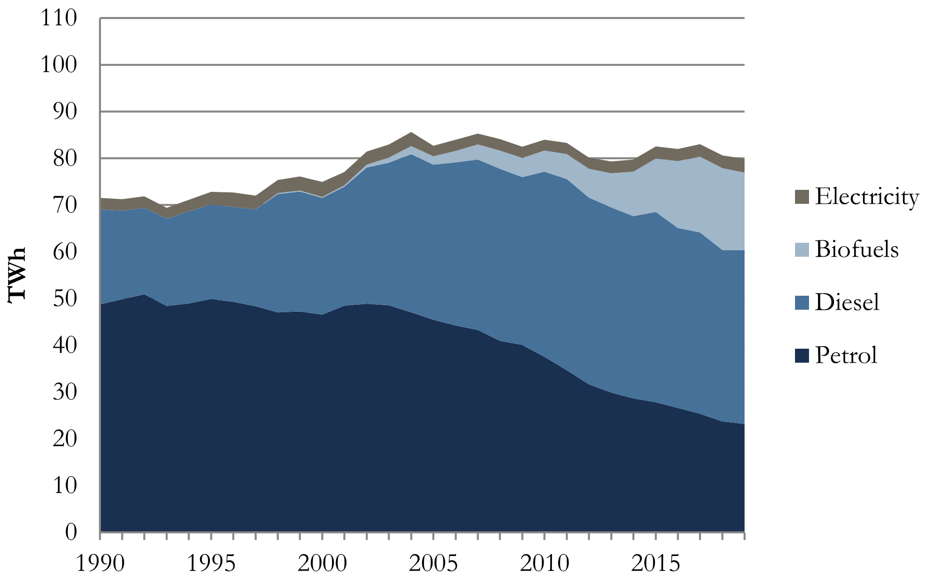


Figure 2.19 Use of petrol, diesel, biofuels and electricity in the domestic transport sector in Sweden (Swedish Energy Agency 2021a).

2.10 Waste

Approximately 139 million tonnes (Mt) of waste was generated in Sweden in 2018 (Swedish Environmental Protection Agency 2020). The categories with the largest volumes were the mining sector (104 Mt), construction sector

(12.4 Mt), households (4.5 Mt) and service industries (2.1 Mt). Accordingly, 75% of the waste was generated in the mining and quarrying industry. The aggregate volume is affected by economic trends and fluctuations. Larger quantities of waste mean that a growing amount requires management. However, since the material and energy content of waste are used to a higher degree and the technology of waste management has improved, the overall environmental impact of waste management has nonetheless decreased.

Owing to Sweden's policy objectives and associated instruments, landfilling of municipal waste has decreased sharply in the past decade to just under 1 % in 2020 (in 2001 the proportion was 23 %). The remainder is sent for materials recovery, incinerated with energy recovery or treated biologically (composted or digested, see Fig. 2.20).

Municipal waste per capita in 2020 was approximately 467 kg. The share of this that goes to material recovery is 33%, to incineration with energy recovery is 46%, biological treatment is 16% and landfills less than 1%. Materials recovery includes various categories of material, such as metal, paper, plastic and glass, and also use of waste for construction purposes.

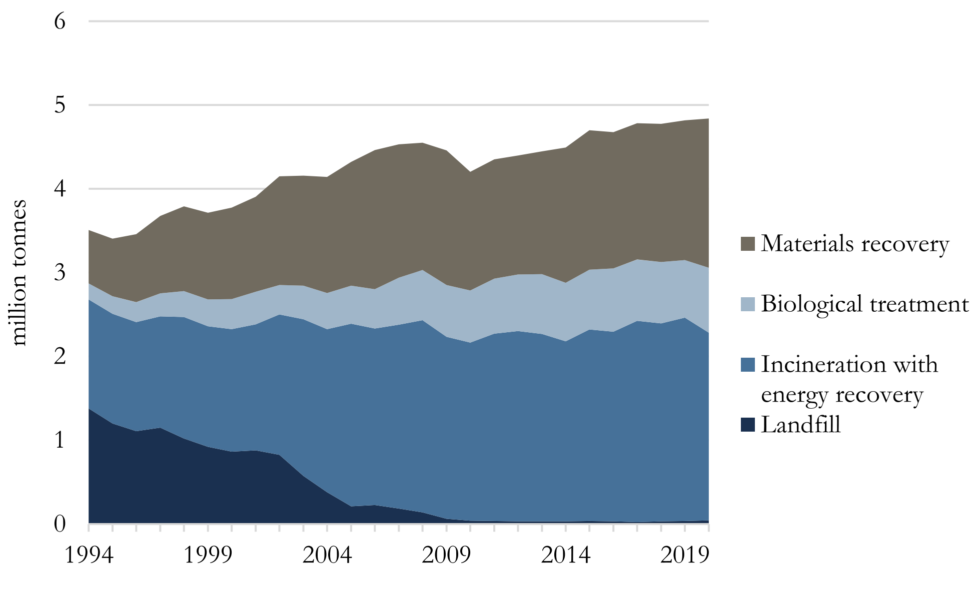


Figure 2.20 Volume trends of household waste (including construction material) treated in Sweden, 1994–2020.

Materials recovery from household waste has increased by 57% since 2001. In 2020, materials were recovered from 1.6 Mt (33 %) of household waste, of which just over 1.1 Mt consisted of packaging and recyclable paper (newspapers).

Biological treatment of waste primarily takes place at mixed-waste digestion plants and composting facilities. Smaller quantities of food waste are also received for digestion at sewage treatment plants. In food and slaughter waste digestion, both biogas and biofertiliser are obtained. The biogas is used mainly as a vehicle fuel, since there is a growing demand for renewable transport fuels and, moreover, using it in this way affords the greatest environmental benefit. Of the volume of biofertiliser produced, amounting to 1.8 million tonnes, 99.9 % was returned to farmland in 2020.

In 2020, there were 34 incineration plants for household waste. These plants produce both district heating and electricity. Roughly half of the heating and hot water requirements in Sweden's building stock ares met by district heating, and in 2020 waste incineration accounted for 18.6 TWh (roughly 25%) of the total heat energy supplied and a further 2.6 TWh of electricity supplied.

Recovery of methane gas takes place from 53 waste treatment plants . In 2020, 136 GWh of landfill gas was collected. 83GWh of this was used for energy (80GWh for heating and 3GWh for eletricity) and the remaining 53GWh was flared to further reduce emissions of methane due to its higher global warming potential compared to carbon dioxide (Avfall Sverige 2021).

Reduced landfilling of waste and improved collection of landfill gas are factors that have contributed to a decrease in greenhouse gas emissions from the waste sector. Increased materials recovery generally means that both energy and materials are saved at the production stage, and this helps to reduce emissions further. In addition, waste incineration with energy recovery results in a reduction in the use of fossil fuels in the electricity and heating sectors.

2.11 Agriculture

The total area of agricultural land in Sweden in 2020 was 3.0 million hectares, which is equivalent to some 7 % of the country's total land area. Farmland comprises both arable and grazing land. The area under cultivation has shrunk by over 10 % since 1990 (Swedish Board of Agriculture 2021). The trend towards fewer, larger farming enterprises has been under way for many decades and the period 1990–2020 was no exception. The predominant use of arable land is cultivation of forage crops, green fodder and cereals. Since 2000, there has been a rise in cultivation of forage and green fodder crops at the expense of cereal growing (see Table 2.4).

The area of arable land left fallow, which shows annual variation, was slightly lower in 2020 than in 1990. Total crop production has fallen by some 5% since 1990 (see Table 2.5).

Table 2.4 Breakdown of agricultural land ('000 ha) (Swedish Board of Agriculture 2021).

	1990	1995	2000	2005	2010	2015	2019	2020	2021
Forage and green fodder crops	969	1067	929	1080	1193	1135	1161	1139	1124
Cereals	1336	1104	1229	1024	963	1034	993	1007	1000
Fallow land	176	279	248	321	177	163	132	138	146
Oilseed rape and turnip rape	168	105	48	82	110	95	106	98	106
Potatoes	36	35	33	30	27	23	24	24	24
Sugar beet	50	58	55	49	38	19	27	30	29
Legumes	33	12	37	41	46	59	44	48	50
Other crops	31	48	47	42	69	56	54	55	56
Unspecified arable land	..	..	80	32	11	6	11	11	11
Unused arable land	46	60	..	2	..	..	..	..	..
Total area of arable land	2845	2767	2706	2703	2634	2590	2551	2550	2546
Grazing land and hay meadows	332	425	..	513	452	450	461	464	464
Total area of farmland	3176	3192	..	3216	3085	3040	3012	3014	3010

Table 2.2.3 Crop production in Sweden (tonnes) (Swedish Board of Agriculture 2021).

	1990	2020	Change (tonnes)	Change, %
Forage and green fodder crops	4357870	4895100	537230	12
Cereals	6211300	5954500	-256800	-4
Oilseed rape and turnip rape	380090	339300	-40790	-11
Potatoes	1186100	877200	-308900	-26

Sugar beet	2775500	2027100	-748400	-27
Total crop production	14910860	14093200	-817660	-5

In 2021, there were 1.5 million cattle, 0.5 million sheep and lambs, and 1.4 million pigs (see Table 2.6). The number of cattle has fallen steadily since the 1980s, and declined by 15 % in the period 1990–2021. The number of dairy cows has fallen sharply, while that of cows used for calf rearing has risen. Sheep and lamb production has increased, peaking in 2017. Pig numbers continue to decline, and have fallen by 40 % since 1990 (Swedish Board of Agriculture 2021).

As a result of increased productivity, the quantity of milk produced has not shown as large a decrease as the number of dairy cows (see Table 2.7).

Table 2.2.4 Livestock numbers ('000) (Swedish Board of Agriculture 2021)

	1990	1995	2000	2005	2010	2015	2019	2020	2021
Cows for milk production	576	482	428	393	348	340	306	303	302
Cows for calf rearing	75	157	167	177	197	184	210	207	210
Total, cows	651	639	595	570	545	524	516	510	512
Heifers, bulls and steers	543	596	589	527	513	488	500	480	476
Calves below 1 year	524	542	500	508	479	467	451	462	465
Total, cattle	1718	1777	1684	1605	1537	1480	1466	1453	1453
Ewes and rams	162	195	198	222	273	289	280	263	272
Lambs	244	266	234	249	292	306	269	238	252
Total, sheep and lambs	406	462	432	471	565	595	549	501	523
Sows and gilts	230	245	206	188	156	142	130	131	129
Pigs for slaughter	1025	1300	1146	1085	937	830	943	869	845
Piglets	1009	768	566	538	427	384	383	368	376
Total, pigs	2264	2313	1918	1811	1520	1356	1456	1368	1351
Horses		85		99	117			89	

Table 2.2.5 Livestock production (tonnes) (Swedish Board of Agriculture 2021).

	1990	2000	2010	2020	Change	Change, %
Milk	3 432 000	3 297 000	2862000	2 772 740	659260	-19

Beef	143 780	149 810	137 800	141 000	2780	-2
Pork	289 150	276 980	263 480	246 540	42610	-15
Mutton, lamb	4 880	3 180	4 070	3 920	960	-20

Total use of nitrogen mineral fertiliser has decreased since 1990 but recently increased again to similar levels (see Table 2.8, Statistics Sweden 2021j). One reason for this decline is decreasing cereal cultivation. Sales are also affected by changes in cereal and mineral fertiliser prices. The result in terms of greenhouse gas emissions from lower nitrogen minieral fertiliser is lower release of nitrous oxide.

Table 2.2.6 Sales of mineral fertiliser expressed as nitrogen nutrient ('000 tonnes) (Statistics Sweden 2021j)

	1989/90	1994/95	1999/00	2004/05	2009/10	2014/15	2018/19	2019/20
Nitrogen (N)	225	198	189	162	168	190	183	215

Since 1990, the arable area, number of cattle and quantities of mineral fertiliser and manure used have decreased, with falling methane and nitrous oxide emissions as a result.

2.12 Forestry

Sweden's forest land amounts to 27.9 million hectares hectares (ha), according to the Swedish Forestry Act. Of the total forest area, 23,5 million ha is regarded as productive forest, corresponding to 58 % of the total land area. Accordingly, there is also 4.4 million ha of unproductive forests (11 % of total land area). It is for the total forest area that greenhouse gas emissions and removals in forests are reported. (Swedish University of Agricultural Sciences 2021)

47% of forest land is owned by individuals, 24% by privately owned limited companies, 6% by other private owners and 22% by state-owned limited companies, the central government and other public owners (Swedish Forest Agency 2021).

The area of forest land excluded from forestry is protected through different regulations. The area of productive forest land formally protected from forestry amounts to 0.87 million ha, of which about half is mountain forests in national parks, nature reserves and nature conservation areas. Roughly 1.32 million ha of Sweden's productive forest area has been voluntarily set aside by the landowners, and this land includes areas of high natural and cultural value or of importance for recreation and outdoor activities (Swedish Forest Agency 2021).

Increased demand for forest raw materials from the forest industry has led to an increase in felling during the period 1990–2019 (see Fig. 2.21). The volume felled varied greatly from year to year because of two storms, Gudrun (2005) and Per (2007). Gudrun, the more severe of the two, brought down some 80% of the normal annual volume felled in Sweden. Despite increased felling, the aggregate standing volume of timber rose from under 3.2 billion m^3 in 2003 to over 3.5 billion m^3 in 2018 (Swedish University of Agricultural Sciences 2021).

The area of regeneration felling in which harvesting residues were used for energy purposes was small at the beginning of the 1990s. Since then, it has successively expanded to some 80,000 ha in 2020. Wood ash is recycled to forest land for the purpose of counteracting acidifying, nutrient-depleting effects on the soil that occur when biomass is removed. In 2020, ash recycling was carried out on less than 14,000 ha.

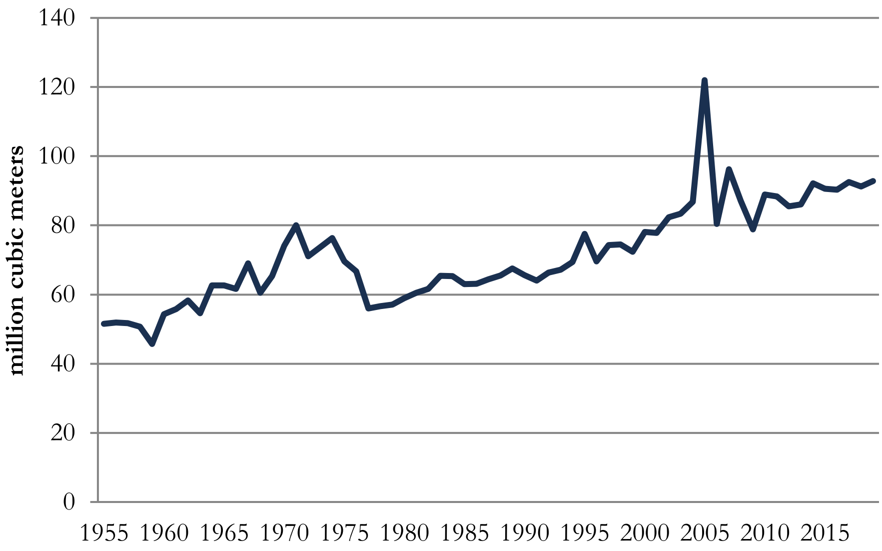


Figure 2.21 Estimated gross annual volume felled in Sweden 1955-2019 (Swedish Forest Agency 2021).

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3. Green house gas inventory information

The information in this chapter is a summary of the 2021 inventory of emissions and removals of greenhouse gases for the years 1990 to 2020, submitted under the UN Framework Convention on Climate Change and the Kyoto Protocol (National Inventory Report Sweden 2022).

3.1 Total emissions and removals of greenhouse gases

In 2020, greenhouse gas emissions (excluding LULUCF) in Sweden was 46.3 million tonnes of carbon dioxide equivalents (Mt CO_2-eq.), see Figure 3.1. Between 2019 and 2020 the total greenhouse gas emissions decreased by approximately 9 %, largely due to the COVID-19-pandemic. Total greenhouse gas emissions have decreased by 25.2 Mt, or 35 %, between 1990 and 2020. Emission levels have varied between a low of 46.3 Mt CO_2-eq. in 2020 and a high of 77.3 Mt CO_2-eq. in 1996. Annual variations are largely due to fluctuations in temperature, precipitation and to the economic situation. The net sink attributable to the land use, land-use change and forestry (LULUCF) sector has varied over the period. In 2020 it amounted to nearly 40 Mt CO_2-eq.

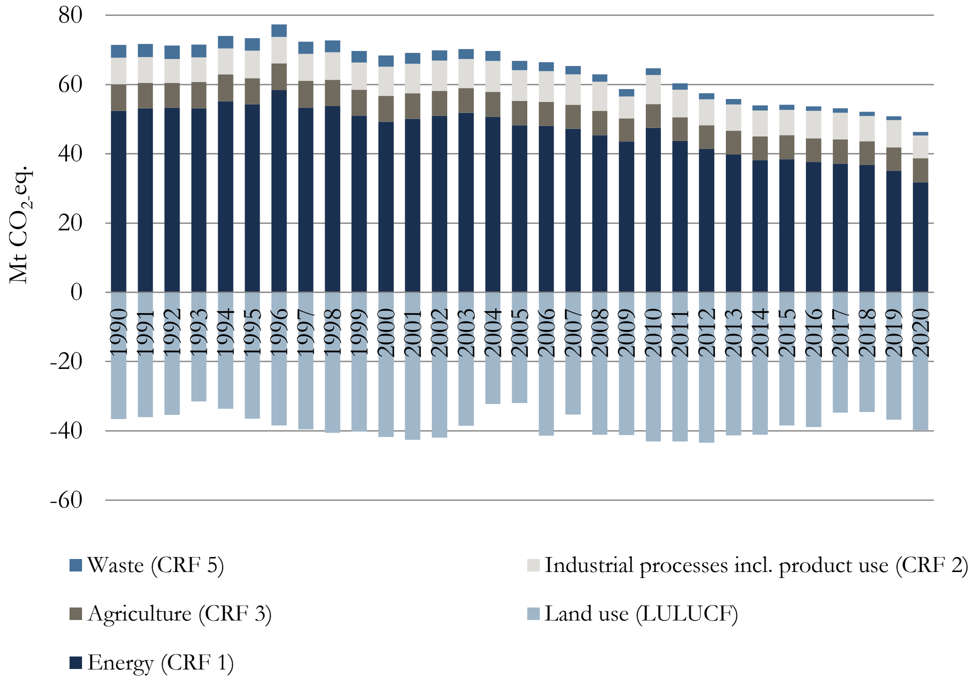


Figure 3.1 Total Greenhouse gas emissions 1990-2020 from different sectors.

In 2020, emissions (excl. LULUCF) of carbon dioxide (CO_2) amounted to 36.5 Mt CO_2 in total, which is equivalent to 79 % of total greenhouse gas emissions, calculated as CO_2-eq. Emissions of methane (CH_4) accounted for 4.1 Mt of CO_2-eq. (about 9 % of total emissions), emissions of nitrous oxide (N_2O) 4.6 Mt (10 %), fluorinated greenhouse gases (HFCs, PFCs and SF6) 1 Mt (2 %), see Figure 3.2. The shares of the different greenhouse gases have remained stable over the period 1990 to 2020.

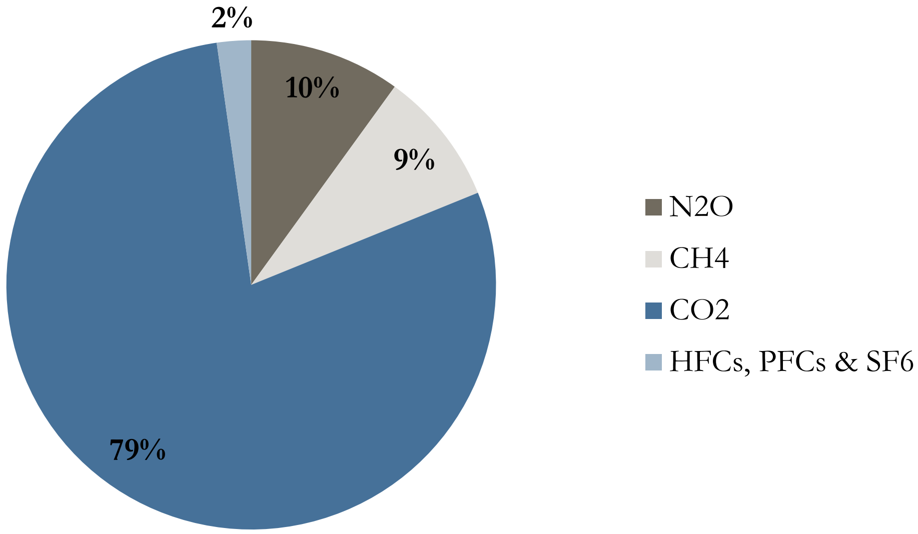


Figure 3.2 Greenhouse gas emissions in 2020 (excl. LULUCF) by gas, in carbon dioxide equivalent.

3.2 Emissions and removals of greenhouse gases by sector

The largest sources of emissions in 2020 was the energy sector (69 %), agriculture (15 %) and industrial processes and product use (14 %), as shown in Figure 3.3.

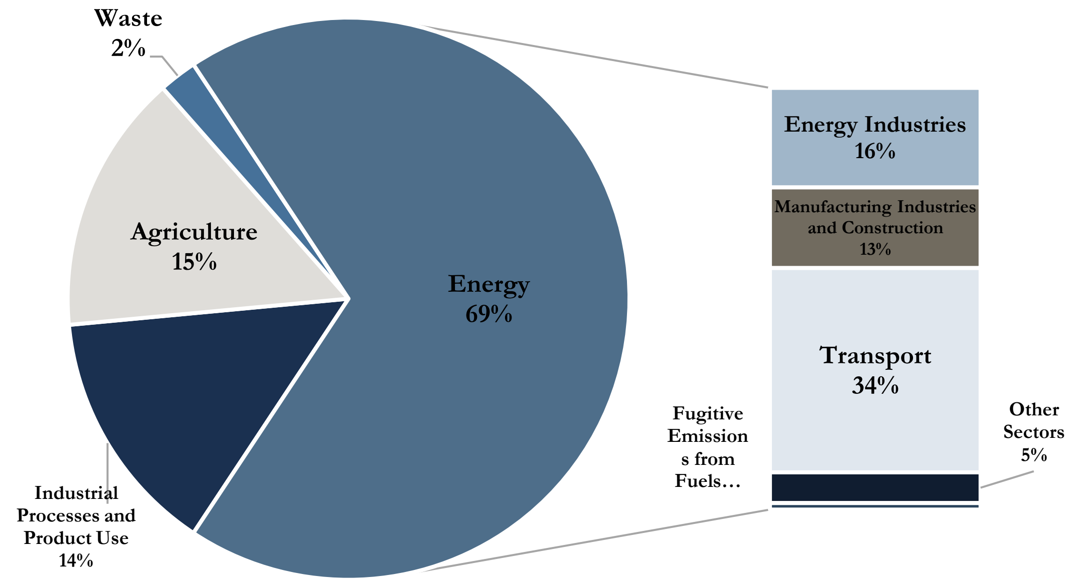
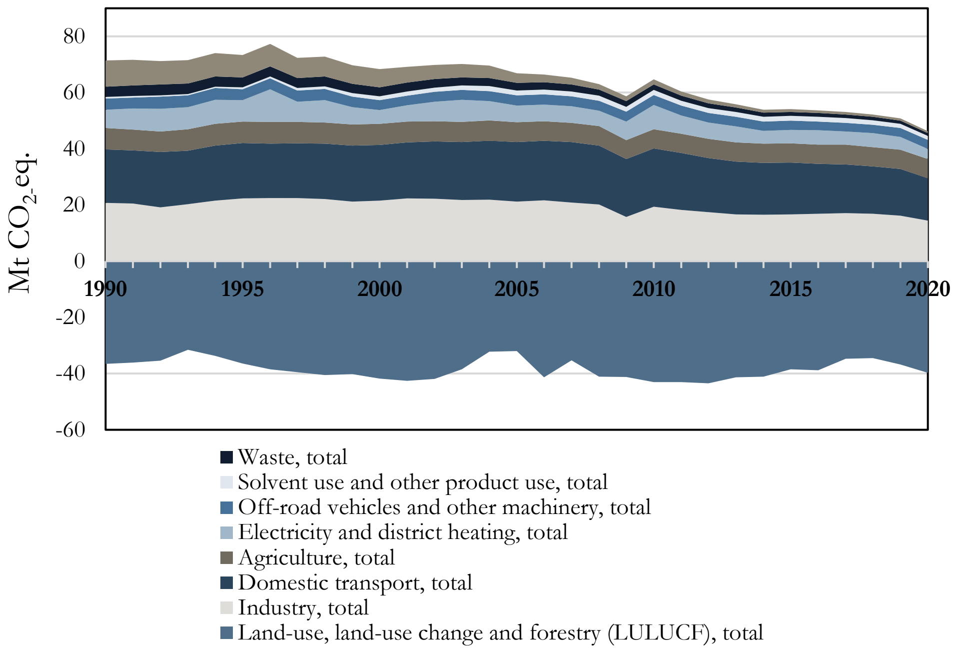


Figure 3.3 Greenhouse gas emissions in 2020 (excl. LULUCF), by sector.

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

BOX 1. 1 The Swedish national sectorial breakdown

The Swedish greenhouse gas inventories are published using a national sectorial breakdown for the purpose of tracking progress with national targets and tracking the effect of implemented policies and measures. The sectorial breakdown is designed to allocate emissions and removals in line with the design of national policies and measures. The aggregation of all industrial emissions in one main sector that is sub-divided by type of industry is the largest difference between the national sectorial breakdown and the IPCC sectors in the Common Reporting Format.

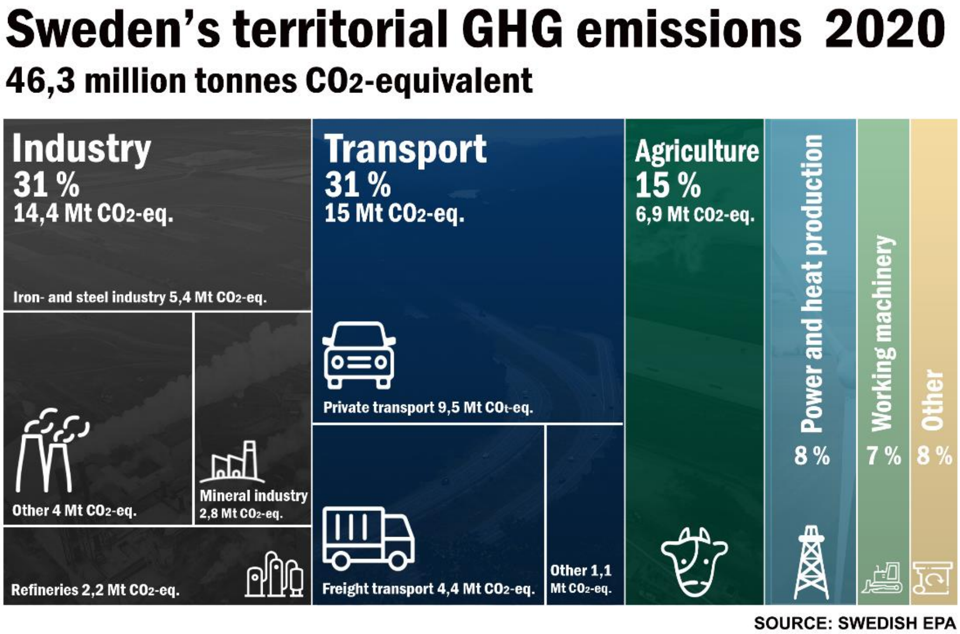


Emissions from **domestic transport** correspond to about one third of Sweden's total emissions (excluding LULUCF and international transport). The other main emission sources in Sweden are agriculture as well as electricity and district heating according to this breakdown. Emissions from domestic road transport respond to 32 % of Sweden's total emissions and have decreased by 21 % since 1990. Emissions from domestic transport, a sector dominated by road transport, increased after 1990 and reached a peak in 2007. Since then, emissions have been declining as a result of a transition to sustainable biofuels and more efficient vehicles. Emissions of greenhouse gases from domestic transport decreased by almost 10 % in 2020. The reduction in emissions is mainly due to reduced car traffic, which is largely a result of the COVID-19-pandemic.

Emissions from **industry** corresponds to 31 % of Sweden's total emissions and have decreased by 31 % since 1990, while changes in the economic development of different industries have resulted in annual variations. The emissions reductions are mainly related to decreased use of oil due to shifts towards biofuels, mainly in the pulp and paper industry. New processes in the chemical industry have also contributed to the decreasing trend. Shifting production levels in response to changing economic conditions in certain industries significantly impacts the trend as well. Since 2017, emissions from industry have decreased and particularly in 2020 as a consequence of the COVID-19-pandemic as the demand within the iron and steel industry was lower.

Greenhouse gas emissions from **agriculture** have been declining slowly and are now about 10 percent lower than in 1990. The decrease is mainly due to a reduced amount of animals) and partly to a reduced use of mineral fertilizers. The number of dairy cows in Sweden has almost halved (47 %) since 1990. This has resulted in that methane emissions from dairy cows' feed digestion have decreased by about one third. Approximately 50 % of the sector's emissions are related to the production of animal foods such as meat, dairy products and eggs.

Electricity and district heating show a trend of decreasing emissions despite the increased demand for district heating. The decrease in emissions is due to a shift towards combustion of more waste and biofuels, and less fossil fuels. Combustion of industry-derived gases is allocated to the industry.



More information about the national breakdown including how different CRF-categories are allocated is available at:
- Sweden's territorial greenhouse gas emission (in Swedish).
- Detailed data and reference to CRF-categories (in English).

3.2.1 Energy industries

Energy industries are dominated by the electricity and heat production with by far the largest part of the emissions and also the only subsector where emissions fluctuate over the years. The fluctuations between different years are large, due to the weather conditions' influence on the electricity and heat production (CRF 1A1a). In 2020, there was a decrease in emissions from the energy industries by 8 % compared to 2019. Sweden´s electricity and heat production is to a large extent composed by renewable energy and district heating is mainly based on biofuels and waste. Therefore, these emissions are

31 % lower than in 1990, even though the supply of district heating has increased with about 50 % in the same period.

Total emissions from energy industries (CRF 1A1) were 7.5 Mt CO_2-eq. in 2020 (Figure 3.4), which is 24 % lower than in 1990. Electricity and heat production (CRF 1A1a) account for the larger part of the emissions with 72 % (5.4 Mt CO_2-eq) in 2020. Emissions from Refineries (1A1b) and Manufacture of solid fuels (CRF 1A1c) amounted to 2.1 CO_2-eq in 2020.

Emissions from production of electricity and heat production totalled 5.4 Mt of CO_2-eq. in 2020. The emissions from electricity and heat production vary over time but have been reduced by 31 % between 1990 and 2020. There is a decrease in emissions in 2020 of 10 % compared 2019 due to decreased usage of fossil fuels and peat because of very warm weather, but also because of decitions by certain facilities to decrease the usage of fossil fuels or to not use certain fossil fuels at all.

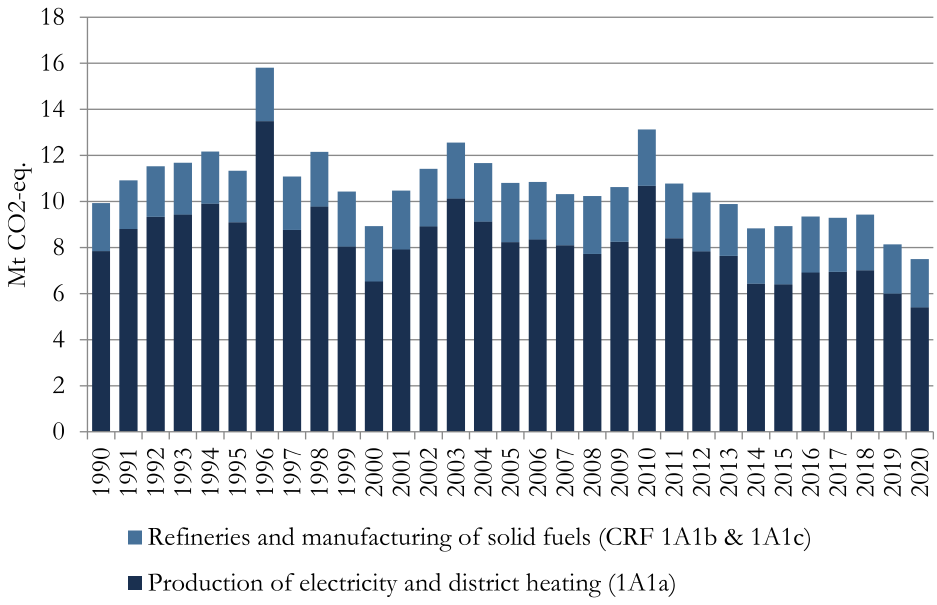


Figure 3.4 Greenhouse gas emissions 1990-2020 from the energy industries (CRF 1A1).

3.2.2 Residential and commercial/institutional

Greenhouse gas emissions from fuel combustion in the residential, commercial and institutional sectors were 79 % lower in 2020 compared to 1990 mainly due to a strong decrease in combustion of fossil fuels for heating in the residential and commercial/institutional sectors, see Figure 3.5. The emissions were approximately 2.3 Mt of CO_2-eq. in 2020. In comparison with 2019 the total emissions from the residential sector decreased by 3 %. Emissions from the commercial/institutional sector decreased with 8 % between 2019 and 2020. The emissions from agriculture, forestry and fisheries (CRF 1A4c) were 1.2 Mt CO_2-eq. in 2020, which is 37 % less than in 1990.

Emissions are primarily due to stationary combustion in homes, non-residential premises or within agriculture, forestry and fisheries. Emissions also come from mobile machinery, off-road vehicles and fishing boats. Oil-fired furnaces have been replaced by district heating, and electricity, including the increased use of heat pumps. Since emissions from stationary combustion for heating purposes have decreased significantly, the main emissions within the sector now come from non-road mobile machinery.

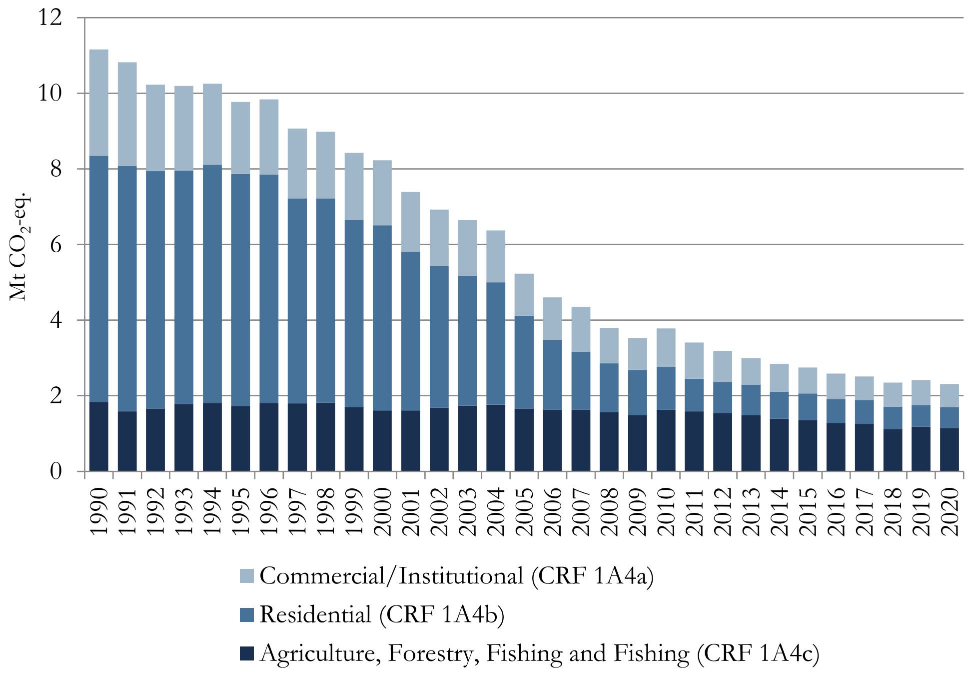


Figure 3.5 Greenhouse gas emissions 1990-2020 from combustion in the commercial and institutional, residential, and agriculture, forestry and fisheries sectors.

3.2.3 Industrial combustion

To cover all industry-related emissions it is necessary to include process emissions and emissions from combustion and fugitive emissions. These are to be reported under separate CRF (Common Reporting Format) categories according to UNFCCC guidelines.

The mining, iron and steel as well as pulp and paper industries are examples of historically important industries for Sweden. Emissions from combustion in manufacturing industries and construction were 6.1 Mt CO_2-eq. in 2020 (Figure 3.6). Emissions in 2020 were 44 % lower than in 1990. Emissions in 2020 decreased by 12 % compared to 2019. Although increasing slightly up until 1997, the emissions have a steady decreasing trend until 2014. The lower emissions in 2009 and higher emissions in 2010 were due to the financial crisis impact on production levels and their subsequent recovery. The decreasing trend is primarily related to a lower use of oil. Oil has been replaced by electricity or biofuels, partly depending on the difference in relative prices between electricity and oil.

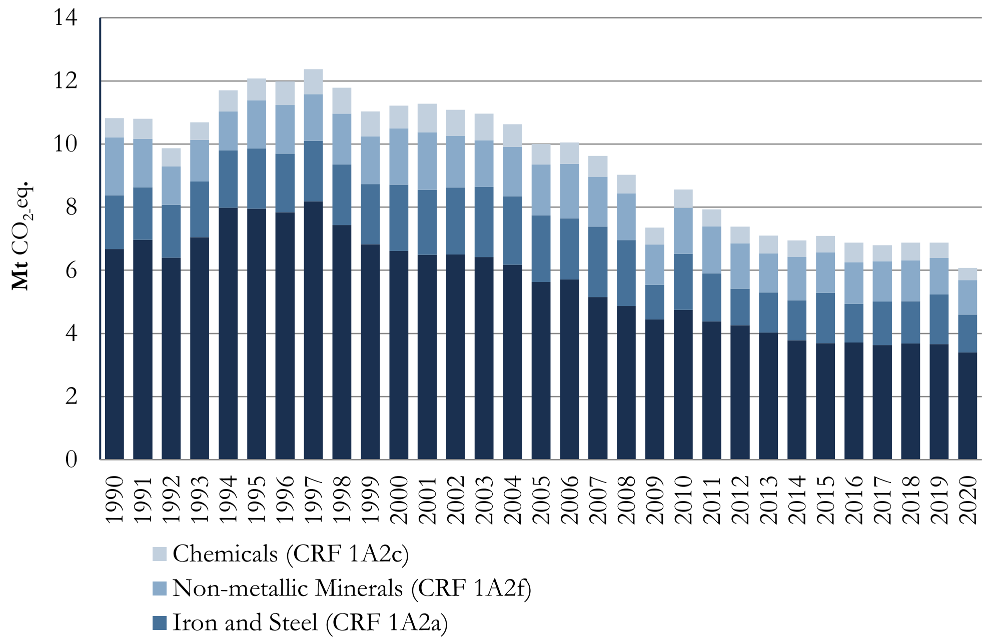


Figure 3.6 Greenhouse gas emissions 1990-2020 from industrial combustion.

3.2.4 Fugitive emissions

Fugitive emissions occur for example in processing, storage and use of fuels, flaring of gas, transmission and distribution of gas. Emissions were around 0.49 Mt of CO_2-eq. in 2020, which is an decrease of 15 % compared to 2019, which already was at a low level compared to earlier years, see Figure 3.7.

The decrese in emission during 2019 is mainly an effect of reduced production due to maintenance at two facilities. During 2020 demand from the sector has been low due to the COVID-19-pandemic, and therefor production has also been low. The increase of fugitive emissions from oil (CRF 1B2a), observed in the time series from 2006, is related to the establishment of hydrogen production facilities at two oil refineries. In total, the emissions from CRF 1B are 38 % higher compared to 1990.

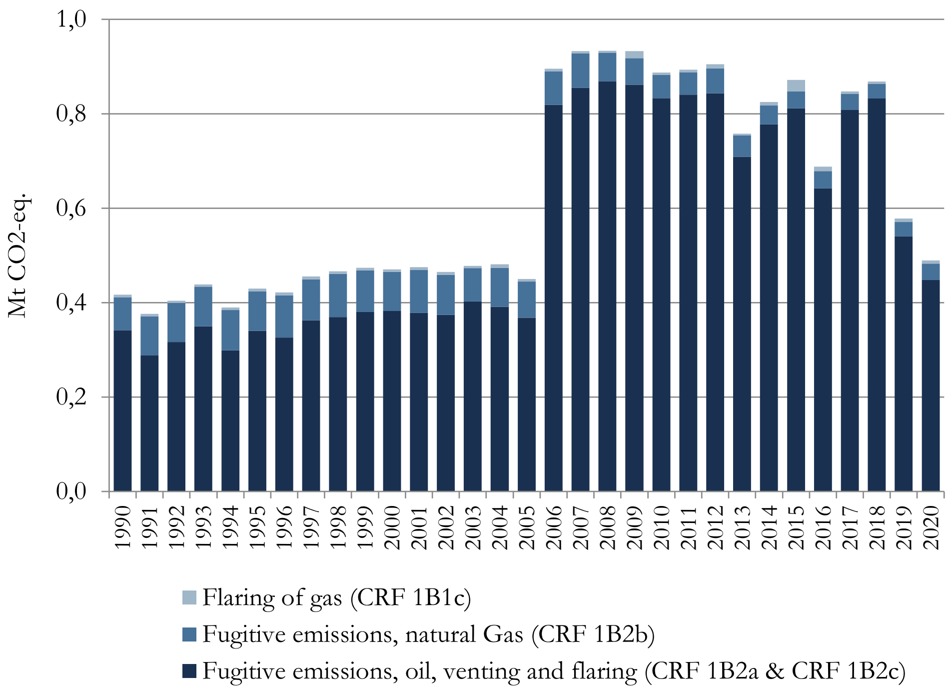


Figure 3.7 Fugitive emissions 1990-2020.

3.2.5 Industrial processes including product use

Emissions from the industrial processes and products use sector represented 14 % of the total national emissions in 2020, The main sources of emissions in the industrial processes and product use sector is the production of iron and steel (included in metal industry; 2C) and the cement and lime industries (included in mineral industry; 2A), see Figure 3.8. Greenhouse gas emissions from the industrial processes and product use sector have decreased by 14 % 2020 compared to 1990. Emissions from the sector did however increase during the 90's and early 00's but peaked in 2004 and has since had an overall decresing trend with some interannual variations, see Figure 3.8.

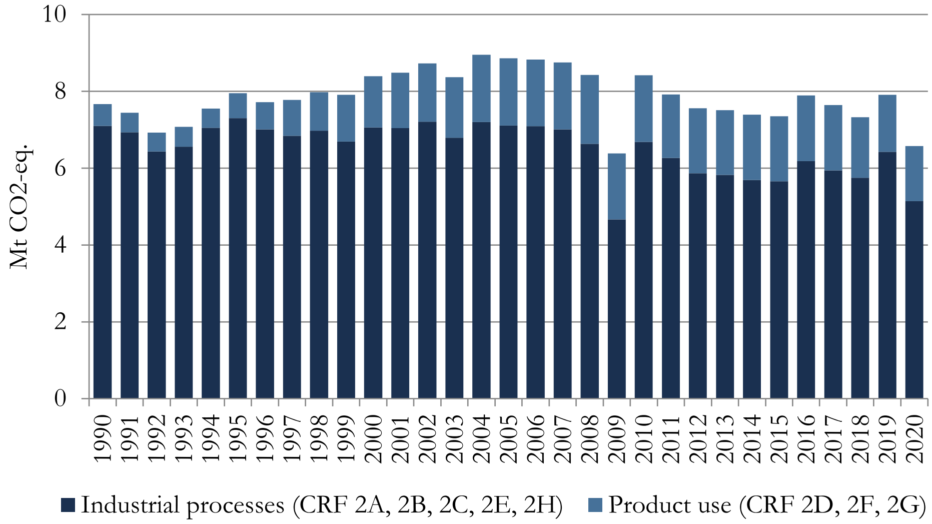


Figure 3.8 Greenhouse gas emissions 1990-2020 from industrial processes and product use.

Greenhouse gas emissions from industrial processes (CRF 2A, 2B, 2C, 2E, 2H) have many interannual variations, but show an overall decreasing trend since 1995. Between 2019 and 2020 emissions decreased with 20 %, which led to a decrease in emissions from industrial processes by 26 % in 2020 compared to 1990, see Figure 3.8. Greenhouse gas emissions from product use (CRF 2D, 2F, 2G) showed an increasing trend that has stabilised since 2004, with a small decrease. Nevertheless, greenhouse gas emissions from product use were about three times higher in 2020 compared to 1990.

3.2.6 Transport

In 2020, emissions of greenhouse gases from domestic transport totalled 15.4 Mt CO_2-eq., equivalent to a third of the national total. The total emissions of greenhouse gas emissions were 23% lower in 2020 compared with 1990, see figure 3.9. The reduction in emissions in the sector during the period is primarily due to the fact that the proportion of biofuels used in road traffic has increased during the period, and that vehicles have become more energy efficient. However, the reduction in emissions has been dampened by an increase in traffic. Emissions from the transport sector decreased by 9 % between 2019 to 2020, which largely is a result of the reduced car traffic during the COVID-19-pandemic.

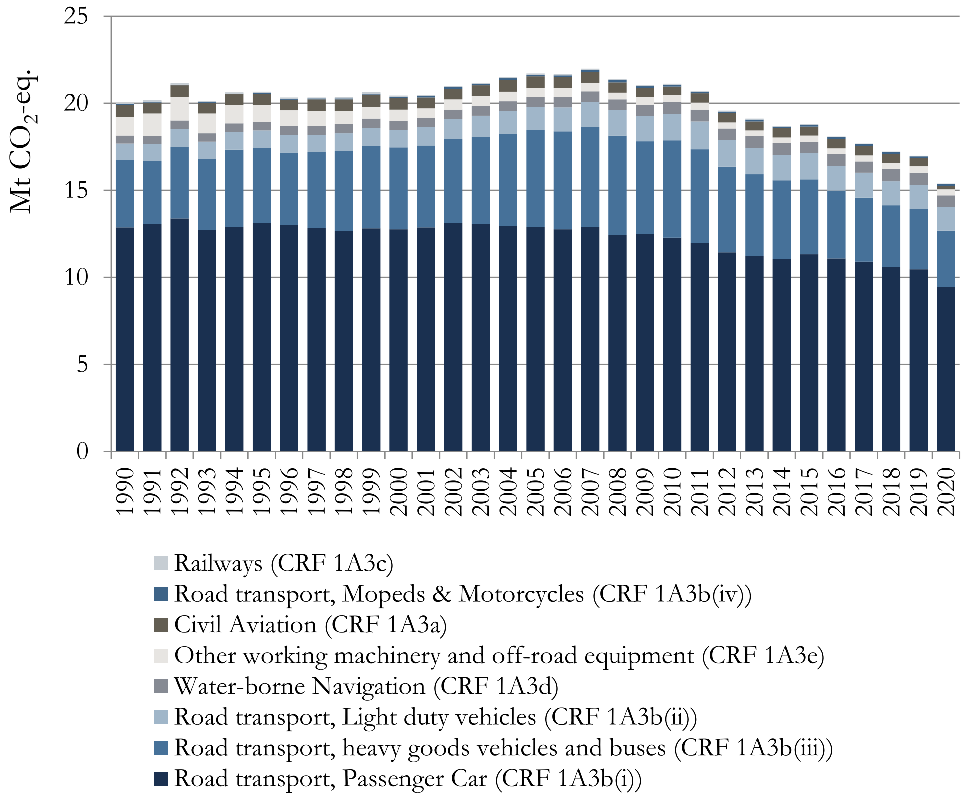


Figure 3.9 Greenhouse gas emissions 1990-2020 from domestic transport.

In addition to emissions from road transport, emissions from transport include emissions from domestic civil aviation, railways, national navigation as well as non-road mobile machinery. In 2020, the greenhouse gas emissions from road transport were 14.3 Mt CO_2-eq., 0.2 Mt CO_2-eq. from domestic aviation, 0.3 Mt CO_2-eq. from domestic navigation, 0.02 Mt CO_2-eq. from railways, and 0.36 Mt CO_2-eq. from non-road mobile machinery.

3.2.7 Waste

Greenhouse gas emissions from the waste sector amounted to 1.02 Mt CO_2-eq. in 2020, or 2 % of the national total of greenhouse gas emissions. Emissions from the waste sector have decreased by about 73% compared to 1990. From 2019 to 2020, emissions have been reduced by 6 % due to continued reduced emissions from landfills. Emissions from waste (CRF 5) include emissions from solid waste disposal (CRF 5A), wastewater treatment and discharge (CRF 5D), biological treatment of solid waste (CRF 5B) and incineration and open burning of waste (CRF 5C). The shares of the sub sectors of the total emissions of the sector are shown in Figure 3.10.

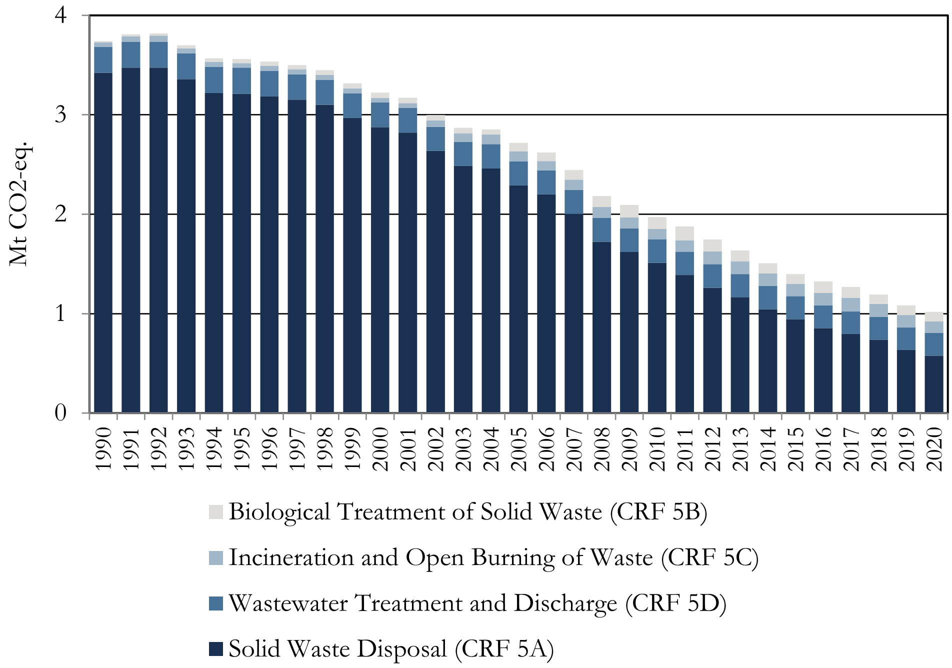


Figure 3.10 Greenhouse gas emissions 1990-2020 from the waste sector, per subsector

Emissions from the waste sector are dominated by methane gas from waste landfills. Methane emissions account for 58 % of emissions, while nitrous oxide emissions from wastewater treatment and biological treatment of solid waste account for 22 % and carbon dioxide emissions from waste incineration account for the rest. A ban has been introduced on landfill which has created a shift towards incineration of waste for energy recovery. Emissions from the incineration of waste for electricity and heat production are allocated to the energy sector and not to the waste sector.

3.2.8 Agriculture

The total greenhouse gas emissions from Agriculture (CRF 3) amounted to about 6.9 Mt CO_2-eq in 2020., which equals to about 15 % of the total national greenhouse gas emissions. Emissions in 2020 were about 10 % lower compared with 1990 levels. The historical emission reduction was due to decline in numbers of livestock, especially dairy cattle as well as decreased emissions from agriculture soils, particularly from the use of mineral fertilizers.

In 2020, agriculture soils (3D) and enteric fermentation (3A) were the dominant sources of the greenhouse gas emission in the sector, accounted for about 47.3 % and 42.4 %, respectively. Manure management (3B) and liming (3G) accounted for about 8.6 % and 1.8 % of the sector's emission, respectively. Emission from urea application (3H) is insignificant (Figure 3.11).

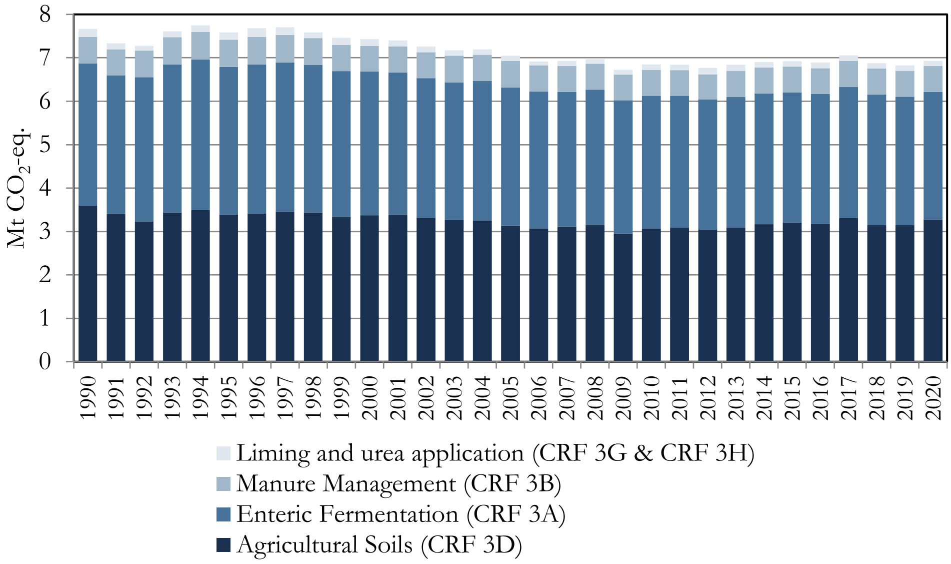


Figure 3.11 Greenhouse gas emissions from agriculture.

Greenhouse gas emissions related to agriculture originate from a range of sources and activities and are dominated by emissions from soil management, enteric fermentation, and manure management. In addition, there are emissions related to the energy use within the sector but reported in the energy sector. The main sources of CH_4 and N_2O emission in Sweden are animal husbandry and crop production. Emission from animal husbandry in Sweden is dominated by beef and dairy cattle but also has significant swine, sheep, and poultry components. Other livestock farming species includes goats, horses, reindeer, and fur-bearing animals. Crop farming includes predominantly the production of cereals, sugar beet and oilseeds.

3.2.9 Land use, Land use change and Forestry

The LULUCF sector has generated annual net removals in Sweden during the whole period 1990-2020 (Figure 3.12). In 2020 total net removal from the sector was estimated to 40 Mt CO_2-eq. During the period total net removals have varied between around 32 to 43 Mt of CO_2-eq. Between 2019 and 2020 the total net removals increased about 8 %.

The total size and variation of net removals in the LULUCF-sector is mainly affected by the carbon stock change in forest land, and changes in the carbon pool living biomass constitute the major part of these changes in net removals followed by carbon stock changes in mineral soils and dead organic matter. Net removals in this sector are heavily influenced by harvests and natural disturbances such as storms, drought and fires on forest land.

The majority of the net removals are in the carbon pools living biomass and mineral soils and the dominating category is forest land. Forest land accounts for 63% of Sweden's land area. Within forest land, the total net removal has varied during the period from 1990 to 2020 and has been on averaged 38 million tonnes CO_2-equivalents. The lowest net removal in living biomass in forest land was 28 Mt of CO_2-eq in 2005 and the highest about 44 Mt of CO_2-eq. in 2012. Between 2019 and 2020 the total net removal on forest land increased slightly.

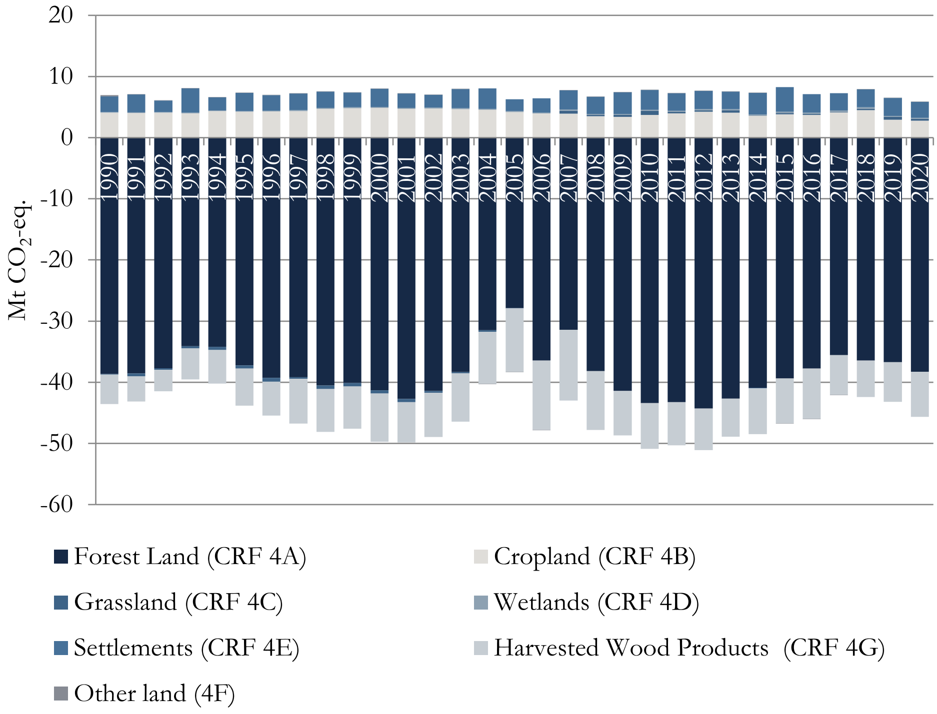


Figure 3.12 Greenhouse gas emissions and removals from land use.

The lowest net removal in living biomass in forest land was 28 Mt of CO_2-eq in 2005 and the highest about 44 Mt of CO_2-eq. in 2012. Between 2019 and 2020 the total net removal on forest land increased slightly. There are two dips in the trend, in 2005 and 2007, because of two severe storms. According to the Swedish National Board of Forestry, the felling, including wood felled by storms, was estimated at 122 Mm^3sk in 2005. However, the decrease in the living biomass in 2005, resulted in an increase in the HWP-pool in 2006. The HWP-pool increased slightly from 6.5 Mt of CO_2-eq in 2019 to 7.3 Mt of CO_2-eq in 2020. The increase was manly in the pulp and paper fraction caused by a higher demand.

3.2.10 International transport

Greenhouse gas emissions from international shipping and aviation, also known as international bunkers, are considerably larger than those from domestic shipping and aviation. In 2020, they amounted to 9.3 Mt of CO_2-eq, which is a decrease of 4 % since 2019 (Figure 3.13). The overall decrease in emissions from international bunkers is a result of the reduced air traffic during the COVID-19-pandemic. On the conterary, greenhouse gas emissions from international shipping increased during 2020.

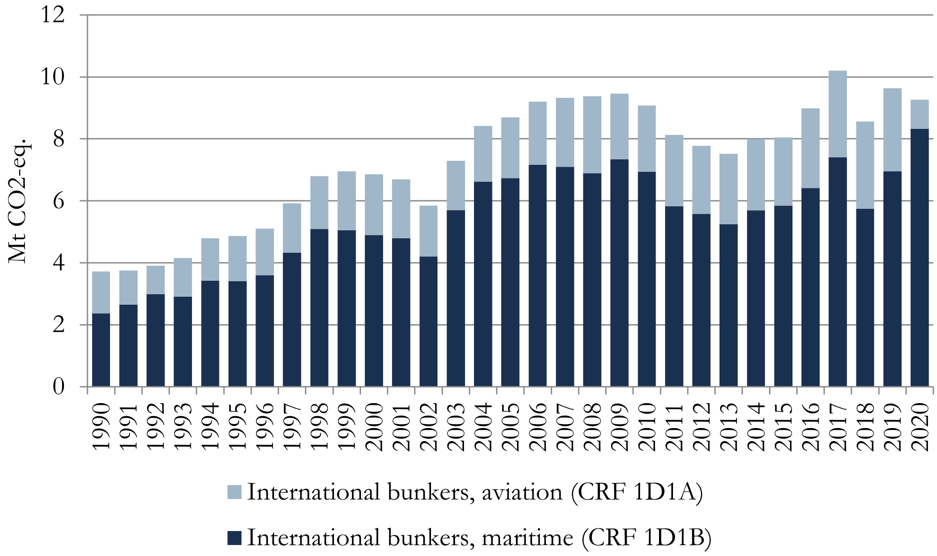


Figure 3.13 Greenhouse gas emissions 1990-2020 from international bunkers.

Emissions from international shipping reached a total of 8.3 Mt of CO_2-eq. in 2020. This is an increase of 20 % compared with 2019 and 251 % higher than in 1990. Greenhouse gas emissions from international aviation bunkers were 0.9 Mt of CO_2-eq. in 2020. This is a decrease of 65 % compared to 2019 and 30 % lower than in 1990. The large reduction in emissions from international aviation during 2020 is a result of the COVID-19-pandemic. During the years before the pandemic, emissions were twice as high as in 1990. Emissions from international bunkering of aviation have varied over time, but the trend points to a rise in these emissions, owing to growth in travel abroad.

3.3 References

National Inventory Report Sweden 2022, Greenhouse gas emission Inventory 1990 – 2020, Submitted under UNFCCC and the Kyoto Protocol.

4. Policies and measures

4.1.1 Background

This chapter provides information on the Swedish climate strategy as well as key policies and measures implemented or decided in Sweden to reduce greenhouse gas emissions. The policies and measures are included in the projections on greenhouse gas emissions reviewed in chapter 5[9]. Further, the chapter includes information on the efforts to avoid adverse effects of policies and measures and work on project-based flexible mechanisms under the Kyoto Protocol. At the end of the chapter the policy instruments and their effects are summarized in a table.

4.1.2 Swedish climate strategy

Sweden's climate strategy has progressively developed since the late 1980s. It consists of objectives, policy instruments and measures, together with regular follow-up and evaluation. In 2017 a new National Climate Policy Framework, ensuring long term order and stability in climate policy, was adopted by the Riksdag (Swedish Parliament).[10]

4.1.3 The Swedish Environmental quality objective-Reduced Climate impact

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

4.1.4 Sweden's national climate policy framework

In June 2017, the Riksdag adopted a proposal on a national climate policy framework for Sweden (Govt. Bill 2016/17:146). The climate policy

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[9] Some of the policy instruments are, due to recent date of decision, not included in the projections in chapter 5. Those are marked with a "*" in the summarizing table at the end of the chapter.

[10] The Swedish climate policy is also presented to the EU in the National Energy and Climate Plan (NECP). For the draft for 2023, see https://commission.europa.eu/system/files/2023-07/EN_SWEDEN%20DRAFT%20UPDATED%20NECP.pdf. This includes targets as well as policies and measures for the five dimensions of EU's energy union of which GHG emissions is one.

framework consists of a Climate Act, national climate targets and a climate policy council. The climate policy framework is the most important climate reform in Sweden's history. It creates order and stability in climate policy and sets long-term conditions for the business sector and society at large.

The climate act impose responsibility on the current Government, and on future governments, to pursue a climate policy that is based on the national climate targets and to provide clear feedback on the progress. As a result Sweden now has long-term climate targets and a council that independently reviews climate policy. The reform is a key component of Sweden's efforts to live up to the Paris Agreement. Information on the climate policy framework is publicly accessible at the website of the Swedish Environmental Policy Framework.[11]

Targets

- By 2045, Sweden is to have no net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions. This means emissions from activities in Swedish territory are to be at least 85 % lower by 2045 compared with 1990. Supplementary measures may count towards achieving zero net emissions, such as increased uptake of carbon dioxide in forests and land, and investments in other countries. International accounting guidelines will be followed for this.

- Emissions in Sweden outside of the EU ETS should, by 2030, be at least 63 % lower than emissions in 1990, and by 2040 at least 75 % lower. To achieve these targets by 2030 and 2040, no more than 8 and 2 percentage points, respectively, of the emissions reductions may be realised through supplementary measures.

- Emissions from domestic transport are to be reduced by at least 70% by 2030 compared with 2010. Domestic aviation[12] is not included in the goal since this subsector is included in the EU ETS.

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[11] https://www.naturvardsverket.se/en/topics/climate-transition/sveriges-klimatarbete/swedens-climate-act-and-climate-policy-framework/

[12] The emissions only includes CO2.

	Historical emissions	Climate target	Climate targets in the Climate Policy Framework	
Swedish emissions in total	- 35 % 1990-2020		Net zero by 2045 Max 15 % supplementary measures	
Emissions from sectors outside the EU ETS	- 36 % 1990-2020	-40 % by 2020 Max 13 % supplementary measures	-63 % by 2030 Max 8 % supplementary measures	-75 % by 2040 Max 2 % supplementary measures
Emissions from domestic transportation	-27 % 2010-2020 Excl. domestic aviation		-70 % by 2030 Compared to 2010	

Figure 4.1 Sweden's national targets included in the climate policy framework.

Climate Act

- The Climate Act legislates that the Government's climate policy must be based on the national climate targets and specifies how the work should be carried out.
- In its Budget Bill, the Government must submit a climate review to the Riksdag every year. The climate review must contain:
    - A report on emissions development.
    - A report on the key political climate decisions taken during the year.
    - An assessment to identify the need for additional policies and measures, and when and how decisions about such policies and measures can be adopted.
- Every fourth year, the Government must develop a climate policy action plan which provides information on planned policies and measures to achieve emission reductions. The Swedish EPA supports the Government with data and analysis.
- The Climate Act entered into force on 1 January 2018.

4.1.5 Climate Policy Council

The climate policy council[13] provides independent assessments of how the overall policy presented by the Government is compatible with the national climate goals.

4.1.6 The Swedish target for 2020

Current climate policy is also set out in two Government Bills, entitled An Integrated Climate and Energy Policy, passed by the Riksdag in June 2009 (Govt. Bills 2008/09:162 and 163). The first of these Bills sets a national milestone target for climate, calling for a 40% reduction in emissions by 2020 compared with 1990. Emission statistics shows that the target was reached mainly through domestic emission reductions (36 percent reduction between 1990 and 2020) in combination with investments in flexible mechanisms. This target applies to activities not included in the EU Emissions Trading System and does not include the LULUCF sector. In addition, the Bills also set targets for energy efficiency and renewable energy.

4.1.7 Institutional arrangements

At the national level, the Swedish Environmental Protection Agency is responsible for the environmental quality objective Reduced Climate Impact and for Sweden's regular climate reporting to the UNFCCC and the EU. Its role thus includes ensuring that new statistics are produced annually on emission trends in the country, and that projections and reports on policies and measures forming part of Sweden's climate strategy are prepared every two years. This work is done in collaboration with the responsible sectoral authorities. The Swedish Energy Agency has a broad sectoral remit covering the supply and use of energy in society and is responsible, among other things, for the action plans being drawn up to achieve further improvements in energy efficiency and increase the use of renewable energy, as well as for Sweden's work on flexible mechanisms. The Swedish International Development Cooperation Agency (Sida), Swedish Transport Administration, Swedish Transport Agency, Swedish Forest Agency, Swedish Board of Agriculture and Swedish National Board of Housing, Building and Planning also have key roles in following up and developing the

[13] www.klimatpolitiskaradet.se/en/

country's climate strategy. No specific legislation or special administrative procedures have been introduced to implement the Kyoto Protocol. The existing structure of central government administration and government

4.1.8 Framework agreement on the Swedish energy policy

The Riksdag has decided on an overall goal for energy policy, which is based on the same three pillars as the energy cooperation in the EU and aims to unite security of supply, competitiveness and ecological sustainability. The energy policy will thus create the conditions for an efficient and sustainable energy use and a cost-effective Swedish energy supply with a low negative impact on health, the environment and the climate, and facilitate the transition to an ecologically sustainable society.[14]

In addition, the Riksdag has decided on energy policy goals linked to certain years based on an energy agreement reached in 2016 between five of the Riksdag political parties.[15] After the agreement was concluded two of the parties have left the agreement. The energy policy goals are:

- In 2020, the share of renewable energy shall be at least 50 percent of the total energy use, the share of renewable energy in the transport sector shall be at least 10 percent and the energy use shall be 20 percent more efficient.
- By 2030, Sweden will have 50 percent more efficient energy use compared to 2005.
- By 2040, the goal is 100 percent renewable electricity production. This is a target, not a deadline for banning nuclear power, nor does it mean closing nuclear power plants through political decisions.

Box 4.1 Riksdag decisions of significance for Swedish climate policy

- In 1988, Sweden's first climate objective was adopted. It covered carbon dioxide only and called for emissions to be stabilised at 'present-day levels'.
- In 1991, the 1988 objective was extended to include all greenhouse gases and all sectors.
- In 1993 a national climate strategy was adopted in line with the UN Framework Convention on Climate Change (UNFCCC) objective of stabilising emissions in developed countries. The new national objective called for carbon dioxide emissions from fossil fuels to be stabilised at 1990 levels by 2000.

[14] Government Bill 2017/18:228, bet. 2017/18:NU22, rskr. 2018/19:411

[15] Government Bill 2017/18:228, bet 2017/18:NU22, rskr. 2018/18:411

- The energy policy guidelines adopted by the Riksdag in 1997 included a strategy to reduce the climate impact of energy use and energy production.
- As part of its 1998 transport policy decision, the Riksdag adopted the goal of stabilising carbon dioxide emissions from transport at 1990 levels by 2010.
- In 1999 the Riksdag decided to introduce a system of 15 environmental quality objectives, including one relating to the greenhouse effect: the environmental objective *Reduced Climate Impact.*In 2005 the Riksdag decided on one additional environmental quality objective A Rich Diversity of Plant and Animal Life.
- In 2002 a Government Bill entitled *Sweden's Climate Strategy* was passed, including climate goals for 2010 and 2050.
- The same year, the Riksdag decided to further develop the system of environmental quality objectives, among other things regarding the responsibilities of different stakeholders for attaining the objectives.
- The 2002 energy policy decision included a climate strategy related to that area.
- A climate policy decision in 2006 evaluated and retained the national target for 2010.
- In 2009 Government Bills proposing *An Integrated Climate and Energy Policy* were passed. They included climate targets, targets for an increased share of renewable energy and improved energy efficiency by 2020, a vision for 2050, and a new interpretation of the overall wording of the climate objective.
- The Government Bills on *An Integrated Climate and Energy Policy* also set out policy for the areas of fossil energy, efficient energy markets, and research and development..
- The Government Bills proposing *An Integrated Climate and Energy Policy* also set out policy on nuclear power. The Riksdag subsequently passed Govt. Bill 2009/10:172, *Nuclear Power – Opening the Way to a Generation Change*, and Govt. Bill 2009/10:173, *Nuclear Power – Increased Liability*. These decisions repealed the Nuclear Phase-Out Act and made it possible to replace permanently closed reactors with new ones on the same site, as well as introducing unlimited liability for power producers for damage arising from nuclear accidents.
- The Government Bill 2016/17:179 *New target for renewable electricity and a check point review for the electricity certificate system 2017* includes a new target for the electricity certificate system by 2030 and a prolongation of the system to 2045.
- The Government Bill 2016/17:146 *A Climate Policy Framework for Sweden* consists of a climate act, new climate targets and a climate policy council. It creates order and stability in climate policy and sets long-term conditions for the business sector and society
- In the Climate Policy Action Plan (Govt. Bill 2019/20:65) the Government describes its plans to achieve the climate goals as decided by the Riksdag. The Climate Act requires the Government to draw up a Climate Policy Action Plan every forth year.
- The Electrification Strategy addresses the conditions in the energy sector for an efficient electrification. This would contribute to reach Sweden's climate objectives.

4.1.9 Regional and local action on climate change

Since 1998, Sweden's county administrative boards (CABs) have been tasked with applying the national environmental quality objectives at the regional level. All 21 CABs have adopted regional climate objectives. As of 2005, their role also included developing regional action programs to achieve the environmental quality objectives. Since 2008, they have also been entrusted with strategic coordination and leadership in regional efforts to implement government policies for a transition to renewable energy and reduced climate impact. The CABs develop and implement regional action plans in collaboration with other stakeholders. They support efforts by the business sector and municipalities in the area of climate and energy. Implementation of regional climate and energy strategies include a variety of measures, such as initiating cooperation and transferring knowledge between regional actors.

Regional energy offices also initiate and participate in a wide range of projects relating to energy efficiency and renewable energy sources, with funding from the Swedish Energy Agency, the EU, CABs, regional development councils and other organisations.

At the municipal level, a wide range of climate activities are being undertaken. Municipalities are obliged to have an energy plan, which is often combined with a climate strategy to reduce greenhouse gas emissions. As a consequence of the autonomy of local governments in Sweden, no local climate targets are formulated by the national government. Reaching the climate targets is the responsibility of the government and any local climate targets are initiated and followed up by the municipalities themselves.

Energy and climate change advisory services, which are partly funded by the Swedish state and municipalities, have been provided since 1998. The Swedish Energy Agency is responsible for the advisory service, including providing support in other languages than Swedish.

The regions have the task of preparing and establishing a strategy for the county's development (regional development strategy) and coordinating efforts to implement the strategy. Economic, social and environmental sustainability is an integral part of analyzes, strategies, programs and initiatives in the regional development work. The region initiates, implements and participates in a wide range of projects relating to climate energy efficiency, renewable energy and reduced climate impact.

In Sweden, municipal self-government, also known as local autonomy, is established and implies that municipalities and regions manage local or regional matters with a high degree of autonomy. Municipalities are allowed to determine their own regional and local climate goals, and this is not monitored or followed up by a compliance system at the national level by the state. At the same time, there are no regulations or compliance system on national level regarding how regions and municipalities should contribute to the national climate goals in Sweden.

4.1.10 Other institutional set-ups to implement the climate targets

The Climate Board

The government's goal is for Sweden to become one of the world's first fossil free welfare nations. To achieve this, all policy areas must move in the same direction and the climate issue must be integrated into all relevant policy areas. For that reason, the government has established a climate board within the Government Offices[16].

The purpose of the Climate Board is to strengthen the government's work to achieve the climate goals and to implement the climate policy action plan. The Climate Board has regular meetings chaired by the Prime Minister. In addition to the Prime Minister and the Minister for the Environment and Climate, six other ministers are included, whose areas are crucial for climate change.

The Electrification Commission

In 2020, the Government set up an Electrification Commission to speed up the work of electrifying the heavy road transport and the transport sector in general. The Commission shall, in consultation with the actors concerned, identify measures that they can take to increase the pace of electrification in the field of transport. The analysis shall include passenger and freight transport within all modes of transport. The Commission focuses in

[16] Klimatkollegiet

particular on how regional freight transport, state roads, industrial routes and transport projects can be electrified.

4.2 Policies and measures in Sweden's climate strategy and their effects

4.2.1 Background and success factors

Sweden has introduced a range of policies and measures directly or indirectly affecting greenhouse gas emissions. The emphasis in the country's climate strategy is on the use of general economic instruments, but in many cases the general economic instruments are supplemented with targeted measures, for example to support the development and market introduction of technology and eliminate barrier effects. Many instruments which interact with carbon dioxide tax and emissions trading have also been adopted to achieve other policy goals than the climate objective, such as energy policy objectives.

Since the early 1990s, two key instruments in reducing Swedish emissions have been energy and carbon taxes. These taxes have been supplemented with other instruments, such as technology procurement, information, a differentiated annual vehicle tax and investment grants. Legislation, as those involving prohibitions, standards, and urban planning, also plays a part in curbing emissions. EU-wide policy instruments, in particular CO_2 emission performance standards for new vehicles and the Emissions Trading System (EU ETS), also have assumed growing importance in Sweden. At the same time, developments in recent decades have been defined by a framework for spatial planning and other long established instruments in Sweden. Of particular importance are earlier decades' investments in an expansion of district heating networks, public transport systems and carbon-free production of electricity.

Given the large number of policies and measures, many of them introduced with other primary objectives than climate mitigation, for example decreasing congestion or increasing the supply of energy from renewable sources, it can be difficult to estimate the progress quantitatively in terms of mitigation impact. Furthermore, picking out the effects of policy instruments from the impact of other, external changes, such as energy prices, is often complicated. For many of the policy instruments, we have not been able to provide a quantitative estimate of the mitigation impact. As several instruments interact, it is also hard to distinguish the effect of a single instrument.In order to ensure that the estimates of mitigation impacts add up, without risking double counting or underestimating mitigation impacts, Sweden has chosen to estimate policy effects for groups of policy instruments. The grouping is based on the degree of interaction between policy instruments.

Yet another difficulty in evaluating policies and measures in Sweden is that instruments which reduce electricity consumption or increase the production of carbon-free electricity have only a limited impact on carbon dioxide emissions inside Sweden's borders, owing to the fact that the electricity production in Sweden is largely fossil free albeit integrated with Nordic/north European market.

It should also be noted that, even before 1990, there were instruments in the Swedish energy sector with a similar steering effect to those used after 1990, and through those instruments incentives were created early on for the introduction of bioenergy and an expansion of district heating. For the energy supply sector and the residential and commercial/institutional sector it may, therefore, be difficult to disentangle the additional effects of policy instruments introduced in Sweden after 1990 from the effects that might otherwise have arisen if instruments had not been subsequently strengthened.

Figure 4.2 illustrates an overall assessment of the impact of economic instruments affecting Sweden's stationary energy system. Forming the basis for the results is the TIMES-NORDIC energy system model, in which a scenario based on policy instruments in place in 1990 has been compared with a scenario reflecting the actual development of instruments (see box 4.2). Economic instruments introduced after 1990 have been important for the reduction of carbon dioxide emissions.

This is most evident for the electricity and district heating sector, see Figure 4.2. Not all policy instruments are included in the analysis why the total effect is underestimated (Profu 2021). The different sectors are described in more detail in the relevant sections of this chapter.

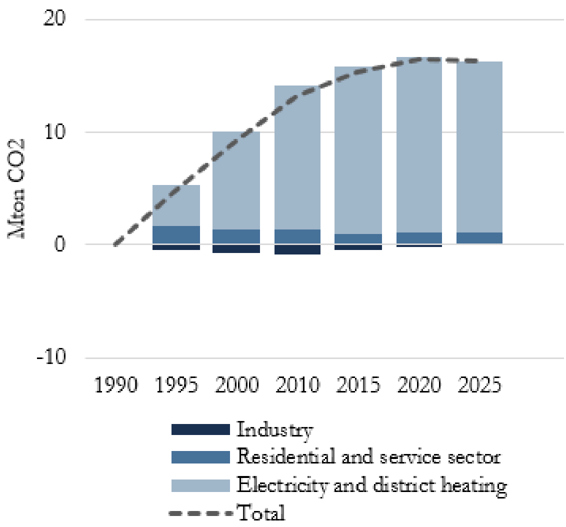

Figure 4.2 Difference in carbon dioxide emissions between a scenario based on 1990 policy instruments and actual development of policy instruments. The importance of policy instruments introduced after 1990 has increased over time, most notable for the eclectricity and district heating sector (Profu 2021).

4.2.2 Innovative policy measures

Two aspects of Swedish climate policy can be particularly highlighted as sources of inspiration for others, the reversed auctions for bio energy with carbon capture and storage (BECCS) as well as the mix of policy instruments and institutional factors enabling transitions in fossil intensive industries, here focusing on fossil free steel production.

Concerning BECCS, both the technology and the policy instruments associated with it can be seen as innovative in an international perspective. Reversed auctions is being used in order to ensure cost effective allocation of the funds set aside for the removal of carbon dioxide emissions that occur when capturing and permanently storing biogenic carbon dioxide emissions from the production of energy from biomass. The ambition is that BECCS will be up and running in the near future. With current policy measures, approx. 2 million tonnes of biogenic carbon will be separated by 2030. The experiences with Sweden's policy for BECCS is particularly relevant for other countries with large point sources of CO2 emissions from sustainable bio energy.

As regard the policy mix for fossil intensive industries, this has been accelerated in Sweden through an effective mix of policies and measures consisting of long-term clear political ambitions, an increasing carbon dioxide price through the EU ETS, support through, for example, Industry Leap, and mobilisation within the dialogue initiative Fossil Free Sweden[17]. In addition, there are important environmental success factors such as the availability of fossil-free electricity and low electricity prices. The climate effect for the transition to fossil free steel production specifically is in the short term negative (increase emissions) as a result of new establishments, but in the long term it can reduce Sweden's emissions by about 5 million tonnes CO2.

4.2.3 Cross-sectoral instruments

EU Emissions Trading System Directive 2003/87/EC

The EU Emissions Trading System (EU ETS) is the EU's most important tool to combat climate change. It was introduced in 2005 and has since been expanded to cover more sectors and greenhouse gases. The rules for monitoring and reporting and for free allocation of allowances have subsequently been improved and harmonized between the EU member states.

The amount of emissions allowed within the system is limited by a cap, which is decreased every year. Almost half of the allowances are allocated for free to installations covered by the system, the rest are auctioned.

Free allocation is used in order to avoid risks of carbon leakage in specific industrial sectors such as steel and cement. As a rule, there is no free allocation for emissions from electricity production. Free allocation to sectors not exposed to carbon leakage will cease in 2030. However, free allocation to district heating and district cooling will continue on a low level.

At the outset, EU ETS covered emissions of carbon dioxide from combustion installations and energy-intensive industries (mineral oil refineries, coke ovens, iron and steel industry, pulp and paper industry, and mineral industry). The scope was extended in 2013 with new greenhouse gases (nitrous oxide and perfluorocarbons) and with some new industrial activities. At present, about 750 Swedish installations are included in the system. At the EU level in total, approximately 13,000 installations are

[17] See the following sections for more detailed descriptions of each policy instrument.

covered, which corresponds approximately to 45 percent of the total EU GHG emissions.

To strengthen EU ETS, the EU has decided on a reform of the system. From 2021 onwards, the annual reduction of the cap will increase from 1.74 % to 2.2 %. A market stability reserve has been introduced to reduce the surplus of emission allowances on the market. From 2023 onwards, allowances held in the market stability reserve above the number of allowances auctioned the previous year will be cancelled. Finally, the auction share has been set to 57 % and free allocation will be focused on sectors highly at risk of carbon leakage.

Emissions from aviation were included in the system in 2012. Because of extensive protests from some countries outside the EU the EU decided on a temporary exemption for flights outside the EEA.

As the ICAO in September 2016 decided to implement a global measure, the Carbon Offsetting and Reduction Scheme for International Aviation (Corsia), the EU has decided to maintain the geographic scope of the EU ETS limited to intra-EEA flights from 2017 onwards. Corsia is implemented in EU law through a revision of the EU ETS legislation. Sweden is the administering Member State for approximately 90 aircraft operators, however only a few were subject to report their emissions in CORSIA in 2020.

In 2021, the European Commission released proposed amendments to the EU ETS as part of the "Fit for 55" package. Key proposed amendments involve tightening the emissions cap. For the sectors covered a -61% emissions reduction target is planned (by 2030 compared to 2005 levels).

The linear reduction factor would be increased from 2.2% to 4.2%. Moreover, the European Commission is proposing to extend the EU ETS to maritime transport, particularly for large ships (above 5000 gross tonnage) from 2023.

Energy tax and carbon tax

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

Carbon tax

A carbon tax, based on the fossil carbon content in the fuel, was introduced in 1991 and aims at reducing the emissions of carbon dioxide in sectors outside the EU ETS. The tax has been raised in several steps since it was first implemented. In total, the tax has increased from SEK 0.25/kg (1991) carbon dioxide to SEK 1.20/kg (2021). In addition to specific tax increases stipulated in government bills, a yearly indexation of the tax level is applied to adjust for changes in the consumer price index and to take account of the development of the gross domestic product (GDP). The GDP-indexation is added to the energy tax. In 2021-2022 the GDP-indexation is put on hold (Gov. Bill 2020/21:196).

The tax level is proportionate to the calculated amount of carbon dioxide emissions based on the fuel's fossil carbon content. This means that biofuels currently are not subject to carbon taxation, if not used within the reduction obligation scheme for motor fuels. With regard to motor fuels, changes to carbon taxation of biofuels were implemented on 1st July 2018 (see separate section on carbon and energy taxation in the transport sector). A reduced carbon tax and energy tax is applied for diesel used in, for example, agriculture, forestry and aquaculture.

Energy tax

Taxes on energy have been used in Sweden for a long time.[18] An energy tax on petrol and diesel was introduced in 1924 and 1937, respectively. Fuel used for heating and electricity became subject to an energy tax in the 1950s.

The aim of the energy tax is mainly fiscal. It does also have the effect to steer energy usage towards Sweden's energy efficiency, renewability and climate targets[19]. The energy tax on motor fuels used in road vehicles and off-road machinery also internalises external costs from the traffic, such as road wear, noise, etc (National Institute of Economic Research, 2013). The energy tax on fuel varies depending on whether it is used as motor fuel or for heating

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[18] Tax on energy is a collective term for excise taxes for fuel and electrical power and is governed by the Act of Excise Duties on Energy (1994:1776).

[19] The energy efficiency target and the renewable target for 2020 are part of Govt. Bills 2008/09:162 and 163.

purposes. The tax level on heating fuels also varies between households, industry and the energy conversion sector. A reduced energy tax is applied in some sectors.

Carbon tax and energy tax on motor fuels used for road vehicles and off-road machinery

Petrol and diesel are covered by both an energy tax and a carbon tax on fuels used in road vehicles, off-road machinery and private ships and boats. Since 1994, the energy tax on fuels and electricity as well as the carbon tax on fuels are adjusted to changes in the consumer price index (CPI), to take account of inflation. As of 2017, tax rates on petrol and diesel are also adjusted to take account of the development of the gross domestic product (GDP).[20] The Parliament has decided (Govt. Bill 2020/21:196) to put the GDP adjustment on hold during 2022 to compensate for increased prices due to the reduction obligation scheme, see below.

In December 2021, the energy tax on diesel (environmental class 1) was SEK 2.478 per liter and the carbon tax was 2.262 per liter, while the energy tax on petrol was SEK 4.13 per liter and the carbon tax was 2.61 per liter. In May 2022 the energy tax on both diesel and petrol was lowered by SEK 0.4 per litre (SEK 0.5 per litre including VAT). At the same time a temporary decrease of the tax rates by 1.05 SEK per litre was implemented (Govt. Bill 2021/22:84 and 2021/22:221).

Swedish Parliament decided to introduce an emission reduction obligation scheme in 2018. In 2021 the reduction levels within the reduction obligation scheme was decided until 2030. The scheme was accompanied by a number of tax rule changes for petrol and diesel. In particular, low-blended biofuels that are covered by the reduction obligation scheme are subject to carbon tax and energy tax rates that correspond to the rates of their fossil equivalents. At the same time, the carbon tax rates for petrol and diesel were adjusted downwards to take account of the share of low-blended biofuel per liter full blend, as a result of the emission reduction obligation scheme. The energy tax on petrol and diesel was also lowered. High-blended and pure biofuels are not covered by the reduction obligation scheme and such

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

sustainable biofuels are still exempted from both the carbon tax and the energy tax.

If the biofuel is classified as petrol or diesel it needs to consist of more than 98 volume percent biomass to be covered by the tax exemption. As the exemption of the carbon and energy tax for these biofuels are not considered compatible with the EU state aid rule, Sweden has sought a prolongation of an exemption which was approved by the European Commission in the autumn 2021. The prolongation of the tax exemption is for one year.[21] Moreover the European Commission approved in the autumn 2020, under EU state aid rule, a 10-year prolongation of the tax exemption (2021-2030) for non food-based biogas and bio propane used for heating or as motor fuel in Sweden. The objective of the tax exemption is to increase the use of biogas and biopropane and to reduce the use of fossil fuels and their greenhouse gas emissions, while facilitating the transition towards advanced biofuels.

Carbon tax and energy tax for heat production

Fuels used for heat production are subject to energy tax as well as carbon tax. Fuels used for heat production in combined heat and power plants (CHPs) and in other heating plants within the EU ETS were subject to 11 % of the carbon tax and 30 % of the energy tax until 31 July 2019. Between 1 august 2019 and 31 December 2022 the tax levels were increased to 91 % of the regular carbon tax and 100 % energy tax. The Carbon tax for heat production within the EU ETS was abolished as of 1 January 2023 since carbon emissions are already priced through the EU ETS. The energy tax for fuels used to produce heat in CHPs outside the EU ETS was raised on the 1st of August 2019 and is now subject to 100 % of the energy tax. These fuels are also subject to 100 % carbon tax.

Carbon tax and energy tax for electricity production

Fuel used for electricity production is exempted from both energy and carbon taxes. However, the use of electricity is generally subject to the energy tax on electricity.

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[21] https://www.regeringen.se/pressmeddelanden/2021/09/klart-med-fortsatt-skattebefrielse-for-flytande-biodrivmedel/ 3 September 2021

Carbon tax and energy tax in the manufacturing industry sector

The manufacturing industry sector is subject to some exemptions and reductions in energy and carbon taxes, primarily due to the fact that most of the manufacturing industry is already covered by the EU ETS. One of the main reasons behind the tax reductions is to avoid the application of more than one policy instrument for the same purpose for cost-efficiency reasons.

The manufacturing industry, both covered and not covered by the EU ETS, used to pay 30 % of the general energy tax. As of 1 January 2022 fuels used for heat production in manufacturing processes in manufacturing industries are subject to 100 % of the energy tax no matter if the industrial activity is part of the EU ETS or not (Govt. Bill 2020/21:97). No carbon tax is charged for fuels used for heat production in manufacturing processes in industries if the industrial plant is part of the EU ETS.

Previously, industries not covered by the ETS had significant reductions in the carbon tax, but in recent years the tax has been raised. The carbon tax reduction was then totally rescinded from 2018. For so-called mining diesel (diesel that is used in working machinery in manufacturing processes in mining industrial activity), energy taxes and carbon taxes were levied with 11% and 60 % respectively of the general levels of taxation until 31 July 2019. This reduction of energy and carbon tax has now been rescinded since August 2019, meaning that the full energy and carbon tax rates are applied.

Carbon tax and energy tax in agriculture, forestry and aquaculture sectors

Up until 2014 the agriculture, forestry and aquaculture sectors paid 30% of the general energy and carbon tax rates for fossil fuel used for heating purposes. Since then, the carbon tax reduction in the sectors has been reduced in steps and was totally rescinded by 1 January 2018. The energy tax was 30 % of the general energy tax rate for heating fuels in these sectors until 1 July 2021. Since then, the reduction has been reduced. It was totally rescinded 1 January 2022 (Govt. Bill 2020/21:97). Diesel for machinery in agricultural, forestry and aquaculture activities are subject to carbon and energy taxation. A special reimbursement has fluctuated over the years. The current level of reimbursement is for carbon tax SEK 2.292 per liter and for energy tax 2.111 SEK per liter.

National and international commercial shipping

Fuels for national and international commercial shipping are not targeted with any energy tax or carbon tax.

Local Climate Investment Program – The Climate Leap

To further stimulate the reduction of greenhouse gas emissions, a program for local investments was introduced in 2015, the Climate Leap. In total, SEK 7.7 billion has been granted for investments within the program (as of November 2021). The Swedish Environmental Protection Agency (Swedish EPA) administers grants for local and regional investments to cut greenhouse gas emissions. Investments in all sectors, except those included in the EU ETS, and all types of organisations are eligible to apply for grants. Some investments in sectors included in the EU ETS are also eligible for grants if these result in an increased utilisation utilisation of waste heat. Applicants compete based on the estimated greenhouse gas reduction of each investment.

Examples of investments that can be granted support are charging infrastructure for electric vehicles, biogas plants, infrastructure for biofuel and changes from fossil oil to biofuel or district heating. In 2022 the budget for the program amounts to SEK 2.8 billion. The budget is estimated to SEK 2.7 billion for 2023 and SEK 3.7 billion for 2024 (Govt. Bill 2021/22:1).

Effects of the Local Climate Investment Program

In total, the investments granted are expected to generate a reduction of approximately 1.5 Mt CO2-eq. per year during the technical lifespan of the investments[22] (Govt. Bill 2021/22:1). Measures in the transport sector represents around 60 % of the total emission reductions while around 35 % of the reductions can be attributed to measures in the residential and service sector along with the industry. It should, however, be noted that the measures in the investment program are of different character, including enabling activities for vehicle shifts such as infrastructure investments,

Including charging infrastructure, and supply of biofuels with an indirect effect on emission reductions. Further, all emission reductions cannot not be

[22] The technical lifespan of the investments is in average 16 years.

attributed to this policy instrument alone, as other instruments will also affect the emissions[23]. E.g. the electric vehicles need the infrastructure but are also affected by other national and EU policy instruments.

A national center for carbon dioxide capture and storage

In order to achieve net zero emissions by 2045, and enable negative emissions thereafter, the Swedish Energy Agency has been appointed as national centre for CCS-related issues.. Tasks include to promote the appropriate implementation of CCS in Sweden, for example by following the latest development, providing the government with necessary analysis and identifying legal barriers for CCS in Sweden. The Agency has also been appointed auctioneer for the support system, through reversed auctions, for BECCS.

National strategy for electrification

The government has decided on a national strategy for electrification. The strategy will contribute to a fast, smart and economically efficient electrification. In the strategy, the government takes a holistic approach to the conditions in the energy sector to enable increased electrification. Means has been allocated to enable the implementation of the strategy to meet society"s needs and expectations. Among other things, the Government intends to set up an electrification council to support the implementation of the electrification strategy. A plan to deal with any obstacles to increased electrification will also be included. To implement the electrification strategy the Government has budgeted SEK 20 million for 2022, SEK 35 million for 2023 and SEK 25 million for 2024 (Govt. Bill 2021/22:1).

The Environmental Code and planning legislation

General legislation in the area of the environment has been collected in the Environmental Code since January 1999. Among other aspects, the Environmental Code contains general rules for consideration to be observed in all activities and measures that are not of negligible significance in individual cases and that can affect the environment. Environmentally hazardous activities, as defined in the 9th chapter, require obtaining a permit. The permit application must include an environmental impact assessment as described in the 6th chapter. In 2018 changes were made in the 6th chapter

[23] This is also why the estimated effect is not included in the summary and CTF tables.

in order to clarify that direct, indirect and cumulative impacts should be included in the environmental impact assessment. Greenhouse gas emissions form part of the permit assessment procedure and the Code also includes requirements to use the best available technology. However, effective 2005, issuing emissions limit values for carbon dioxide or limiting the use of fossil fuels for installations covered by the EU Emissions Trading Scheme is no longer permitted.

Measures in the area of public planning chiefly impact emission trends in the longer term and may have significance from this point of view. Measures in public planning are principally governed by the Planning and Building Act (PBL)(SFS 2010:900), but many measures are also covered by the Environmental Code. Since May 2011, the PBL introduced new requirements on considering the environmental and climate aspects of planning. The longer term significance of the development of the built environment for energy and transport needs has been increasingly highlighted, and the PBL also made it mandatory to consider inter-municipal and regional circumstances in planning. To enhance the implementation of the requirements in the PBL, the National Board of Housing, Building and Planning published new guidelines in 2017 for municipal structure planning, aimed at reducing greenhouse gas emissions.

In 2016 changes to annual report legislation came into force. Large corporations must now comply with new regulations for sustainability reporting. Sustainability reports must include information needed to understand a company's development, position, earnings and the consequences of their operations that concern the environment.

From 1 January 2022, the requirement for a climate declaration applies to the construction of new buildings. This means that builders must report the impact on the climate of a new building. The purpose of the law on climate declaration for new buildings (SFS 2021:78) is to help reduce the climate impact from the construction phase.

The Swedish Government has adopted the objective to make Sweden one of the world's first fossil-free welfare states. This ambition requires a mobilisation of the entire society, not least municipalities, cities and business. The governmental initiative 'Fossil Free Sweden', launched in 2015, aims to strengthen the dialogue between the state and the business sector, municipalities and civil society. A national coordinator, appointed by the government, is the link between the actors and the government in efforts to remove obstacles and create conditions to speed up the reduction of greenhouse gas emissions. Fossil Free Sweden is open to all actors who support the declaration drawn up for the initiative. The declaration stipulates that actors participating in the initiative share the view that the world must become fossil free. It also stipulates that actors who participate must be able to present concrete measures to reduce emissions. So far, more than 500 actors have signed the declaration and 22 roadmaps from different sectors have been submitted to the government (Fossilfritt Sverige, 2021).

Climate change communication

Swedish governmental authorities have a long experience of using communication of knowledge as policy instruments for the public and business sectors and for citizens. Some examples:

The Swedish Environmental Protection Agency is a driving force and provides support in climate work in Sweden. The website www.naturvardsverket.se is a hub for statistics and facts on emissions and knowledge on effective mitigation activities. It is widely used by policymakers, media, business, organizations and researchers.

The Swedish Meteorological and Hydrological Institute (SMHI) develops and distributes information about the weather, water and climate change adaptation. The National Knowledge Centre for Climate Change Adaptation, set up at SMHI, launched the Swedish Portal for Climate Change Adaptation, with facts and guidance on adaptation to a warmer climate.

The Swedish Energy Agency is responsible for giving both citizens and businesses information and advice on more efficient energy use. On-line energy tests; the websites where you find energy tests of white goods for consumers, are the most visited on the Swedish Energy Agency’s web. Energy and climate advisers in Sweden’s municipalities reply free of charge to questions about heating, energy costs and efficiency, transport, climate and government grants relating to energy.

The Swedish Forest Agency and the *Swedish Board of Agriculture* focus on e-services and digital information to land and forest owners, forest officers and farmers on how to reduce the climate impact of forestry, agriculture as well as on climate adaptation.

The Swedish Civil Contingencies Agency are in charge of prevention and mitigation of the effects of natural accidents and support measures to adapt the work of social protection and preparedness to a changing climate.

Public awareness

Public awareness on climate change is generally high in Sweden. The Swedish Environmental Protection Agency regularly conducts surveys of Swedes' attitudes on climate issues. The purpose is to measure the public preparedness on cutting emissions based on their own lifestyle and consumption, and the general attitudes on public climate change instruments. The survey conducted in 2021 (SEPA/Gullers 2021) shows that there is a great commitment among the public in Sweden to solve the climate issue. Swedes are keen to contribute and very positive about societal climate initiatives and corporate climate work.

Education and training

In cooperation with the Swedish Environmental Protection Agency, The National Swedish Agency for Education has clarified the connection between curriculum and syllabus and the national environmental goal Reduced Climate Impact. In-depth teaching on climate issues is common in upper secondary level. The National Swedish Agency for Education is currently working towards goal 4 in the Agenda 2030: Ensure inclusive and quality education for all and promote lifelong learning. The work is carried out together with relevant stakeholders.

Higher education institutions offer courses on the scientific basics of the climate and/or climate-related subjects like energy and forestry. There are various networks and centers of competence, for example, the Centre for Climate and Safety at Karlstad University and the Centre for Climate and Environmental Research at Lund University.

Increased competence for climate transition

To meet future needs in the labour market as a result of the climate transition, there is a need for educational initiatives. Government-funded education aimed at key competences in the labour market can facilitate the transition of industry and society to a circular economy and help reduce unemployment. The Government proposes that SEK 100 million be allocated for 2022. For 2023 and 2024 the allocation is estimated at SEK 100 million per year.

Research and development

Public investment in climate-related research and development are aimed at creating better prerequisites for achieving the substantial longer term emissions reduction required. Swedish climate-related research covers a broad spectrum, from natural sciences to humanities, but with an emphasis on technical and scientific research and development. Three important research areas are energy, transport and industry, for which the Government has decided to grant extensive funding.

Energy and climate issues are closely linked, and the solutions to the challenge of climate change are largely energy-related. The overall objective of energy research and innovation in Sweden is to contribute to fulfilling the national energy and climate objectives, the long-term energy and climate policy, and energy-related environmental objectives.

In the budget bill for 2022 (Govt. Bill 2021/22:1) the Government allocates SEK 1.43 billion for energy research in 2022. Estimated amounts for 2023 and 2024 are SEK 1.37 billion and SEK 1.38 billion respectively.

Alongside the contribution to energy research, climate-related research is also being financed by other national research funding programs. In Government Bill 2020/21:60 (Research, freedom, future – knowledge and innovation for Sweden) climate is listed as one of several societal challenges that require special contributions.

A national ten-year research program for climate was established in 2017 with an annual budget (from 2021) of SEK 230 million (Formas.se, 2021.11.13).

In order to reduce greenhouse gas emissions from working machineries and strengthen the competitiveness of the Swedish automotive industry, the Government has decided on targeted support for research, development and market introduction for working machineries in 2021 and 2022 (Government Bill 2020/21:1).

Sweden's strategy for a circular economy

Transforming production and consumption towards a circular economy has a large potential to reduce the use of materials and thus the negative impact on the climate. This requires a shift from virgin materials to circular material flows. This, in turn, requires toxic chemical to be removed (see section 4.2.7). To enable a circular economy the Swedish Government has presented a strategy[24] as well as two more hands-on action[25] plans for the transformation, the second focusing on plastics[26].

4.2.4 Energy – production of electricity and district heating and residential and service sector

Energy Efficiency Directive 2012/27/EU

The Energy Efficiency Directive came into force in December 2012, replacing the Energy Services Directive and the Cogeneration Directive 2004/8/EC. The Directive establishes a set of binding measures to help the EU reach its 20% energy efficiency target for 2020. Under the Directive, all EU countries are required to use energy more efficiently at all stages in the energy chain from production to final consumption.

To adapt Swedish regulations to the Directive, the following changes were implemented: i) Large enterprises must conduct an energy audit every fourth year; ii) electricity suppliers must invoice customers for the measured consumption of electricity, if the supplier has access to measurements; iii) new requirements are established on the measurement of energy consumption in apartments; and iv) requirements are tightened on authorities to use energy more efficiently. The main part of the new legislation came into force 1 June 2014 (Govt. Bill 2013/14:174). Moreover,

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[24] Sverige strategi cirkulär ekonomi.pdf

[25] Cirkulär ekonomi. Handlingsplan för omställning av Sverige.pdf

[26] Sveriges handlingsplan för plast.pdf

changes were made in the Electricity Law (SFS 2014:1064) requiring network operators to adjust tariffs and other practices to promote energy efficiency.

On 30 November 2016, the European Commission presented a package of legislative proposals containing measures in the EU"s energy policy, the so-called Clean-energy-for-all package. Putting energy efficiency first is an important goal in the package. The package included a proposal to amend the EED. The European Parliament and Council Directive (EU) 2018/2002 of 11 December 2018 amending Directive 2012/27 / EU on energy efficiency (amending directive) entered into force on 24 December 2018.

The amending directive includes a headline target of at least 32.5% improved energy efficiency by 2030. The target can be reviewed and sharpened. The directive requires Member States to achieve cumulative energy savings obligations for the period 2021-2030. The directive also includes revised requirements regarding metering and billing of energy. In 2021, as part of the "Fit for 55", the European Commission proposed amendments to the directive, introducing a higher target for reducing primary (39%) and final (36%) energy consumption by 2030 now binding at EU level, in line with the Climate Target Plan, up from the current target of 32.5% (for both primary and final consumption) (Commission proposes new Energy Efficiency Directive | European Commission (europa.eu)).

Renewable Energy Directive 2009/28/EC

The EU has adopted a binding target requiring an increase in the percentage of renewable energy, currently at 8.5%, to 20% of total energy use over the period 2005–2020. Responsibility for attaining this target has been shared among the Member States. According to this burden sharing, Sweden had to increase its share from just under 44% (2007) to 49% in 2020. Sweden reached the EU commitment (49%) and the national target (50%) back in 2012. Since then, the use of renewable energy has increased to a level of 56% in 2019.

The EU has adopted a revised Renewable Energy Directive that sets a new binding renewable energy target for the EU for 2030 of at least 32 %, including a review clause by 2023 for an upward revision of the EU level target. In 2021, as part of the "Fit for 55" package, the European Commission proposed amendments to the directive, increasing the current

EU-level target to at least 40% by 2030, which represents doubling the current renewables share of 19.7% in a decade (Commission presents Renewable Energy Directive revision | European Commission (europa.eu)).

EU has also set a specific target for the share of renewable energy in the transport sector to increase to 10% in 2020 (Renewable Energy Directive 2009/28/EC). In 2019 the share of renewable energy in the transport sector in Sweden according to the renewable directive's calculation methodology was already 30,3%.

Production of electricity and district heating

The production of district heating has risen approximately 50% since 1990. At the same time, emissions from this source have been significantly reduced, as the expansion largely has been achieved by the increased use of biofuels. The carbon tax is one of the main factors behind this trend, but the electricity certificate system has also been important in phasing out fossil fuels in the sector. The low emissions from electricity generation are explained by the fact that nuclear power and hydropower account for a dominant share of production, while additional production of electricity in recent years chiefly comes from biomass-fired combined heat and power plants (CHPs) and wind power.

Tax on waste incineration

Between 2020–2022 incineration of waste was taxed (SFS 2019:1274). The tax was gradually increased and in 2022 it was SEK 125 per ton. The tax excludes for example hazardous waste and bio energy. The tax was abolished as of 1 January 2023.

Electricity certificate system

An electricity certificate system aiming to support electricity based on renewable energy was introduced in 2003. Conceptually, the system works as follows. Electricity suppliers are obliged by law to submit electricity certificates corresponding to a certain share, or quota, of their electricity deliveries. The quota is gradually being increased yearly up to 2020.

Electricity producers are allocated a certificate from the central government for every megawatt-hour (MWh) of renewable electricity produced. The producers are allowed to sell the certificates in an open market where the price is set by the seller and buyer. The certificates thereby provide extra profit for the producers of renewable electricity (SFS 2011:1200).

The electricity certificate system was earlier prolonged up until 2045 (Govt. Bill 2016/17:179) but the rapid development with regard to the expansion of renewable electricity production has led to the electricity certificate system now fulfills a limited function. Therefore, the government proposed, and the Parliament decided, that new electricity generation facilities may not be eligible for the electricity certificate system after the end of 2021 and the electricity certificate system will be terminated by the end of 2035 (Government Bill 2020/21:16; Näringsutskottets betänkande 2020/21:NU6).

Initiatives for wind power

Research programs. Different programs have promoted the dissemination of knowledge and information about wind power. An example is the research program Vindval, which aims to collect and provide scientific knowledge about wind power's impacts on humans and on nature (Swedish EPA 2021, naturvardsverket.se/vindval).

Designation of areas of national interest for wind power. Since 2004, certain land and water areas in Sweden have been designated as areas of national interest for wind power. There are 313 such areas in Sweden, of which 284 are located onshore and 29 offshore. The most recent update was carried out in 2013 and four areas were added in 2015. The total area of these national interests for wind power is roughly 7,6000 km2, representing about 1.5% of the country's land area, including Swedish waters (Swedish Energy Agency 2021).

A national strategy for sustainable wind power expansion. The Swedish Energy Agency and the Swedish Environmental Protection Agency have jointly developed a national strategy for sustainable wind power expansion, which was presented in January 2021. The strategy, which only covers land-based wind power, contains a regional distribution of a national development need and a national planning basis (Swedish Energy Agency, 2021)[27]

[27] Swedish Energy Agency, 2021. Nationell för hållbar vindkraft. https://energimyndigheten.a-w2m.se/Home.mvc?ResourceId=183601

Support for storage of self-produced electricity

During 2016-2020 support was available for private individuals for installation of systems for storage of self-produced electricity. Grants were awarded with a maximum of 60 percent of the eligible costs, however, with a maximum of SEK 50,000 (SFS 2016:899). In 2021 the support system was replaced by tax reduction for installation of green technology.

Tax reduction for installation of green technology

With the aim to reduce greenhouse gas emissions private individuals are, since 1 January 2021, eligible to a tax reduction for installation of green technology including solar cells, systems for storage of self-produced electricity and at home charging stations. The tax reduction is given on the cost of labour and materials. For installation of mains-connected solar cell systems the tax reduction is 20 %, for installation of a system for storage of electricity and for installation of at home charging stations for electric vehicles the deduction is 50 %. The tax reduction cannot be more than SEK 50,000 per person and year (Govt. Bill 2022/23:15).[28]

Tax reduction for micro-production of renewable electricity

A tax reduction for households and businesses was introduced in 2015 to stimulate investment in the micro-production of renewable electricity. The income tax reduction is SEK 0.60/kWh renewable electricity fed into the grid in a connection point with a fuse size of up to 100 Amps, but limited to the amount of electricity received from the grid in the same connection point. The tax reduction is capped at SEK 18,000 per year.

Effects of policy instruments in the electricity and district heating sector

Estimates using the TIMES-NORDIC modelling tool (see Box 4.2) show that emissions from the electricity and district heating sector (including back-pressure power) could have been 9-15 Mt CO2 higher per year in the time period 20052000-2020 if policy instruments had remained at their 1990 levels (see Table 4.1). The difference in modelled emissions is due above all to significantly greater use of coal in the scenario based on 1990 instruments than in the one based on current levels of instruments, in which fossil fuels have been replaced by renewables.

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[28] Energimyndigheten.se, Så kan du få skattereduktion för grön teknik, 2021.01.22

In summary, the influence of policy instruments in the sector has led to increased costs for fossil fuels at the same time as the conditions for biofuels and wind power for electricity production have improved. After 2005 the impact of the policy instruments on the fossil fuels for CHP has been the same as, or even less than, in 1990. Low prices, until recently, in the EU ETS strengthen this picture. However, thanks to the electricity certificate system, which is bringing in incentives for renewable fuels, the fossil fuels are kept away. Even if the steering effect of electricity certificate system is reduced in recent years the total effect for the period 1990-2050 is a strong drive away from fossil fuels (Profu 2021).

Table 4.1 Estimated aggregate effects of policy instruments introduced since 1990 on emissions from electricity and district heating production in Sweden, compared with a scenario based on 1990 instruments (Mt CO2 eq per year) (Profu 2021)

1995	2000	2010	2015	2020	2025	2030	2035	2040	2045	2050
3.6	8.7	12.8	14.8	15.5	15.1	6.2	3.2	4.1	6.0	6.2

Residential and commercial/institutional

Greenhouse gas emissions from heating individual homes, and commercial and institutional premises (heating other than district heating), have fallen dramatically since 1990. The energy and carbon taxes are seen as the instruments contributing most to reducing the use of fossil fuels in this sector in recent decades. The aggregate level of taxes on fossil fuel use for heating in the sector has risen steadily since 1990, even though the increase in recent years is modest. This has made it considerably more expensive to use these fuels than if energy taxation was kept at its 1990 level (Profu 2021). Oil prices and the available technologies for fossil-fuel substitutes have also had significant impact on trends in the sector.

Alongside carbon and energy taxes, there are several instruments targeting energy use in homes, and commercial and institutional premises. Some of the most important ones include building regulations, energy performance certificates, and the Ecodesign, Energy Labelling and Energy Efficiency Directives. In addition, there are instruments such as technology procurement, network initiatives and information campaigns at the local, regional and national levels.

Ecodesign Directive (2009/125/EC), Energy Labelling Directive 2010/30/EU and the Ecodesign Act

Energy labelling is mandatory for the product groups that are regulated by the Energy Labelling Directive (2010/30/EU) and applies to all EU member states. Energy labeling makes the product"s energy use visible and facilitates for consumers who want to make energy smart choices.

The Ecodesign Directive (2009/125/EC) aims to improve the products' environmental performance during their full life cycle. The requirements act as a floor to prohibit and remove the very worst products on the market, seen from an energy perspective. In principle, these rules can be applied to all energy-related products (except transport) and cover all energy sources. Sweden is particularly active in market surveillance activities, involving laboratory tests of products as well as supervision of distributors. The directive has been implemented in Sweden through the Ecodesign Act (SFS 2008:112).

Energy Performance of Buildings Directive 2010/31/EC

The Energy Performance of Buildings Directive is a framework within which EU Member States have decided on requirements for setting minimum energy performance standards, building energy certificates and inspections or advice on boilers and air conditioning systems. The aim of the directive is to reduce greenhouse gas emissions from the EU Member States and secure the energy supply in the medium and long-term.

Law on energy performance certificates for buildings

Based on the Energy Performance of Buildings Directive, Sweden has implemented a law on energy performance certificates for buildings (SFS 2006:985). The law includes an obligation for owners of single-family and multi-dwelling buildings and of commercial premises to declare the energy use of buildings and certain parameters regarding the indoor environment. The aim is to promote efficient energy use and a healthy indoor environment by requiring property owners to learn more about which measures are cost-effective to implement for improving building energy performance.

Building regulations

Building regulations have been used since the 1960s to set minimum requirements for energy use in new buildings in Sweden. Since 2009, building regulations for new production have included stricter requirements for electrically heated buildings. Stricter requirements for energy use in new buildings with other heating systems took effect in 2012. Regulations include requirements for specific energy use (kWh/m2 and year) and average thermal transmittance (W/m2K).

Training programs in building for low energy consumption

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

Support for market introduction, technology procurement and networks

Technology procurement is an instrument designed to initiate a market transition and disseminate new, more efficient technology, such as new products, systems and processes. Network-based procurement of technology is an approach that encompasses the entire decision-making process, from feasibility study and purchaser group, to requirements specification and dissemination and further development of more energy-efficient technology. It is being used in areas like heating and control, ventilation and lighting. The Swedish Energy Agency coordinates procurement networks for housing (BeBo), commercial and institutional premises (BeLok), small houses (BeSmå), food distribution (ReLivs, and new construction of, and conversion to, energy-efficient buildings (LÅGAN).

Effects of policy instruments in the residential and service sector

Between the early 1990s and the present day, carbon and energy taxes have helped to phase out oil-based and electric heating. The aggregate level of taxes on fossil fuel use for heating in the residential and service sector has risen steadily since 1990, even though the increase in recent years has slowed down, making it considerably more expensive to burn these fuels than it would have been if energy taxation had been kept at its 1990 level (Profu 2021). This is shown in figure 4.3.

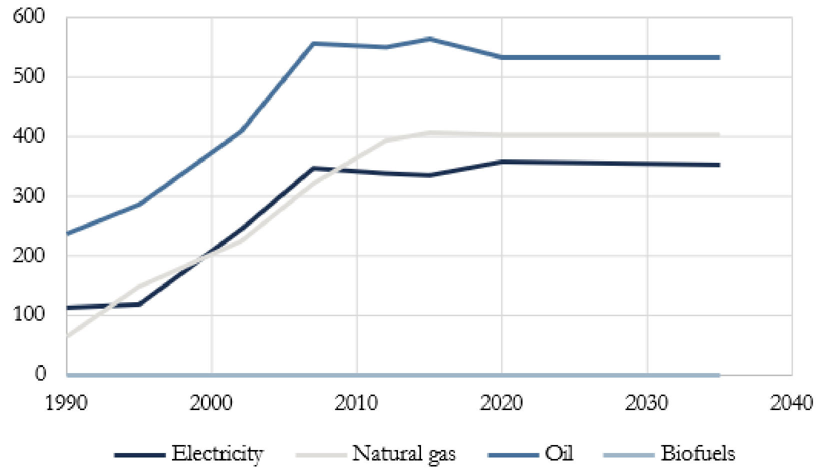

Figure 4.3 Policy instruments affecting light fuel oil, biofuels, natural gas and electricity in the residential and service sector: development between 1990 and 202015, and model assumptions for 20325 (constant 2015 2020 prices) (Profu 202117a).

4.2.5 Industrial emissions from combustion and processes (including emissions of fluorinated green house gases

Total greenhouse gas emissions from combustion in manufacturing industries have decreased since 1997. The instruments affecting combustion emissions from the industrial sector are the EU ETS, energy and carbon taxes, the electricity certificate system and the Environmental Code, the Energy Step, Energy Audits, Energy and climate coaches, and Energy efficiency networks.

Greenhouse gas emissions from industrial processes show an overall decreasing trend since 2006. The instruments primarily affecting process related emissions are the EU ETS, the Environmental Code, the Industrial Leap, the Energy Step and Energy Audits.

Industrial Leap

The Industrial Leap is a long-term reform which began in 2018 and continues until 2040. It consists of a government scheme that aims to support development of technology and processes to reduce the process-related greenhouse gas emissions in Swedish industry. Financial support, administered by the Swedish Energy Agency, may be provided for research, feasibility studies, pilot and demonstration projects as well as full-scale investments. Projects related to mitigation, as well as to negative emissions, are eligible for funding. The target group for support is industries with process-related emissions, along with universities and research institutes.

One example of a project funded is the initiative "Hydrogen Breakthrough Ironmaking Technology", HYBRIT, which aims at ending the use of coal, traditionally needed for ore-based steel-making, and substitute it with hydrogen. The production of hydrogen is moreover planned to be produced from fossil-free electricity. The result would be fossil-free steel-making technology, which has potential to cut Swedish emissions by 10 percent.

In 2018, the government budgeted SEK 300 million for the program. The budget for the Industiral Leap increased the following years (Govt. Bill 2020/21:1). In the budget for 2022 the Government proposes allocations of SEK 909 million for 2022, SEK 754 million for 2023, and SEK 757 million for 2024 (Govt. Bill 2021/22:1).

Support scheme for BECCS

Following the budget for 2022 the Government proposes a support system designed as a reversed auction where the winning company (the company offering the most cost efficient solution) will receive support for capture, transport and storage of biogen carbon dioxide. The Swedish Energy Agency has been appointed as auctioneer and is authorized up to SEK 36 billion for this purpose for the period 2026-2046. A first such auction will be launched late 2022. The Swedish Energy Agency is also allocated SEK 15 million annually (from 2022) for administrative support of the system.

Energy audits and the Energy Step for large enterprises

The law on energy audit in large enterprises aims at promoting improved energy efficiency (SFS 2014:266)[29]. The law requires large enterprises to conduct energy audits, including information of total energy use, as well as proposals of cost-efficient measures to improve energy efficiency. The audit must be conducted at least every fourth year.

Enterprises that are subject to the law, and have conducted an energy audit, have had the possibility to apply for support in terms of an in-depth projection of arrangements and additional costs in investment decisions to

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[29] The law is part of fulfilling the EU Energy Efficiency Directive, EED (Directive 2012/27/EU)

increase energy efficiency through the Energy Step Program. The program had a budget of totally SEK 125 million during the period 2018–2020. There is a need for further efforts to achieve the Swedish Parliament's goal of 50 percent more efficient energy use by 2030.

A government green credit guarantee

In 2021 a state green credit guarantee was introduced with a limit of SEK 10 bn (Govt. Bill 2021/22:1). It was introduced to facilitate major industrial investments that contribute to achieving the goals in the Environmental quality objectives system and the Climate Policy Framework. In the budget bill for 2022 the Government proposes a limit of SEK 50 bn for 2022, SEK 65 bn for 2023 and SEK 80 bn for 2024 for the credit guarantee (Govt. Bill 2021/22:1, ch. 9.4, Table 9.8).

Effects of The Industry Leap combined with other instruments

The projects that have received support through the Industry Leap until 13 January 2021 is estimated to have a total potential to contribute to the reduction of greenhouse gas emissions by a further 11 million tonnes of carbon dioxide equivalents per year compared to the most recent reference scenario. Of these, just under 8 million tonnes refer to a further reduction in industrial emissions and 1-2 million tonnes refers to negative emissions through capture and storage of biogenic carbon dioxide emissions (BECCS). When industrial projects are also included in the reference scenario, the potential for reduced industrial emissions rises to 9 million tonnes of carbon dioxide equivalents per year (Govt. Bill 2021/22:1).

The overall reduction potential mentioned above cannot be attributed as a potential future effect of the Industry Leap alone. The instrument operates in interaction with several others, that in combination may contribute to an overall emission reduction of the volume mentioned.

4.2.6 Regulations governing emissions of fluorinated greenhouse gases

EU Regulation (No 517/2014) on fluorinated greenhouse gases and BREF

The EU Regulation (No 517/2014) on fluorinated greenhouse gases (f-gases) entered into force on 1 January 2015. The regulation strengthens measures from former EU Regulation No 842/2006 on f-gases, including hydrofluorocarbons (HFCs), perfluorocarbons (PFCs) and sulphur hexafluoride (SF6). The regulation aims to cut emissions by two-thirds from current levels by 2030, and includes provisions for the use, reuse and destruction of f-gases. Most importantly, the regulation includes a mechanism for quantified emission reductions of substances containing HFCs, with a gradual decreasing cap for the total HFC emissions.

The EU adopted a Best Available Techniques reference document (BREF) for the non-ferrous metal industry in June 2016. These could significantly reduce emissions from aluminium production.

Swedish Regulation 2016:1128 on fluorinated gases

Swedish Regulation 2016:1128 on fluorinated greenhouse gases complements the EU regulation. Provisions in Sweden for cooling and air conditioning and heat pump equipment include:

- Requirements on leak checks in conjunction with installation, reconstruction and other interventions.
- Requirements on leakage checks and certified competence, also applying to mobile equipment containing f-gases.
- The results of periodic inspections must be reported to the supervisory authority.
- The supervisory authority must be informed before the installation of equipment containing more than ten kilograms of refrigerants.
- It is prohibited to sell f-gases as refrigerants to recipients other than those stated in the regulation.
- Upon disposal, importers and those who transfer refrigerants are required to take back any refrigerants that they delivered, free of charge, and to provide containers for this purpose.
- Equipment manufactured, imported or brought into Sweden shall be provided with accurate and easy-to-understand operating and maintenance instructions.

4.2.7 Domestic transport

Emissions from domestic transport, where road transport dominates, increased after 1990, reaching a peak in 2007. Since then, emissions have been declining.

The decrease in emissions since 2007 can be attributed to policy instruments introduced both nationally and at the EU level. The most significant ones include carbon dioxide emission EU performance standards for new vehicles, vehicle taxes and vehicle fuel taxes, and more recently, a greenhouse gas emission reduction obligation for petrol and diesel. These have resulted in more energy-efficient vehicles and a greater use of renewable fuels. Reducing transport-related emissions is essential to meet the 2030 climate targets set by the Swedish Parliament. Consequently, the Government has implemented several policies and measures aimed at the transport sector in the last years.

Aviation

Tax on air travel

A tax on air travel was introduced in 2018. The tax aims to reduce the climate impact of aviation. For domestic flights the tax is SEK 64 for a one-way ticket and SEK 128 for a round trip. The tax is described further in section 4.2.10.

Reduction obligation scheme for aviation

In 2021 a reduction obligation scheme for aviation was introduced for renewable fuels. The level is 0,8 percent in 2021 and will increase to 27 percent[30] in 2030 (prop. 2020/21:135, bet. 2020/21:MJU20, rskr. 2020/21:303).

Differentiated take-off and landing fees for aviation

In 2021 a decision was taken to introduce differentiated take-off and landing fees. The fees are differentiated according to environmental performance of the aircrafts. Initially, the differentiated fees are introduced at the two largest airports, Landvetter and Arlanda.

[30] 1% and 30% respectively in volume.

Aviation in the EU Emissions Trading System

Aviation is included in the EU Emissions Trading System as of 2012 in accordance with EU Regulation No 421/2014 of the European Parliament and of the Council of 16 April 2014 amending Directive 2003/87/EC. As part of the Fit for 55 legislative package the European Commission is now proposing to revise the ETS aviation rules. This includes a reduced number of free allowances allocated to aircraft operators to reach full auctioning by 2027.

Road transport

Emission reduction obligation (Fuel change)*

In July 2018, a greenhouse gas emission reduction obligation for petrol and diesel in conjunction with fuel tax reforms, called the Fuel Change, was implemented. The emission reduction obligation establishes an obligation on petrol and diesel suppliers to reduce life-cycle carbon dioxide emissions. The obligation replaces the former tax exemption for low-blended biofuels, i.e. biofuels covered by the scheme will be subject to the same tax rate per liter as fossil equivalents. At the same time, both the carbon dioxide and energy tax rates for fuels covered by the Reduction obligation scheme have been reduced.

When implementing the scheme the adjustment of the carbon tax rate was implemented to reflect the reduced greenhouse gas emissions that the blend-in of sustainable biofuels entails. The energy tax rate was reduced to maintain a stable price-level for fuels, so that consumers would be largely unaffected by the reform. High-blended biofuels are not covered by the scheme and are, if sustainable, completely exempt from both carbon dioxide and energy tax.

Bonus–malussystem for new light-duty vehicles*

A bonus–malus system for new light-duty (max 3,5 tonnes) vehicles has been in place between July 2018 and November 2022. Vehicles with low carbon dioxide emissions qualified for a bonus at purchase, while vehicles with high carbon dioxide emissions are subject to an increased vehicle tax (malus) during the first three years from the date when the car first becomes taxable. The system covered purchases of new passenger cars, including campers, and vans. Cars adapted for alternative fuels such as ethanol and gas, except LPG, are exempted from the increased tax. The aim of the system has been to increase the proportion of environmentally friendly vehicles sold.

From 2021 a maximum bonus has been given to new vehicles with zero emissions from the exhaust pipe -– SEK 70,000. At 60 grams of carbon dioxide per kilometer, the bonus ends. The maximum bonus for vehicles with emissions above zero amounts to SEK 45,000. Gas-powered cars received a bonus amount of SEK 10,000 regardless of their level of carbon dioxide emissions.

Vehicles with emission in the range of 60-90 grams of carbon dioxide per kilometer neither qualified for any bonus, nor have they been subject to malus. Vehicles with emissions exceeding 90 grams per kilometer are subject to malus. In the range of 90–130 grams per kilometer the increased annual vehicle tax is SEK 107 per gram. For emissions exceeding 130 grams per kilometer the increased annual vehicle tax is SEK 132 per gram.

As of 1 June 2022 vehicles with emissions exceeding 75 grams carbon dioxide per kilometer are subject to malus and emissions exceeding 125 grams per kilometer are taxed at SEK 132 per gram. The system was abolished in November 2022.

Requirements for renewable fuels at filling stations

The availability of renewable fuels has been subject to legislation requiring that filling stations with annual sales of petrol and diesel above a specified level must supply at least one kind of renewable fuel. The law (SFS 2005:1248) became effective 1 January 2006. This requirement has resulted in an increased number of mainly E85 pumps. As of 2015, the legal requirements were loosened so that filling stations selling more than 1,500 m3 of petrol or diesel must supply at least one kind of renewable fuel.

EC Fuel Quality Directive

In 2009, Directive 2009/30/EC was adopted to revise the Fuel Quality Directive (98/70/EC). It introduces requirements for fuel suppliers to reduce the greenhouse gas intensity of energy supplied for road transport (low carbon fuel standard) by 6 percent until 2020. The emission reduction obligation in Sweden is more ambitious than this, see Table 4.3 above. In addition, the Renewable Energy Directive (2009/28/EC) establishes sustainability criteria that must be met by biofuels if they are to count towards the obligation to reduce greenhouse gas intensity.

Emission performance standards for new vehicles

Manufacturers selling vehicles in the EU are subject to EU regulations (Nos 443/2009 and 510/2011) that set emission performance standards for new passenger cars and vans as part of the Community's integrated approach to reducing CO2 emissions from light-duty vehicles. Under these regulations, new passenger cars should not emit an average of more than 95 g CO2/km by 2021. New vans should not emit an average of more than 147 g CO2/km by 2020. New standards for 2025 and 2030 were adopted by the EU during 2019. Accordingly, CO2-emissions from new passenger cars and new vansare to be reduced by 37.5 percent and 31 percent respectively by 2030 compared to average emissions 2021. Following the Fit for 55 package, the European Commission is preparing a revision of the standards. Proposed reduction levels, 2030 compared to 2021, are 55 percent for new passenger cars and 50 percent for vans. By 2035 the reduction target is 100 percent for both categories (European Commission 2021.07.14). In 2019 the EU also adopted CO2-emissions standards for heavy-duty vehicles. Emissions from new heavy-duty vehicles in 2025 are to be 15 percent below the average for 2019, and 30 percent lower compared to 2019 by 2030.

CO2-based vehicle tax

In 2006 Sweden implemented a CO2-based vehicle tax system for passenger cars. For older vehicles the tax is weight-based. All vehicles in the system are subject to a basic charge of SEK 360 per year. In addition, vehicles are subject to a CO2 component depending on their level of carbon dioxide emissions per kilometer in mixed driving. The CO2 component is SEK 22 per gram carbon dioxide per kilometer exceeding 111 grams. For diesel cars that first become taxable on 1 July 2018 or later, a fuel surcharge is added, together with an environmental surcharge. For other diesel cars in the CO2-based system, the CO2 component is multiplied by a fuel factor of 2.37 and an environmental surcharge is added. For cars adapted for alternative fuels such as ethanol and gas, except LPG, the CO2 component is SEK 11 per gram carbon dioxide per kilometer exceeding 111 grams. Vans and campers are also included in the CO2-based vehicle tax system since 2011. The main purpose of the CO2-based differentiation is to reduce carbon dioxide emissions by making car buyers choose fuel efficient cars.

The CO2-based vehicle tax system applied to cars that first became taxable before the bonus–malus system was introduced in July 2018, and also to any car “leaving” the bonus–malus system three years after it first became taxable.

Climate premiums for electric buses, heavy-duty vehicles and working machinery

Since January 2020 regional public transport agencies, public transport companies, municipalities and limited companies[31] are eligible to apply for climate premiums for electric buses. Companies and municipalities are also eligible to apply for climate premiums, for Electric and other renewable-fueled heavy-duty vehicles as well as for electric tractors and working machinery. The total budget for these premiums is SEK 1 430 million for 2022, SEK 330 million for 2023, and SEK 300 for 2024 (Govt. Bill 2021/22:1). The bulk (SEK 1100 million) of the premium for 2022 is earmarked for electric buses.

Local Climate Investment Program (Climate leap)

The Climate Leap is a comprehensive investment support scheme. Municipalities, companies, organisations and others can apply for investment support for measures to reduce climate impact. A large number of these investments relate to the transport sector, such as investments in biogas plants or the installation of charging points for electric vehicles. The program is prolonged until 2026 with a total budget for the period 2015-2026 of SEK 12.2 billion (Govt. Bill 2021/22:1). More about the Climate leap in section 4.2.2 Cross-sectoral instruments.

Tax reduction for installation of green technology*

With the aim to reduce greenhouse gas emissions private individuals are, since 2021, eligible to a tax reduction for installation of green technology including solar cells, systems for storage of self-produced electricity and at home charging stations (Govt. Bill 2021/22:1). The tax reduction is given on

[31] Which by the regional public transport authorities have been given the authority to enter into public transport contracts.

the cost of labor and materials. For installation of home charging stations for electric vehicles the reduction is 50 % (Govt. Bill 2020/21:1).

Urban environment agreements

Urban environment agreements is a scheme for investments in public transport, cycling infrastructure or sustainable freight transport at the Regional and local level in Sweden. The scheme commenced in 2015. In the national plan for the transport infrastructure 2022-2033, SEK 6 billion for the period 2022-2027 is allocated to the urban environmental agreements.

Municipalities are eligible to apply for grants to cover part of the investment costs for public transport infrastructure. The investment should be coupled with other actions aiming at increasing the long-term sustainability of urban areas, including increased housing construction, and the transport system. The scheme is administered by the Swedish Transport Administration.

Research and demonstration

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

- FFI – Strategic vehicle research and innovation
- F3 – Collaboration program for renewable fuels and systems
- SFC – Research on biomass gasification
- Battery funding program
- Vinnova – Innovations for a sustainable society
- Triple F (Fossil Free Freight) focusing on three major challenges: A more transport efficient society; energy efficient and fossil-free vehicles and ships; increased share of renewable fuels.

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

Consideration of climate in long-term infrastructure planning

In 2021, the Riksdag decided on an economic framework for a new twelve-year national infrastructure plan. In 2022 the government then adopted a new national plan for transport infrastructure for 2022-2033, to be implemented by The Swedish Transport Administration with other relevant actors. The Swedish Transport Administration is responsible for long-term planning of all modes of infrastructure for transport. Planning is undertaken in dialogue with local and regional planning bodies. Under the applicable legislation there is a clear requirement to take environmental consideration in the planning process.

Eco-bonus system to stimulate transfer from road to shipping*

In 2018, the government launched a temporary eco-bonus support aimed at stimulating the transfer of goods from road to shipping to reduce greenhouse gas emissions from heavy transport. The annual budget of the eco-bonus system for heavy transports is SEK 50 million for 2020-2022.

The eco-bonus system for heavy transports is prolonged for the period 2022-2024. This period the scope is broader, althogh inimize not yet decided, and the annual budgdet is SEK 100 million (Govt. Bill 2020/21:1; 2021/22:1).

Environmental compensation for railway transport of goods

In 2018 an environmental compensation scheme was introduced to stimulate railway transports of goods. SEK 550 million is budgeted per year between 2021-2025 (Govt. Bill 2021/22:1). An extra SEK 697 million was budgeted for 2022.

Congestion tax

Congestion tax is levied in the cities of Stockholm and Gothenburg since 2007 and 2013, respectively. The tax is levied during such hours and on such places where there is considered to be congestion. Various levels of tax are levied throughout the day (in Stockholm for 2022: SEK 11–45, in Gothenburg for 2022: SEK 9–22) with a maximum amount per day of SEK 135 in Stockholm and SEK 60 in Gothenburg.

Low emission zone

Eight municipalities in Sweden have already set up low emission zones, restricting access to lorries and buses that don't meet specific requirements. From 2020 and onwards municipalities also have the possibility to set restrictions on cars, based on two new environmental categories of low emissions zones.

State co-financing for certain regional public transport facilities

Government co-financing for certain regional public transport facilities is an investment support for infrastructure for regional public transport.

Investment support may also be provided for vessels in regional public transport as well as for improved environment and traffic safety on municipal roads and streets. Co-financing amounts to a maximum of 50 % of the costs (SFS 2009:237).

Support for electric charging infrastructure for heavy vehicles

The Government decided in its Budget Bill for 2021 on a support scheme for regional electrification pilots with charging infrastructure for heavy vehicles. The aim is to enable electrification of heavy road transport in the busiest areas. Tank infrastructure for hydrogen is also included in the support scheme (Government Bill 2020/21:1). SEK 400 million is allocated for 2021, SEK 550 million for 2022 and SEK 1 billion for 2023 (Govt. Bill 2021/22:1).

Support for electric fast charging infrastructure

In July 2020 the Government decided on a new support for public fast charging infrastructure in connection with major roads in areas where fast charging is missing. The support aims at ensuring basic access to charging infrastructure for fast charging of electric vehicles throughout the country. The support adds up to SEK 150 million for the period 2020-2022 and is administrated by Swedish Transport Administration (Govt. Bill 2021/22:1, UO 21; Trafikverket 2021).34

National ticket system for public transport

The Government proposes additional funds for the introduction of a national ticket system for all public transport throughout Sweden. The system will make it easier for travelers to choose to travel by public transport, which is judged to have positive effects for both leisure travelers and work commuting and benefit local and regional labor market regions. SEK 105 million is allocated for 2022 and 2023 respectively. SEK 1 million is allocated for 2024 (Govt. Bill 2021/22:1).

Night train traffic in Sweden and abroad

To bind Sweden together, and at the same time contribute to sustainable travel, opportunities are needed to continue night trains to and from upper Norrland and Jämtland in the future. New carriages and locomotives are also needed for traffic.

In July 2020, the Swedish Transport Administration was commissioned to carry out a procurement of night train traffic through Sweden and Denmark, which contributes to the establishment of international night train connections with daily departures from Sweden to other European countries. Traffic between Stockholm and Hamburg started in September 2022.

The effort contributes to meeting, and contributes to, a growing demand for travel by night train abroad so that the conditions are improved for continued night train traffic on commercial grounds. If train travel replaces travel by air and car, a great climate benefit can be achieved (Govt. Bill 2021/22:1).

Conversion premium

To reduce emissions from the existing vehicle fleet the Government proposed in its budget bill for 2021 that a conversion premium for cars from fossil fuels to biofuels or biogas should be introduced in 2022 (Govt. Bill 2020/21:1).

Effects of selected policy instruments in the transport sector

Emissions from domestic transport account for about one third of Sweden"s total greenhouse gas emissions and about half of greenhouse gas emissions in the non-trading sector. The transport sector has a sector-specific intermediate target by 2030, which means that emissions from domestic transport (excluding domestic flights) will be reduced by at least 70% by 2030 compared to 2010. Greenhouse gas emissions from domestic transport (excluding domestic flights) amounted to 15 million tonnes of CO2 equivalent in 2020, which is a decrease of 10% compared to 2019.

Road traffic accounts for by far the largest share (about 95%) of emissions from transport in the country, of which passenger cars account for about 63% and heavy and light trucks account for about 30%. Compared to 1990, emissions from domestic transport (excluding domestic flights) have decreased by 21%%. The reduction in emissions is mainly a result of an increase in the share of biofuels while at the same time making vehicles more energy efficient.

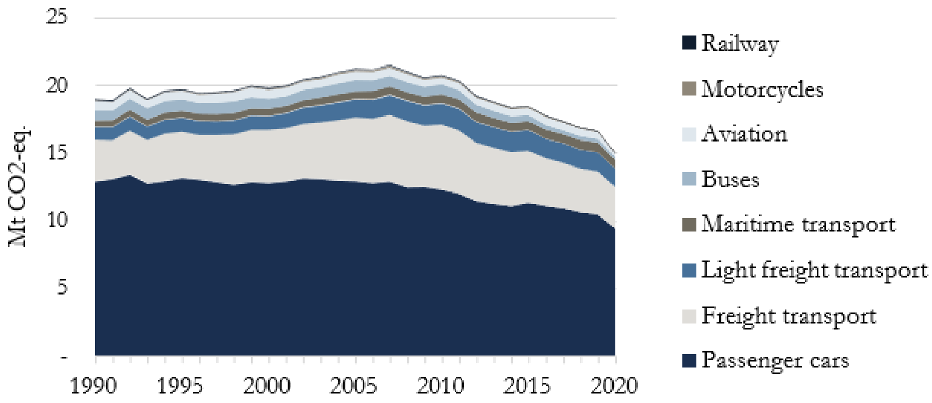

Figure 4.4 Greenhouse gas emissions from domestic traffic, excluding domestic aviation, 1990 -2020 (SEPA 2021).

The combined effects of the emission reduction obligation (Fuel change)* and policies affecting fuel efficiency and the introduction of electric vehicles

The final reduction effect and the total volumes of sustainable biofuels needed to meet the emission reduction obligation in 2030, depends on the development of the demand for petrol and diesel, which in turn depends on the level of traffic and the level of fuel efficiency in the vehicle fleet, including the amount of battery electric and plug-in hybrid electric vehicles.

The potential emission reduction effect that may be attributed to the reduction obligation depends therefore to a large degree on the assumptions made regarding other factors also influencing the fuel demand. .

Compared to the projection scenario, see chapter 5, where the assumed level of electric vehicles in 2030 is low compared to more recent estimates and the actual introduction shares in recent years, the Swedish EPA estimate an effect of approximately 5–6 million tonnes of carbon dioxide per year in 2030 resulting from the reduction obligation[32]. The volumes of biofuels increase substantially in this assessment. The corresponding effect of the reduction obligation in mobile machinery was estimated to 1,5-1,8 million tonnes.

However, there are challenges linked to the volumes of biofuels needed and the possibility of achieving targets for air quality regarding nitrogen dioxides. There is also uncertainty about how large volumes of biofuels can be available nationally and internationally in different time perspectives, depending on how demand develops in other countries and sectors, for example in aviation. Constraints in the supply of sustainable biofuels globally can also lead to higher costs.

The final reduction effect and the total volumes of sustainable biofuels needed to meet the emission reduction obligation in 2030, depends on the development of the demand for petrol and diesel, which in turn depends on the level of traffic and the level of fuel efficiency in the vehicle fleet, including the amount of battery electric and plug-in hybrid electric vehicles.

In a sensitivity analysis the rate of electrification in the vehicle fleet is assumed to be higher, more in line with the market development in recent years in Sweden ("elektrifieringsscenario" ER 2021:06). In this scenario the emissions decrease with approximately 2,7 million tonnes of carbon dioxide per year in 2030 compared to the projection in chapter 5, due to the increased energy efficiency in the vehicle fleet.

This effect may be attributed to national and EU-instruments in combination that affects the choice and the performance of new cars introduced to the market, see next section. National instruments and EU standards contribute and interact with policies enabling vehicle charging. The fuel price development is also of importance for the overall development.

[32] Estimates for 2025 and 2035 (see Tables 4.5 and 5.20) are based on extrapolation of the results of previous analysis.

The increase in demand for biofuels is lowered quite substantially in the scenario with a higher electrification rate and the overall effect of the reduction obligation is, accordingly, reduced to 3-4 million tonnes of carbon dioxide per year in 2030. When the estimated effect in mobile machinery is added this sensitivity analys result in total in 4-6 million tonnes reduction of carbon dioxide per year in 2030 due to the reduction obligation.

When it comes to the rate of electrification of cars in Sweden it could be noted that the latest statistics show a significant increase in sales of rechargeable cars in Sweden. In 2020, the share of electric cars and plug-in electric hybrids sold in Sweden was about 31 percent of sales of passenger cars. In 2021, the share had risen to 45 percent of new car sales. At the same time, the proportion of electric cars is increasing in relation to plug-in hybrids. The proportion is among the highest in EU member states in terms of the share of chargeable cars in new car sales (IEA 2021).

National and EU instruments for energy efficiency

New cars are becoming more and more energy efficient, and CO2 emissions from the average car have steadily declined since the mid 1990's with an acceleration around 2005. In recent years an increasing share of chargeable cars in new cars sales contributes the most to the decrease in average CO2-emissions from new cars.

There are several policy instruments that have interacted to promote the energy efficiency of new cars sold in Sweden. First, several national instruments[33] have been introduced since 2005. Second, the EU has introduced carbon dioxide emission standards for new cars. In the previous national communication, NC7, The Swedish Transport Administration assessed the effect on national emissions of the EU CO2 standards for new cars and the national instruments introduced since 2005 that affect car choices. This assessment has been updated and revised by the SwEPA for this communication, since both the EU performance standards and the national instruments has been amended to stricter levels in recent years.

[33] CO2-based vehicle tax, green-car insurance premium, super-green car rebate, tax exemption for environmentally friendly vehicles, reduced taxable values for some company cars with environmentally friendly technology, bonus–malus system, grants for charging infrastructure etc.

The updated assessment shows a greater effect of the EU CO2 standards compared to the previous estimate. The increased effect can be explained by the amendment of the EU CO2 standards on light duty vehicles, with stricter requirements in 2025 and 2030 in combination with the introduction of EU CO2 standards also on heavy duty vehicles. The assessment also indicates that the national instruments has an additional effect on the emissions in 2030 when combined with EU CO2 standards. The scenario "with EU CO2 standards and national incentives", builds on the development in "the electrification scenario" mentioned in the previous section.

The emission effect increases over time as the share of the fleet replaced by vehicles meeting stricter standards grows. In 2030, the total effect compared to the scenario without EU-standards and national incentives is estimated to approximately 8 million tonnes CO2/year.[34]

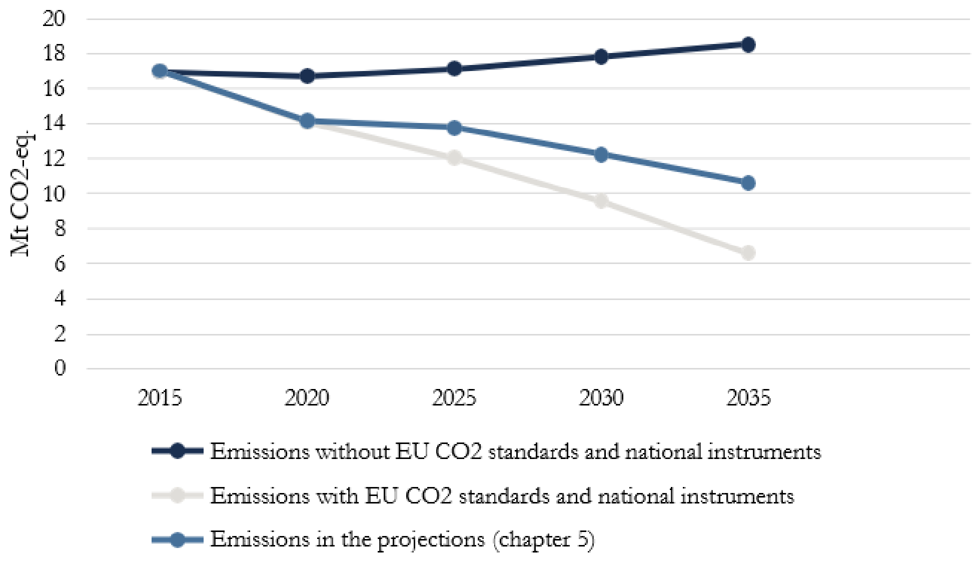

Figure 4.5 Historic and future CO2 emissions from passenger cars, light duty and heavy duty vehicles in total, with and without implemented policy instruments for energy efficiency.

4.2.8 Waste

Emissions from wastehave declined. There has been a series of policy instruments at both national and EU levels. Demand for waste as a fuel for

[34] Estimates for 2025 and 2035 (see Tables 4.5 and 5.20) are based on extrapolation of the results of previous analysis.

district heating has also strongly encouraged diversion from landfill to incineration.

Landfill Directive (1999/31/EC)

The Landfill Directive requires landfilling of biodegradable waste to be reduced and for methane to be collected from landfills, preferably with energy recovery. Sweden has, however, introduced more far-reaching national instruments resulting in earlier attained emissions reductions.

Landfill tax

In 2000 a tax of 250 SEK per tonne landfilled waste was imposed on waste disposal to landfill (SFS 1999:673). The landfill tax has been increased gradually, and is today 555 SEK per tonne landfilled waste (Swedish Tax Agency 2021).[35]

Ban on landfilling combustible and organic materials and methane collection

Under the Swedish Ordinance on the Landfill of Waste (SFS 2001:512), a ban on landfilling combustible materials was introduced in 2002 and a similar ban was imposed for organic material in 2005. The ordinance also regulates the collection and disposal of methane gas from landfills. The ordinance is intended to prevent and reduce adverse effects on human health and the environment from landfilling.

Extended producer responsibility

A set of ordinances mandates extended producer responsibility for producers of eight product groups. Producer responsibility promotes sorting, collection and recycling of certain waste flows[36]. Producer responsibility aims to incentivise producers to develop more resource-efficient products that are easier to recycle and do not contain environmentally hazardous substances. It also aims to reduce the amount of waste. The legislation on extended producer responsibility contains national targets for recycling, and has resulted in increased separated collection of

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[35] https://skatteverket.se/foretagochorganisationer/skatter/punktskatter/avfallsskatt.4.18e1b10334ebe8bc80002886.html

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

waste fractions and increased recycling (apart from pharmaceuticals and radioactive products, where there are no specific targets).

The municipal waste planning requirement

Since 1991, there has been a requirement that all the municipalities in Sweden must have their own municipal waste plan. A Swedish EPA regulation (NFS 2006:6) sets out the minimum requirements of what each municipality must include in its waste plan, such as a description of the current situation, recycling plants and landfills, environmental assessment, measures and monitoring. Both the national waste plan (Swedish EPA 2012) and the national prevention program (Swedish EPA 2015) act as guidance for the municipalities in developing their local plans and deciding on prioritised actions.

The Waste Directive, Regulation on shipment of waste and REACH

Several EU regulations and directives are crucial for facilitating the Swedish strategy for a circular economy (see above). These include the Directive on waste (2008/98/EC), the regulation on shipment of waste ((EC) No 1013/2006) and Regulation ((EC) No 1907/2006) concerning the Registration, Evaluation, Authorisation and Restriction of Chemicals (REACH). Transforming production and consumption towards a circular economy has a large potential to reduce the use of materials and thus the Negative impact on the climate. This requires a shift from virgin materials to circular material flows. This, in turn, requires toxic chemical to be removed.

Effects of policy instruments in the waste sector

An analysis of the combined effect of policy instruments influencing methane emissions from landfill sites showed that, in a scenario based on instruments decided on at the time of the analysis, emissions would end up around 1.7 Mt CO2 eq lower in 2015 than in a scenario based on 1990. By 2020, the difference was assessed to be 1.9 Mt CO2 eq (Swedish Environmental Protection Agency, 2001).

According to preliminary statistics from the Swedish Environmental Protection Agency, emissions from waste have decreased by 4.6 per cent in 2020 compared to the previous year. Behind this development are the landfill bans and taxation of landfilling of waste, which were introduced in the early 2000:s.

Common Agricultural Policy

In 2021 the European Parliament the Council ot the EU and and the European Commission agreed on the reform of the CAP. The new CAP for the period 2023-2027 aims to support the transition towards sustainable agriculture and forestry in the EU and to contribite to the goals of the European Green Deal. 40% of the CAP budget will have to be climate relevant (European Commission 2021).[37] The current CAP of 2013 is extended untill 2023.

In 2013, the Council of EU Agriculture Ministers formally adopted the four Basic Regulations for a reformed CAP. Based on certain requirements, farmers can receive support for measures aimed at producing non-profitable services delivered to the wider public, such as landscapes, farmland biodiversity and climate change mitigation. Through the CAP's second pillar for rural development member states have access to a wide range of measures to encourage higher environmental performance including climate mitigation and adaptation. The policy also requires member states to allocate a minimum share of the second pillar funds to such measures. According to the *Strategic plan for the implementation of the common agricultural policy in Sweden 2023-2027* "[c]limate-impacting emissions from the agricultural sector can be reduced but not completely removed". Measures, mentioned in the Strategic plan, where agriculture can contribute to reduced climate impact include becoming more resource efficient per unit produced, increasing carbon storage in soil and contributing to increased production of renewable energy.

Rural Development Program (pillar 2 of the CAP)

The Swedish Government decided on a Rural Development Program in June 2014. The program for 2014–2020, extended until 2022, includes investment grants for young entrepreneurs, capacity building, cooperation and innovation, support to areas with natural constraints, animal welfare subsidies, ecological farming, and environmental and climate actions.

Measures specifically contributing to climate change mitigation include those aimed at: increasing energy efficiency; production and use of renewable energy (including biogas production and establishment of perennial energy

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[37] https://ec.europa.eu/info/food-farming-fisheries/key-policies/common-agricultural-policy/new-cap-2023-27_en

crops); conversion from fossil to renewable energy sources; improved manure handling; more efficient use of nitrogen; climate and energy advice; measures to prevent the risk of nitrogen leakage; restoration and establishment of wetlands; promotion of grass ley and catch crop production in intensive cropping areas; conservation of semi-natural pastures; and other separate projects relating to climate and energy. The program budget for 2014-2020 totalled SEK 36 billion, of which 59% is financed by Sweden and

The program budget for 2014-2020 totalled SEK 36 billion, of which 59% is financed by Sweden and the remaining 41% by the EU. For the extention period 2021-2022 the program budget is SEK 10.5 billion (Swedish Board of Agriculture 2021).[38]

The rural network

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

Support for biogas production

In 2015, the Government introduced a support scheme for biogas production through anaerobic digestion of manure. The support program ends in 2023. It aims to increase biogas production from manure and thereby gain two-fold environmental and climate benefits through reduced methane emissions from manure and the substitution of fossil energy.[39] The increased digestion of manure offers several environmental benefits. It reduces both emissions of greenhouse gases and eutrophication of fresh and marine waters as well as produces biogas for energy. The biogas generated can be used to generate electricity or heat, or as vehicle fuel. The subsidy amounts to a maximum of 0.40 SEK/kWh of biogas produced. The support amounts to SEK 30 million for 2021 and SEK 22.5 million per year for

[38] Landsbygdsprogrammet - Jordbruksverket.se

[39] Jordbruksverket.se/stod/fornybar-energi/godselgasstod

2022-2023. Support for investments in new biogas plants can also be granted through the Rural Development Program.

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

Forest Policy and the Forest Act

The Swedish Forest Policy has two overarching, equal objectives: the production objective and the environment objective.

The production objective means that forests and forest lands should be used effectively and responsibly so they produce sustainable yields. The direction of forest production should be given flexibility in the use of what the forests produce.

The environment objective means that the natural productive capacity of forest land should be preserved. Biodiversity and genetic variation in forests should be secured. Forests should be managed in a manner that enables naturally occurring plant and animal species to survive in natural conditions and in viable populations. Threatened species and habitats should be protected. Cultural heritage assets of forests and their aesthetic and social values should be safeguarded. Under the Forest Policy, there are no production subsidies, and forest owners have considerable freedom and responsibility to independently conduct long-term sustainable forest management. The regulations in the Forestry Act (as of 1993) concerning timber production cover the notification of felling, the lowest age for felling, requirements for reforestation, guidelines for thinning and measures to limit damage. Special regulations apply to certain types of forests, such as subalpine forests and deciduous forests. Examples of regulations concerning nature conservation and cultural heritage include not disturbing important biotopes, buffer zones and arable land, and leaving older trees, high stumps and dead wood in situ. Sustainable forest management influences carbon dioxide removals and emissions in various ways, through the production of renewable raw materials that can replace fossil fuels and materials that generate emissions of greenhouse gases while maintaining or increasing carbon stocks in biomass, soils and harvested wood products.

Regulation on land drainage in the Environmental Code

The Swedish Environmental Code is a coordinated and broad piece of environmental legislation aimed at promoting sustainable development so that present and future generations can live in a good, healthy environment. For example, chapter 11 of the Code contains regulations on land drainage, which can be used to reduce emissions from peat soils with large carbon stocks. Land drainage measures are actions taken to remove water from soil or protect against water. In order for the measure to be a land drainage measure according to the Environmental Code, the purpose of the measure is to permanently increase the soil"s suitability for a specific purpose, such as cultivation, development, peat cover, road construction, garden plant or golf courses.

In central parts of the southern Swedish highlands and north of the limes norrlandicus (the biogeographical boundary of northern Sweden), drainage may only be undertaken with a permit. In the rest of the country, and on sites specially protected under the RAMSAR Convention, such schemes are prohibited. Land drainage has decreased since the beginning of the 1990s and is now occurring only to a very limited extent.

Provisions on nature reserves and habitat protection in the Environmental Code and nature conservation agreements

In Sweden, forests and land are allocated for the conservation of biodiversity, nurture and preserve valuable natural environments, protect, restore or create valuable natural environments and for outdoor recreation. These measures, for example in the form of nature reserves, nature conservation agreements and voluntary disposal of land, are also positive for carbon stocks in forest biomass and soil coal by allowing them to be maintained or continue to increase.

Nature reserves

In Sweden, nature reserves[40] are one of the most common ways of protecting valuable nature in the long term. At present, there are close to 5000 nature reserves in Sweden. The seventh chapter of the Environmental Code contains the regulations for the establishment of nature reserves. The

[40] http://www.naturvardsverket.se/Var-natur/Skyddad-natur/Naturreservat/

work of establishing nature reserves is led by the Swedish Environmental Protection Agency.

Nature conservation agreements

Nature conservation agreement is a civil law agreement (Swedish Environmental Protection Agency 2019c). The property owner and the state or a municipality agree on a certain financial compensation for the property owner, for example, to refrain from, for example, forestry. The Swedish Forest Agency and the Swedish Environmental Protection Agency together guide how to go about it. For the landowner it should not matter what authority you agree with.

The Swedish National Forest Program

In 2015 the Government initiated a comprehensive dialogue with stakeholders within the Swedish National Forest Program.

In 2018, the Government adopted a strategy for Sweden's National Forest Program, followed by an action plan with specific measures. The action plan will be updated in dialogue with interested parties. The core of the National Forest Programme is the broad dialogue on the role forests play to ensure a sustainable society and a growing bioeconomy.

The strategy for the National Forest Programme focuses on objectives in five main areas:

- Sustainable forest management with greater climate benefits
- Multiple uses of forest resources for more jobs and sustainable growth throughout the country
- World-class innovation and processed forest products
- Sustainable use and conservation of forests as a profile issue in Sweden's international cooperation
- A knowledge leap to ensure the sustainable use and conservation of forests

Methods for increased carbon sinks

The Swedish Forest Agency receives SEK 1.5 million per year in 2021 and 2022 to develop methods for increased carbon sinks. In addition, the Agency receives an additional SEK 30 million for efforts to monitor, prevent and combat forest damage. Combating forest damage can contribute to reduced climate impacts by promoting forest growth and reducing natural emissions (Govt. Bill 2021/22:1).

Support for re-wetting of wetlands

Since 1990, the Swedish state has funded the rewetting of more than 3500 ha of drained wetlands on organic soils for purposes such as nutrient retention and biodiversity. Data of rewetting efforts from the period 1990 to 2019 vary in quality, and the total area of forest land (150 ha) is likely underestimated. Rewetting of much larger areas on forest land have been funded and reported, but they have not been registered into the utilized database.

In 2020 the Government decided on a new support scheme for re-wetting previously drained wetlands, which aims at providing climate benefits while also strengthening biodiversity, balance water flows, increase the addition to ground water and reduce eutrophication. The re-wetting of wetlands on peat soils are expected to reduce the CO2 emissions caused by the drainage. The initiative is implemented primarily by raising funds within the local nature conservation initiative (LONA). The initiative is based on voluntary participation by landowners (Government Bill 2020/21:1). SEK 350 million is allocated for the support in 2021. For 2022 and 2023 SEK 325 million and 100 million is proposed respectively (Govt. Bill 2021/22:1).

The Swedish Forest Agency has also received SEK 5 million in funding for the advice to forest owners regarding re-wetting previously ditched or drained wetlands.

Effects on LULUCF (re-wetting)

The investment in re-wetting measures is estimated to contribute to an emission reduction of a total of 1.5-3.6 million tonnes of CO2-equivalents over a twenty-year period. For 2030, the emission reduction is estimated at 0.08-0.18 million tonnes of CO2-equivalents depending on which land is re-wetted. The same emission reduction is expected for 2040 (Govt. Bill 2021/22:1).

Implementation of Articles 3.3 and 3.4 of the Kyoto Protocol

For the second commitment period of the Kyoto Protocol (2013–2020), Sweden has decided to account for changes in removals and emissions from mandatory activities: afforestation, reforestation, deforestation and forest management (Swedish EPA 2016). Sweden has not elected additional voluntary activities under Article 3(4) for the second commitment period of the Kyoto Protocol.

Sweden established the definition of forest back for the first commitment period under the Kyoto Protocol. The definition follows the criteria for forest land as derived from the FAO definition and the IPCC’s good practice guidance. Sweden intends to apply the provisions to exclude emissions from natural disturbances for the accounting of afforestation and reforestation under Article 3(3) and forest management under Article 3(4) during the second commitment period of the Kyoto Protocol.

The forest management reference level for Sweden is -41.3 million tonnes of CO2-equivalents per year, applying a first-order decay function for harvested wood products. The forest management reference level was based on averages of the projected emissions/removals for carbon pools and included sources for forest management data series for the period 2013–2020, taking into account policies implemented before mid 2009. Sweden is allowed to claim a maximum credit of 2.5 million tonnes of CO2 per year in the second commitment period of the Protocol. For the years 2013-2019 Sweden has reported a net sink from forest management that is significantly larger than the cap of credits from forest management of 2.5 million tonnes of CO2 per year. The full description of the forest management reference level calculations can be found in Sweden’s submission of information on forest management reference levels (Swedish Govt. 2011).

Under the Kyoto Protocol, the National Communication is to include information on national legislative or administrative procedures to ensure that implementation of Articles 3.3 and 3.4 also contributes to the conservation of biodiversity and sustainable use of natural resources.

Sweden's current forest policy puts great emphasis on using forests sustainably as a natural resource and on conserving biodiversity. Under the Forestry Act, forests are to be managed and harvested in such a way as to contribute to sustainable forestry. The provisions of environmental legislation on nature reserves and habitat protection areas provide long-term formal protection for forest areas of high biological value, and the Forestry Act stipulates that forests must be managed using measures that meet good environmental standards. There has therefore been no need for supplementary legislation to conserve biodiversity and ensure sustainable use of natural resources as a consequence of implementation of Articles 3.3 and 3.4.

4.2.10 Shipping water-borne navigation and aviation, including international bunkers in Sweden

Tax on air travel*

A tax on air travel was introduced in 2018. The tax aims to reduce the climate impact of aviation. The tax is regulated in the Swedish act SFS 2017:1200 regarding tax on air travel. It is designed as a tax on commercial

ICAO

Within the ICAO, Sweden and the EU have been pressing for action to limit greenhouse gas emissions from international aviation, using a unified global measure. ICAO decided in 2016 to develop a market-based mechanism, Carbon Offsetting and Reduction Scheme for International Aviation, CORSIA, to compensate for some of the CO2 emissions from international aviation. The ICAO Council adopted this mechanism in 2018. Sweden is among the nations that have voluntarily participated in the scheme from its outset. Sweden is a long-standing member of the Committee on Aviation Environment Protection (CAEP) and relevant subgroups that have been working on the technical parts of the proposal.

CAEP is also working with analyses and policy measures for sustainable aviation fuels, metrics and possible measures for reducing emissions through operative procedures and studies of non-CO2 effects from particles and nitrogen oxides.

International Maritime Organization (IMO)

Sweden has been working actively in the International Maritime Organization (IMO) for many years, pushing for the adoption of ambitious reduction measures.

The Energy Efficiency Design Index (EEDI), which is a standardized way to describe ships' energy efficiency, was made mandatory from 2013 for most (some 85 %) newly built vessels. All ships, to which the regulation applies, have to comply with the required EEDI level, which is set relative to a reference line, depending on ship type and size and year of building. The mandatory Ship Energy Efficiency Management Plan (SEEMP) was also introduced in 2013. The SEEMP is to be used in ships' management systems to improve energy efficiency in both existing and new ships. Both the EEDI end SEEMP applies to ships in international traffic with a gross tonnage of more than 400. Since 2019 the IMO data collection system for fuel oil consumption of ships (DCS) mandates all ships in international traffic with a gross tonnage of more than 5000 to collect and report data related to fuel consumption. The system is similar to the monitoring, reporting and verficiation system (MRV) of EU that entered into force in 2018.

In 2018 the IMO adopted an initial strategy on the reduction of greenhouse gas emissions from ships, setting out a vision to reduce GHG emissions from international shipping and phase them out, as soon as possible during this century. IMO is now focusing on developing measures to meet the ambitions in the initial strategy. A first measure, aiming to complement and strengthen the EEDI and SEEMP was approved in 2020 and, provided formal adoption in 2021, is expected to enter into force in 2022/2023.

Sweden actively promotes the use of batteries and alternative fuels as well as related infrastructure. In 2015, the IMO adopted the IGF Code, which is a regulatory framework for ships using gases or other low-flashpoint fuels.

Guidelines for using methanol as marine fuel (MSC.1/Circ.1621) were approved in 2020, and will be included in the IGF code after a test period of 3 to 5 years. Work on guidelines for fuel cells is also under way, which will allow for the use of hydrogen propulsion.

Many Swedish ports have invested in infrastructure allowing ships to use shore-side electricity, considerably reducing their emissions. The Port of

Stockholm has introduced attractive incentives for ships using this infrastructure. All these measures form part of a national policy framework for development of alternative fuels and related infrastructure, implementing directive 2014/94/EU.

Part from greenhouse gases, emissions of black carbon from ships is also having considerable impact, not least in the Arctic. Black carbon emissions from shipping are now under review by the IMO, with a particular focus on the potential impacts of future Arctic shipping. Sweden was one of the countries that proposed to raise this issue on IMO's agenda.

4.2.11 Efforts to avoid adverse effects of policies and measures introduced as part of the country's climate strategy

Parties under the UN Framework Convention of Climate Change should strive to implement policies and measures in such a way as to minimise adverse effects. These include the adverse effects of climate change, effects on international trade, and the social, environmental and economic impact on other parties, especially developing countries.

Sweden has not made any changes since the seventh National Communication on climate change in the work to avoid adverse effects of policies and measures introduced as part of the country's climate strategy.

Under Sweden's policy for global development (PGD), all policy areas should interact in a coherent way so the country can make an effective contribution to equitable and sustainable global development. When decisions in a given policy area are judged to affect this goal of equitable and sustainable global development, an impact assessment must be carried out. The policy's two perspectives – a rights perspective and the perspective of poor people on development – should serve as a guide. In the framework of the PGD, for example, coordination and collaboration take place through a Reference group on trade policy at the Ministry for Foreign Affairs. Regular meetings of this group, which includes representatives of business, the Swedish International Development Cooperation Agency (Sida) and civil society organisations have created a basis for broad consultation on trade policy.

In connection with decision making on policies and measures in Sweden and at the EU level, impact assessments are carried out, including environmental impact assessments. To the extent possible, such assessments include an appraisal of the risk of adverse effects on other countries. Both beneficial and adverse effects need to be taken into account. Sweden is helping to implement a range of measures that could improve the ability of developing countries to adapt to climate change and take action of their own to reduce their greenhouse gas emissions. Finally, Sweden has designed a broad-ranging climate strategy that encompasses many different types of measures and most sectors, both inside and outside the country. This, combined with all the greenhouse gases regulated by the Kyoto Protocol, represents a fundamental effort to minimise the risk of adverse effects.

As regard domestic economic and social consequences of climate policies and measures, this is addressed in several ways. An important component is impact assessment of policy changes which includes the description of how specific policy changes affects different groups. When it comes to the broader structural changes resulting from the country's climate policy, this is, for example, addressed by the government's Transition package, including reformation of labour laws, guidance and economic support for retraining (see Swedish Government, 2023b).

An example of how climate mitigation is addressed together with social and economic issues in a more integrated manner at the EU level is the Just Transition Fund. This is a financial instrument within the Cohesion Policy, which seeks to provide support to territories facing serious socio-economic challenges arising from the transition towards climate neutrality. Sweden has received €155 million to support transitioning not a green and competitive industry at the same time as maintaining employment. A particular focus is on steel industry in the region of Norrbotten, mineral industry in the region of Gotland and metal industry in Västerbotten. Measures and indicators for are detailed in Swedish Agency for Economic and Regional Growth (2022).

4.2.12 Policies and practices that encourage activities that lead to greater levels of anthropogenic GHG emissions

The latest inventory of policies and practices that encourage activities that lead to greater levels of anthropogenic GHG emissions than would otherwise occur was carried out by the Swedish Environmental Protection

Agency in 2017 as part of an inventory of potentially environmental damaging subsidies (Swedish Environmental Protection Agency, 2017). Sweden is also involved in ongoing methodological work for enabling the analysis of potentially environmentally damaging (implicit and explicit) subsidies in various international contexts. Previously, the Swedish carbon and energy taxes have included several reductions. In recent years Sweden has been working on reforming these in order not to encourage activities that lead to greater levels of GHG emissions. This work is further described in NC8 section 4.2.2 Cross sectoral instruments.

4.3 The Swedish program for International Climate Initiatives

The core mission of the Swedish Program for International Climate Initiatives is to support the development of international climate cooperation, to achieve cost-effective greenhouse gas reductions and to contribute to sustainable development in developing countries. Initially, the program consisted solely of projects and multilateral funds generating emission reductions under the Kyoto Protocol. In 2018, the program was expanded to include the development of new types of cooperation under the Paris Agreement, in particular its Article 6.

4.3.1 Project-based flexible mechanisms under the Kyoto Protocol

The Swedish Program for International Climate Initiatives was launched in the early 2000s and has led to emission reductions in developing countries while generating emission reduction units for Sweden. It supports the development of effective climate policy instruments through the implementation of market-based mechanisms which contribute to cost-effective greenhouse gas reductions, and also promotes sustainable development in host countries. The program has involved participation in individual projects for Clean Development Mechanism (CDM) and Joint Implementation (JI) as well as multilateral carbon funds and collaborations. The projects and the emissions reductions they generate are scrutinized and verified by the UNFCCC, ensuring the projects' additionality, cost effectiveness and promotion of sustainable development.

Throughout the program, Sweden has supported over 90 bilateral projects through CDM and JI and has participated in 11 multilateral carbon funds[41]. By the end of 2020, SEK 1,8 billion had been granted, corresponding to approximately 31 Mt CO2 -eq. The program has a total commitment of approximately SEK 1,9 billion[42] and is expected to generate emission reductions equivalent to a total of 35 Mt CO2 -eq. The program is expected to close in 2025, with final payments in 2022.

All projects are carried out in developing countries, and priority has been given to projects in least developed countries (LDCs), small island developing states (SIDS) and in Sub-Saharan Africa. Overall, the program supports climate projects in more than 50 developing countries. A majority of the projects are in renewable energy, energy efficiency and waste management.

Sweden's participation in multilateral funds offers an opportunity to support a larger number of projects across several regions and project categories. Collaboration in multilateral funds has also provided a valuable knowledge exchange, network development and many insights into carbon pricing and implementation.

Sweden has decided to cancel all emission reduction units received up until the end of 2019. The cancelled international credits have not been used to fulfil commitments under the Kyoto Protocol. Instead, the financial support related to cancelled international credits has been reported as climate finance (see section 7.4.3.)

4.3.2 New market mechanisms under the Paris Agreement

Since 2018, the Swedish Energy Agency (SEA) has received funding aimed at supporting the development of new international forms of cooperation under the Paris Agreement, namely Article 6. The aim is to contribute to increased climate ambition and to provide results-based climate finance or,

[41] Future Carbon Fund (FCF), Asia Pacific Carbon Fund (APCF), Transformative Carbon Asset Facility (TCAF), Carbon Initiative for Development (Ci-Dev), Carbon Partnership Facility (CPF), Pilot Auction Facility for Methane and Climate Change Mitigation (PAF), Umbrella Carbon Facility Tranche 2 (UCF T2), Prototype Carbon Fund (PCF), Multilateral Carbon Credit Fund (MCCF), Testing Ground Facility (TGF) and Partnership for Market Readiness (PMR).

[42] Calculated with currency rates from October 2021.

alongside other supplementary measures, contribute to the fulfilment of Sweden's national climate targets.

In 2018, the SEA commissioned nine virtual pilots to be developed in seven different countries. Each pilot resulted in a report, presenting a blueprint of a mitigation activity in a real-world Article 6 setting. In late 2019, efforts moved closer toward developing concrete, bilateral collaborations under Article 6 as the SEA launched a global call for proposals on international climate collaborations within the Article 6 framework. Over 60 proposals were received, out of which six activities were selected for further development of detailed mitigation activity design documents, focusing on compliance with the Article 6 framework. These project documents formed a foundation for future decisions on financing and implementation.

In parallel to the progress of these Article 6 activities, there are ongoing dialogues with the respective host countries to find agreement on the conditions and rules for the collaboration. In 2019, the SEA entered into an agreement with the Global Green Growth Institute (GGGI) for a tailor-made Article 6-program. The objective of the agreement is to develop ideas for feasible Article 6-activites and build the competence and institutional infrastructure necessary for host countries to trade with emission outcomes. In 2020, the program with GGGI resulted in four proposals for mitigation activities in three different countries, as well as blueprints for host country agreements and institutional infrastructure.

The work is also focused on methodological development with a special focus on monitoring, reporting and verification (MRV) and sustainable development. Representing Sweden in the negotiations of the rulebook for Article 6, the SEA is actively working for robust rules on sustainable development and environmental integrity. The SEA also participates in several capacity building initiatives aimed at supporting countries in entering collaborations under Article 6, such as the Article 6 Support Facility hosted by the Asian Development Bank and the Climate Market Club hosted by the World Bank.

4.4 Cost-effectiveness of policies and measures in Sweden's climate strategy and non-GHG mitigation benefits

4.4.1 Cost-effectiveness of policy instruments

The concept of cost-effectiveness refers in this context to achieving a given objective at the lowest possible cost. To be able to assess the cost-effectiveness of different policies and measures, there thus needs to be an objective and an estimate of the costs of the instruments concerned. In the case of a national target for greenhouse gas emissions, the relevant costs are the economic costs, i.e. the change in current and future households' scope for consumption (in a wide sense) due to the instruments.

A given instrument may be intended to achieve a number of objectives, and it may therefore be difficult to correctly allocate the costs stemming from it. An instrument may for example – as is commonly the case in Sweden's climate strategy – be designed to be of significance for several environmental objectives at once, but also to help meet broader energy, waste and employment policy goals.

By and large, general, cross-sectoral policy instruments, such as a carbon dioxide tax or an emissions trading system, which impose the same marginal cost on emissions, have potential to be cost-effective. This is due to the flexibility they offer in the choice of measures to reduce emissions, resulting in low-cost actions being implemented.

It can be argued that there are two main reasons for supplementing general instruments with more targeted ones. The first has to do with the existence of other market failures than the actual emission of greenhouse gases. These include, for example, knowledge leakage from R&D investments, other obstacles to new technology and infrastructure, and various information failures. (Swedish EPA 2012).

The second reason is that there are sometimes factors restricting the implementation of the, in theory, most cost effective policy. This may mean that, instead of introducing the first choice of instrument, the second-best solution may be applied, such as a less cost effective instrument or several blunter ones. This may be because the first choice of instrument is not judged feasible to implement due to factors such as political feasibility or EU regulations such as the state aid rules and the energy tax regulation.

Following Sterner (2018): “In an ideal world, there would never be a need for anything other than carbon pricing. But according to the theory of “"”second-best”"”, sometimes, in the presence of several external effects and/or obstacles to decision-making, it can be optimal with completely different policy combinations – which would not be optimal in an ideal situation.”

Moreover, there is a risk that, because of conflicts with other goals, general policy instruments cannot be designed in a theoretically desirable way. Targeted instruments can then help to increase awareness of the options for action available. This means that, in certain cases, it may be cost-effective to combine general and targeted instruments. In the words of Meckling et al. (2018): “As countries move toward deeper emissions cuts, combining and sequencing policies will prove critical to avoid environmental, economic, and political dead-ends in decarbonizing energy systems.”

4.4.2 Non GHG mitigation benefits

There are considerable non mitigation benefits of GHG mitigation in Sweden. One area where these are considerable relates to air pollution. These are presented in the recent concluded reporting under EU Governance regulation (2018/1999), where GHG relevant PaMs are viewed from an air quality perspective. The reported data will be made available by EEA.[43] The reporting is related to the national air pollution control program which sets out how Sweden intends to implement measures and instruments to meet the requirements for emission reductions under the cap directive. This was adopted by the Swedish government in March 2019.[44]

4.5 Progress toquantified economy-wide emission reduction target

This section presents estimates of emission reductions and removals and the use of units from the market-based mechanisms and land use, land-use change and forestry activities

For quantification of progress towards the 2020 targets, the change in greenhouse gas emissions is a key indicator. The Convention target for a reduction of emissions of 20 % from 1990 to 2020 refers only to emissions

[43] See EEA Reportnet 3, https://reportnet.europa.eu/

[44] In Swedish this is found at: Nationellt luftvårdsprogram (naturvardsverket.se)

of the EU-27+UK as a whole. Greenhouse gas emissions of the EU-27+UK are calculated as the sum of all member states' emissions. The Swedish greenhouse gas emissions constitute 1.1 % of the entire EU-27+UK emissions when measured for the year 2020 (submission 2022).

Use of flexible mechanisms takes place by operators in the EU Emissions Trading System (ETS) on the one hand, and by governments on the other hand to achieve the Effort Sharing Decision (ESD) target. More information on use in the ETS is contained in the fifth Biennial Report of the European Union.

The compliance assessment under the ESD[45] for the years 2013, 2014, 2015, 2016, 2017, 2018 and 2019 will be completed in 2022. Sweden have not needed to use any other units than the Annual Emissions Allocations (AEA, EU-ESD units) for the compliance since Sweden overachieved our commitment. The same will apply to ESD emissions for the year 2020 but the accounting will not be completed before 2023. In CTF Table 4b Sweden report NE. For the moment, Sweden does not foresee any need to make use of flexible mechanisms under the ESD.

[45] Decision No 406/2009/EC

4.6 Summary of policies and measures[46]

Cross-cutting

Name of policy/measure	Sectors primarily affected	GHG(s) primarily affected	Primary objective	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing agency	Estimate of mitigation impact in Mt CO2 eq per year compared with 1990 instruments[47]						
									2010	2015	2020	2025	2030	2040	2050
Local climate investment program (Climate leap)	Cross-cutting	All	Enhance and speed reduction of greenhouse gas emissions	Economic	Implemented	Grants for local and regional investments, in all sectors, except those included in the EU ETS to cut greenhouse gas emissions.	2015	Swedish Environmental Protection Agency	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
Environmental Code	Cross-cutting	All	Ecologically sustainable development	Regulatory	Implemented	General rules for consideration to be observed in all activities and measures that are not of negligible significance and that can affect the environment	1999	Swedish Environmental Protection Agency	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
Planning and Building Act (PBL)	Cross-cutting	All	Promote sustainable development of society	Regulatory	Implemented	In 2011, the PBL introduced new requirements on considering the environmental and climate aspects of planning.	2011	Swedish National Board of Housing, Building and Planning	N.E.	N.E.	N.E .	N.E.	N.E.	N.E.	N.E.
Fossil-Free Sweden initiative	Cross-cutting	Carbon dioxide	Mobilize efforts from actors to reduce the use of fossil fuels.	Information, Voluntary Agreement	Implemented	Strengthen the dialogue between the state and the business sector, municipalities and civil society	2015	Fossil free Sweden	N.E.	N.E.	N.E .	N.E.	N.E.	N.E.	N.E.

[46] Some of the policy instruments are, due to recent date of decision, not included in the scenarios in chapter 5. Those are mar ked with a "*" in the table.

[47] For several policies/measures there is no reliable estimate of mitigation impact. This is indicated with "N.E." in the table.

Climate and energy advice	Cross-cutting	All	Greater awareness of possible measures	Information	Implemented	Energy and climate advisers in municipalities reply free of charge to questions about heating, energy costs and efficiency, transport, climate and government grants relating to energy	1998	Swedish Energy Agency	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.

Research and development	Cross-cutting	All	Development of technology with very low climate impact	Research	Implemented	Climate-related research and development aimed at achieving emissions reduction	1990	Swedish Energy Agency (mainly)	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
A national center for carbon dioxide capture and storage*	Cross-cutting	Carbon dioxide	Enable negative emissions	Information	Adopted	Promote the appropriate application of CCS in Sweden, enable the export of CO2 from Swedish operations for long term geological storage, ensures that transport and storage is safe	2021	Swedish Energy Agency	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
National strategy for electrification*	Cross-cutting	Carbon dioxide	Contribute to a fast, smart and economically efficient electrification	Regulatory, information	Planned (2022-2024)	Contribute to a fast, smart and economically efficient electrification	2022	Government Offices	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
Increased competence for climate transition*	Cross-cutting	All	To meet future needs in the labour market as a result of the climate transition	Education	Planned	To meet future needs in the labour market as a result of the climate transition	2022	The Legal, Financial and Administrative Services Agency	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.
Education and training	Cross-cutting	All	Education on climate related issues	Education	Adopted	Clarify the connection between curriculum and syllabus and the national environmental goal Reduced Climate Impact	2020	The National Swedish Agency for Education, Swedish Environmental	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.	N.E.

								Protection Agency	
Energy tax	Cross-cutting	Carbon dioxide	Fiscal, and to improve efficiency of energy use	Economic	Implemented	The aim is mainly fiscal. It also steer energy usage towards Sweden's energy efficiency, renewability and climate targets	1957	Swedish Tax Agency	See sectoral impact estimation impact in tables below
Carbon dioxide tax	Cross-cutting	Carbon dioxide	Reduce use of fossil fuels	Economic	Implemented	Based on the fossil carbon content in the fuel	1991	Swedish Tax Agency	See sectoral impact estimation impact in tables below
Strategy for a circular economy*	Cross-cutting	All	Transition to circular ecoomy	Information	Adopted	The strategy aims a providing a vision and direction for different actors.	2020	Government Offices	N.E.
EU ETS	Cross-cutting	Carbon dioxide	Reduce use of fossil fuels in trading sector	Economic	Implemented	The amount of emissions allowed within the system is limited by a cap, which is decreased every year. Almost half of the allowances are allocated for free, the rest are auctioned.	2005	Swedish Environmental Protection Agency and Swedish Energy Agency	See sectoral impact estimation impact in tables below

Production of electricity and district heating

<table>
<tr><th rowspan="2">Name of policy/measure</th><th rowspan="2">Sectors primarily affected</th><th rowspan="2">GHG(s) primarily affected</th><th rowspan="2">Primary objective</th><th rowspan="2">Type of instrument</th><th rowspan="2">Status of implementation</th><th rowspan="2">Brief description</th><th rowspan="2">Start year of implementation</th><th rowspan="2">Implementing agency</th><th colspan="7">Estimate of mitigation impact in Mt CO2 eq per year compared with 1990 instruments[46]</th></tr>
<tr><th>2010</th><th>2015</th><th>2020</th><th>2025</th><th>2030</th><th>2040</th><th>2050</th></tr>
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<tr><td>Carbon dioxide tax</td><td>Cross-sectoral</td><td>Carbon dioxide</td><td>Reduce use of fossil fuels</td><td>Economic</td><td>Implemented</td><td>Based on the fossil carbon content in the fuel</td><td>1991</td><td>Swedish Tax Agency</td></tr>
<tr><td>Electricity certificate system</td><td>Energy</td><td>Carbon dioxide</td><td>Increase supply of electricity from renewable energy sources</td><td>Economic</td><td>Implemented</td><td>Electricity suppliers are obliged by law to submit electricity certificates corresponding to a certain share of their electricity deliveries.</td><td>2003</td><td>Swedish Energy Agency</td></tr>
<tr><td>EU Emissions Trading System (EU ETS)</td><td>Cross-sectoral</td><td>Carbon dioxide</td><td>Reduce use of fossil fuels in trading sector</td><td>Economic</td><td>Implemented</td><td>The amount of emissions allowed within the system is limited by a cap, which is decreased every year. Almost half of the allowances are allocated for free, the rest are auctioned.</td><td>2005</td><td>Swedish Environmental Protection Agency and Swedish Energy Agency</td></tr>
<tr><td>Initiatives for wind power</td><td>Energy</td><td>Carbon dioxide</td><td>Increase supply of electricity from renewable energy sources</td><td>Regulatory, Information, Research</td><td>Implemented</td><td>This include research programs, designation of areas of national interest for wind power</td><td>2004</td><td>Swedish Energy Agency</td><td>N.E</td><td>N.E</td><td>N.E</td><td>N.E.</td><td>N.E</td><td>N.E</td><td>N.E</td></tr>
</table>

Support for solar power Income tax reduction for micro production of renewable energy	Energy	Carbon dioxide	Increase supply of electricity from renewable energy sources	Economic	Implemented	A subsidy for installations of solar power systems	2009	Swedish Energy Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Income tax reduction for micro production of renewable energy	Energy	Carbon dioxide	Increase micro production of renewable energy	Economic	Implemented	Tax reduction for households and businesses to stimulate investment in the micro-production of renewable electricity	2015	Swedish Tax Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Tax on waste incineration	Energy	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	Incineration of waste is taxed. The tax has gradually been increased and is from 2022 SEK 125 per ton. The tax excludes for example hazardous waste and bio energy.	2020	Swedish Tax Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Tax reduction for installation of green technology*	Energy	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	Individuals are eligible to a tax reduction for installation of green technology including solar cells, systems for storage of self-produced electricity and at home charging stations	2021	Swedish Tax Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E

Residential and commercial/institutional sector

<table>
<tr><th rowspan="2">Name of policy/measure</th><th rowspan="2">Sectors primarily affected</th><th rowspan="2">GHG(s) primarily affected</th><th rowspan="2">Primary objective</th><th rowspan="2">Type of instrument</th><th rowspan="2">Status of implementation</th><th rowspan="2">Brief description</th><th rowspan="2">Start year of implementation</th><th rowspan="2">Implementing agency</th><th colspan="7">Estimate of mitigation impact in Mt CO2 eq per year compared with 1990 instruments[48]</th></tr>
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<tr><td>Carbon dioxide tax</td><td>Cross-sectoral</td><td>Carbon dioxide</td><td>Reduce use of fossil fuels</td><td>Economic</td><td>Implemented</td><td>Based on the fossil carbon content in the fuel</td><td>1991</td><td>Swedish Tax Agency</td></tr>
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<tr><td>Building regulations</td><td>Energy</td><td>Carbon dioxide</td><td>More efficient energy use</td><td>Regulatory</td><td>Implemented</td><td>Requirements for energy use in new buildings</td><td>2009 (1960s)</td><td>Swedish National Board of Housing, Building and Planning</td></tr>
<tr><td>Energy declarations (Law on energy performance certificates for buildings)</td><td>Energy</td><td>Carbon dioxide</td><td>More efficient energy use</td><td>Regulatory and information</td><td>Implemented</td><td>Obligation for owners to declare the energy use of buildings</td><td>2006</td><td>Swedish National Board of Housing, Building and Planning</td></tr>
</table>

[48] For aggregated effects for the sector, see Table 4.2

Ecodesign Directive	Energy	Carbon dioxide	More efficient energy use	Regulatory	Implemented	Aims to improve the products' environmental performance during their full life cycle	2008	Swedish Energy Agency							
Mandatory energy labelling	Energy	Carbon dioxide	More efficient energy use	Information	Implemented	Makes the product's energy use visible and facilitates for consumers who want to make energy smart choices	1995	Swedish Energy Agency							
Training programs in building for low energy consumption	Energy	Carbon dioxide	More efficient energy use	Education	Implemented	Target different construction stakeholders, such as architects, engineers, clients, technicians, installers, site managers and teachers in building programs	2016	Swedish Energy Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Technology procurement	Energy	Carbon dioxide	More efficient energy use and increased use of renewable energy	Economic	Implemented	An instrument designed to initiate a market transition and disseminate new, more efficient technology, such as new products, systems and processes	N.d.	Swedish Energy Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Energy Performance of Buildings Directive 2010/31/EC	Energy	Carbon dioxide	More efficient energy use and reduce emissions	Regulatory	Implemented	A framework within which EU Member States have decided on minimum energy performance standards, building energy certificates etc	2010	Swedish National Board of Housing, Building and Planning	N.E	N.E	N.E	N.E.	N.E	N.E	N.E

Industrial emissions from combustion and processes

<table>
<thead>
<tr><th rowspan="2">Name of policy/measure</th><th rowspan="2">Sectors primarily affected</th><th rowspan="2">GHG(s) primarily affected</th><th rowspan="2">Primary objective</th><th rowspan="2">Type of instrument</th><th rowspan="2">Status of implementation</th><th rowspan="2">Brief description</th><th rowspan="2">Start year of implementation</th><th rowspan="2">Implementing agency</th><th colspan="7">Estimate of mitigation impact in Mt CO2 eq per year compared with 1990 instruments[46]</th></tr>
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</thead>
<tbody>
<tr><td>Energy tax</td><td>Cross-sectoral</td><td>Carbon dioxide</td><td>Fiscal, and to improve efficiency of energy use</td><td>Economic</td><td>Implemented</td><td>The aim is mainly fiscal. It also steer energy usage towards Sweden’s energy efficiency, renewability and climate targets</td><td>1957</td><td>Swedish Tax Agency</td><td rowspan="4">-0.9</td><td rowspan="4">-0.5</td><td rowspan="4">-0.1</td><td rowspan="4">0.2</td><td rowspan="4">0.5</td><td rowspan="4">0.8</td><td rowspan="4">3.3</td></tr>
<tr><td>Carbon dioxide tax, incl. stepwise reduced carbon dioxide tax relief for industry outside EU ETS</td><td>Cross-sectoral</td><td>Carbon dioxide</td><td>Reduce use of fossil fuels</td><td>Economic</td><td>Implemented</td><td>Based on the fossil carbon content in the fuel</td><td>1991-</td><td>Swedish Tax Agency</td></tr>
<tr><td>Electricity certificate system</td><td>Energy</td><td>Carbon dioxide</td><td>Increase supply of electricity from renewable energy sources</td><td>Economic</td><td>Implemented</td><td>Electricity suppliers are obliged by law to submit electricity certificates corresponding to a certain share of their electricity deliveries.</td><td>2003</td><td>Swedish Energy Agency</td></tr>
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</table>

Energy audit for large enterprises	Industry/ industrial processes	Carbon dioxide	More efficient energy use	Regulatory and information	Implemented	Requires large enterprises to conduct energy audits, including information of total energy use	2014	Swedish Energy Agency	N.E	N.E	N.E	N.E	N.E	N.E	N.E
Environmental Code	Industry/ industrial processes	All	Ecologically sustainable development	Regulatory	Implemented	General rules for consideration to be observed in all activities and measures that are not of negligible significance and that can affect the environment	1999	Swedish Environmental Protection Agency	N.E	N.E	N.E	N.E	N.E	N.E	N.E
Industrial Leap, in combination with several other policy instruments enabling the investmens in low carbon technologises	Industry/ industrial processes	All	Reduce greenhouse gas emissions	Research, ecoomic	Implemented	A government scheme that supports development of technology and processes to reduce the process-related greenhouse gas emissions in Swedish industry	2018	Swedish Energy Agency	N.E.	N.E	N.E.	N.E	N.E.	N.E.	N.E.
Operating aid for BECCS*	Industry/ industrial processes	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Planned	A reversed auction where the company offering the most cost efficient solution will receive operating aid to operate a BECCS facility.	2022	Swedish Energy Agency	N.E.	N.E	N.E.	N.E.	.1-2	.1-2	.1-2

Product use

Name of policy/measure	Sectors primarily affected	GHG(s) primarily affected	Primary objective	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing agency	Estimate of mitigation impact in Mt CO2 eq per year compared with 1990 instruments[46]						
									2010	2015	2020	2025	2030	2040	2050
EU regulation on Fluorinated greenhouse gases and BREF	Industry/ industrial processes	HFCs	Reduce use of HFCs	Regulatory	Implemented	Includes a mechanism for quantified emission reductions of substances containing HFCs	2015	Swedish Environmental Protection Agency	0.2	0.5	0.7	N.E	N.E	N.E	N.E
EU regulation on mobile air conditioning units in cars	Industry/ industrial processes	HFCs	Reduce use of HFCs	Regulatory	Implemented	Requirements for vehicles as regards emissions from, and the safe functioning of, air-conditioning systems fitted to vehicles.	2006	Swedish Environmental Protection Agency							
Swedish regulation on fluorinated gases and ozone depleting substances	Industry/ industrial processes	HFCs	Reduce use of HFCs and ozone depleting substances	Regulatory	Implemented	Prohibition to sell f- gases as refrigerants to recipients other than those stated in the regulation etc	2016	Swedish Environmental Protection Agency							

Agriculture

Name of policy/measure	Sectors primarily affected	GHG(s) primarily affected	Primary objective	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing agency	Estimate of mitigation impact in Mt CO2 eq per year compared with 1990 instruments[46]						
									2010	2015	2020	2025	2030	2040	2050
Common Agricultural Policy	Agriculture	Nitrous oxide, methane and carbon dioxide	Sustainable agriculture	Economic	Implemented	Common Agricultural Policy of the EU	2021 (for the period 2023-2027)	Swedish Board of Agriculture	N.E	N.E	N.E	N.E	N.E	N.E	N.E
Measures under the Rural Development Program	Agriculture	Nitrous oxide, methane and carbon dioxide	Reduced Climate Impact, a varied agricultural landscape and zero eutrophication	Economic	Implemented	Support to areas with natural constraints, animal welfare subsidies, ecological farming, and environmental and climate actions, etc.	2014	Swedish Board of Agriculture	N.E	N.E	N.E	N.E	N.E	N.E	N.E
Support for biogas production	Agriculture	Methane	Reducing emissions of greenhouse gases and production of biogas for energy purposes	Economic	Implemented	Increase biogas production from manure and thereby gain two-fold benefits through reduced methane emissions from manure and the substitution of fossil energy	2015	Swedish Board of Agriculture	N.E	N.E	N.E	N.E	N.E	N.E	N.E
The rural network	Agriculture	Nitrous oxide, methane and carbon dioxide	Reinforce implementation of the Rural Development Program	Information	Implemented	Brings together actors at the local, regional and central levels for exchanging information and experiences	2007	Swedish Board of Agriculture	N.E	N.E	N.E	N.E	N.E	N.E	N.E
Focus on nutrients advisory service	Agriculture	Nitrous oxide, methane and carbon dioxide	GHG emission reductions and energy efficiency	Information	Implemented	Initial focus on reduced nutrient leaching. Today, it also provides advice targeting GHG emission	2001	Swedish Board of Agriculture	N.E	N.E	N.E	N.E	N.E	N.E	N.E

Transport

Name of policy/measure	Sectors primarily affected	GHG(s) primarily affected	Primary objective	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing agency	Estimate of mitigation impact in Mt CO_2 eq per year compared with 1990 instruments[46]						
									2010	2015	2020	2025	2030	2040	2050
Energy tax, including stepwise increase of tax on diesel and petrol	Cross-sectoral	Carbon dioxide	Fiscal, and to improve efficiency of energy use	Economic	Implemented	The aim is mainly fiscal. It also steer energy usage towards Sweden's energy efficiency, renewability and climate targets	1924	Swedish Tax Agency	2	2	2.3	N.E	N.E	N.E.	N.E.
Carbon dioxide tax	Cross-sectoral	Carbon dioxide	Reduce use of fossil fuels	Economic	Implemented	Based on the fossil carbon content in the fuel	1991	Swedish Tax Agency							
Emission performance standards for new vehicles	Transport	Carbon dioxide	Reduce carbon dioxide emissions	Regulatory	Implemented	Manufacturers selling vehicles in the EU are subject to EU regulations that set emission performance standards	2015 (2017 and 2020)	Swedish Transport Administration	N.E	N.E	3	5	8	N.E	N.E.
CO_2-based vehicle tax	Transport	Carbon dioxide	Reduce carbon dioxide emissions	Economic	Implemented	All vehicles in the system are subject to a basic charge of SEK 360 per year. In addition, vehicles are subject to a CO_2 component depending on their level of CO_2 emissions per kilometer in mixed driving.	2006	Swedish Tax Agency							
Super-green car rebate (replaced by the bonus-malus system in 2018)	Transport	Carbon dioxide	Reduce carbon dioxide emissions	Economic	Expired	A subsidy aimed to contribute to technology development and to lower barriers for a large-scale introduction of environmental friendly cars	2012	Swedish Transport Agency							

Tax exemption for environmental friendly vehicles	Transport	Carbon dioxide	Reduce carbon dioxide emissions	Economic	Expired	Lower tax for vehicles with environmental friendly technology	2010	Swedish Tax Agency							
Reduced taxable values for some company cars with environmentally friendly technology	Transport	Carbon dioxide	Reduce carbon dioxide emissions	Economic	Implemented	To increase the incentive to purchase company cars that use environmental technologies, those who use green cars receive relatively favorable tax treatment	1990	Swedish Tax Agency							
Support for charging infrastructure	Transport	Carbon dioxide	Reduce carbon dioxide emissions	Economic	Implemented	Ensuring basic access to charging infrastructure for charging of electric vehicles	2020	Swedish Transport Administration	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Local climate investment program (Climate leap)	Transport	All	Enhance and speed reduction of greenhouse gas emissions	Economic	Implemented	Municipalities, companies, organisations and others can apply for investment support for measures to reduce climate impact	2015	Swedish Environmental Protection Agency	N.E.	N.E.	N.E.	N.E.	N.E	N.E.	N.E[49]
Support for research and demonstration	Transport	Carbon dioxide	Develop technology for sustainable growth and reduced fossil fuel dependence	Research, economic	Implemented	Swedish agencies are financing several large research projects covering the entire chain from cultivation of raw materials for bio- based motor fuels to the use of new fuels	N.d.	Vinnova and Swedish Energy Agency (mainly)	N.E	N.E	N.E	N.E.	N.E	N.E	N.E

[49] The program is expected to generate total reductions of 1.5 Mt CO2-eq. per year during the technical lifespan of the investments. 60% of these, i.e. 0.9 Mt CO2-eq. per year, are from the transport sector. The technical lifespan of the investments is in average 16 years.

Consideration of climate in long-term infrastructure planning	Transport	Carbon dioxide	Take environmental and climate issues into account in planning all modes of transport	Regulatory	Implemented	Planning is undertaken in dialogue with local and regional planning bodies with a requirement to take environmental and climate issues into account	2018	The Swedish Transport Administration	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Tax on air travel	Transport	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	A tax on commercial flights paid for passengers travelling from a Swedish airport	2018	Swedish Tax Energy	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Reduction obligation scheme for aviation*	Transport	Carbon dioxide	Reduce greenhouse gas emissions	Regulatory	Implemented	The level of renewable fuels was 0,8 percent in 2021 and will increase to 27 percent in 2030	2021	Swedish Energy Agency	N.E	N.E	N.E.	0.2	1[50]	1[51]	1.152 [52] (2045)
Differentiated take- off and landing fees for aviation*	Transport	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	The fees are differented according to environmental performance of the aircrafts	2021	Swedish Energy Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Aviation in the EU ETS	Transport	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	Aviation is included in the EU Emissions Trading System	2012	Swedish Environmental Protection Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E

[50] Domestic 0.1

[51] Domestic 0.1

[52] Domestic 0.1

Emission reduction obligation*[53]		Carbon dioxide	Reduce greenhouse gas emissions	Regulatory	Implemented	An obligation on petrol and diesel suppliers to reduce life-cycle carbon dioxide emissions, by gradually increasing blending with sustainable biofuels,	2018	Swedish Energy Agency	N.E	N.E	N.E	4.0	.4-6[54]	N.E	N.E.
Climate premiums for electrical buses, heavy-duty vehicles and working machinery	Transport	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	Regional public transport agencies, public transport companies, municipalities and limited companies are eligible to apply for climate premiums	2020	Swedish Energy Agency	N.E	N.E	N.E	N.E	N.E	N.E	N.E
Tax reduction for installation of green technology*	Transport	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	Private individuals are eligible to a tax reduction for installation of green technology	2021	Swedish Tax Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Eco-bonus system for heavy transport	Transport	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	Support aimed at stimulating the transfer of goods from road to shipping to reduce greenhouse gas emissions from heavy transport	2018	Swedish Transport Administration	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Environmental compensation for railway transport of goods	Transport	Carbon dioxide	Reduce greenhouse gas emissions	Economic	Implemented	Suport to stimulate railway transports of goods	2018	Swedish Transport Administration	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Congestion tax	Transport	Carbon dioxide	Reduce congestion	Economic	Implemented	The tax is levied during such hours and on such places where there is considered to be congestion	2007	Swedish Transport Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E

[53] The reduction obligation is today more ambitious then assumed in the projections in chapter 5.

[54] Including the effect from mobile machinery. The result is the additional effect compared to the development In the reference scenario in projections chapter.

Low emission zone	Transport	Carbon dioxide	Restrict traffic	Regulatory	Implemented	Restricting access to vehicles that don't meet specific requirements	2013 (2020 for cars)	Swedish Transport Agency	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
State co-financing for certain regional public transport facilities	Transport	Carbon dioxide	Support for infrastructure for public transport	Economic	Implemented	An investment support for infrastructure for regional public transport.	2009	Swedish Transport Administration	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Urban environmental agreements	Transport	Carbon dioxide	Reduce carbon dioxide emissions and incentivise building of public transport	Economic	Implemented	A scheme for investments in public transport, cycling infrastructure or sustainable freight transport at the regional and local level	2015	Swedish Transport Administration	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
National ticket system for public transport*	Transport	Carbon dioxide	Facilitate travel by public transport	Economic	Planned	The system will make it easier for travelers to choose to travel by public transport	2022	Swedish Transport Administration	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Conversion premium*	Transport	Carbon dioxide	Reduce emissions from cars	Economic	Planned	A conversion premium for cars from fossil fuels to biofuels or biogas	2022	Swedish Tax Energy	N.E	N.E	N.E	N.E	N.E	N.E	Conversion premium*
Night train traffic in Sweden and abroad*	Transport	Carbon dioxide	Replace travel by air and car	Economic	Adopted	Procurement of night train traffic through Sweden and Denmark	2022	Swedish Transport Administration	N.E	N.E	N.E	N.E.	N.E	N.E	N.E
Continued tax exemption for clean and highly mixed biofuels*	Transport	Carbon dioxide	Compensate for increased costs	Economic	Implemented	An exemption of the carbon and energy tax for biofuels are not considered compatible with the EU state aid rule why Sweden has sought a prolongation of an exemption	2020 (2021 for biogas)	Swedish Tax Energy	N.E	N.E	N.E	N.E	N.E	N.E	N.E

Waste

<table>
<tr><th rowspan="2">Name of policy/measure</th><th rowspan="2">Sectors primarily affected</th><th rowspan="2">GHG(s) primarily affected</th><th rowspan="2">Primary objective</th><th rowspan="2">Type of instrument</th><th rowspan="2">Status of implementation</th><th rowspan="2">Brief description</th><th rowspan="2">Start year of implementation</th><th rowspan="2">Implementing agency</th><th colspan="7">Estimate of mitigation impact in Mt CO2 eq per year compared with 1990 instruments[46]</th></tr>
<tr><th>2010</th><th>2015</th><th>2020</th><th>2025</th><th>2030</th><th>2040</th><th>2050</th></tr>
<tr><td>Landfill tax</td><td>Waste</td><td>Methane</td><td>Increase recycling and reduce total quantities of waste</td><td>Economic</td><td>Implemented</td><td>The tax has been increased gradually, and is today 555 SEK per tonne landfilled waste</td><td>2000</td><td>Swedish Tax Agency</td><td rowspan="4">1.4</td><td rowspan="4">1.7</td><td rowspan="4">1.9</td><td rowspan="4">2.0</td><td rowspan="4">2.2.</td><td rowspan="4">N.E.</td><td rowspan="4">N.E.</td></tr>
<tr><td>Bans on landfill of combustible waste (2002) and of organic waste (2005)</td><td>Waste</td><td>Methane</td><td>Improved landfill management, enhanced recycling, improved wastewater management systems</td><td>Regulatory</td><td>Implemented</td><td>Intended to prevent and reduce adverse effects on human health and the environment from landfilling.</td><td>2002</td><td>Swedish Environmental Protection Agency</td></tr>
<tr><td>Extended producer responsibility</td><td>Waste</td><td>Carbon dioxide</td><td>Increase resource efficiency</td><td>Regulatory</td><td>Implemented</td><td>Producer responsibility promotes sorting, collection and recycling of certain waste flows</td><td>1994</td><td>Swedish Environmental Protection Agency</td></tr>
<tr><td>Rules on municipal waste planning</td><td>Waste</td><td>Methane, Carbon dioxide</td><td>Increase resource efficiency</td><td>Regulatory</td><td>Implemented</td><td>A requirement that all the municipalities in Sweden must have their own municipal waste plan</td><td>1991</td><td>Swedish Environmental Protection Agency</td></tr>
</table>

Land use, Land use change and forestry (LULUCF)

Name of policy/measure	Sectors primarily affected	GHG(s) primarily affected	Primary objective	Type of instrument	Status of implementation	Brief description	Start year of implementation	Implementing agency	Estimate of mitigation impact in Mt CO2 eq per year compared with 1990 instruments[46]						
									2010	2015	2020	2025	2030	2040	2050
Provisions of Forestry Act	Forestry/ LULUCF	Carbon dioxide	Achieve environmental and production objectives for sustainable forest management	Regulatory	Implemented	Regulations concerning nature conservation and cultural heritage include not disturbing important biotopes, buffer zones and arable land, and leaving older trees, high stumps and dead wood in situ.	1993	Swedish Forest Agency	N.E	N.E	N.E	N.E	N.E	N.E	N.E
Provisions of Envionmental Code including land drainage	Forestry/ LULUCF	Carbon dioxide and methane	Biodiversity	Regulatory	Implemented	A coordinated, broad and strict piece of environmental legislation aimed at promoting sustainable development so that present and future generations can live in a good, healthy environment	1999	County administrative boards	N.E.	N.E	N.E	N.E	N.E	N.E	N.E
Provisions on nature reserves and habitat protection areas in Environmental Code, and nature conservation agreements	Forestry/ LULUCF	Carbon dioxide	Biodiversity	Regulatory	Implemented	The property owner and the state or a municipality agree on a certain financial compensation for the property owner, for example, to refrain from, for example, forestry	N.D	Swedish Environmental	N.E.	N.E	N.E	N.E	N.E	N.E	N.E
Swedish National Forest Program	Forestry/ LULUCF	Carbon dioxide	Increase the national supply of bio-based materials and energy	Information	Implemented	A broad dialogue on the role forests play to ensure a sustainable society and a growing bioeconomy	2018	Swedish Forest Agency	N.E.	N.E	N.E	N.E	N.E	N.E	N.E

Methods for increased carbon sinks*	Forestry/ LULUCF	Carbon dioxide	Promote forest growth and prevente damage	Information	Implemented	Develop methods for increased carbon sinks	2021	Swedish Forest Agency	N.E.	N.E	N.E	N.E	N.E	N.E	N.E
Support for re-wetting of wetlands	Forestry/ LULUCF	Carbon dioxie	Provide climate benefits and strengthen biodiversity	Economic, information	Implemented	Rewetting of drained wetlands on organic soils for purposes such as nutrient retention and biodiversity.	1990	Swedish Forest Agency	N.E.	N.E.	N.E.	N.E	0.08-0.18	0.08-0.18	N.E.

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5. Projections of greenhouse gas emissions and removals and total effect of policies and measures

This section presents projections of greenhouse gas emissions and removals for various sectors and in total[55]. The information is based on Sweden's report on projections submitted to the EU[56] in accordance with the requirements of the EU Regulation on Goverance of the Energy Union and Climate Action[57]. The projections with existing measures are based on the policies and measures adopted by the EU and the Riksdag (the Swedish Parliament) up to June 2020. The base-year for the projections is 2018[58].

Model-based calculations and, to some extent, expert evaluations were used to produce the projections. The projections are based on a number of assumptions, all of which are characterised by uncertainty. The results should be interpreted with this in mind. The projections can be mainly regarded as a consequential analysis of the assumptions made. The method for estimating the projections was mainly developed for medium-term or long-term projections, so the projections do not take into account shorter-term variations. However, the effects of the Covid-19 pandemic have partly been taken into account in the short term. For calculation assumptions and the methodology employed, see Annex 5.

In addition to the projections with existing measures, sensitivity projections have been calculated for emissions in the energy sector, for the road transportation sector and for the LULUCF sector. Projections with additional measures are not provided since there were no planned measures in Sweden when producing the projections. However, policies and measures are continuously developed and new measures have been adopted and planned since the projections were produced, see chapter 4.

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[55] All emissions and removals of greenhouse gases use global warming potentials from IPCC Forth Assessment Report (AR4)

[56] Ministry of the Environment. 2021.

[57] Regulation (EU) No 2018/1999.

[58] National Inventory Report Submission 2021 were used when producing the projections. For this Fifth Biennial Report the historical emissions and removals of greenhouse gases presented are based on National Inventpry Report Submission 2022.

5.1 Greenhouse gas emission projections

Total greenhouse gas emissions in Sweden in 2020[59] were 46.3 Mt CO_2-eq. (excluding The Land Use, Land Use Change and Forestry sector). Total emissions decreased by 25.2 million tonnes, or 35 %, between 1990 and 2020. The projection results point to a gradual decline in total emissions of greenhouse gases (excl. LULUCF) over the projection period. Projected emissions for 2030 are 39 % below 1990 levels, and by 2040 total emissions are projected to be 45 % below 1990 levels. See Table 5.1 and Figure 5.1.

The LULUCF sector contributed to an annual net removal of carbon dioxide in Sweden during the period 1990–2020 and is expected to continue to do so during the projection period.

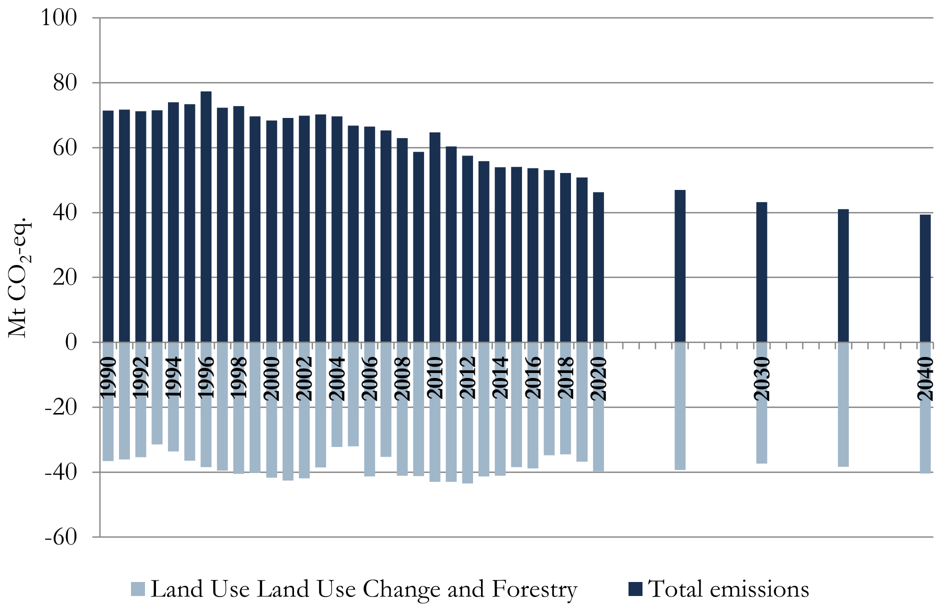

Figure 5.1 Historical and projected emissions and removals of greenhouse gases with existing measures (WEM).

Table 5.1 Historical and projected emissions and removals of greenhouse gases by sector (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Energy excl. transport	32.3	16.4	17.4	16.6	16.3	16.2	-49%	-50%

[59] National Inventory Report Sweden, Submission 2022

Transport	20.0	15.4	15.2	13.6	12.0	10.7	-31%	-46%
Industrial processes and product use	7.7	6.6	7.2	6.1	6.0	6.0	-20%	-22%
Agriculture	7.7	6.9	6.3	6.1	6.0	5.9	-20%	-22%
Waste	3.7	1.0	0.9	0.8	0.7	0.6	-79%	-83%
Total emissions	**71.4**	**46.3**	**47.0**	**43.2**	**41.0**	**39.4**	**-39%**	**-45%**
LULUCF	-36.6	-39.8	-39.3	-37.4	-38.4	-40.4	2%	10%

5.2 Projections by gas

In 2019, carbon dioxide emissions accounted for 79aro % of greenhouse gas emissions, while methane emissions accounted for around 9 %, nitrous oxide for around 10 % and fluorinated greenhouse gases for just over 2 %. Between 1990 and 2040, emissions of all gases are projected to decrease. See Table 5.2.

Table 5.2 Historical and projected emissions of greenhouse gases per gas (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	57.6	36.5	38.1	35.0	33.1	31.7	-39%	-45%
Methane	7.4	4.1	3.6	3.4	3.2	3.1	-55%	-58%
Nitrous oxide	5.8	4.6	4.5	4.4	4.3	4.3	-24%	-26%
HFC	0.006	0.9	0.7	0.5	0.3	0.3	7011%	4282%
PFC	0.6	0.07	0.04	0.04	0.04	0.04	-92%	-92%
SF_6	0.1	0.04	0.03	0.03	0.03	0.02	-71%	-76%
Total emissions (excl. LULUCF)	**71.4**	**46.3**	**47.0**	**43.2**	**41.0**	**39.4**	**-39%**	**-45%**

5.3 Projections by sector

In the projections, the emissions from all sectors are decreasing until 2040. The largest reduction is projected for the energy and transport sectors, see z

Figure 5.2 Historical and projected emissions of greenhouse gases by sector.

5.3.1 Energy industries (Electricity- and heat production, Refineries, Manufacturing of solid fuels)

Emissions from energy industries, i.e. production of electricity and district heating, refineries and the manufacturing of solid fuels, are projected to decrease slightly to 2040. However, projections for subsectors show differing trends.

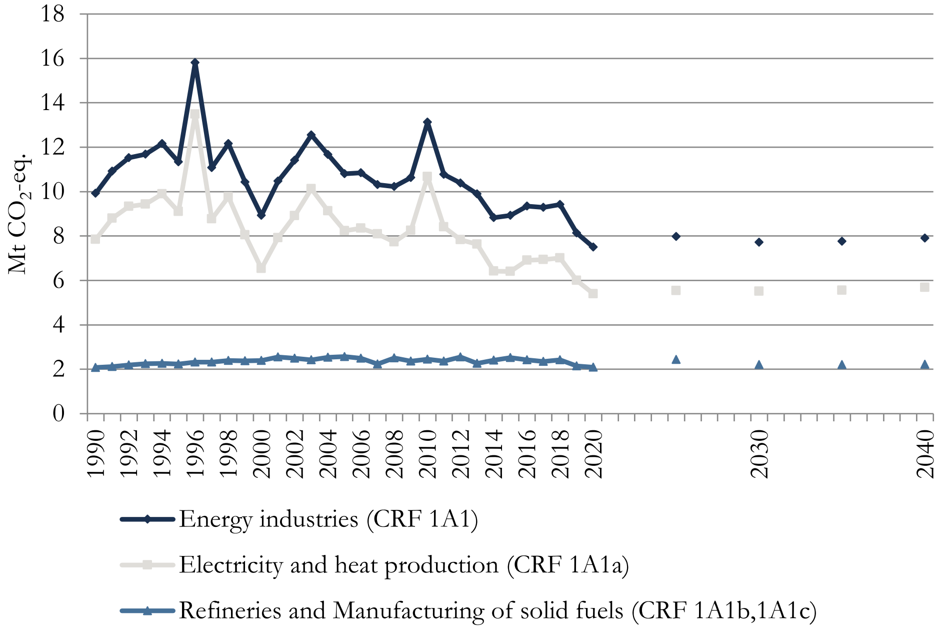

Figure 5.3 Historical and projected emissions of greenhouse gases from energy industries.

Emissions of greenhouse gases from electricity and heat production have varied since 1990, mainly due to temperature variations and precipitation. The production of electricity is expected to increase during the projection period while the productions of district heating is expected to remain stable.. However, emissions do not increase to the same extent as production, mainly due to biofuels and incineration of waste and also increased use of wind and solar power. Emissions are projected to decrease and then stabilize, see Table 5.3 and Figure 5.3. An increased use of waste contributes to the increase in emissions, but this increase is partly offset by increased use of biomass and wind and solar power, as well as decreased use of oil and coal. Production of electricity is assumed to grow more than consumption, resulting in a projected export of about 40 TWh by 2040.

Table 5.3 Historical and projected emissions of greenhouse gases from electricity and heat production (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	7.7	5.2	5.3	5.3	5.3	5.4	-31%	-29%
Methane	0.02	0.05	0.05	0.04	0.04	0.04	159%	173%
Nitrous oxide	0.1	0.2	0.2	0.2	0.2	0.2	59%	68%
Total emissions	**7.8**	**5.4**	**5.5**	**5.5**	**5.6**	**5.7**	**-30%**	**-28%**

Emissions from refineries and manufacturing of solid fuels are projected to increase slightly during the projection period, see Table 5.4 and Figure 5.3. The emissions from refineries are expected to continue to increase slightly until 2040, compared to the 1990 level. The emissions from refineries are also accounted for in the sector of fugitive emissions. The emissions from manufacturing of solid fuels are estimated to remain stable until 2025 and then decrease due to an assumed shift to fossil free technology.

Table 5.4 Historical and projected emissions of greenhouse gases from refineries and manufacturing of solid fuels (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	2.1	2.1	2.4	2.2	2.2	2.2	6%	7%
Methane	0.001	0.001	0.001	0.001	0.001	0.001	-8%	-8%
Nitrous oxide	0.001	0.001	0.001	0.001	0.001	0.001	-25%	-24%
Total emissions	**2.1**	**2.1**	**2.4**	**2.2**	**2.2**	**2.2**	**6%**	**7%**

5.3.2 Residential and commercial/institutional

Emissions from households and premises and from combustion in the agricultural, forestry and fishing sectors are projected to continue to decrease, see Table5.5 and Figure 5.4. This decline is mainly due to a continuing replacement of individual oil-fuelled boilers for heating and hot water purposes in households and premises with district heating, electric heating, heat pumps and biomass. The shift to electric and district heating results in decreased emissions in this sector. However, since the increased production of electricity and heat is mainly based on wind power, biomass and waste, and with district heating being a more efficient way of heating, emissions on the whole still decrease.

Total emissions from combustion in the agricultural, forestry and fishing sectors are projected to decrease during the projection period. Emissions from energy consumption in the agricultural sector are expected to decrease to some extent during the projection period, due to a reduction in the use of diesel fuel for working machinery and a reduction in oil consumption for buildings. Emissions from working machinery in the forestry sector and from fishing are assumed to remain at about the same level during the entire projection period.

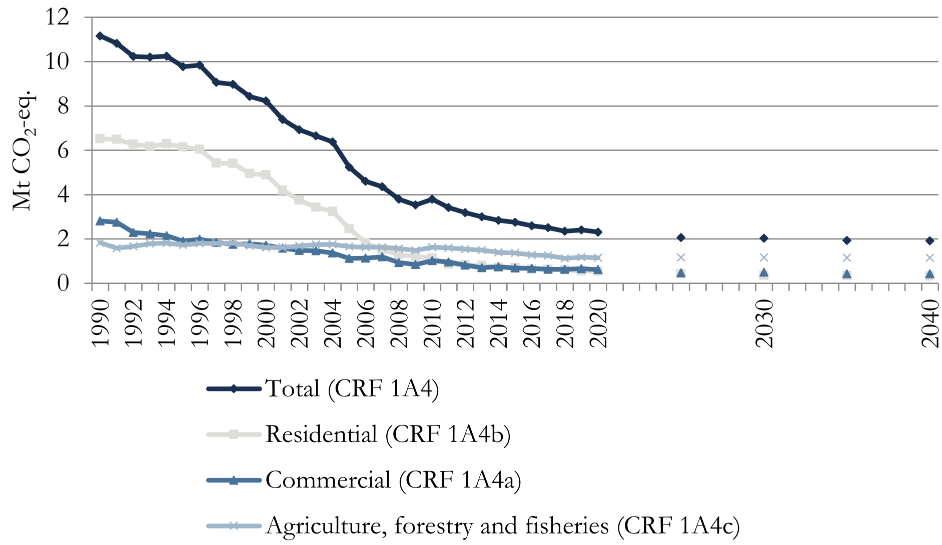

Figure 5.4 Historical and projected emissions of greenhouse gases from combustion in households, premises, agriculture, forestry and fisheries.

Table 5.5 Historical and projected emissions of greenhouse gases from residential and commercial sectors (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	10.9	2.2	1.9	1.9	1.8	1.8	-83%	-83%
Methane	0.1	0.06	0.05	0.05	0.04	0.04	-57%	-69%
Nitrous oxide	0.2	0.1	0.1	0.1	0.1	0.1	-51%	-57%
Total emissions	**11.2**	**2.3**	**2.1**	**2.0**	**1.9**	**1.9**	**-83%**	**-83%**

5.3.3 Industrial combustion

To cover all industry-related emissions, it is necessary to take account of process emissions, emissions from combustion, part of energy industries and fugitive emissions, which according to UNFCCC guidelines are to be reported under separate CRF (Common Reporting Format) categories.

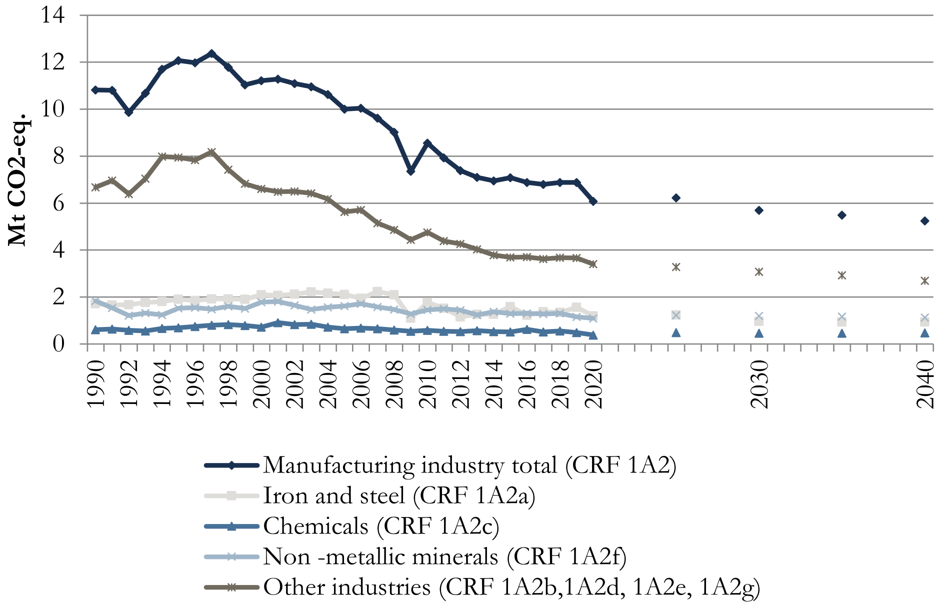

Figure 5.5 Historical and projected emissions of greenhouse gases from combustion in manufacturing industries.

Emissions from combustion in manufacturing industries are projected to decrease to 2040, because the use of biofuel and electricity is expected to increase more than the use of fossil fuels, see Table 5.6 and Figure 5.5. This decrease in emissions is mainly due to a shift in the pulp and paper industry from using fossil fuels to using biofuels. Emissions from the mineral industry are also expected to decrease, while emissions from the chemical industry and the iron and steel industry remain relatively stable in the projection.

Table 5.6 Historical and projected emissions of greenhouse gases from combustion in manufacturing industries (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	10.7	5.9	6.0	5.5	5.3	5.1	-48%	-52%
Methane	0.02	0.02	0.03	0.03	0.03	0.03	13%	16%
Nitrous oxide	0.1	0.1	0.1	0.1	0.2	0.2	8%	10%

Total emissions	**10.8**	**6.1**	**6.2**	**5.7**	**5.5**	**5.2**	**-47%**	**-52%**

5.3.4 Fugitive emissions

The majority of fugitive emissions originate from refineries. Emissions are assumed to remain at the same level during the projections period, see Table 5.7.

Table 5.7 Historical and projected emissions of greenhouse gases from fugitive emissions (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	0.3	0.4	0.9	1.0	1.0	1.0	165%	170%
Methane	0.1	0.04	0.06	0.06	0.06	0.06	-25%	-25%
Nitrous oxide	0.001	0.001	0.001	0.001	0.001	0.001	4%	4%
Total emissions	**0.4**	**0.5**	**0.9**	**1.0**	**1.0**	**1.0**	**128%**	**133%**

5.3.5 Industrial processes and product use

The industrial processes and product use sector contributes with greenhouse gas emissions from the materials used in industrial processes and the use of solvents and other products, including the use of fluorinated greenhouse gases.

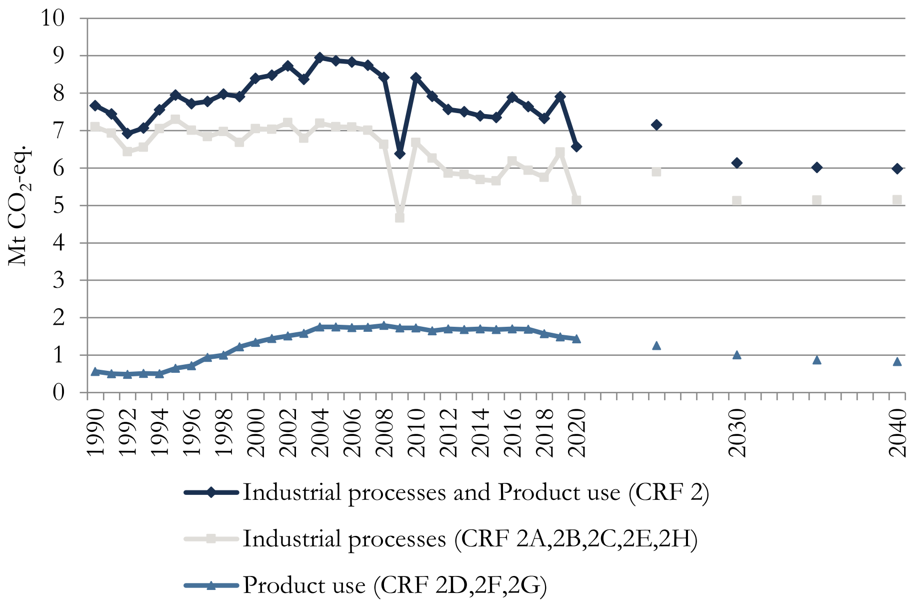

Figure 5.6 Historical and projected emissions of greenhouse gases from industrial processes and product use.

Greenhouse gas emissions from industrial processes and product use are projected to decrease slightly to 2040, see Table 4.8 and Figure 4.6. This decrease is due to a decrease in emissions of fluorinated greenhouse gases but also a decrease in emissions from carbon dioxide are expected after 2030..

Carbon dioxide emissions are expected to decrease to 2040. The decrease is mainly due to a decrease in emissions from the metal industry until 2040 and especially after 2030, due to a shift to fossil-free technology in a part of the iron and steel industry. The emissions of carbon dioxide from the mineral industry are expected to slightly increase until 2040 compared with 1990 due to a projected continuing increase in constructing new buildings. The emissions of greenhouse gases from chemical industry are assumed to remain around the same level as in 2019. The emissions from fuel combustion in industry are reported in the energy.

Emissions of fluorinated greenhouse gases are expected to decrease to 2040 due to a ban on their use that resulted from EU regulations.

Table 5.8 Historical and projected emissions of greenhouse gases from industrial processes and product use sector (million tonnes CO_2-equivalents).

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	6.0	5.3	6.2	5.4	5.4	5.4	-10%	-10%
Methane	0.03	0.01	0.01	0.01	0.01	0.01	-65%	-66%
Nitrous oxide	1.0	0.2	0.2	0.2	0.2	0.2	-78%	-79%
Fluorinated greenhouse gases	0.7	1.0	0.8	0.5	0.4	0.4	-21%	-48%
Total emissions	**7.7**	**6.6**	**7.2**	**6.1**	**6.0**	**6.0**	**-20%**	**-22%**

5.3.6 Domestic transport

Emissions from domestic transport, especially from road transport, are projected to decrease to 2040 for several reasons, see Table 5.9, Table 5.10 and Figure 5.7. The decrease in emissions is mainly due to large reductions from cars. One reason for this decrease is an ongoing improvement of energy efficiency due to EU CO_2 requirements that limits the emissions from new cars, heavy duty and light-duty lorries. Another reason for the decrease is a greater use of biofuels. It is in particular the obligatory low-blend of biofuels in petrol and diesel by which suppliers must reduce carbon dioxide emissions.

Emissions from domestic aviation have decreased in recent years, mostly due to higher efficiency. In the projection, travel is assumed to increase from today's level over the entire projection period, resulting in increasing emissions. Emissions from domestic navigation have varied between 0.5 and 0.7 Mt CO_2-eq. Emissions are assumed to be around 0.7 million tonnes until 2040. Emissions from railways are low during the projection period.

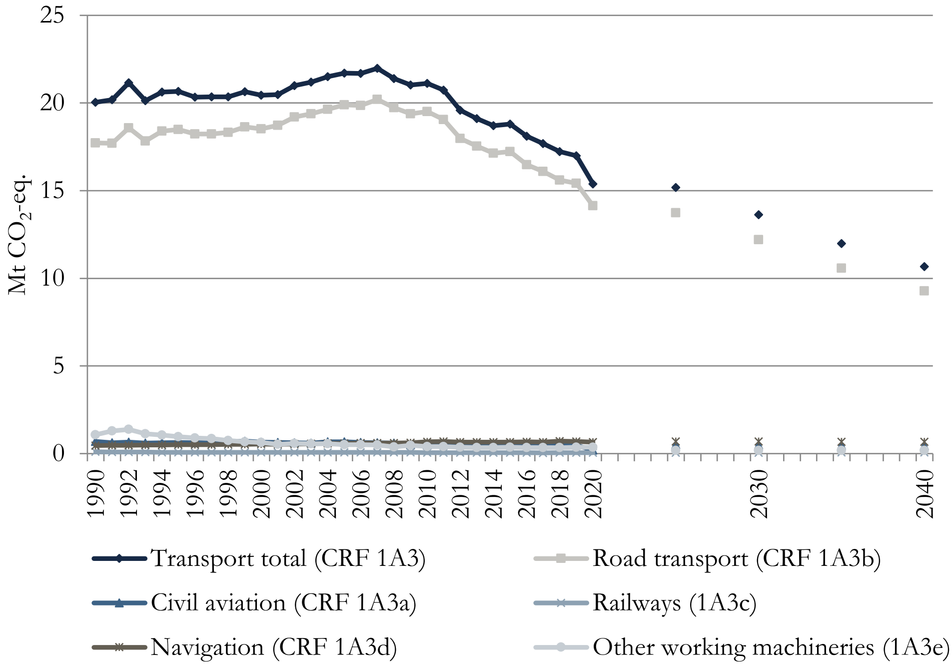

Figure 5.7 Historical and projected emissions of greenhouse gases from the domestic transport sector.

Table 5.9 Historical and projected emissions of greenhouse gases from different transport modes (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Road transportation	17.7	14.1	13.7	12.2	10.6	9.3	-31%	-48%
Civil aviation	0.7	0.2	0.5	0.5	0.5	0.5	-28%	-34%
Navigation	0.5	0.7	0.7	0.7	0.7	0.7	50%	44%
Railways	0.1	0.04	0.06	0.06	0.06	0.07	-43%	-36%
Other*	1.1	0.4	0.4	0.4	0.4	0.4	-67%	-67%

Table 5.10 Historical and projected emissions of greenhouse gases from domestic transport (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	19.7	15.2	14.9	13.4	11.7	10.4	-31%	-46%
Methane	0.2	0.05	0.04	0.04	0.04	0.04	-78%	-79%
Nitrous oxide	0.2	0.2	0.2	0.2	0.2	0.2	24%	15%
Total emissions	**20.0**	**15.4**	**15.2**	**13.6**	**12.0**	**10.7**	**-31%**	**-46%**

5.3.7 Waste

Methane emissions from landfill are projected to decrease by 96 % to 2040 compared to 1990, see Table 4.11 and Figure 4.8. This decrease is mainly due to a ban, from 2002, on depositing combustible materials in landfills and a ban, from 2005, on depositing organic materials in landfill. Furthermore, a tax on depositing waste in landfill was introduced in 2000.

Emissions of carbon dioxide from waste incineration and nitrous oxide from wastewater treatment are low and are expected to remain stable during the entire projection period. However, emissions of nitrous oxide and methane from biological treatment of solid waste are expected to increase slightly during the period, due to increased production of biogas.

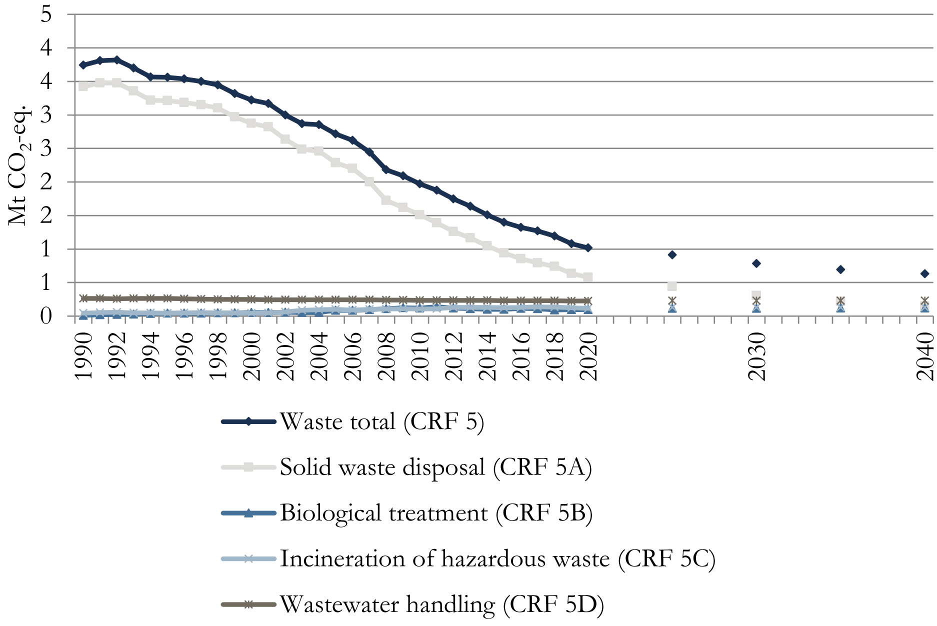

Figure 5.8 Historical and projected emissions of greenhouse gases from the waste sector.

Table 5.11 Historical and projected emissions of greenhouse gases from the waste sector (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	0.04	0.1	0.1	0.1	0.1	0.1	189%	189%
Methane	3.5	0.7	0.6	0.4	0.3	0.3	-88%	-92%
Nitrous oxide	0.2	0.2	0.2	0.2	0.2	0.2	0%	0%
Total	**3.7**	**1.0**	**0.9**	**0.8**	**0.7**	**0.6**	**-79%**	**-83%**

5.3.8 Agriculture

Greenhouse gas emissions from agriculture have decreased since 1990, mainly due to improved production efficiency and fewer cattle. This in turn has led to lower methane emissions from the digestion process in ruminant animals and reduced emissions of methane and nitrous oxide from manure. Emissions of nitrous oxide from agricultural land have also declined as a result of reduced cereal acreage, reduced use of fertilizers, reduced nitrogen leaching and a transition from solid manure to slurry management.

Emissions from agriculture are estimated to decrease as a result of a continuously declining cattle population, see Table 5.12, Table 5.13 and Figure 5.9. The reduced numbers of dairy cows until 2040 are primarily a result of increased productivity, product pricing mechanisms and continuous adaptation to EU agricultural policy regulations.

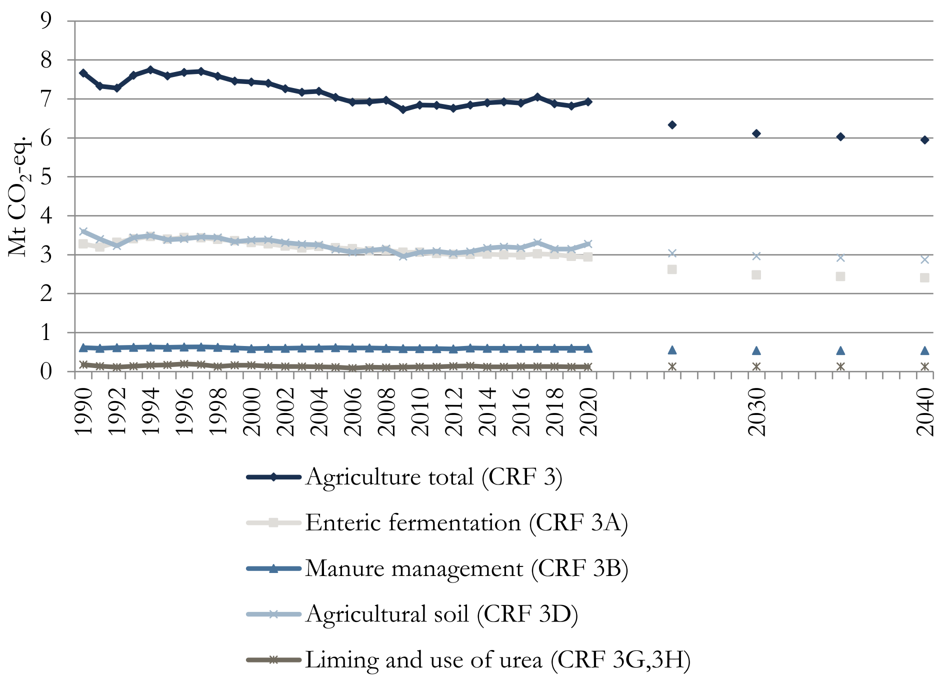

Figure 5.9 Historical and projected emissions of greenhouse gases from agriculture.

Table 5.12 Historical and projected emissions of greenhouse gases from agriculture per gas (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Methane	3.5	3.2	2.9	2.7	2.7	2.6	-23%	-25%
Nitrous oxide	4.0	3.6	3.3	3.3	3.2	3.2	-18%	-20%
Carbon dioxide	0.2	0.1	0.1	0.1	0.1	0.1	-29%	-29%
Total emissions	**7.7**	**6.9**	**6.3**	**6.1**	**6.0**	**5.9**	**-20%**	**-22%**

Table 5.13 Historical and projected emissions of greenhouse gases from agriculture (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Enteric fermentation	3.3	2.9	2.6	2.5	2.4	2.4	-24%	-27%
Manure management	0.6	0.6	0.6	0.5	0.5	0.5	-12%	-12%
Agricultural land	3.6	3.3	3.0	3.0	2.9	2.9	-18%	-20%
Liming/Use of urea	0.2	0.1	0.1	0.1	0.1	0.1	-29%	-29%
Total emissions	**7.7**	**6.9**	**6.3**	**6.1**	**6.0**	**5.9**	**-20%**	**-22%**

5.3.9 Land use, Land Use Change and Forestry (LULUCF)

The LULUCF sector contributed to the total greenhouse gas budget with an annual net removal of greenhouse gases in Sweden during the period 1990–2020. Net removals for LULUCF are expected to increase to 2040, see Table 5.14, Table 5.15 and Figure 5.10. This trend is mainly due to a increase in removals from forest land. The projections for removals of carbon dioxide from forest land is based on the assumption that the current harvest intensity (2015-2019) persist over time and a climate effect which gives a positive effect on the annual gross increment.

The projections are based on a number of assumptions which are characterised by uncertainties. A sensitivity analysis has been performed for the LULUCF projection, simulating forest land using the same settings but without the climate effect which gives a positive effect on the annual gross increment. The net removals for the LULUCF-sector are instead projected to decrease to 2040. See also section 5.6.

Net emissions from cropland have varied during the period 1990–2020. The emissions are projected to decrease slightly based on a projected slight decrease in area and the average net emissions per area for the latest ten years.Net emissions from settlements are caused by felling due to urbanisation and the establishment of power lines and forest roads. These emissions are projected to be at the same level for the entire projection period as the average for the last ten years. The carbon stock changes in grassland and wetlands were small during the period 1990–2020 and are projected to stay low during the projection period.

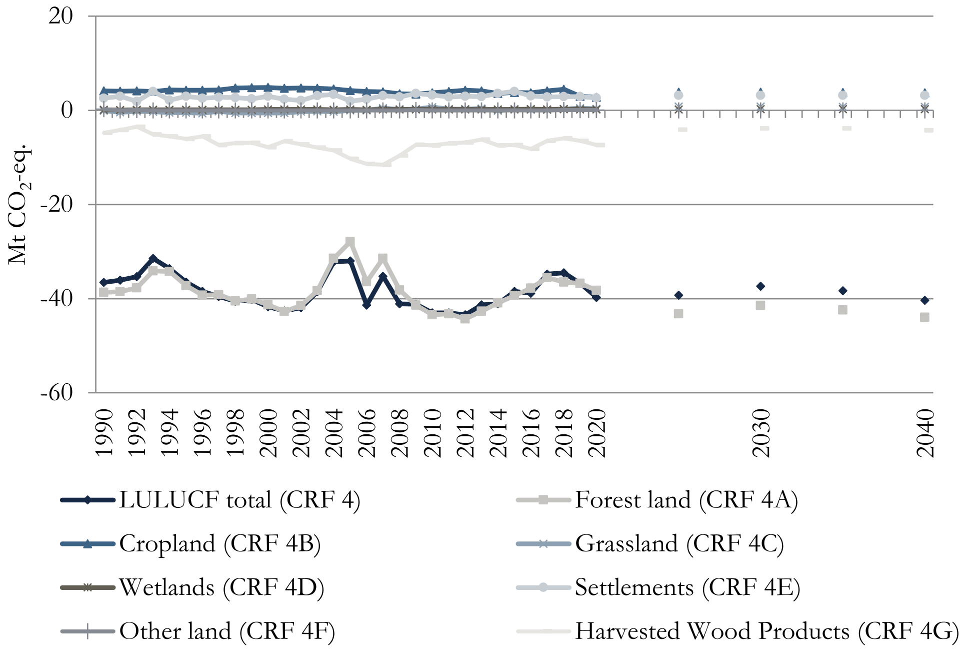

Figure 5.10 Emissions (+) and removals (-) from the LULUCF sector and its subcategories in Mt CO2-equivalents per year.

Table 5.14 Historical and projected emissions (+) end removals (-) of greenhouse gases from LULUCF (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Forest land	-38.7	-37.8	-43.2	-41.5	-42.4	-44.0	7%	14%
Cropland	4.1	2.8	3.9	3.8	3.8	3.7	-7%	-10%
Grassland	0.1	0.3	0.8	0.8	0.8	0.7	413%	397%
Wetlands	0.1	0.2	0.2	0.2	0.2	0.3	181%	216%
Settlements	2.6	2.6	3.2	3.2	3.2	3.2	23%	23%
Other land	0.2	-0.02	-0.005	-0.005	-0.005	-0.005	-102%	-102%
HWP	-4.8	-7.4	-4.1	-3.9	-3.8	-4.3	-20%	-11%
Total net removals	**-36.6**	**-39.8**	**-39.3**	**-37.4**	**-38.4**	**-40.4**	**2%**	**10%**

Table 5.15 Historical and projected emissions (+) end removals (-) of greenhouse gases from LULUCF per gas (Mt CO_2-eq.)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Carbon dioxide	-38.3	-41.5	-37.4	-40.9	-38.9	-41.9	2%	10%
Methane	0.5	0.4	0.4	0.4	0.4	0.4	-9%	-11%
Nitrous oxide	1.2	1.3	1.1	1.1	1.1	1.1	-5%	-6%
Total net removals	**-36.6**	**-39.8**	**-39.3**	**-37.4**	**-38.4**	**-40.4**	**2%**	**10%**

5.3.10 International transport

Emissions from bunkers for international transport are projected to increase to 2040, mainly due to increased emissions from international aviation, see Table 5.16 and Figure 5.11. This increase is explained by an expected increase in private consumption during the projection period, resulting in increased number of passengers.

The increased use of fuel for international navigation is due to an increase in passenger traffic, growth in exports of goods and increased refuelling in Sweden. The projection is based on the assumption that transport volumes will increase as transportation becomes more efficient. This leads to projected emissions from international navigation at about the same level during the projection period. The number of international bunkers counted in Sweden also depends largely on where international ships and airplanes choose to refuel.

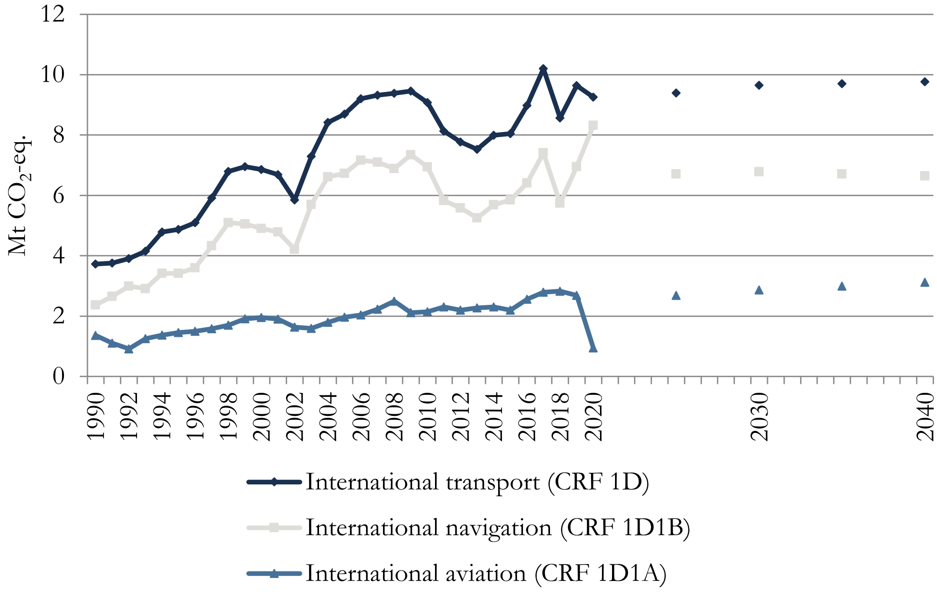

Figure 5.11 Historical and projected emissions of greenhouse gases from international bunkers.

Table 5.16 Historical and projected emissions of greenhouse gases from international bunkers (million tonnes CO_2-equivalents)

	1990	2019	2025	2030	2035	2040	1990-2030	1990-2040
Navigation	2.4	8.3	6.7	6.8	6.7	6.6	186%	180%
Aviation	1.4	0.9	2.7	2.9	3.0	3.1	111%	130%
Total emissions	**3.7**	**9.3**	**9.4**	**9.6**	**9.7**	**9.8**	**159%**	**162%**

5.4 Sensitivity analysis

Sensitivity calculations were produced by varying some parameters in the energy sector (incl. transport) and some in the transport sector. Aggregated for all sectors, the sensitivity calculations show that the emission level in 2040 may be 40 to 46 % lower than 1990 levels, depending on the sensitivity projection, see Table 5.17. However, this does not include uncertainty in the calculations, which may expand the percentage span between the projections.

Table 5.17 Historical and projected total emissions of greenhouse gases for different projections in the sensitive analysis excl. LULUCF (million tonnes CO_2-equivalents)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Projections WEM	71.4	46.3	47.0	43.2	41.0	39.4	-39%	-45%
Energy sector including transport								
Projection "Lower fossil fuel prices"			48.1	43.9	42.8	42.5	-38%	-40%
Projection "Lower GDP"			46.9	42.9	40.4	38.6	-40%	-46%
Transport sector								
Projections "Lower mileage"			46.9	42.9	40.6	38.9	-40%	-45%

Two sensitivity projections were calculated for the energy sector including transport: one projection with 30 % lower fossil fuel prices and one with 30 % lower economic growth than in the reference projections. Lower fossil fuel prices also result in higher economic growth than in the reference projections. All other assumptions are identical to the assumptions in the reference projection.

Results of the sensitivity projections show that the projection with lower fossil fuel prices results in higher emissions in 2040 compared to the reference projection, as expected. A lower fossil fuel price decreases the incentive to replace fossil fuels and increase energy efficiency in industry, giving higher emissions in the transport sector.

The projection with lower economic growth than in the reference projection results in lower emissions in the energy and transport sectors compared to the reference projection. The main reason for the decreased emissions is a lower energy demand, due to lower production in the industrial sector. Lower economic growth leads to a lower demand for the transportation of both goods and people.

For the road transportation sector, a projection with lower mileage were performed separatelyAll other assumptions are identical to the ones in the reference projections. In the projection, mileage is assumed to be 10 %

lower in 2040 compared to the reference projection. Results show that the projections with lower mileage result in reductions in emissions.

5.4.1 Sensitivity calculations for the LULUCF-sector

The projections for the LULUCF-sector is based on a number of assumptions which are characterised by uncertainties. The result should be interpreted with that in mind. A sensitivity projection has been calculated for the LULUCF sector. In the reference projections a positive climate effect which gives a positive effect on the annual gross increment by 21 % 2070-2100 compared to 1970-2000 was included for forest management and HWP. In the sensitivity projections no positive climate effect is included. All other assumptions are identical to the ones in the reference projection.

The calculations of the sensitivity projections show that the projection with no climate effect results in a decrease in net removals until 2040 instead of an increase as in the reference projection. The emissions are projected to be around 30 million tonnes in 2040 which is about 11 million tonnes lower compared to the reference projection with climate effect.

Table 5.18 Historical and projected emissions and removals of greenhouse gases for different projections in the sensitive analysis for the LULUCF sector (Mt CO_2-eq.)

	1990	2020	2025	2030	2035	2040	1990-2030	1990-2040
Total LULUCF with climate effect	-36.6	-39.8	-39.3	-37.4	-38.4	-40.4	2%	11%
Total LULUCF without climate effect	-36.6	-39.8	-35.4	-30.3	-30.7	-29.1	-17%	-20%

5.5 Comparison with the Seventh National Communication

The projections presented in 2018 in Sweden's Seventh National Communication (NC7) were based on the inventory submission of 2017. The projections presented in this report are based on the inventory submission of 2022.

The projections presented in 2018 in Sweden's Seventh National Communication and Third Biennial Report (BR3) showed reductions in total greenhouse gas emissions of 35 % between 1990 and 2030. The projections set out here, in the Eighth National Communication (NC8) and the Fifth Biennial Report (BR5), uses partly different assumptions and assessments based on trends over the last few years, see Table 5.18. The new projections show a decrease in total greenhouse gas emissions of 39 % between 1990 and 2030. A comparison of percentage changes in emissions overall and by sector is shown in Figure 5.12.

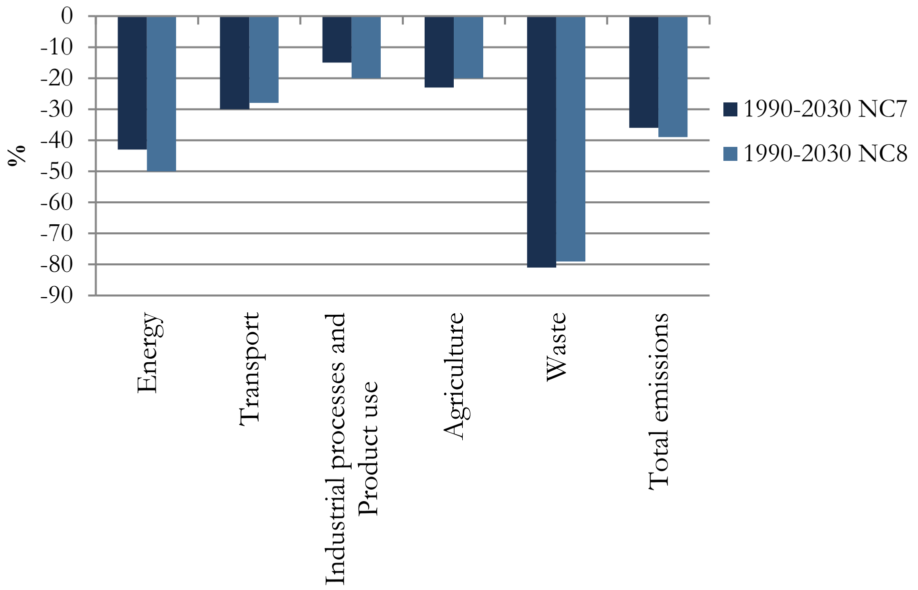

Figure 5.12 Percentage changes in emissions between 1990 and 2030 respectively as projected in NC7 and NC8, overall and by sector.

The projections presented here indicate a larger reduction of emissions by 2030 for some sectors compared with those in NC7. The difference is mainly due to differing assumptions, for instance regarding fossil fuel prices, and assumptions based on the trend over the last few years.

Table 5.19 Key assumptions in the Seventh and Eighth National Communication

	NC7	NC8
	2013-2035	**2015-2035**
GDP (annual change %)	2.28	1.72
	2030 *(2013 prices)*	**2030** *(2016 prices)*
Price of crude oil (USD/barrel)	117	89
Price of coal (USD/tonne)	110	86

Price of natural gas (USD/MBtu)	12	6
Emissions trading (Euro/tonne CO_2)	42	30
Electricity prince (SEK/kWh)	0.53	0.33
Electricity certificates (new renewable electricity compared with 2012)	28.4 TWh by 2020	28.4 TWh by 2020

5.6 Assessment of aggregate effects of policies and measures

This section describes the overall effects of the instruments introduced since 1990 and reported and quantified in Chapter 4. Table 5.19 presents the aggregate effects of the instruments implemented, for which estimates have been made.

Table 5.20 Estimated effects of economic instruments implemented, by sector (million tonnes CO_2 equivalent/ year) (summary of account in Chapter 4)

Sector	2015	2020	2020	2030	2035
Electricity and district heating	14,8	15,5	15,1	6,2	3,2
Residential and service sector	1,0	1,1	1,0	1,0	1,0
Industry	-0,5	-0,1	0,2	0,5	0,7
Transport	2,0	5,5	10,0	14,0	16,6
Waste	1,7	1,9	2,0	2,2	2,3
Total	19,0	23,9	28,3	23,9	23,8

*Depending on the success of BECCS.

Further, the table includes only the policies and measures for which effects per year have been estimated. Other policies and measures presented in chapter 4 also affect the emissions.

5.7 Progress towards targets under the UNFCCC, the Kyoto protocol and the EU

The EU submitted a pledge in 2010 to reduce GHG emissions by 20 % compared with 1990 levels by 2020. Because this target under the Convention was only submitted by the EU and its 28 Member States together (EU-28) and not by each Member State, there are no specified Convention targets for individual Member States. For this reason, Sweden, as part of the EU-28, takes on a quantified economy-wide emission reduction target jointly with all other Member States. (For more information see Sweden’s fifth Biennial Report chapter 2) In addition to the Convention target, the EU and its Member States have a commitment under the Kyoto protocol for the period 2013–2020.

For the EU as a whole, the Kyoto commitment is the same as the Convention target except that it also includes LULUCF (excluding aviation emissions). This means that the Swedish part and the EU jointly commitment is the same as under the Convention (-17% under ESD). Together with the ESD target Sweden will account for the mandatory parts in article 3.3 and 3.4 in the Kyoto Protocol for LULUCF. Sweden has chosen commitment period accounting. The Swedish commitment under the Kyoto Protocol is explained in the Swedish Initial report for the second commitment period.

5.7.1 Sweden’s commitment according to the Effort Sharing Decision

Under the EU Climate and Energy Package, greenhouse gas emissions from the EU are to be reduced by 20 % compared with 1990 by 2020. Emissions from installations included in the EU Emissions Trading System (EU ETS) are to fall by 21 % between 2005 and 2020 for the EU as a whole. Emissions not covered by the trading system are to be reduced in line with the Effort Sharing Decision (ESD) (EU Decision 406/2009/EC). For Sweden, this decision means that emissions must decrease by 17 % between 2005 and 2020, in line with a target emissions trajectory. This means that the ESD emissions must decrease linearly from 41.7 Mt in 2013 to 36.1 Mt in 2020[60].

Furthermore, Sweden can use credits from international project activities to meet the target. The annual use is restricted to 3 % of 2005 emissions[61], which equals 10.9 million tonnes for the entire period 2013–2020. In addition, 1 % of 2005 emissions can be used in international projects fulfilling certain requirements. This corresponds to 3.6 million additional tonnes for the entire period 2013–2020. The maximum possible annual use of international credits thus amounts to a maximum of 1.8 million tonnes. A Member State may transfer up to 5 % of their allocated Annual Emissions Allocations (AEA) for a given year to other Member States. Furthermore, 5 % of the own AEAs can be carried over from the following year, and if there is a surplus of allowances it can be banked to following years or transferred to other Member States.

[60] In 2017 the target for 2020 was adjusted from 37.2 to 36.1 million, because the historical emissions are lower due to methodological changes. Commission Decision 2017/1471 amending decision 2013/162/EU to revise Member States’ annual emissions allocations for the period from 2017 to 2020.

[61] According to National Inventory Report submission 2012

For the years 2013-2019, Sweden's ESD-emissions have been lower than the ESD-targets, see Figure 5.13. The surplus amount of AEAs was over 5 million tonnes per year compared to the Swedish ESD target, see Table 5.20. The surplus for 2013-2018 was deleted. The government has proposed to the Swedish Parliament that also the surplus for 2019 should be deleted. Compliance for 2019 is planned to be performed in 2022.

The target for Sweden is set to 36.1 Mt CO_2-eq. in 2020 (EU Decision C(2013)1708). ESD emissions were 29.6 million tonnes in 2020. The overachievement in 2020, compared to the Swedish target, is estimated to be over 6 million tonnes, without the use of international credits. Note that these figures are preliminary and compliance are planned to be performed in 2023 after review.

Table 5.20 Sweden's historical and projected emissions of greenhouse gases (based onNational Inventory Report submission 2017) presented as total emissions, ETS emissions, CO_2-emissions from domestic aviation and emissions covered by the Effort Sharing Decision (ESD) in relation to ESD target (scope 2013-2020, excl. aviation). (million tonnes CO_2-equivalents)

	2013	2014	2015	2016	2017	2018	2019	2020	2030	2040
Total emissions	55.8	53.9	54.1	53.7	53.1	52.2	50.8	46.3	46.2	39.1
ETS emissions	20.1	19.3	19.2	19.7	19.6	19.9	19.8	16.5	16.6	16.2
Domestic aviation	0.5	0.5	0.5	0.5	0.5	0.5	0.5	0.2	0.5	04
ESD emissions[62] [63]	35.2	34.1	34.4	33.4	32.9	31.8	31.6	29.6	26.1	22.5
ESD target[64]	41.7	41.0	40.4	39.8	37.8	37.2	36.7	36.1		

[62] ESD emissions include emissions that are covered by the Effort Sharing Decision and are calculated as total emissions excl. LULUCF minus CO_2 emissions from domestic aviation minus emissions from EU ETS.

[63] Historical emissions are presented according to National Inventory Report submission 2022. The ESD emissions for compliance are based on relevant submission and the ESD-emissions in 2013 according to submission 2016 were 35.3 Mt CO_2-eq. which means a surplus of 6.4 million AEAs deleted. Emissions in 2014 were 34.5 Mt CO_2-eq. (sub 2016) a surplus of 6.5 million AEAs was deleted. Emissions in 2015 were 33.9 Mt CO_2-eq. (sub2017), a surplus of 6.5 million AEAs deleted. Emissions in 2016 were 32.6 Mt CO_2-eq. (sub2018), a surplus of 7.2 million AEAs was deleted. Emissions in 2017 were 32.5 Mt CO_2-eq. (sub2019), a surplus of 5.3 million AEAs was deleted. Emissions in 2018 were 31.4 Mt CO_2-eq. (sub2020), a surplus of 5.8 million AEAs was deleted. Emissions in 2019 were 31.7 Mt CO_2-eq. (sub2021), a surplus of 5.0 million AEAs is planned to be deleted.

[64] According to the revised targets in EU decision C(2013) 1708 on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC.

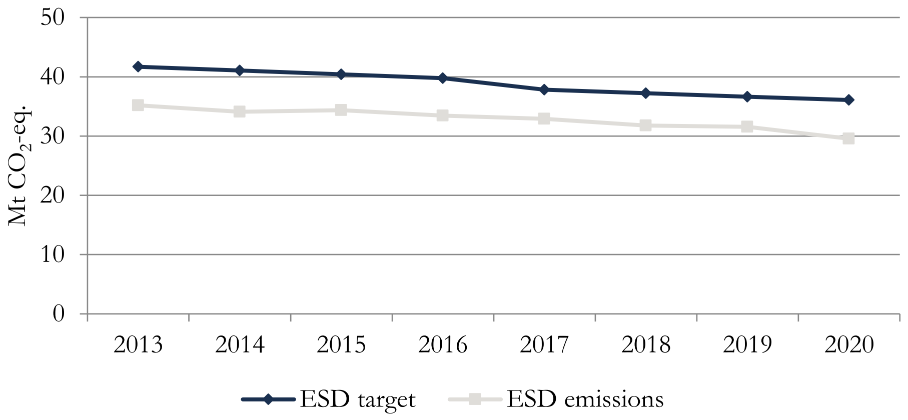

Figure 5.13 The ESD target (scope 13-20), emissions in 2013–2015 and the projected Swedish ESD emissions (scope 13-20).

5.8 Target fulfilment in relation to domestic targets

According to the 2009 climate policy resolution of the Swedish Parliament, the Swedish target for emissions that are not included in the EU ETS, must be reduced by 40 %, or around 20 Mt CO_2-eq., between 1990 and 2020[65], of which one third can be reduced through emission reductions in other countries.

In 2020, the national target will preliminarily be 28.7 Mt CO_2-eq.. Projections indicate that emissions will decrease to around 29.6 Mt CO_2-eq. and there will be a gap to target of approximately 0.8 Mt CO_2-eq. in 2020. Note that numbers are preliminary until 2022–2023, when a definitive calculation can be done, based on reviewed inventory data. If a gap to the target still remains, it can be closed by emission reductions in other countries.

In June 2017, the Parliament in Sweden adopted a climate policy framework including targets for 2045. By 2045, Sweden is to have no net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions. Emissions outside the EU ETS should be at least 63 % lower by 2030 than emissions in 1990, and at least 75 % lower by 2040. To achieve

[65] This was equivalent to a decrease of 33 % between 2005 and 2020 when the target was adopted in 2009 (EU ETS scope 2008–12). In the third period of EU ETS, 2013–2020, the scope of the EU ETS was extended to include additional sectors. The target was consequently adjusted corresponding to emissions in the transferred sectors.

these targets, no more than 8 and 2 percentage points, respectively, of the emissions reductions may be realised through supplementary measures such as increase in carbon sinks, verified emissions reductions through investments in other countries and carbon capiture and storage of biogenic carbon dioxide. A reduction of 63 % means that the target is preliminary set to 17 Mt CO_2-eq. in 2030. The emissions outside EU ETS are projected to decrease to 26 Mt CO_2-eq. by 2030, which indicate a gap of around 9 Mt CO_2-eq. In addition, emissions from domestic transport are to be reduced by at least 70 % by 2030, compared to 2010. Emissions from domestic transport are projected to decrease by 35 % between 2010 and 2030.

5.9 References

Commission decision (EU) (2017/1471) of 10 August 2017 amending Decision 2013/162/EU to revise Member States' annual emission allocations for the period from 2017 to 2020

Commission Decision (2013/162/EU) of 26 March 2013 on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council *(notified under document C(2013) 1708)*

Commission Implementing decision (2013/634/EU) of 31 October 2013 on the adjustments to Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC of the European Parliament and of the Council

EU Decision No 406/2009/EC of the European Parliament and of the Council of 23 April 2009 on the effort of Member States to reduce their greenhouse gas emissions to meet the Community's greenhouse gas emission reduction commitments up to 2020.

EU Decision C (2013) 1708 on determining Member States' annual emission allocations for the period from 2013 to 2020 pursuant to Decision No 406/2009/EC.

EU regulation No 525/2013 of the European parliament and of the Council Decision on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change and repealing Decision No 280/2004/EC

EU regulation No 2018/1999 of the European parliament and of the Council Decision on on the Governance of the Energy Union and Climate Action.

Govt. Bill 2020/21:1 *Budgetpropositionen för 2021.* Ministry of Finance

Ministry of the Environment. 2021. Report for Sweden on *climate policies and measures and on projections* March 2021. In accordance with article18 under Regulation (EU) No 2018/1999 of the European Parliament and of the Council Decision on the Governance of the Energy Union and Climate Action.

National Inventory Report Sweden, Submission 2021.

National Inventory Report Sweden, Submission 2022.

6. Vulnerability assessment, climate change impacts and adaptation measures

As a result of global warming, temperatures in Sweden will increase by 2–6 degrees Celsius by the end of the century, depending on climate scenario (www.smhi.se). The temperature rise will vary depending on location, with the most significant rise in temperature expected in the northern part of Sweden. The increase will be more substantial in winter than in summer, which will result in milder winters with decreasing snow cover. Average annual temperatures in Sweden already rise approximately twice as fast as the global average. Climate change will also result in changing precipitation patterns, with an expected increase in precipitation by 0–30 % by 2100, varying by location and scenario. The most pronounced increase will be during winter. During summer, rainfall in southern Sweden is expected to decrease, and increasing evaporation may lead to a shortage of drinking water in certain areas, especially in southeastern Sweden.

Natural and human systems in Sweden will be affected by climate change in a number of ways. Heavy rainfall and cloudbursts are already causing significant economic damage, and deaths have occurred. The occurrence of extreme weather events is expected to increase. Climate change affects human health in various ways, but the magnitude of impacts on health is difficult to predict and varies with local preconditions and the vulnerability of the population. Climate disruption also has important impacts on agriculture, cultural heritage, forestry, housing, infrastructure, the natural environment and ecosystems, reindeer husbandry and many other aspects of Swedish society.

Efforts are being made to improve adaptive capacity, with several national authorities developing adaptation plans for their areas of responsibility. Adaptation plans are also in place at the regional level, and in many municipalities. Significant progress and increased awareness of the importance of adaptation have been achieved over the last few years.

Adaptation to climate change spans many different sectors. Thus, it is important to consider adaptation measures with multiple and cross-sectoral benefits as well as those involving conflicting targets. Furthermore, adaptation to climate change should follow a gender-responsive, transparent and just approach.

6.1 Expected impacts of climate change

6.1.1 Climate research and climate services

In Sweden, extensive research is carried out on climate change and its current and potential future effects. Information from government authorities is freely available and open to all. Although it is not always easy to use or understand for the uninitiated user, efforts are underway to ensure that citizens and stakeholders receive relevant and useable information to enable further adaptation activities.

Research on climate and climate change is carried out at many universities and institutes around Sweden. One of the main sites is the Rossby Centre at SMHI, which focuses on improving the understanding of the future climate with regards to meteorological, oceanographic and hydrological aspects. The Centre conducts work both on model development and evaluation of data, as well as modelling applications for process studies and climate change research in support of impact and adaptation studies.

Scenarios and indices on climate change in Sweden are readily available. SMHI's website at http://www.smhi.se/klimat presents climate information through maps, diagrams and downloadable data, free of charge, on both national and regional scales. Information is also available explaining the results, including uncertainties, and how they have been developed. An introduction to climate scenarios is available (in Swedish). The site also contains guidance (in Swedish) that provides support for interpreting and using climate scenarios.

During 2021, SMHI is reviewing the climate services at smhi.se. The new service will present data from meteorological, hydrological and oceanographical modelling. Since these activities are based on different models and their aim is to present data on different parts of the climate system they will not be entirely consistent. The core is, however, data from CORDEX (cordex.org) at ca. 12.5 km resolution and mostly bias adjusted.

Two degrees globally – projected effects on Sweden

The goal of the Paris Agreement is to limit global warming to well below 2°C, preferably to 1.5°C, compared to pre-industrial (1881–1910) levels. According to observations, the average global annual temperature 2020 was

1.2 °C above pre-industrial levels. The rate of warming is approximately 0.2 °C per decade. If the current rate remains, this means that 1.5 °C will be reached in about 15 years, and 2 °C in about 40 years. However, estimates of the rate of warming get less certain with time. A high level of future warming is relatively more dependent on future emissions, compared to lower warming levels, which to a greater extent are the result of past emissions. As the magnitude of future emissions gets increasingly uncertain with time, estimates of future warming rates also get less certain with time.

All warming levels show the same pattern of temperature increase, with the greatest warming taking place in the north of Sweden (Figure 6.1). Note that Figure 6.1 shows deviations from the average of 1980–2010, which is already almost a degree warmer that pre-industrial times.

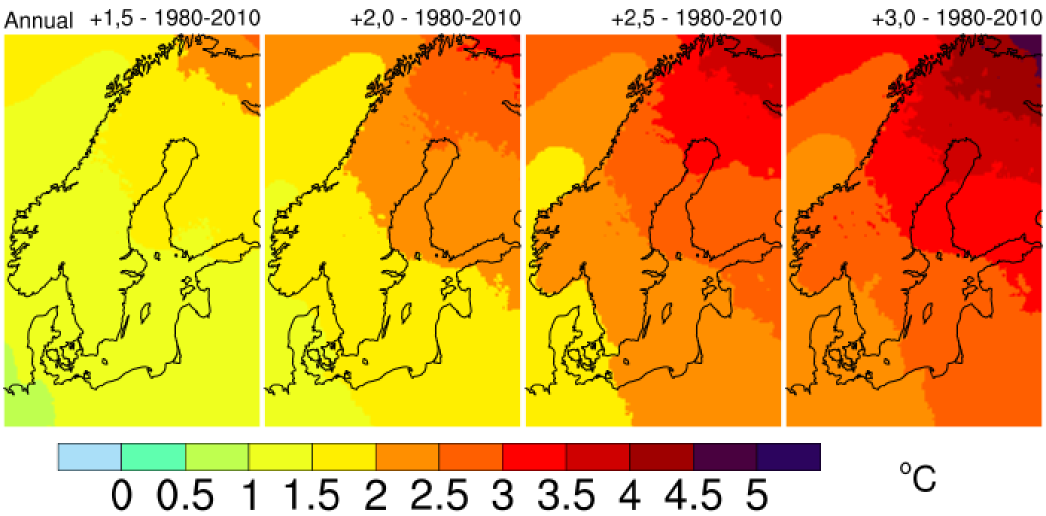

Figure 6.1 Change in average temperature between the reference period (1980–2010) and at 1.5 °C, 2 °C, 2.5 °C and 3 °C global warming compared to pre-industrial time. Note that deviations from the average of 1980–2010 are shown, an average which is already almost a degree warmer that pre-industrial times.

6.1.2 Changes in climate variables

Climate change variables are the basic climatic factors of temperature, precipitation and wind. Changes in these variables will in turn cause climate change impacts.

6.1.2.1 Temperature

The average global temperature is projected to increase by between 0.5 and 5 degrees Celsius by the year 2100, compared to the reference period 1961–

1990. A more pronounced warming than the global is expected in Sweden during the same period.

The regional climate scenarios developed for Sweden, based on global climate scenarios RCP 2.6, RCP 4.5 and RCP 8.5, show that Sweden's annual mean temperature will increase by 2 to 6 degrees Celsius by the period 2071–2100 compared with the reference period 1961–1990, depending on the chosen scenario. The greatest temperature increase is expected to be during the winter, between 2 and 8 degrees by the end of the century. Changes in the summer are estimated to be less than in the winter, with between 1 and 5 degrees Celsius warmer temperatures.

The changes have significant regional differences, with the biggest effect in the north of Sweden. This is mainly due to a decrease in snow coverage, which leads to an enhanced warming since less white snow on the ground, reflecting solar radiation, leads to the ground absorbing more energy. In addition, the thermal conductivity of ground free from snow coverage is greater than if there is an insulating snow cover on the ground.

Precipitation

Precipitation in Sweden is expected to increase by 0–30 % over the next century, depending on scenario and location. Variations in precipitation between different years and different decades are greater than for temperature. This means that it is more difficult to distinguish the trend from variability, and the actual outcome over the coming 5–20 years may not follow the projections. The greatest relative precipitation increase will occur during spring.

During the summer, the precipitation increase in southern Sweden is projected to be small, while changes for the northern part of the country is more significant. It is worth noting that the summer season will extend with climate change.

Snow conditions are affected by increasing temperature. The cold season will be shorter and a larger fraction of the annual precipitation will fall as rain instead of snow. Consequently, the snow season will become shorter and the maximum snow cover less thick, despite increasing winter precipitation.

Wind

Climate scenarios provide no clear answers on how the wind climate might change in the future. Global models show large differences in the changes of circulation across the Northern Atlantic. Small changes in storm tracks can have a large impact on the local wind climate, even though the wind climate in Europe as a whole remains unchanged.

There are many complex factors and circumstances that affect the course, strength and frequency of storms. A warmer ocean surface and more water vapour in the atmosphere etc. contribute to the development of storms. At the same time this warming leads to reduced differences between warm and cold air masses, which play an important role in the development of intense storms. This may in turn counteract the amplifying effect that warming has on storm development.

Projections over Sweden show very small or no changes in wind. The only exception is wind speed over the parts of the Baltic Sea that will become ice-free in a warmer climate. Here, there is a tendency of a small increase in speed.

Milder winters with increased precipitation are expected to become more common in a future climate, and gradually the conditions for ground frost will change. As a result, the risk of storm damage, due to falling trees, can increase regardless of changes in the wind climate. The extent of damage also depends on other factors that are more related to human behaviour and our vulnerability to disruptions in infrastructure, not least regarding electricity dependence.

6.1.3 Climate change impacts

Climate change impacts are described by IPCC as impacts on physical, biological and socioeconomic systems (IPCC, WGII, 2013). Examples of impacts on physical systems include shrinkage of glaciers, decrease in snow cover, longer growing season and more intense rainfall. Impacts on biological systems include species migration and earlier phenology (for example, earlier flowering in plant species). Signals of climate change impacts may be clearer in physical systems than in biological systems, which can also be affected by complex changes that have no relation to climate change, such as land-use change, eutrophication and acidification.

The impacts of climate change are even more difficult to detect in socioeconomic systems, because such systems are not only strongly affected by other changes but also by adaptation processes. In many cases, climate change impacts in socioeconomic systems are in fact adaptation, for example when farmers sow crops earlier in response to warmer spring temperatures. Impacts on socioeconomic systems are presented with the risks and vulnerabilities in section

6.1.4 Physical systems

Wildfire and drought

Compared to many other countries, Sweden has mostly been spared from major disasters caused by extreme drought. During dry years, however, water shortages pose serious challenges both locally and regionally. Mainly the eastern parts of southern and central Sweden are affected. The extremely hot and dry summer of 2018 resulted in water shortages, damaged grazing and lack of fodder for grazing animals, reduced water levels in certain lakes, and very low groundwater levels in smaller aquifers at the end of summer.

Climate scenarios indicate a decrease in water availability in large parts of southern Sweden. This is mainly due to an increased water consumption of plants in a warmer climate with longer growing seasons. The greatest changes in the occurrence of drought are expected in southern Sweden and in areas around lakes Vänern and Vättern, with an increase of over 60 days of drought every year by the end of the century.

Drought can cause water scarcity and hamper vegetation growth. In southern Sweden, water demand is often greatest when resources are at their lowest. High temperatures and a longer growing season will increase evaporation from the ground and from growing plants and will exacerbate the consequences. Drought causes low water flow in waterways and low water levels in lakes, leading to water shortages and competition between different types of water use such as for water supply, irrigation, sewerage or industrial processes.

Drought increases the risk of wildfires. Every year, on average 3,000–4,000 wildfires occur in Sweden. The extent of forest fires varies from year to year, but often more than 2,000 hectares of land are affected. The financial impacts are large in terms of emergency response and damage to forests and buildings. Almost half of all forest fires are caused by human behaviour. The summers of 2014 and 2018 were characterized by unusually large and fierce forest fires in Sweden. In the biggest single wildfire for at least 60 years, almost 14,000 hectares burned in one location in central Sweden in 2014. During the exceptionally hot and dry summer of 2018, many wildfires raged, together consuming more than 25,000 hectares of forest in mid-north Sweden.

It is not just drought and wind conditions, and the composition of the forest, that determine the size of a wildfire, but also how quickly the fire is discovered and the availability of firefighting resources. Consequently, large forest areas in the sparsely populated parts of the north, and along the coast in northern Sweden as well as inland, often suffer from large fires.

Humidity

Humidity is the proportion of water vapour in the atmosphere and occurs when water in oceans and lakes, for example, warms up and evaporates. Humidity has a major impact on weather and climate. Water vapour is the most abundant of all greenhouse gases and has the greatest effect on Earth's warming. As the climate warms, evaporation will increase so that the atmosphere becomes more humid, which amplifies the initial warming.

Low humidity can cause materials to dry out and high humidity can lead to mould or corrosion. If electronic devices are exposed to dry air, this can cause static electricity, while high humidity can lead to condensation with flashover as a result. Foodstuffs can dry out or turn mouldy if stored in too dry or wet conditions. Humidity also significantly affects the formation of ice, for instance on roads, aircraft, wind turbines and masts.

Relative humidity is the amount of water vapour in the air relative to the maximum amount at the same temperature. When relative humidity is high and wind is weak, the air might feel sticky and muggy. During these conditions, sweat cannot evaporate and in combination with high temperatures this can lead to heatstroke.

Growing season

The length of the growing season (the number of days when the average daily temperature for a single period is over 5 degrees Celsius) has already increased in Sweden. The greatest increase is seen in the north, where the growing season has increased by around two weeks since 1980 (www.smhi.se). By the end of the century, the vegetation period is expected to increase by one to two months throughout Sweden, compared to the period 1971-2000.

Changes in the timings of the growing season can cause problems for plants and animals. For example, a plant that flowers too early, before pollinators are active, will not be pollinated.

An increase in temperature will cause temperature zones to move north. Each degree of increase in average temperature corresponds to a south-north distance of about 150 kilometres in Sweden. This impacts ecosystems and plants endemic to a specific temperature zone that is shifting northwards. For example, bare mountainous areas in Sweden are in decline as the tree line progresses northward when the temperature increases.

Heatwaves

While definitions vary, a heatwave normally describes a prolonged period of warm conditions for a specific area. SMHI defines it as "a continuous period when the highest temperature of the day is at least 25 °C for at least five days in a row".

Heatwaves are quite rare in Sweden compared with southern Europe. However, the optimal temperature varies between different countries and since Sweden's population is used to a cooler climate a temperature increase will affect health. Recent research has shown that warm periods lead to both increased mortality and morbidity in Sweden.

For cities, the urban heat island effect is another important aspect. How people live and whether they have access to cooler areas such as lush parks, forests, waterways, cool historical buildings such as stone churches, and air-conditioned indoor environments, are all important factors for reducing the effects of heatwaves. Social isolation can lead to increased vulnerability to extreme heat, and socially deprived areas often provide less access to cool spaces.

For Sweden, heatwaves are likely to occur more often in the future. Researchers at the Rossby Centre at SMHI have calculated that periods with extremely hot temperatures that have occurred every 20 years on average may occur every 3 to 5 years at the end of the century. In southern Sweden, temperatures could reach as much as +40 °C every 20 years.

Groundwater levels and groundwater quality

Groundwater levels will be affected by any future change in precipitation and temperature. For the northern and western parts of Sweden, the increase in precipitation could lead to an increase in groundwater levels. However, groundwater levels are expected to decrease in the south-eastern parts of Sweden due to decreasing groundwater recharge as a consequence of decreasing precipitation and increasing evaporation.

The water table fluctuates between seasons and is lower during the summer, in most of Sweden. The length of the period with a reduced water table during summer may be extended because of earlier snow melt, higher temperatures and longer summers. This can cause problems for domestic water supplies, especially in southern Sweden.

Groundwater quality may be affected by an increasing inflow of surface water, by changes in land use and changes in groundwater levels. Coastal aquifers will be affected due to sea level rise, with a higher risk of salt water intrusion in domestic wells. It is not currently certain when and to what extent this will become a problem in Sweden, since land rise still compensates for some sea level rise, except in the south.

Heavy precipitation

Events of heavy precipitation have a major impact on society. Flooded roads, infrastructure, and buildings as well as ruined harvests are some of the negative effects caused by heavy precipitation. In urban areas runoff often occurs from small areas with a high proportion of impervious surfaces, and this process can be rapid. In winter, heavy loads of snow can overload roofs and bridges.

Extreme rainfall over northern Sweden's second largest city, Gävle, and the surrounding region in August 2021 caused significant damage. In only 24 hours, 161 mm of rain fell over the city, equal to more than double the average for the month. Extensive damage to buildings and infrastructure resulted from significant flooding. In some places, the water levels reached 3 m from street level. Police instructed the city's population of 100,000 not to leave their homes during the event. All public transport was cancelled. Fire and rescue services could only respond to a fraction of the flooding events.

Extreme rainfall can also lead to high water flows in rivers and lakes. A large part of the flooding that affects Sweden is caused by the combined effect of several smaller rain events in succession, when already saturated ground is exposed to additional rainfall. Intense and local thunderstorms can also bring very large amounts of rain. This can cause problems in cities where stormwater systems cannot handle large amounts of rainfall or put pressure on dam structures.

Climate scenarios indicate that torrential rain (more than 40 mm rain per day) in Sweden is becoming more common in a warmer climate. In the future, we can expect more frequent cloudbursts and an increase in their intensity. The intensity of heavy rainfall events may increase by 40–80 % until 2100 (www.smhi.se). As always, there are large regional and local differences.

During summer, the intensity of heavy rainfall is generally estimated to increase by 10–15 % in Sweden by the end of the century. The rain intensity of a 10-year rain, which on average will return every ten years is expected to rise by about 10%. In line with this, the expected return period of a 20-year rain will drop to 6–10 years during the summer and 2–4 years during winter. This is based on comparisons between the periods 1961–1990 and 2071–2100 (www.smhi.se).

Snow, ice and zero crossings

Sweden is a large country with great variations in temperature and precipitation. This is especially apparent when looking at snow and ice cover.

Large amounts of snow can cause major problems in traffic and damage to buildings, overhead power lines and trees. The problems tend to get worse when combined with strong winds or if the snow is wet and heavy.

About 85% of Sweden's exports and imports are transported via commercial shipping. This is affected by ice cover – large parts of Sweden's waters freeze every year, and every winter approximately 500–2,000 ships require icebreaker assistance to get in and out of Swedish ports. During severe winters, sea ice may also affect other infrastructure such as bridges, passenger ships and coastal communities. Ice condition can hamper crisis management, such as search and rescue and oil spill response. Snow and ice also provide opportunities for recreation such as skiing and ice skating and for tourism.

With climate change, snow cover duration is expected to decrease, and in the southern parts of the country, long-lasting snow cover is expected to disappear completely. This may reduce the extent of spring floods, but increase water flows during the winter.

The ice season and its geographical extent will also be reduced. In all scenarios, the changes are greatest in the south, while the Bothnian Bay and northern Bothnian Sea are least affected. None of the scenarios indicate that sea ice will disappear completely from the Baltic region during the present century, and it is important to remember that variations from year to year will continue to be significant. This means that severe winter conditions may occur in the future, although they might be less frequent. The same patterns can be seen for lakes. Major changes are expected to occur during autumn with later ice formation, and during spring with earlier ice break-up. This can affect wildlife dependent on ice-cover for raising their young.

A day with zero crossing is defined as a day with temperatures both below 0 °C and above 0 °C measured two metres above the ground. Zero crossings are very common in central Sweden, with an average of 100–120 days per year. The least number of zero crossings occurs in southern Sweden, around Lake Vänern and along the coast. Zero crossings can cause damage to roads, buildings, bridges and other stone constructions. They also increase the risk for traffic accidents and impacts reindeer food search.

It is expected that there will be a decrease in the number of zero crossings throughout the country during autumn and spring. In the wintertime the number of days with zero crossings will also decrease in the south, while there will be an increase in central and northern Sweden.

Sea level and water levels in lakes

Many processes affect the sea levels along our coasts and water levels in our lakes. Processes affecting sea levels include wind, air pressure, regional sea level rise and local postglacial rebound. Water levels in lakes are affected mostly by rainfall, snowmelt and regulation of lakes and watercourses.

Global mean sea level (GMSL) is rising at an accelerating rate. During the period 2006–2018 the rate of GMSL rise was almost triple that of the period 1901–1971 and almost double that of 1971–2006. The primary causes of sea level rise are the melting of ice sheets and glaciers, and thermal expansion caused by rising ocean temperatures (IPCC, 2021).

Global mean sea level will continue to rise over the 21st century. According to *IPCC Climate Change 2021: The Physical Science Basis*, the likely GMSL rise by 2100 is between 28–55 cm under a very low emissions scenario (SSP1-1.9) and 63–101 cm under a very high emissions scenario (SSP5-8.5), relative to 1995–2014. Under a very high emissions scenario, a GMSL rise above the likely range, approaching 2 m by 2100, cannot be ruled out due to deep uncertainty in ice sheet processes.

By the middle of the next century (2150), the likely GMSL rise is 37–86 cm under a very low emissions scenario and 98–188 cm under a very high emissions scenario (SSP5-8.5). Again, due to deep uncertainty in ice sheet processes, a GMSL rise approaching 5 m by 2150 cannot be ruled out under a very high emissions scenario (IPCC, 2021).

Global sea levels are committed to rise for centuries to millennia, due to continuing deep ocean warming and melting of ice sheets. Over the coming 2,000 years, studies suggest that GMSL may rise by about 2–3 m for a peak warming of 1.5 °C, by 2–6 m for a peak warming of about 2 °C, and by 19–22 m for a peak global heating of about 5 °C (IPCC, 2021).

How regional mean sea levels in Sweden will change in the future is mainly determined by the sea levels of the world's oceans and ongoing postglacial rebound (Figure 6.2). Land uplift counteracts sea level rise to varying degrees and in Sweden varies from less than 1 mm/year in the southernmost part of the country to around 10 mm/year along parts of the coast in the Gulf of Bothnia. Factors such as land ice melt, ground water changes, steric effects and changes in sea-level pressure and winds also affect changes in mean sea level regionally (Hieronymus and Kalén, 2020).

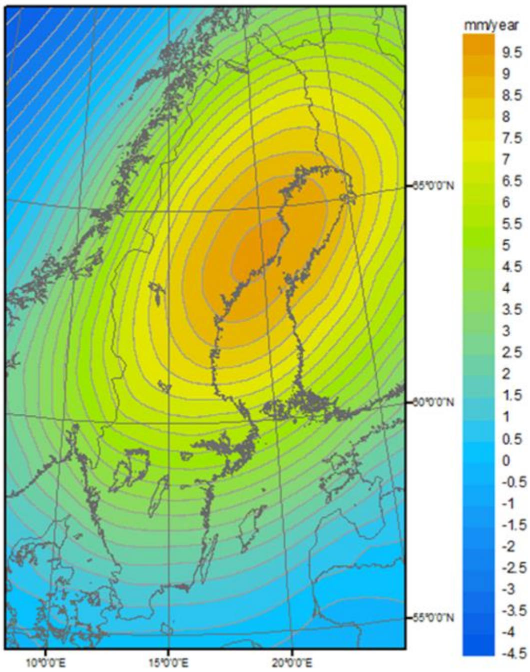

Figure 6.2 Levelled land uplift (mm/year) from the official land uplift model NKG2016LU, released by the Nordic Commission of Geodesy in 2016 and provided by the Swedish Mapping, Cadastral and Land Registration Authority.

SMHI's measurements show that since the late 1800s, sea levels have risen by about 25 cm along the coasts of Sweden, corresponding to an average rate of about 2 mm/year. Consistent with the IPCC's assessment of GMSL rise, SMHI's measurements show accelerating sea level rise in recent years (SMHI, 2021b).

The actual change in mean sea level in most of Sweden has, however, been considerably smaller primarily due to postglacial rebound. In fact, large parts of Sweden are still experiencing decreasing sea levels. The southernmost part of Sweden, where land uplift is close to zero, will be most affected by future sea level rise. However, as sea level rise continues to accelerate, the effect will be evident along other parts of the coast as well.

The water level in lakes is mainly controlled by the amount of inflow and outflow to and from the lakes, how much rain falls directly on a lake and how much water evaporates. Many waterbodies are regulated, and especially in the case of the largest power producing rivers, this has a big effect on water levels. Regulation already affects river flow in ways that are similar to the projected effects of climate change at the end of the century. Regulation typically reduces the spring flood and increases winter flow. It is not possible to give a general answer to how water levels in lakes will change in a future climate. Some lakes may experience higher water levels, while other lakes, mostly in south-eastern Sweden, may have problems with low water levels. Seasonal variations in levels can also change.

High water levels in lakes can lead to flooding with implications for a variety of interests such as housing, agriculture, electricity and water supply. It can also cause increased mobility of pollutants. Low water levels may have implications for water supply, irrigation and ecosystem health, among other things. For lakes Mälaren and Vänern, low water levels can affect shipping.

Flooding

An area covered in water, which normally is not under water, is described as being flooded. The underlying causes vary depending on where the flooding occurs – along the coasts, in rivers, in lakes or in cities. The risk of flooding also depends on other factors such as how waterways are regulated, what preventive measures are adopted and how buildings and infrastructure will change.

Flooding due to extreme water flows may become more common in large parts of southern Sweden and in the north-west of the country. However, local differences are significant. For large parts of Sweden, spring floods are expected to be lower and winter floods will increase. Extreme floods are expected to occur less often in northern Sweden and in the western part of central Sweden. The reason for this is that the most extreme floods in these areas historically have been associated with spring snowmelt. In the rest of the country, extreme floods are expected to become more common.

Storm surges, i.e. rapid short-term increases in sea level that typically occur during situations with strong onshore winds and low pressure, may cause problems with flooding and erosion along the coasts. Flooding of industrial areas may also dislodge pollutants which may move into waterways or into the groundwater.

The mean sea level is the starting point of storm surges. Thus, changes in mean sea level has a direct effect on the severity of storm surge events (Figure 6.3). With rising sea levels and thus a higher starting point, a smaller contribution from the weather is required to reach the same water levels as in today's storm surge events.

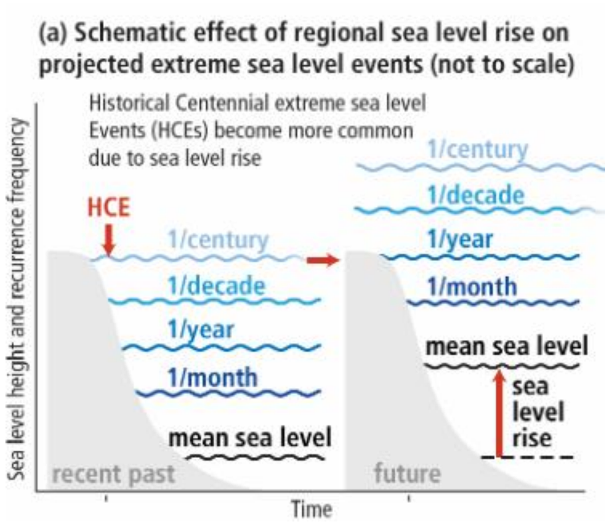

Figure 6.3 Due to projected global mean sea level (GMSL) rise, local sea levels that historically occurred once per century (historical centennial events, HCEs) are projected to become at least annual events at many locations globally during the 21st century. The height of an HCE varies widely, and depending on the level of exposure can already cause severe impacts. Impacts will continue to increase with rising frequency of HCEs. Figure SPM.4 (a) from Summary for Policymakers (IPCC, 2019).

Since the effect of sea level rise is counteracted by land uplift, to varying degrees in different places in Sweden, the likely future change in mean sea level differs by location. Especially in the south of Sweden, where land uplift is small, the water levels experienced during today's storm surges will become more common in the future (Hieronymus and Kalén, 2020).

6.1.4.1 Hydrological flows

The stream flow patterns in Sweden are expected to change in a future climate. The changes depend mainly on how precipitation will change, but also changes in temperature that affect snow melt, evapotranspiration and the length of the vegetation period.

The annual average stream flow is expected to decrease in the eastern parts of Götaland (southern Sweden) and Svealand (mid-Sweden), while an increase can be seen in large parts of Norrland (northern Sweden). High flows are expected to become less frequent in large parts of northern Sweden as the spring flood is projected to decrease. However, in parts of southern Sweden high flows may occur more regularly. In south-eastern Sweden, low water flows are estimated to become more frequent in summertime due to increasing evaporation and vegetation water demand.

Higher rates of flow can also lead to the inundation of old and new industrial areas, sewage treatment plants, etc. This can result in pollution shocks that may affect human, plant and animal life.

Erosion and landslides

Erosion is the wearing down of the landscape by running water, waves, wind and ice. In Sweden, mainly water erosion is of significance to built-up areas. Coastal erosion is affected primarily by geological conditions, sea level rise, wave climate, wind conditions and currents.

In a changing climate, increasing water flows, more intense precipitation and changing ground conditions may increase the risk of landslides in large parts of Sweden. Increased precipitation and water runoff can cause high flows and erosion along river banks and watercourses. The areas most affected by landslides in Sweden are the western parts of the country and areas in central and northern Sweden. The countryside as well as built-up areas are affected. Decreased soil stability due to increased precipitation and erosion can also cause landslides.

Göta älv, the largest river in Sweden, with its surrounding river basin is very vulnerable to erosion and landslides. In the past, catastrophic events have occurred along the river. As the risk of landslides increases further with an increase in river flow, high discharges to the river from the regulated Lake

Vänern are not possible. This in turn increases the risk of flooding around Lake Vänern. The lower reaches of Göta älv are also affected by sea level rise.

In a changing climate, the risk of ravine development might increase in parts of south-western and central Sweden, as well as parts of the north. An increased risk of moraine landslides and mudslides is also expected in central areas.

As a consequence of rising sea levels, coastal erosion will increase along the coast, primarily along sandy coasts in southern Sweden. Frequent sand erosion takes place, for example, along the coast of Skåne, where the coastline has moved 200 m inland over the last 35 years in certain locations.

6.1.5 Biodiversity, ecosystems and climate change

An acceleration of the global mean temperature risks having far-reaching consequences for Sweden's natural environment and its unique composition of species. A warmer climate with shifting and moving climate and vegetation zones brings significant ecosystem changes. Habitats and populations risk disappearing, moving or shrinking, while others may have new and expanded distribution areas. Climate change also leads to phenological changes affecting the lifecycles of species (seasonal activity, reproduction and migration), and can cause a mis-match between species adapted to each other. Changes in geographical distribution and phenological changes in turn affect interactions between species, food availability, susceptibility to predation or the incidence of pathogens. For example, in temperate aquatic systems, as in Sweden, the timing of the natural spring flowering of algae becomes destabilized or weakened, thus affecting the food base of many other species.

Rapid changes to environmental conditions often lead to favorable conditions for adaptable and short-lived species, while species growing more slowly diminish. In time, this affects the total productivity and stability of entire ecosystem food webs. Extreme weather conditions occurring more frequently and intensively can also lead to sudden disruptions of biodiversity and species distribution. Prolonged heatwaves for instance, could cause damage to terrestrial and aquatic environments, where most species are ectothermic and cannot regulate their temperature. An example of such a sudden disruption is the severe drought that hit Sweden in 2018 which contributed to the extinction of two of Sweden's day butterfly species (Holst et.al. 2020). Biodiversity and ecosystem composition are also threatened by invasive alien species that benefit from more favorable temperature conditions.

Mountainous areas are particularly sensitive to climate change. Warmer temperatures, reduced snow cover and a rising tree line are expected to have extensive negative consequences for Sweden's unique alpine biodiversity and habitats. Parts of Scandinavia's northern mountain range are located in the Arctic, which is warming more than twice as fast as the global average, putting further pressure on its ecosystems.

Elevated water temperatures can considerably affect both freshwater and saltwater species, and species needing colder water may disappear when the temperature rises. Rising temperatures in the Baltic Sea due to climate change leads to a lack of oxygen, and studies from SMHI show that around 30 percent of the ocean floor is suffering from hypoxia. The salinity of the Baltic Sea is also expected to change, due to climatological factors such as increased flows of freshwater due to increased precipitation. These factors, in combination with acidification and eutrophication, have far-reaching effects on marine life.

A changing climate in combination with unsustainable land-use and land-use change leads to extensive loss of biodiversity. Thus, climate disruption compounds other existing environmental impacts and accentuates any lack of biological diversity. Conversely, a rich biodiversity is a key component of a healthy ecosystem, as this increases resilience to climatic disturbances. Thus, protecting and sustainably managing biodiversity, as well as safeguarding intact and functioning ecosystems, becomes an important part of strengthening resilience to a changing climate. Resilient ecosystems are a key factor both for sustainable climate change adaptation and mitigation.

6.2 Assessment of risk and vulnerability

The first vulnerability assessment of climate change impacts in Sweden was initiated in 2005 and resulted in a report to the Government in 2007. The report assessed Swedish society's vulnerability to global climate change, the regional and local impacts of these changes and the costs of the damage caused by climate change. An updated assessment was made in 2015, and a number of suggested actions from this report are now being carried out. For example, an inquiry into the legislative framework for adaptation, detailing any required amendments and clarifying roles and responsibilities was reported in May 2017.

In January 2019, a Government regulation on the work of Swedish authorities on adaptation to climate change entered into force. The regulation establishes that 32 national authorities and all 21 County Administrative Boards, within their areas of responsibility and within their missions, shall initiate, support and monitor adaptation to climate change. The regulation also establishes that these authorities shall implement vulnerability assessments, a task that most of the authorities have completed.

6.2.1 Assessment of impact, risk and vulnerability for socio-economic sectors

Unless otherwise indicated, the information in this section originates from www.klimatanpassning.se, and has been provided by the national authorities responsible for each area.

Spatial planning

Sustainable spatial planning needs to ensure that all future exploitation takes climate change into consideration, thus reducing risks and costs for future generations, and thereby ensuring good and healthy living environments for all. In a rapidly changing climate, spatial planning provides key opportunities for long-term, preventive and resilient climate change adaptation. In order for spatial planning to be effective and long-lasting, it is important to take into consideration the long-term effects of a changing climate on the buildings or infrastructure planned. The climate effects that call for a more sustainable and flexible spatial planning that takes negative effects such as landslides, erosion and flooding, heatwaves, and water shortages into account. Robust spatial planning may prevent the occurrence or reduce the consequences of such events.

In Sweden, landslides, mudslides and erosion, flooding, high temperatures and water shortage are among the priority areas for adaptation, as identified in the National Adaptation Strategy from 2018. Considerable work has been carried out to further analyse and define the risks that these climate effects can bring. For example, an investigation carried out in 2021 identifies 10 geographical areas at risk of landslides, mudslides, erosion and flooding connected to climate change (SGI & MSB, 2021). The investigation also proposes action that needs to be taken to improve conditions for adaptation work that can reduce the risks.

In general, Waterfront housing, buildings and infrastructure are often already exposed to the risk of flooding, and are especially vulnerable to the effects of climate change. Rising sea levels will result in an increased risk of flooding in coastal areas. Buildings close to lakes and waterways may be exposed to an increased risk of flooding and landslides as precipitation becomes more intense and frequent in the future. Adaptation measures include soft and hard coastal defences and planned retreat.

Buildings are also affected more directly by a changing climate, through changing snow and wind loads. A warmer and damper climate increases the risk of problems caused by humidity and mould. While the demand for heating decreases in the future, the need for cooling increases, as a consequence of increasing temperatures, and longer and more intense heatwaves. Spatial planning may reduce the effect of heatwaves through the integration of parks, trees and nature-based solutions into planning.

Cultural heritage represents irreplaceable values that need to be considered in spatial planning. Many built-up environments and old cities of great cultural value are located in coastal areas, vulnerable to rising sea levels and extreme weather, and will require adaptation measures.

Health effects

Climate change impacts human health directly and indirectly. A risk vulnerability analysis published by the Public Health Agency in 2021 (Folkhälsomyndigheten, 2021) concludes that the greatest risks to public health in Sweden in a warmer climate are heat waves and tick-borne diseases, with regards to severity as well as likelihood. The analysis also shows that there is a high probability that climate change will lead to a higher prevalence of pollen allergies and water- and food-borne infections, as well as an increase in negative health effects due to an increase in number and severity of floods and a deterioration in drinking water quality.

A reduction in the number of extremely cold days will have a direct positive health effect in Sweden. On the other hand, more frequent and intense heatwaves have a large negative impact on health with significant increases in mortality being reported. Identified vulnerable groups include people with pre-existing cardiovascular and respiratory diseases and socio-economically vulnerable groups. Young children and elderly people are also at risk, especially those who spend a lot of time indoors, where temperatures may be significantly higher than outdoors, particularly if buildings are not adapted to a warmer climate.

Air pollution can further exacerbate the health risks posed by high temperatures. Especially simultaneous heatwaves and forest fires can be harmful. Preventive measures and information for high-risk groups is important, as is adapting buildings such as retirement homes, hospitals and other care facilities to higher temperatures. In the outdoor environment, green spaces such as parks and forests reduce heat exposure and contribute to many other positive health outcomes, both in terms of prevention and health promotion.

Indirectly, a warmer climate affects pollen-producing species and increases the risk of vector-borne diseases. For example, the high-risk season for Lyme disease and TBE may increase by up to four months by the end of the century. A changing climate may also contribute to the introduction of new disease-carrying organisms, vectors and pathogens. There is a need for increased interdisciplinary and inter-sectoral collaboration on human, animal and ecosystem health, primarily concerning surveillance, particularly of zoonotic diseases.

The risk of water borne infections increases during warm summers when more people swim outdoors. Wounds infected by vibrio bacteria in water represent a new problem that emerged in the Baltic Sea region in the 2000s. These bacteria increase in number with higher water temperatures. Higher water temperatures also increase the risk of toxic algal blooms and the growth of gastro-intestinal bacteria.

Climate change also affects mental health. Climate disruption may impact mental health in a number of ways, including through eco-anxiety, i.e. fear over what may happen in a changing climate, and solastalgia, i.e. the distressing sense of loss when familiar environments are damaged or destroyed.

Drinking water

Climate change already impacts the secure supply of drinking water. Increasing average temperatures, greater volumes of precipitation, altered drainage patterns, and changing evaporation and groundwater formation all create new challenges.

Extreme weather events such as heatwaves, drought, torrential rain, storms, flooding, high water levels in rivers and forest fires, lead to quantitative and qualitative changes to raw water resources. Rising sea levels affect groundwater resources through saltwater intrusion into coastal aquifers. As the sea level rises, lakes close to the coastline used for water provisioning may be flooded by sea water and thus destroyed as supplies of drinking water.

The availability and quality of both groundwater and surface water may be affected by a changing climate. Surface water resources are more exposed than groundwater resources to a range of risk factors and are therefore more vulnerable to increases in temperature, precipitation intensity and pollution.

Even in the current climate, low water flows and water shortages occur in parts of Sweden. In the future, it is expected that low water flow will occur more often in southern Sweden, primarily in the southeast. This may lead to shortages or lack of drinking water.

Changing climate conditions place new demands on planning, water treatment and monitoring. To ensure the quality and security of Sweden's water supply in the future, stronger protection of all water supplies, not least water protection areas where drinking water is sourced, becomes even more important. Actions must be taken to manage increasing microbiological and chemical risks in affected areas. Enhanced water treatment technology may need to be introduced to manage bacteria, viruses and parasites.

Stormwater and wastewater

Water drainage systems will be affected by an increasing intensity of rainfall as well as increased water levels in seas, waterways and lakes. In recent years, several incidents of extreme precipitation and flooding in cities have focused attention on urban water management. It is expected that climate change will bring more rain and more intense rainfall. This adds additional stress to water systems.

Improved and extended implementation of nature-based solutions is important for adaptation. Nature based solutions include parks, forests, gardens and green roofs and can also involve waterways, wetlands and sustainable drainage systems. Additionally, reducing the extent of impervious surfaces, especially in cities, by transforming roads and parking lots into parks and rain gardens have multiple benefits in terms of adapting to extreme weather events, as well as improving human health.

Stormwater management requires collaboration across several sectors in society, since one single stakeholder does not have an overarching responsibility for the issue.

Energy security

Climate change affects energy supply, with regard to production, distribution and usage. It can be assumed that in the future most electricity will still be required during the winter, despite an increased need for cooling during the summer in parts of Sweden.

Large parts of the energy system are directly dependent upon the weather and will most likely be even more dependent on weather conditions in the future, due to an increased use of renewables. Thus, the impacts of a changing climate need to be evaluated in light of a rapidly changing energy system. At the same time, climate change will require changes to the energy system.

Extreme weather events have a major effect on energy supply, as high temperatures, flooding, strong winds and storms can cause operational disruptions both in the production and distribution of energy. Many of the interruptions to the electricity supply that occur today, can be attributed to weather-related problems.

Increasing unpredictability is another consequence of climate change, and a growing concern for the hydropower sector. More unpredictable seasonal changes, e.g. in terms of the magnitude and timing of winter snowfall or mild weather, make decisions on water storage in hydropower reservoirs more challenging. If hydropower reservoirs are filled to their maximum in autumn (as has been the case historically), margins decrease for storing water during mild and rainy winters. However, if reservoirs are not filled to their maximum, to keep capacity for a potentially mild winter, but the winter is cold, the capacity to deliver electricity from hydropower decreases.

Climate change will result in certain events taking place with greater frequency and severity than they currently are. Although climate change is not expected to make storms worse in Sweden, storms are (and will be) a significant cause for electrical outages also in the future, due to trees falling across power lines.

Electricity and biofuels are important to the industrial, housing and service sectors. While outages in the electricity supply have direct consequences, disruptions to the supply of biofuels take longer before they affect the user. In a changing climate, biofuel supply can be reduced due to e.g. forest fires and damage to forests from pests and pathogens.

As a result of global heating, an increased need for cooling is expected in summer. However, electricity usage will remain greatest during the winter, as a result of the considerable consumption of electricity for heating. There may be a reduction in the need for heating in the context of a milder winter climate in the future.

The effects on Sweden's energy system will vary throughout the country. The need for cooling is expected to be greatest in the south, where it is likely that the most severe heatwaves will occur.

Dam safety

Hydropower is the most important asset in Sweden's energy system as is manifested by a large number of dams and reservoirs in rivers throughout Sweden. Although an important source of renewable energy, hydropower also harms or destroys river ecosystems and biodiversity along affected rivers. Dealing with this conflict, in a wider context of global heating and biodiversity loss, is an important issue.

An increase in run-off and extreme floods are the dominant concerns for dam safety in terms of climate change. If the inflow exceeds the discharge capacity of a dam facility, the reservoir water level will rise, potentially overtop the dam crest and cause a catastrophic dam failure. For about 400 dam facilities, a failure – with uncontrolled release of the impounded water – would cause significant consequences in the river valley downstream, such as flooding of communities and loss of human lives, serious damage to critical infrastructure and services vital to society and the environment, and/or major economic damage.

Other risks linked to a changing climate and climate-related extremes, e.g. torrential rain, temperature changes, snow and ground frost, wildfires and storms, also affect dam safety to a certain extent, but not to the same extent as extreme floods. In addition to changes in flood magnitude, shifts in flood season could put stress on the operation of complex hydropower schemes and reservoir management.

The potential impact of climate change, the large number of dams in Sweden, their long service-life and the considerable timescale for implementation of adaptation measures, call for a systematic approach and multi-decadal perspective. Adaptation of dams include both structural and non-structural measures. Enhanced discharge capacity is an example of a local structural measure, typically guided by reassessment of design criteria using climate change scenarios. Revision of reservoir operation strategies is a non-structural measure with regional potential in intensively developed river systems.

During 2021–2023 a committee overseen by the responsible authority and state-owned enterprise, Svenska kraftnät, will compile an updated knowledge base of climatological factors and trends of importance for dam safety applications. The committee will map the vulnerability to climate change of high consequence dams in Sweden and outline a climate change adaptation strategy.

Agriculture

Agriculture needs to adapt both to the climate change already noticeable today and to future changes to the climate. Sweden will experience an increase in average temperature, a longer growing season, increased but more unevenly distributed precipitation and more extreme weather events.

Harvests may be negatively impacted as a result of either increased or reduced precipitation. There will be increased risks of drought and flooding, reduced water accessibility, an increased spread of disease and invasive species, changes in species distribution and increased heat stress. Climate change may also lead to more disruptions to trade and infrastructure in the event of extreme weather situations. Increased domestic production of food can reduce the vulnerability to global disruptions to food production, trade and infrastructure.

In the short and medium term, Swedish agriculture may benefit from larger harvests of certain crops and the cultivation of new crops. However, a changing climate represents greater risks. In order to reach a sustainable production of food, agriculture needs to adapt to meet the conditions of a changing climate.

Changes to water management, such as increased irrigation, improved drainage and ecosystem-based management of watersheds are important adaptation measures. Although only about 3% of all water abstraction is used for irrigation, most irrigation is concentrated to the southern province of Skåne. Water for irrigation is needed when water is scarce in streams and rivers, increasing the stress on ecosystems. The need for irrigation is rapidly increasing as the vegetation period gets longer in a warming climate and as the occurrence of droughts and heatwaves increases.

Cultivating a greater diversity of crops and plant varieties, extending the use of integrated pest management practices, and introducing agroforestry are some examples of other adaptive measures already introduced on certain farms. A greater diversity of cultivated crops and a diversification of cultivation methods can spread risks.

Animal husbandry

Climate change increases the risk of outbreaks of infectious animal diseases, mainly due to ecosystem changes and an increased presence of ticks and insect vectors. Many vector-borne diseases are zoonotic, and may spread between animals and humans. However, it is difficult to say to what extent this will happen. It is also difficult to distinguish the impact of climate change on infectious diseases from the influence of other anthropogenic factors.

It is important that Sweden continues to undertake current measures and further develops surveillance and handling of new or emerging animal infectious diseases. Furthermore, established cooperation between concerned government agencies needs to continue.

In a warmer climate, animal husbandry may benefit from an extended grazing season as well as from possibilities for new feed crops. However, drought may cause water scarcity and reduced harvests of feed crops. Farm animals housed indoors may suffer from heat stress, increasing the risks of mortality and disease. Stables in Sweden are in general built to protect animals from wind and low temperatures, not from heat. The risk of heat stress can be reduced by outdoor grazing with access to shade (tree cover), and night time grazing instead of day time grazing, as well as improved indoor ventilation.

Reindeer husbandry

Reindeer herding depends upon well-functioning ecosystems, which makes it vulnerable to climate change. Sudden weather changes, shifting seasons, changes in vegetation and increased unpredictability are among the effects of climate change, posing major challenges to the reindeer herding sector – both now and in the future.

Climate change will result in increased uncertainty, poorer winter grazing, a lack of cooling patches of snow in summer, and uncertainty with regard to ice conditions when moving reindeer herds. Increasing occurrence of zero passages creates difficulties for grazing, resulting in reindeer herding requiring more substantial supplementary resources[66]. A changing climate also has a social and economic impact on Sámi communities. Members of Sámi districts have an exclusive right to reindeer herding in Sweden. In addition, a reduction in reindeer grazing affects biological diversity in the mountain areas negatively, as previously bare mountain regions become covered in bush vegetation[67].

The combined impact of climate change and increased exploitation in northern Sweden makes adaptation measures for reindeer herding more difficult. Reindeer herding can adapt to climate change by reducing

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66 https://www.amap.no/documents/download/2981/inline

67 https://pub.epsilon.slu.se/15019/8/tunon_h_etal_180122.pdf

vulnerabilities, increasing resilience, improving flexibility and by gaining access to pastures and influence over competing land use such as mining, energy generation and industrial forestry. Climate adaptation for this sector needs a holistic approach, since reindeer herding depends on a cohesive landscape and a functioning ecosystem. Protection of old-growth forests is beneficial to reindeer.

Forestry

Climate change has a direct impact on forests and forestry. In a warmer climate, the growing season is extended, and forest growth will increase. However, the potential for damage to forests will also increase. Milder winters improve the survival of deer, leading to increased grazing of pine and broadleaf vegetation. Conditions will improve for certain insects, pests and pathogenic fungi, facilitating their spread. Invasive species, including potentially invasive tree species, such as *Pinus contorta*, may spread further in a warmer climate.

Climate change demands adaptation of forestry practices. Possible adaptation measures include an increased diversity of tree species used in forestry, an increase in the use of deciduous trees, as well as selective forestry practices and enhanced protection of ecosystems. Also, changing climate conditions are addressed in Swedish plant breeding programmes.

In a changing climate, the risk of forest fires will increase, especially in southern Sweden. When the snow-free and summer seasons lengthen, the fire season and periods with a high risk of wildfire are extended. Deciduous trees and wetlands reduce the impact of forest fires. Thus, restoring deciduous woodland and wetlands may mitigate an increased risk of forest fires.

As the growing season is extended, more harvesting may occur during this season, increasing the risk of root rot. We may see more storm damage in the future as water levels in the ground become higher during winter and ground frost is absent. Especially the edges of clear-cuts are vulnerable to storm damage. High water levels also lead to an increase in soil erosion if heavy machinery is used in forestry operations, according to current practices. Afforestation during dry years will become more difficult, especially in clear-cut forests.

Improved respect for the forest environment and alternative forestry methods, especially in humid environments and along creeks, will be needed when forestry practices take place on non-frozen woodland. Extending no-cut buffer zones along creeks and rivers constitute one adaptation measure with multiple benefits, both in terms of climate change and biodiversity. Continuous cover and diversified forestry mitigate several impacts of climate change, providing a greater resilience to pest and storm damage, drought, and erosion.

Insurance and financial markets

Climate disruption will present new conditions for the insurance industry and financial markets. An acceleration of climate-related risks, e.g. in the form of more frequent and/or more severe extreme weather conditions, will result in increasing damage costs and hence in higher insurance costs. Indirect costs and risk might also arise due to degrading ecosystems, increasing health-related complications and lower increase in productivity.

The Swedish insurance sector is one of the financial sectors most clearly affected by climate risks due to damage costs from flooding, storms, and drought. The insurance sector is already showing a statistically significant trend towards an increase in number of incidents due to extreme-weather events. Although a great proportion of this trend derives from increasing value of insured assets, climate change related damages are becoming more frequent.

In Sweden, almost all property owners and tenants have some form of insurance protection against natural disasters and damage. This is relatively unique in comparison to many other European countries where it is no longer possible to sign a private insurance with relevance to climate-related risks. However, insurance covers citizens and businesses against unpredictable events. If an event is no longer unpredictable, it no longer qualifies for insurance cover. This may apply to repeated flooding of a basement, for example. Home insurance in Sweden typically includes cover for flooding, but this practice may become difficult to maintain with repeated incidents and increasing costs.

When the risk of damage is deemed too high, it may become impossible to insure property. One national insurance company in Sweden has already stated that they no longer will offer insurance for new development in areas that the count administrative boards has considered unsuitable due to the risk of climate effects.

Furthermore, as stated in Sweden's national strategy on climate change adaptation, the responsibility for safeguarding property is firstly the property-owner (individuals and businesses alike, as well as local and national authorities). This creates a will to avoid new development in high-risk areas and to undertake adaptation measures. Preventive action decreases the risk of flooding. Although no insurance mechanisms currently support preventive action, property owners can, for example, separate wastewater from stormwater and avoid paving surfaces. To support home owners, scientists and insurance companies have developed the web-based tool Vis-adapt (http://visadapt.itn.liu.se/). This tool provides information about the effects of a changing climate and advice on how to avoid damage to buildings.

Especially in major cities, damage may go far beyond individual home owners, as e.g. cloudbursts and flooding can impair important societal functions, including critical infrastructure or health care facilities, leading to escalating damage costs for society.

Climate change will affect financial markets and investments. Key considerations in financial markets include the calculation of risk, achievement of profit through growth and proliferation of financial assets themselves, and avoidance of loss. Balancing different types of risk can be very difficult, and climate change has long been absent in different types of risk analyses. The extension of financial capital to new areas of economic and social life may increase the vulnerability of financial markets to climate disruption, and in turn increase the vulnerability of social and economic life at large.

New government rules, regulations and taxes, the revaluation of fossil energy reserves (linked to the carbon bubble) and extreme weather events are factors that affect financial markets. Thus, climate change, as well as society's efforts to mitigate and adapt to climate change, may have an important influence on financial markets. Especially when political will is present, steps towards a transformation of the financial system are facilitated. The increasingly distant relationship between financial capital and the natural world, society and ecosystems has delayed the response of financial markets to climate change. Making resilience and sustainability fundamental conditions for sound investments would pave the way for a more long-term balance between socioecological considerations, climate risks and investments.

Railways and roads

Transport on railways and roads is likely to increase in the future, which places demands on a robust infrastructure. At the same time, climate change increases the risk of cloudbursts, flooding and landslides, affecting roads and railways. Increasing climate risks may lead to an increase in accidents. Changes in groundwater levels may affect drainage and buoyancy. Low bridges may need to be rebuilt at higher levels. Identifying areas at risk and taking measures can address these problems.

Warmer winters will decrease the need for salting roads, and probably for clearing them of snow. There may be more zero crossings in the northern and central parts of the country, leading to increased risks of difficult driving conditions and damage to roads and other infrastructure. Long periods of warm weather affect railways negatively. Railway lines and various other components can expand in the heat, which may cause traffic disruptions.

The Swedish Transport Administration works to increase the robustness of the transport system by decreasing the risk of damage caused by landslides, erosion and flooding. Trees growing close to railway tracks are removed, and risk inventories are carried out across the country.

Electronic communication

Society is dependent on well-functioning and safe electronic communication, which in turn depends on a continuous supply of electricity. Even short power cuts can have serious consequences for users.

The increased risk of storm damage to forests affects overhead power lines, as well as communication masts. Continuously, work is underway to move power lines underground, making the power supply network less sensitive to weather extremes. However, overhead lines, and the risks connected to them, will remain for years.

During floods, entire areas are likely to lose power, compromising electronic communications. Many large fibre cables are incorporated into bridges and will be damaged if a bridge is flushed away. Work is ongoing to protect electronic communication, for example by increasing the robustness of systems and their resilience to precipitation, wind, lightning strikes, dampness, extreme temperatures, floods, landslides and fire.

Shipping

Shipping in Swedish waters is not affected by climate change to a great degree. Increased water depth resulting from rising sea levels does not bring any negative effects for shipping, but could mean problems in certain ports. Quays in the south of Sweden will need to be adjusted to higher water levels.

Increased water flows could cause problems through an increased risk of erosion and landslides in narrow passages, such as canals. The risk of landslides is high along Göta älv, which constitutes an important shipping route in western Sweden, and shipping there may be affected. An inventory has been carried out of the risks along the river due to a changing climate. Less ice cover and a shorter ice season are positive for shipping.

Aviation

Aviation is not affected by climate change to a great degree. Changes in ground frost and groundwater could affect the buoyancy of airfields, and increased precipitation could put an increased strain on stormwater systems at airports. Heat may affect the surfacing of runways.

The need for de-icing may decrease in the south of Sweden but increase in the north, as winter days become less cold and increasingly damp. Action taken by airports may include continuous maintenance of the stormwater systems and a thicker layer of concrete to counteract the loss of buoyancy.

Cultural heritage

Adapting Sweden's cultural heritage to climate change involves measures to prevent or mitigate damage caused by a changing climate. Both material values, represented in buildings, ruins, museum collections, objects, archaeological sites and physical landscapes, as well as immaterial values, such as traditional methods of house-building and cultivation of land, need to be considered when adapting to climate change.

The degradation processes for most materials are affected by temperature and humidity. Higher temperatures speed up chemical reactions and changes in materials, and variations in humidity affect the degradation of most materials.

Climate change risks can be both immediate and clearly visible, such as flooding and landslides, but also slow and difficult to identify, such as gradual sea level rise, or mould and overgrowth. Slow effects require systematic monitoring in order to be detected in time. Adaptation activities can also cause damage to cultural heritage sites, for example the construction of erosion protection close to archaeological sites.

Many of the risks to cultural heritage posed by a changing climate can be seen already today, but could intensify, become more common or have greater consequences in the future. Preventive measures such as risk analysis, surveillance and maintenance are essential to prevent and mitigate damage to cultural heritage.

Climate disruption has a particular social and economic impact on Sámi communities and their cultural heritage, which is closely linked to the land and surrounding ecosystems.

Tourism

The COVID-19-pandemic illustrates the substantial impact pandemics can have on tourism. However, both national and international tourism is expected to increase in Sweden, with big cities as a main tourist destination. Coastal areas are important both for tourists and for the recreation of the local population. Here, the most important resources are beaches, lakes and the sea. In the north of Sweden, winter tourism is also very important, as are hunting and fishing tourism. Ecotourism, including wildlife watching, is an emerging branch of tourism in Sweden.

Summer tourism can benefit from a changing climate with higher air temperatures and warmer summers, while conditions for winter tourism becomes more unfavorable. Decreasing snow cover during winter months are already affecting skiing facilities, who are becoming more dependent on producing snow for the winter season. At the same time, the ski resorts have developed towards having activities all year round, with a mixed range of activities. In this way, companies and destinations can become less vulnerable to climate change such as declining snow supply.

Tourism around the Mediterranean may decrease in the future, due to hotter summers. The strong warming expected in the European Alps may lead to decreasing tourism there too. This could bring more tourists to Scandinavia. The tourism industry in Sweden could benefit from a changing climate with warmer summers. However, winters with less snow cover are already negatively affecting ski resorts, which become more dependent on production of artificial snow to prolong a shorter snow season.

Increasing tourism demands management of tourism flows. Tourism puts heavy pressure on ecosystems, water supplies, infrastructure and local communities, and requires limitations, as well as concern for sustainability and resilience in affected communities.

Impact of global change

The effects of a changing climate can have consequences far beyond an affected region. No country is an island in relation to climate change. Cross-border effects result from the interaction of different processes in social and ecological systems and are intimately linked to the global character of climate disruption. Tipping points in the climate system as well as in non-climatological systems may have unforeseen consequences on both global, regional and national level. Transgressing such tipping points, or thresholds, may cause profound and possibly irreversible effects on society. Although difficult to quantify, tipping points involve the largest potential risks of climate change.

It is crucial to include the interaction between climatological and non-climatological factors in an analysis of the effects of climate change on an individual country, or an individual sector, and to keep in mind that these interactions are transnational to varying degrees. For an extensively internationalised country like Sweden, it is important to analyse the consequences for Sweden from changes in the rest of the world. The impacts of climate change on infectious diseases, economic development, trade flows, inequality, security and conflict, geopolitics and migration, as well as the linkages between them, present relevant areas for further study. In both a national and a global context, key considerations also include just adaptation, as well as concern for socio-economic and gender equality in climate change adaptation processes.

Climate-related developments in regions bordering Europe may have profound effects also in Sweden. The heating of the Arctic region, leading to a retreat of sea ice, opens the region to trans-Arctic shipping and exploitation of natural resources. As a result, possibilities for both international competition and cooperation increase. As global heating makes Africa, the Middle East and Central Asia less climatologically liveable regions, migration to Europe may increase further, bringing both substantial challenges and opportunities.

6.3 Adaptation measures

6.3.1 Domestic adaptation policies and strategies

In 2018, the Government presented a National Strategy for Climate Change Adaptation (Govt. Bill 2017/18:163 2018. *National Strategy for Climate Change Adaptation*), aimed at strengthening climate change adaptation work and its coordination in Sweden, including through prioritization of actions and investments. The strategy gives the National Board of Housing, Building and Planning the task of coordinating national adaptation work within the field of spatial planning.

Efforts at the national, regional and municipal levels will be needed in order to take climate change adaptation measures into consideration in spatial planning and thus reducing risks and costs for future generations. This work is carried out through close cooperation between national authorities; the National Board of Housing, Building and Planning, together with the Swedish Meteorological and Hydrological Institute (SMHI), the Swedish Geotechnical Institute (SGI), the Swedish Civil Contingencies Agency (MSB), and the County Administrative Boards. Together, these authorities aim to strengthen municipal climate change adaptation work on spatial planning.

The strategy also proposes changes to the Planning and Building Act (2010:900), later adopted by the Swedish Parliament. The altered legislation specifies planning and building regulations requiring municipalities to outline their views on climate-related risks in their comprehensive planning. It also gives local municipalities the power to introduce specific climate adaptation measures, such as requiring a permit for landowners to fell trees or take measures increasing soil imperviousness, if stated in detailed development plans.

The National Strategy for Climate Change Adaptation identifies prioritized adaptation challenges, including: landslides, erosion and flooding that threaten communities, infrastructure and businesses; high temperatures that involve risks for the health and wellbeing of people and animals; water shortages for individuals, agriculture and industry; biological and ecological effects that affect sustainable development; impacts on domestic and international food production and commerce; and increased incidence of pests, diseases and invasive non-native species that affect people, animals and plants.

In particular, the National Strategy highlights the need for identifying specific risk areas in Sweden regarding landslides, flooding and erosion, and to rank them based on likelihood, potential consequences and specific problems. In June 2021, the Swedish Geotechnical Institute (SGI) and the Swedish Civil Contingencies Agency (MSB) delivered a comprehensive analysis of the geographical areas in Sweden most at risk from landslides, erosion and flooding (SGI & MSB, 2021). In a report to the government, ten national risk areas are identified, where complex climate-related risks threaten human lives and health, ecosystems, infrastructure, housing and cultural heritage (see map, Figure 6.4). The analysis concludes that Sweden's capacity for climate change adaptation needs to grow further, both in terms of preventive action, planning and interagency coordination.

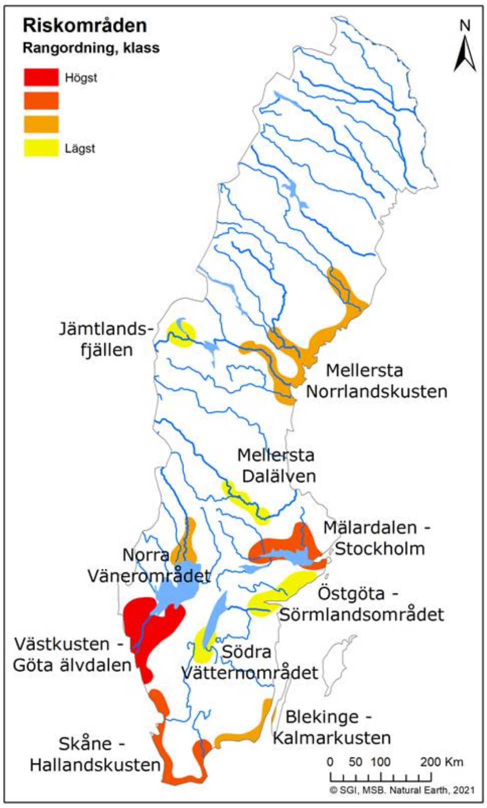

Figure 6.4 The ten geographical areas in Sweden most at risk from landslides, erosion and flooding. Risk areas are ranked from highest risk (red) to lower risk (yellow) (SGI & MSB, 2021).

The National Strategy also identifies ten key principles aimed at guiding climate change adaptation work in Sweden:

- Sustainable development
- Mutual support
- Scientific basis
- The precautionary principle
- Integration of adaptation measures
- Flexibility
- Managing uncertainty
- Managing risk
- Time perspective
- Transparency

The National Strategy will be revised every five years, from 2023 onwards. The Swedish National Expert Council for Climate Adaptation, appointed by the government and established in 2018, is tasked with supporting the government in formulating a revised National Strategy.

The Expert Council for Climate Adaptation evaluates climate change adaptation in Sweden and advices the government on preparing for climate change, by submitting an analysis report every five years. The report is used to support the government in updating the National Strategy for Climate Change Adaptation The first report, submitted to the Government in February 2022, outlines:

- Recommended focus areas for Sweden’s work on climate change adaptation
- A prioritization of adaptation measures based on an assessment of risk, costs and benefits
- A cross-sectoral assessment of the societal impacts of climate change
- A follow-up and evaluation of national work related to climate change adaptation.

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

Many Swedish authorities play an important role in adaptation work through their respective sectoral responsibilities and are working on preventive measures, building knowledge, providing guidelines, and improving resilience. For example, in spring 2021, the Swedish Environmental Protection Agency presented Sweden’s first national guideline for working with nature-based solutions as a climate adaptation tool.

The regional government offices (County Administrative Boards) are responsible for coordinating regional adaptation and supporting local actors in their adaptation work. The County Administrative Boards report annually to the Government on the actions taken to adapt to climate change.

In 2012, SMHI was tasked to form the National Knowledge Centre for Adaptation, to assist municipalities, regions, authorities and other stakeholders in their adaptation efforts. In 2021, the Centre has a budget of SEK 19 million.

6.3.2 Adaptation action plans

The Government Ordinance on the work of Sweden's authorities on adaptation to climate change establishes that national authorities shall implement vulnerability assessments, a task that most of the 53 authorities covered by the ordinance have completed.

Monitoring of the work carried out by the authorities is carried out by SMHI annually. The report on work carried out in 2020 (SMHI, 2020b) shows that many consider risks connected to flooding to be important within their areas of responsibility, and this is also the area where most actions are carried out or planned. However, many authorities still need to carry out additional analytical work to specify risks and opportunities further, in order to identify effective adaptation actions.

An analysis completed in 2020, based on a survey of a majority of Swedish municipalities (SMHI, 2020a) showed that the majority of municipalities have identified the need to take action with regard to climate change adaptation, and around half of the municipalities have developed action plans, at least to some extent. However, few municipalities have evaluated whether measures taken to adapt to a changing climate have made the municipality less vulnerable to climate disruption. Coastal municipalities, larger cities and municipalities close to larger cities, as well as municipalities in the southern part of Sweden, have come further in the climate change adaptation process than rural and northern municipalities.

6.3.3 Implementation

In the 2018 budget proposal, the Government announced a specific initiative for co-financing landslide mitigation measures along the Göta älv river in western Sweden (SEK 215 million in 2021). The risk of landslides along the river is high already in today's climate, but increasing precipitation and increasing drainage will make the risk considerably higher in the future.

Municipalities can also include adaptation measures when applying for other forms of government grants such as the greener cities grant. Through appropriation 1:10 Climate Change Adaptation, preventive and knowledge-enhancing initiatives are funded (SEK 78 million in 2021). Such initiatives have a focus on e.g. landslides, flooding and erosion mapping, directed by the Swedish Geotechnical Institute and the Swedish Civil Contingencies

Agency, and on knowledge-enhancing initiatives by SMHI. Climate change adaptation should be integrated into relevant activities and sectors, and spending on increased resilience in projects and sectors is therefore not specified.

In Sweden, the main principle for financing adaptation measures is that the responsibility for preventing and repairing damage due to extreme weather events does not differ from the responsibility for other forms of risk management. This means that the authority or individual who is normally responsible for a sector or property is so also for its adaptation to the effects of climate change.

In built-up areas where the risk of natural disasters is particularly high, municipalities can apply for state funding for preventive actions (through appropriation 2:2 Preventive measures against landslides and other natural accidents). There is about SEK 25 million available annually for the years 2021–2023. The funding is administrated by the Swedish Civil Contingencies Agency. Contributions can be made with up to 60% of eligible costs or to a maximum of 60% of the value of objects threatened by natural disaster. With this funding, municipalities can implement protection measures against landslides and flooding in practice.

A National Network for Adaptation, consisting of 27 national authorities, all 21 County Administrative Boards and the Swedish Association of Local Authorities and Regions (SKR), provides an arena for knowledge exchange across sectors. The network aims to increase the resilience of society to climate change, and the secretariat for the network is provided by SMHI.

Swedish municipalities, local actors and county administrative boards can also apply for government grants for nature-based solutions for water retention and drought resistance such as river and wetland restoration trough the Local Nature Conservation Initiative (LONA) (total of 108 million SEK 2020). The Swedish Environmental Protection Agency also guides municipalities and County Administrative Boards in their applications for financing trough the EU LIFE-programme for investments in environment and climate action.

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

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

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

Several coordination forums with relevance for adaptation currently exist in Sweden. Through these forums, sectoral agencies and other stakeholders can share experiences and plan key actions. These forums include:

- Agency network for shore erosion
- Committee on dimensioned flows in hydroelectric dams in a changing climate
- Delegation for landslides
- National network for drinking water
- National network for adaptation
- Regional network for coastal cooperation in Skåne and Halland

Implementation at the local level

Sweden's municipalities are obliged to carry out risk and vulnerability assessments as a basis for coping with extraordinary events and crises. Such analyses also cover events that will be affected by climate change.

Concrete adaptation measures have been initiated in many instances, above all in municipalities hit by extreme weather events. Regarding the nationally prioritized challenges, municipalities have mostly undertaken adaptation measures towards flooding, landslides and erosion, whereas few measures have been undertaken with regards to the effects on domestic and international food production and trade (SMHI, 2020a).

Most municipalities integrate climate change adaptation measures into spatial planning, especially concerning flooding, landslides and erosion. One fourth of municipalities consider heatwaves in their spatial planning, while one third have developed routines, checklists and action plans to counter extreme heat. Examples of physical measures introduced by municipalities include stabilizing and reinforcing measures to counter landslides, measures to manage stormwater through delay and retention of water flows, such as dams, reservoirs and rain gardens, as well as removal of impervious surfaces.

6.3.4 Monitoring and evaluation framework

An assessment report on the Swedish climate change adaptation strategy and the actions taken since 2007 was submitted to the Government in March 2015.

The report highlights the need to develop suitable instruments and indicators to evaluate the implemented adaptation measures. It is proposed that close cooperation should take place with the European Environment Agency to ensure the comparability of any future Swedish evaluation system with the activities of the European Commission.

In 2016, SMHI developed an initial proposal for a system for evaluating and monitoring the adaptation work in Sweden. The system looks at the actions taken as well as their effects.

At the request of the Government, in 2020 SMHI developed a more detailed proposal for a system to monitor and evaluate the national work on adaptation to climate change. The system includes data collection, aimed at answering three questions: 1) Have basic processes been established? 2) Is action being taken, and is it having an effect on vulnerability? and, finally, 3) Have actions proposed in the National Strategy for Climate Change Adaptation been implemented, and is it steering the work in the desired direction? In developing the proposal, experiences from monitoring and evaluation systems in other countries were considered, as were Swedish systems for monitoring and evaluation within other fields. Regard was also given to existing data collection and reporting requirements. A report for the consideration of the Ministry of the Environment was presented in December 2020.

The Government Ordinance on the work of Sweden's authorities on adaptation to climate change establishes that all 53 national and regional authorities covered by the regulation shall report on their work every year to SMHI. SMHI carries out an analysis of the supplied information, and completes a report to the Government. To date, two such analyses have been carried out, for work undertaken in 2019 (SMHI, 2020b) and in 2020 (SMHI, 2021c).

Sweden reports on its work on adaptation according to Article 12 in the Climate Convention and Article 13 in the Paris Agreement. The first mandatory reporting under Article 19 and Part 1 of Annex VIII of the Governance Regulation and Annex 1 of the Implementing Act to the European Commission was completed in March 2021.

6.3.5 Progress and outcomes of adaptation actions

Sweden is facing climate risks such as sea level rise, flooding, landslides, erosion, storm damage, drinking water contamination, heatwaves, drought, forest fires, spread of diseases and challenges for reindeer herding. Climate change adaptation initiatives in Sweden have advanced significantly in recent years to address such current and future threats.

In Sweden, municipalities play a particularly important role in enabling adaptation to climate change, since they are responsible for the implementation of many climate change adaptation measures in practice.

There is a positive trend regarding municipal climate change adaptation work. However, although 90 percent of municipalities have identified a need to take action with regards to climate change adaptation, the progress of different municipalities varies widely. Few municipalities have evaluated whether measures taken to adapt to a changing climate have made the municipality less vulnerable. Coastal municipalities, larger cities and municipalities close to larger cities, as well as municipalities in the southern part of Sweden have come further in climate change adaptation work than rural and northern municipalities. (SMHI, 2020a)

Case studies on adaptation actions and their outcomes

The Swedish National Knowledge Centre for Climate Change Adaptation gathers case studies on adaptation work in Sweden. The purpose of these case studies is to provide inspiration and to share experiences of different types of adaptation work. Sweden has gathered and described more than 75 case studies on adaptation, at www.klimatanpassning.se, including more than 65 translated into English, at www.klimatanpassning.se/en/cases.

Installing new water treatment filters reduces future economic and health losses

SMHI has analysed a number of cases of adaptation action in order to quantify the costs and benefits. For example, in one case study the analysis shows that installing a new filter in a water treatment facility in Gothenburg, at a cost of approximately €40 million, will deliver benefits worth over €250 million in the form of reduced economic losses due to illness. Importantly, the measure also reduces health risks of around half a million people. The installation of new water filters is partly financed through green bonds.

Agroforestry improves the resilience of agriculture

Agroforestry methods constitute a small but growing niche in Sweden's agricultural sector. Several trials are ongoing, one of them at Hånsta Östgärde farm in Uppland, where fruit and nut trees as well as berry bushes are planted in rows between fields. This agroforestry method increases resilience as risks are spread over a larger number of crops. In hotter and more extreme climate conditions, important benefits of planting rows of bushes and trees between fields include the provision of shade for other crops, temperature regulation, and protection of soil and crops from wind erosion.

Ecosystem based forestry spreads risks in managed forests

Although clear-cutting still dominates forestry in Sweden, alternative forestry methods are being explored on a small scale. Ecosystem-based forestry methods, such as the Lübeck method, are based on the idea that managed forests should mimic natural forests. Such forestry methods could increase the resilience of Sweden's forests to climate change. Mixed forests mimicking natural ecosystems inherently spread risks due to a variation of tree species and age. Such forests are more resistant to pests and invasive species. In a rapidly changing climate, advantages of maintaining a continuous tree cover also include a reduced risk of landslides, erosion and storm damage in exposed locations. Also, less disturbance of the tree canopy improves the ability of forests to manage drought and heavy precipitation events.

Networking at the municipal level reinforces local climate change adaptation

Officials working on climate change adaptation in local municipalities often work alone. This makes it important to identify forms of cooperation between municipalities. Forming local climate change adaptation networks facilitates learning from each other and supporting each other in day-to-day adaptation work. One such adaptation network has been established in the Gothenburg region. The thirteen network municipalities meet four times a year, allowing members to share experiences and learn from each other, creating a common knowledge base. An expert group, participating once a year, is associated with the network. This group includes researchers from four universities, a landscape architect, and representatives from the National Board of Housing, Building and Planning and the Swedish Meteorological and Hydrological Institute (SMHI).

Reindeer herding action plans identify vulnerabilities and adaptation measures

To improve the picture of how a warming climate affects reindeer husbandry, and how impacts can be addressed, the Sámi Parliament and the County Administrative Boards in northern Sweden initiated a pilot project, where four Sámi districts carried out climate and vulnerability analyses and developed action plans. The Sámi districts concluded that climate impacts are becoming increasingly evident, affecting reindeer husbandry in many ways. For example, due to landscape fragmentation, many reindeer herding districts lack large contiguous grazing lands to spread their herds on when the pasture freezes. Competitive land use, such as forestry, mining and hydropower, reduces the area of grazing land and makes it more difficult for reindeer to move. Proposed measures include identifying alternative winter grazing land, as forests with hanging lichens, an important feed source for reindeer, have largely disappeared in recent decades due to intensive industrial forestry, including clear-cutting of old growth forests.

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7. Provision of financial, technological and capacity-building support to developing country Parties

7.1 Introduction

Climate change is the defining issue of our time and a top priority for the Swedish government. Sweden has a long history of support for work on climate change issues in developing countries, in an array of sectors and on a long-term basis but has raised its ambitions further since the adoption of the Paris Agreement. Sweden has consistently called for coherent and co-ordinated implementation of the Paris Agreement, Agenda 2030 and the Addis Ababa Action Agenda for development finance – on both global and national levels. Effective financing of climate action is facilitated by mainstreaming climate action in national budget and planning processes, thereby paving the way for successful national resource mobilisation. A large number of Swedish actors, such as ministries, government agencies, state-owned companies, non-governmental organisations, universities and the private sector are engaged in climate actions such as providing grants and innovative finance, technology transfer, research and various forms of capacity building.

The continuous progress in the development of methodologies to track climate finance, as well as the efforts within the EU to harmonise methodologies, make it difficult to directly compare the numbers in this report with previous reports. Any differences between climate reporting to EU and the UNFCCC might be due to quality assurances or new information being available. The underlying methodology is the same for both EU and UNFCCC reports.

7.2 Governing policies and principles

7.2.1 Policy framework for Swedish development cooperation and humanitarian aid

In December 2016, the Government adopted a policy framework outlining the direction of Swedish development cooperation and humanitarian aid. The purpose of the policy framework is to have a knowledge-based, broadly supported framework that is aligned with the internationally adopted 2030 Agenda for Sustainable Development. At the same time, the Swedish policy framework also goes beyond the 2030 Agenda in a number of aspects, such as gender equality, democracy and human rights.

Environment and climate change are one of the key areas of the policy, one of three top priorities of the government, and in addition, an environment and climate change perspective shall be integrated in all Swedish development cooperation. The policy highlights that Sweden will support low and middle-income countries' accession to, and implementation of, commitments under the climate convention, and the implementation of their Nationally Determined Contributions under the Paris Agreement.

7.2.2 Key principles

The principles contained in the Paris Declaration of 2005, the Accra Agenda of 2008 and the Busan Partnership of 2011, and the outcome document from the second high-level meeting of the Global Partnership for Effective Development Cooperation in Nairobi (2016) are pivotal to international development cooperation and climate finance. National ownership is also key to securing long-term sustainability of climate change-related initiatives. External actors should seek to improve coordination and alignment to the national systems and processes of developing countries so as to ensure transparency and mutual accountability.

Within the multilateral funds Sweden has been a champion for direct access, where national authorities are able to directly access financing and manage all aspects of the projects/programs. In our bilateral work the countries' and organisations' own needs, priorities and strategies are weighed into the strategies, and a fundamental entry point for all of Sida's contributions. Sweden consider the countries' NDC:s and NAP:s and development plans areas central tools for Sida for understanding needs, priorities and where the funding gap is the largest in our partner countries in terms of financial and capacity building support.

7.2.3 New and additional measures

According to the UN Framework Convention on Climate Change, "The developed country Parties […] shall provide new and additional financial resources to meet the agreed full costs incurred by developing country Parties in complying with their obligations". 'New and additional resources' is a complex term, used in many multilateral contexts. There is currently no international agreement on how it should be defined. Sweden is one of few OECD DAC members to have met, and even far exceeded, the UN international development aid goal of 0.7 % of gross national income (GNI).

There is broad Parliamentary support, to continue delivering 1 % of Sweden's GNI to Official Development Assistance (ODA). Against this background, all climate finance provided by Sweden during 2017-2020 should be viewed as new and additional. Figures for total Swedish ODA 2017-2020 are shown in Table 7.1, together with the share of climate finance compared to total ODA. Figure 7.1 shows climate finance based on type of support. Sweden's overall climate financing having increased more than threefold since 2014.

Table 7.1 Total Swedish official development assistance, 2017–2020[68]

	2017	2018	2019	2020
ODA SEK million	46 129	48 950	50 710	52 110
ODA USD million	5 396	5 631	5 362	5 658
ODA % of GNI[69]	0,99	1,00	1,00	1,00
Climate finance SEK million	4 583	5 670	8 031	7 316
Climate finance (USD million)	536	649	849	794
Climate finance (% of ODA)	10	11,5	15,8	14

[68] Total ODA corresponds to total ODA in the budget bill. In Sweden's previous Biennial report under the UNFCCC, total ODA corresponded to the amount reported to the OECD DAC. However, considering that Sweden, in 2020, reported a debt note to the Green Climate fund á 8 billion SEK, which is included in the OECD DAC 2020 outcome, whereas actual payments are allocated over several years, the budget bill ODA level makes for a more relevant comparison. Climate finance corresponds to estimated climate finance based on policy markers and core support to organizations reported to the OECD DAC. Imputed climate finance for core support is based on data from the OECD DAC: https://webfs.oecd.org/climate/Imputed_multilateral_shares_climate.xlsx. Exchange rates are according to https://data.oecd.org/conversion/exchange-rates.htm. Any differences between climate reporting to EU and the UNFCCC might be due to quality assurances or new information being available. The underlying methodology is the same for both EU and UNFCCC reports. Climate finance for 2017 also includes 118 (million SEK) other official flows (OOF), for 2018 89 (million SEK) for 2019 74 (million SEK) and 42 million SEK for 2020.

[69] BNI according to ENS 2010

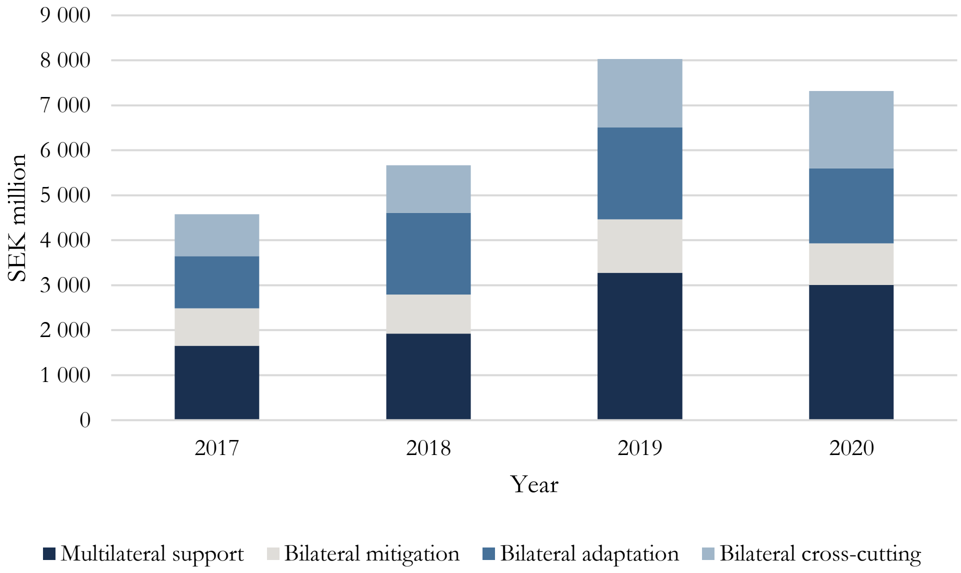

Figure 7.1 Total Swedish climate finance, 2017-2020. Multilateral support in this report refer to climate share of core contribution to multilateral organizations with reference to OECD DAC imputed climate shares. Sida performed quality assurance spot-checks of reported data for 2017 and 2018, and a number of adjustments were made during Sweden's in country review 2023. These concerned primarily broad framework agreements with Swedish civil society organisations, as well as a couple of humanitarian contributions. The adjustments resulted in a decrease in Sida's climate finance for 2017-2018. In addition, Sida has updated the climate finance reporting for 2020, following feedback from OECD/DAC on Sweden's official development finance reporting.

7.3 Multilateral financial support

In 2020 total climate finance channeled through multilateral organizations wereas climate specific support were 3004 MSEK. Sweden is one of the largest per capita donors in the world to the financial mechanism under the UN Framework Convention on Climate Change – the Green Climate Fund (GCF) and the Global Environment Facility (GEF). In addition, Sweden provided substantial climate finance through a number of other multilateral climate change funds, such as the Adaptation Fund, the Least Developed Countries Fund, the Climate Investment Funds (CIF) as well as the Global Centre for Adaptation. Sweden was also instrumental in a renewed replenishment of the Nordic Development Fund (NDF) in 2020 with first instalments due in 2022. Multilateral core support to climate finance refers to the estimated amount of multilateral core support that is considered climate specific, using the OECD DAC imputed multilateral (climate) shares[70].

[70] Imputed climate finance for core support is based on data from the OECD DAC: https://webfs.oecd.org/climate/Imputed_multilateral_shares_climate.xlsx.

Sweden was also instrumental in a renewed replenishment the replenishment of the Nordic Development fund (NDF) in 2020 and made new commitments to the Climate Investment Funds' (CIFs) Industry Transitioning Program, as well as the Global Center for Adaptation.

Multilateral climate finance (presented in CTF Table 7) is mainly managed by the Ministry for Foreign Affairs, including core support to Multilateral Development Banks (MDB) and UN organisations. Sweden considers core funding key for flexibility, rapid response, long-term planning and in line with the principles of aid effectiveness, and has thus chosen to present some of this support in Table 7 (note that it does not necessarily provide an exhaustive list of all of Sweden's multilateral contributions; for example imputed climate shares are unavailable for some organizations that Sweden provides with core support which may have climate activities to some degree).

The Ministry of Climate and Enterprise administered support to a number of strategic initiatives linked to the UNFCCC negotiations, such as the UNFCCC Trust Fund Fund for Supplementary Activities and Trust Fund for Participation, the New Climate Economy, the International Insitute for Environment and Development, the International Institute for Sustainable Development's work with the Global Subsidies Initiative, and the OECD:s Research Collaborative on Tracking Climate Finance. The Swedish Energy Agency, the Swedish Environmental Protection Agency and the Swedish Meteorological and Hydrological Institute were also involved in important climate initiatives, programs and mechanisms, such as the Climate and Clean Air Coalition, and the Sustainable Development Initiative.

Sweden has been a champion of gender integration in the multilateral climate funds, including the promotion of separate gender policies and action plans that support gender-responsive actions. During the reporting period, for example the GCF adopted an updated gender policy in 2019. Integration of gender issues continues to improve, thus also contributing to raising the efficiency and long-term sustainability of the projects and programs funded by multilateral climate funds.

7.4 Bilateral financial support

In this chapter three sections will follow: multi-bilateral, bilateral support from Sida and bilateral support from the Swedish Energy Agency. In Sweden, climate finance data is provided by three government agencies (Ministry for Foreign Affairs, Sida and Swedish Energy Agency). The vast majority of bilateral support is provided by Sida.

In 2020[71], total bilateral finance support was 4313 MSEK (924 MSEK for bilateral mitigation, 1667 MSEK for bilateral adaptation and 1721 MSEK for Cross-cutting). For an overview, see table 7.2 below.

Table 7.2. Total bilateral climate finance 2017-2020.

Total bilateral finance 2017		
Type of support	**Climate finance (MSEK)**	**Climate finance (MUSD)**
Mitigation	831	97
Adaptation	1159	136
Cross-cutting	939	110
Total	**2929**	**343**
Total bilateral finance 2018		
Type of support	**Climate finance (MSEK)**	**Climate finance (MUSD)**
Mitigation	872	100
Adaptation	1810	208
Cross-cutting	1063	122
Total	**3746**	**431**
Total bilateral finance 2019		
Type of support	**Climate finance (MSEK)**	**Climate finance (MUSD)**
Mitigation	1190	126
Adaptation	2041	216
Cross-cutting	1526	161
Total	**4756**	**503**
Total bilateral finance 2020		
Type of support	**Climate finance (MSEK)**	**Climate finance (MUSD)**
Mitigation	924	100
Adaptation	1667	181
Cross-cutting	1721	187
Total	**4313**	**468**

[71] In 2017, total bilateral climate finance support was 2929 MSEK (831 MSEK for bilateral mitigation, 1159 MSEK for bilateral adaptation and 939 MSEK for Cross-cutting. In 2018, total bilateral climate finance support was 3746 MSEK (872 MSEK for bilateral mitigation, 1810 MSEK for bilateral adaptation and 1063 MSEK for Cross-cutting. In 2019, total bilateral climate finance support was 4756 MSEK (1190 MSEK for bilateral mitigation, 2041 MSEK for bilateral adaptation and 1526 MSEK for Cross-cutting.

7.4.1 Multi-bilateral support

An overview of Sweden's earmarked multilateral support (multi-bi) in 2020, with respect to type of support, is presented in Figure 7.2 (corresponding outcome in 2019 is not readily available).

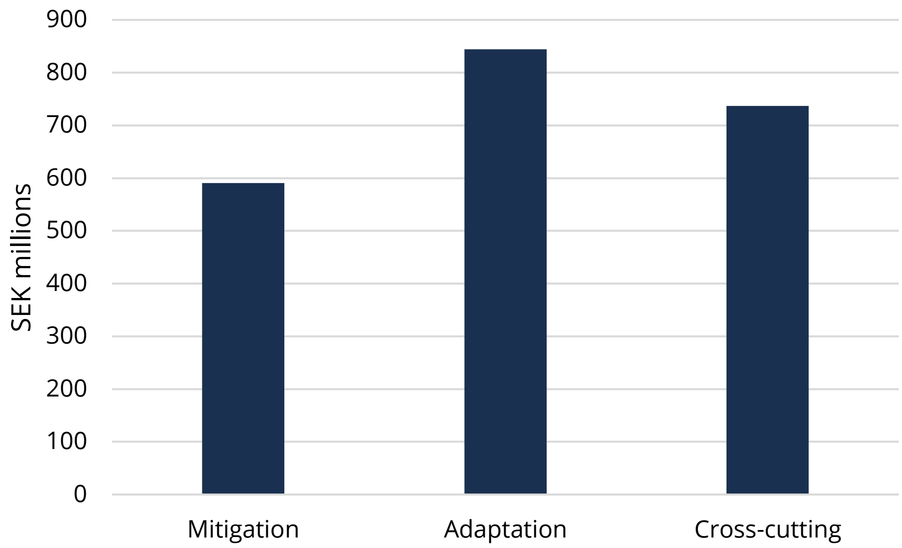

Figure 7.2 Swedish multi-bilateral climate finance 2020 by type of support.

More detailed information for each year can be found in Annex 6 (Provision of financial, technological and capacity-building support to developing country Parties).

7.4.2 Methodology for tracking climate-related bilateral ODA

The Swedish bilateral support provided through Sida includes support to bilateral, regional and global institutions and organisations (including so-called 'multi-bi' support), and is reported in CTF Table 6: summary information, 8: details at component level, 9: description of examples of transfer of or access to environmentally sound technologies, 10: examples of technology development support, and 11: examples of capacity building support.

Online publishing

Detailed information about Sida's operations is continuously published online according to the internationally agreed International Aid Transparency (IATI) standard at www.openaid.se.

Tracking, coefficients and range of countries

Sida uses the OECD DAC Rio markers for climate change mitigation and climate change adaptation to track climate finance. The components are marked using a scale of 0–2, where 2 represents 'principal objective', 1 'significant objective' and 0 'not targeted'. In climate finance reporting, Sweden includes the full amount of finance to components that have climate change as a principal objective, but only 40 % of the finance provided to components with climate change as a significant objective (see Table 7.3).

In CTF Table 6 and 8, the disbursed amounts presented are already weighted with the coefficients. These standard coefficients are relatively simple to apply, while they help avoid over-reporting of finance that does not have climate change as the main objective. This approach is in line with the reporting of several donors including the European Commission. To acknowledge the synergies between mitigation and adaptation, and ensure that there is no double counting, the type of climate change action is determined as mitigation, adaptation or cross-cutting according to 7.4

Table 7.3 Matrix of how the type of contribution is determined based on the two Rio Markers, climate change mitigation (CCM) and climate change adaptation (CCA), and the application of coefficients.

Rio Marker	CCM 2	CCM 1	CCM 0
CCA 2	Cross-cutting; 100% of finance	CCA; 100% of finance	CCA; 100% of finance
CCA 1	CCM; 100% of finance	Cross-cutting; 40% of finance	CCA; 40% of finance
CCA 0	CCM; 100% of finance	CCM; 40% of finance	Not climate finance

Gender equality integration

The OECD DAC gender policy marker is used to track gender equality integration in climate finance. The climate contributions that are marked with the gender policy marker 1 or 2 are considered gender integrated. Level of gender integration for Sweden's bilateral support is presented in Figure 7.3.

Mobilisation of finance

In addition to climate finance in the form of grants, Sida provides guarantees to support actors to mobilise climate finance from private and public sources; see the section "Mobilised finance".

7.4.3 Bilateral financial support through Sida

The majority of Swedish climate finance to low- and middle-income countries is channelled as bilateral ODA through Sida. Sida provides climate change support at several levels, including support to local and national institutions, bilateral support to multilateral organisations[72] and support to other regional and global organisations. The support is provided to partner organisations both with climate change as a main objective ('principal objective' according to DAC terminology), and as a secondary objective ('significant objective' according to DAC terminology), i.e. integrated in contributions that have other main objectives. This is done in cooperation with a variety of actors, including government institutions, multilateral organisations, research institutions, non-governmental organisations, the private sector and Swedish authorities.

Table 7.4. Climate finance provided by Sida during 2017 -2020. Note that this table only include climate finance data from Sida and not from the Swedish MFA or Swedish Energy Agency.

	2017		2018		2019		2020	
	MSEK	MUSD	MSEK	MUSD	MSEK	MUSD	MSEK	MUSD
Adaptation	1107	130	1810	208	2041	216	1569	170
Cross-cutting	927	108	1057	122	1521	161	1348	146
Mitigation	630	74	754	87	1091	115	863	94
Total	**2664**	**312**	**3662**	**417**	**4653**	**492**	**3781**	**411**

[72] "Multi-bi" according to OECD DAC definitions.

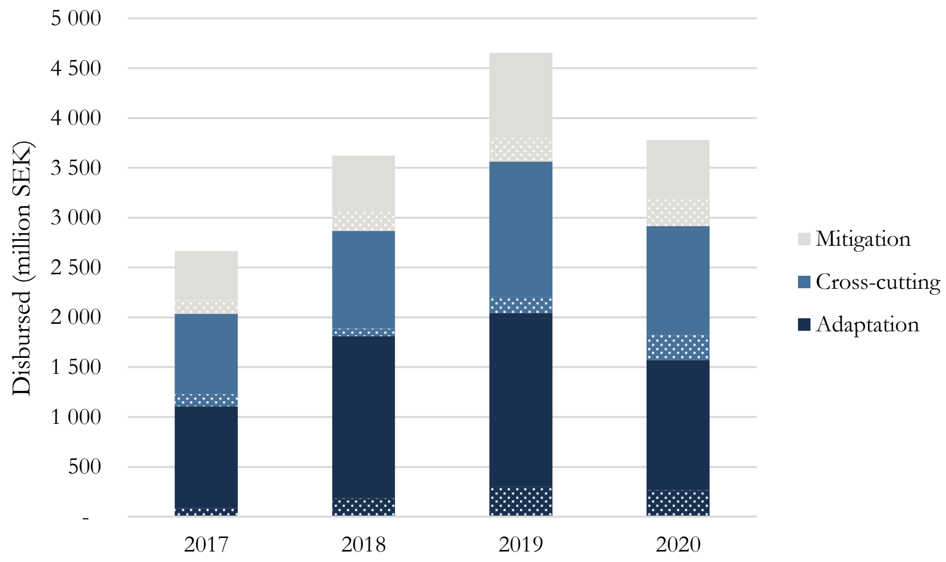

Figure 7.3 Climate finance provided by Sweden through Sida during 2017 –2020, by type of climate action, and levels of gender equality integration (The figures represent disbursements to non annex I parties plus regional and global contributions for 2017 –2020). Solid fields represent disbursements to contributions integrating gender equality.

As shown in Figure 7.3, Sweden increased its bilateral climate finance substantially from 2017 to 2019. More specifically, the overall increase was 75 %. In 2020, the bilateral climate finance dropped with 23 % due to delays and reallocation of funds as a result of the COVID-19-pandemic as well as quality assurance of data. Between 2017 and 2020, the financial support to mitigation increased by 37 % while support to cross-cutting initiatives increased by 45 %. The financial support to adaptation increased with 42 % during the same period and continues to constitute a significant proportion of the climate finance (42% in 2020).

Sida has made efforts to focus on supporting countries in climate change adaptation since the Climate Change Initiative of the Swedish Government 2009–2013. Since then, Sida has continued to strengthen the focus on adaptation and increasingly meet the growing demand from country partners and organisations in this field. Sweden has also continued providing significant support to the Adaptation Fund and adaptation windows in other multilateral funds. Globally, the majority of international climate finance continues to be directed to climate change mitigation (70 % in 2018) and only a relatively small proportion to climate change adaptation (21 % in

2018).[73] While adaptation is underfunded, the needs continue to grow, as do demands for support from Sida's work is conducted within the framework of bilateral, regional and global development cooperation strategies decided by the Swedish Government. Sida provides resources that enable development initiatives focusing on the poorest and most vulnerable people. Broad-based local and national ownership is key to sustainable development and sustainable results from climate finance. The countries' and organisations' own needs, priorities and strategies are weighed into the bilateral strategies, and constitute a fundamental entry point in all of Sida's operations.

The countries that have received most bilateral climate finance from Sweden during 2017-2020 are presented in Table 7.5. African countries are among the main recipients of Swedish bilateral climate finance in general, and Mozambique has been among the top five recipients all four years. In other regions, Afghanistan and Bangladesh are among the top recipients. It can also be highlighted that several fragile states, such as Somalia, are among the top recipients despite the conflict/post-conflict context that makes implementation highly challenging. For all countries, payments may vary significantly between years. This depends greatly on context and a range of reasons, including administrative and political reasons.

Table 7.5. A summary of the top five countries receiving bilateral climate finance during 2017 – 2020. Most of the countries are among Sweden's major bilateral development cooperation partners. Note that this table only include climate finance data from Sida, and and not from MFA or Swedish Energy Agency.

2017	Country	Disbursed (MSEK)	Disbursed (MUSD)
1	Kenya	178	21
2	Tanzania	165	19
3	Mozambique	130	15
4	Mali	128	15
5	Zambia	82	10
2018	**Country**	**Disbursed (MSEK)**	**Disbursed (MUSD)**
1	Tanzania	198	23
2	Mozambique	176	20
3	Mali	150	17
4	Kenya	117	13
5	Burkina Faso	105	12
2019	**Country**	**Disbursed (MSEK)**	**Disbursed (MUSD)**

[73] OECD-DAC. November 2020

1	Mozambique	255	27
2	Burkina Faso	239	25
3	Somalia	167	18
4	Mali	140	15
5	Kenya	132	14
2020	**Country**	**Disbursed (MSEK)**	**Disbursed (MUSD)**
1	Mozambique	181	20
2	Somalia	171	19
3	Burkina Faso	136	15
4	Kenya	130	14
5	Bangladesh	87	9

BOX 7.1

Sida has provided funding to DemoEnvironment, a challenge fund with the purpose of increasing technology transfers to a selection of developing countries in order to improve living conditions and health of people in poverty, enhance the ability to adapt in the cooperation countries, and decrease negative impact on the environment and climate. In 2020, it was concluded that a majority of the projects carried out with support from the DemoEnvironment challenge fund have successfully implemented new technologies, which in turn can be established in the recipient countries in the future. DemoEnvironment has for example i) supported the implementation of technology enabling the production of roof tiles made from sand and recycled plastic in Kenya, while creating employment opportunities for local women; ii) enabled technology transfer for sustainable forestry in Mozambique; and iii) financed technology for the production of briquettes from faecal waste in Kenya, which has created employment opportunities and improved sanitation practices.

BOX 7.2

Sida supports the Inclusive Green Economy (IGE) programme, contributing to a transformation shift towards an inclusive green economy in Ethiopia, Kenya, Rwanda, Tanzania and Uganda. The programme builds on the participating countries' own current work on inclusive green economy and focuses on enhancing governmental capacities to successfully combine environmentally friendly and economically successful policies. Activities include sharpening present policy and practice instruments, such as taxes, fees, pollution charges, green investments and subsidies. Participants include senior civil servants in government, high-level policy and decision-makers but also academics and civil society representatives. After the end of the programme, participants will be accredited IGE fellows, with a regional network to share best-practices and the possibility of training colleagues in successful implementation of IGE practices. The initiative is considered to have both climate change adaptation and mitigation as significant objectives, hence approximately 3.6 MSEK (that is 40% of the total disbursement in 2020) is identified as climate finance (see section 7.4.1 above for more information about the methodology).

BOX 7.3

Sida provides funding to ICIMOD, an intergovernmental organisation with eight member countries in the Hindu Kush Himalayan region. The overall objective of ICIMOD's work is that men, women, and children in the region enjoy improved well-being in a healthy mountain environment. The programme aims to contribute to reduced poverty, reduced physical and social vulnerability and improvement of ecosystem services. Activities and results include: development and dissemination of flood early warning systems; climate change adapted value chains; measurement, monitoring and management of air pollution; strengthening of women's capacity and leadership roles in agriculture and local decision making bodies; strengthening the regional cooperation through technical exchanges and management of transboundary natural resources; and increasing the global awareness of the importance of mountain areas for resilient living conditions and ecosystems. ICIMOD coordinated the HKH assessment, which was published in 2020 and yielded great interest. With more than 2 000 media mentions, 580k downloads, 715 native tweets and 82 citations, the publication has the widest reach of any ICIMOD publication in the institution's history. In 2020, ICIMOD was accredited by the Adaptation Fund, the only accredited regional organisation in Asia.

BOX 7.4

Sida supports the Rwandan national climate and environment fund (FONERWA). The Fund has the objective to mobilise domestic and international climate finance, and secure sustainable financing to support projects that contribute to environmental sustainability, resilience to climate change and green growth. The Fund is open to line ministries and districts, civil society organisations, private entities and research institutions. The support is expected to i) provide access to sustainable and equitable finance that enables public and private entities to address climate and environment priorities; ii) improve skills of national stakeholders and CSOs in the design of project proposals; iii) result in bankable projects approved for funding by the FONERWA board; and iv) enable implementation of projects and dissemination of lessons learned. These outcomes will be achieved by activities such as training of national CSOs by international NGOs in developing proposals and increased participation of national CSOs in addressing climate change and environmental challenges. The support from Sida specifically provides technical assistance to environmental CSOs, capacity building of FONERWA and tools for improved gender integration. The projects supported by FONERWA are often pilots, in which new innovative methods are applied, such as climate-smart production of vegetables or clean cooking. In a newly completed project, electric motorcycle taxis were introduced and recommendations were provided to the Rwandan government for continued development of electric transport.

Equality between women and men is a prerequisite for sustainability and for achieving the goals of UNFCCC and the Paris Agreement. Sida is committed to integrating the gender equality perspective throughout its operations, including the support for climate action. The level of gender integration in Sida's climate finance 2017-2020 is presented in Figure 7.3. The overall level of gender integration is around 85%. There is a slightly decreasing trend, and therefore further stepping up of efforts need to be sought. Sida's voluntary reporting of gender integration in the NC and other climate finance reporting is done to track the progress, stimulate further integration and encourage other actors to do the same. Sweden has also been a champion for gender integration in the multilateral climate funds, including the promotion of separate gender policies and action plans. Improved integration of gender issues contributes to the efficiency and long-term sustainability of projects and programs funded by multilateral climate funds.

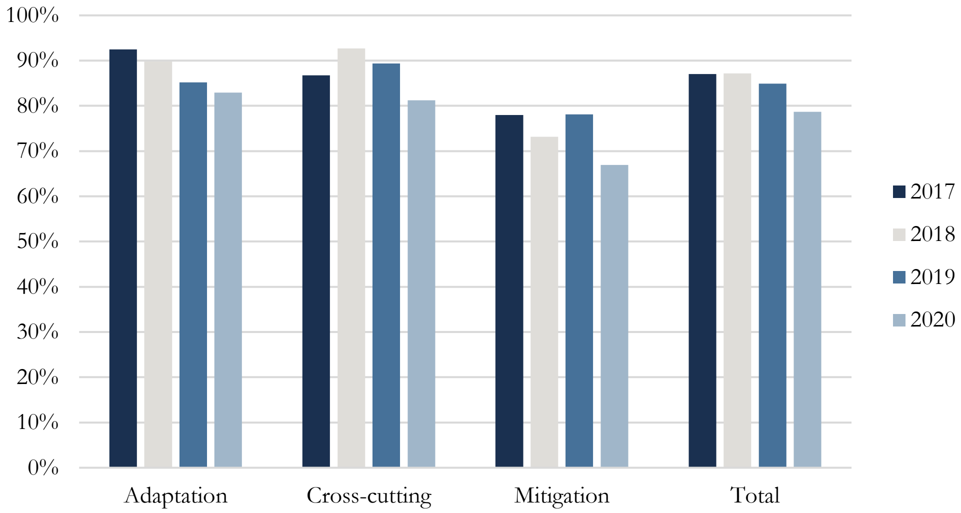

Figure 7.4 Level of gender equality integration in Sida's climate finance during 2017 –2020. The figures represent disbursements to non annex I parties plus regional and global contributions for 2017 –2020.

The climate finance Sida provided in 2017-2020 was distributed among sectors[74] as shown in Figure 7.4. The largest climate finance disbursements were made to initiatives within the sectors 'agriculture', 'energy', 'environmental policy and administration' and 'urban development, rural development and multisector'. Climate change can be better integrated within sectors such as health, education and social protection as well as within humanitarian support and disaster risk reduction

The climate finance Sida disbursed in 2017–2020 was distributed among geographic regions and global organisations as shown in Figure 7.5. The largest proportion of the financing was provided to local, national and regional actors in Africa. The large portfolio of climate change initiatives at the global level increased during the time period, as did to some extent the smaller portfolios in Latin America and Asia.

[74] Sector classification according to UNFCCC reporting guidelines (sectors include Energy; Transport; Industry; Agriculture; Forestry; Water and sanitation; Cross-cutting; and Other). The category "Other" includes Health, Education, Social protection, Banking and Trade according to OECD -DAC. Sectors 15 Government and civil society, 41 Environmental policy and administration, 43 Urban development, rural development and multisector and 72-74 Humanitarian and DRR are OECD-DAC sectors and have been lifted out from the category "Other" since a significant proportion of climate finance falls within these sectors.

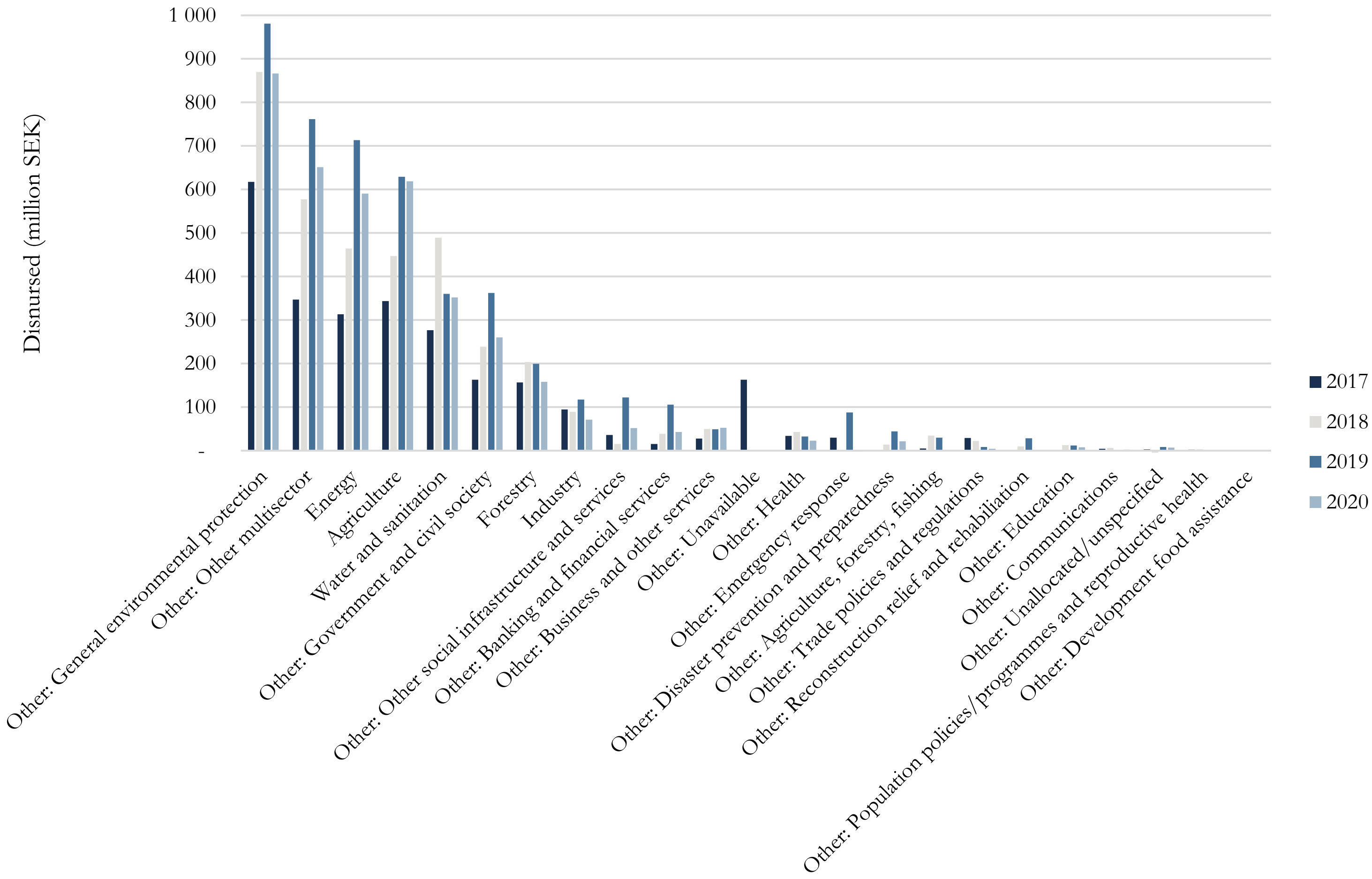

Figure 7.5 Sida's climate finance by sector during 2017 –2020.

7.4.4 Bilateral financial support through the project-based flexible mechanisms under the Kyoto Protocol

Since the start of the program in 2002, Sweden has participated in a number of climate initiatives for collaborative efforts under the Kyoto Protocol. The program consists of bilateral projects part of the Clean Development Mechanism (CDM) and Joint Implementation (JI) as well as multilateral carbon funds. The program provides results-based climate finance, generating certified emission reductions. By the end of 2020, 91 bilateral projects and 11 multilateral funds[75] had generated emission reductions equivalent to approximately 31 Mt CO2 -eq. The number of active initiatives is steadily decreasing. The program is expected to close by 2025 with final payments in 2022. Priority project types are renewable energy, energy efficiency and waste management. Priority has been given to projects set in Sub-Saharan Africa (32 % of emission reduction units), India (17 % of emission reduction units) and China (17 % of emission reduction units).[76] For bilateral projects, Small Island Developing States (SIDS) account for 2% of portfolio emission reduction volume, and Least Developed Countries (LDC) for 13% of portfolio emission reduction volume.[77]

In 2017-2020, a total of SEK 623 million was paid out to bilateral projects and multilateral funds, and 15,9 million certified emission reductions were delivered. Up until the end of the program, another 4 million emission reduction units are expected to be delivered. All emission reductions delivered up until June 1st 2023 have been cancelled. Emission reductions received in 2017-2018 were cancelled in 2020, whilst emission reductions received in 2019 were cancelled in 2021.[78] The cancellation of units received in 2020 was conducted in 2023 (KN2023/03293). Cancelled emission reductions have been permanently removed from the market and have not been used to fulfil Sweden's commitments under the Kyoto Protocol.

However, out of the cancelled emission reductions for 2020, 641 388 emission reductions have been cancelled for use towards fulfilment of the Swedish national target for 2020.[79] Since the main objective of the projects is climate change mitigation, the support provided is regarded as 100% climate

[75] Future Carbon Fund (FCF), Asia Pacific Carbon Fund (APCF), Transformative Carbon Asset Facility (TCAF), Carbon Initiative for Development (Ci-Dev), Carbon Partnership Facility (CPF), Pilot Auction Facility for Methane and Climate Change Mitigation (PAF), Umbrella Carbon Facility Tranche 2 (UCF T2), Prototype Carbon Fund (PCF), Multilateral Carbon Credit Fund (MCCF), Testing Ground Facility (TGF) and Partnership for Market Readiness (PMR).

[76] Including delivered emission reductions as well as projected deliveries until the end of the program.

[77] Can be compared to the global CDM-market where SIDS represent 0,3 percent and LDCs represent 1,7 percent. http://www.cdmpipeline.org/ overview (20211019).Using the OECD DAC definition of Least Developed Countries: https://www.oecd.org/dac/financing- sustainable-development/development-finance-standards/DAC-List-ODA-Recipients-for-reporting- 2021-flows.pdf

[78] Reference M2020/00283/KI; M2021/00442. Support for units received in 2017-2018 was not reported in Sweden's fourth Biennial Report as the units had not yet been cancelled at the time of writing the report.

[79] Emission reductions were used to fulfil the national target to reduce emissions not covered by the EU Emission Trading System (EU ETS) by 40 percent compared to emission levels in 1990. Emission reductions were thus not used to meet Sweden's commitments under the Kyoto Protocol as an EU member state.

finance according to the Rio markers (climate change mitigation is principal objective).

Through Emission Reduction Purchase Agreements, the Swedish Energy Agency commits to purchasing the generated international credits when they are certified by the CDM board. The actual payment is done once the international credits have been generated, verified, and certified by the UNFCCC and forwarded to Sweden's holding account. The cancelled international credits have been reported as climate finance the year of the financial flow from the Swedish government to the project owner.

Table 7.6 Bilateral financial support through the Program for International Climate Initiatives during 2017–2020.

Year	MSEK
2017	118
2018	89
2019	74
2020	43
Total	324

7.5 Financial flows leverages by bilateral climate finance

7.5.1 Mobilisation of capital through Sida

Since 2009, Sweden has an Ordinance for Financing of Development Loans and Guarantees for Development Cooperation. This provides opportunities to expand and leverage available resources for development by linking public measures with market finance. Guarantees stimulate mobilisation of both private and public capital, including partner countries' domestic capital. Sida helps lenders deal with risks by insuring eligible projects against losses relating to the different market risks. A common set-up is that Sida covers part of the loss if the borrower fails to repay its loan to a bank. Sida's guarantees are based on a set of simple key principles and conditions: additionality, risk-sharing, risk reflecting premium, and that it should be non-distortionary. In 2020, Sida had guarantees to climate-relevant initiatives with a total guarantee volume of approximately 5 billion SEK, mobilising about 14.7 billion SEK. Note that part of the mobilised capital is provided by Development Finance Institutions (DFIs) that are partly or fully owned by public entities.

Sida continuously works to enhance mobilisation of additional climate finance and is currently leading a project with the objective to increase access and implementation of innovative partnership- and financing methods and tools, as well as increasing the knowledge and engagement around innovative financing amongst a broad network of actors. The project supports the Global Innovation Lab for Climate Finance – an incubator which works with identifying and strengthening innovative financing instruments that mobilise capital within climate finance, including sectors such as sustainable cities, renewable energy and sustainable food systems.

Sida implements the methodology for calculating mobilized private capital outlined in the DAC directives: In the case of guarantees, the mobilized amount is attributed to guarantors pro-rata, i.e. according to the amounts guaranteed by each guarantor. The reporting is made on commitment basis. Sida reports subsidies separately, as ODA grants. While the relevance of guarantees and any other reported instruments is made based on the Rio markers for climate change adaptation and climate change mitigation, the amounts guaranteed and mobilized are not (contrary to the reporting of ODA flows) weighted according to the levels of the markers.

Table 7.7 Guarantees provided by Sida in 2020 for climate-relevant investments.[80]

	Agreement period	Guaranteed amount (MSEK)	Guaranteed amount (mUSD)	Mobilised amount (MSEK)	Mobilised amount (mUSD)	Main source of mobilised capital
54020146 - Portfolio Guarantee - Asian Development Bank	2016-10-03 - 2026-12-31	2000	217	4235	460	Public
54020185 - Guarantee of IFC´s loan portfolio	2017-11-13 - 2042-11-13	535	58	3842	417	Public
10421 - NEFCO guarantee energy efficiency Ukraine education	2017-11-01 - 2032-12-31	270	29	1500	163	Public
54020115 - Pakistan - Guar Windpower	2013-10-14 - 2024-11-18	480	52	1071	116	Public
54020111 - Deutsche Bank Consortium II: Guarantee 2012-2018	2012-08-01 - 2020-01-31	14	2	835	91	Private
54020134 - Conflict-Affected and Fragile Economies Facility (CAFEF/MIGA)- Guarantee	2013-06-01 - 2034-06-30	200	22	684	74	Public

[80] Note that this is a complete list of all the climate relevant guarantees that are cur rently ongoing. The amounts included in the table refer to the total amount of the guarantee (not the yearly amount), i.e. the guarantees included in this list run over several years. All climate relevant guarantees that are currently active are included for transparency reasons.

54020155 - NEFCO Portfolio guarantee	2015-01-01 - 2029-12-31	300	33	600	65	Public
13406 - SunFunder Guarantee	2019-12-23 - 2029-02-15	363	39	540	59	Private
10121 - Portfolio Guarantee Georgia	2018-12-18 - 2025-12-31	220	24	440	48	Private
10154 - Private Agriculture Sector Support (PASS)	2017-09-26 - 2024-09-26	190	21	264	29	Public and Private
54020158 - Global Guarantee Facility Household Technologies	2014-12-01 - 2029-09-28	160	17	210	23	Private
12866 - Lendahand crowdfunding guarantee	2018-12-18 - 2023-12-18	60	6	120	13	Private
11016 - TRINE, 2018-2022, Crowdfunding Renewable Energy	2018-03-12 - 2023-03-11	60	7	100	11	Private
51180131 - Renewable Energy Guarantee - Uganda	2019-08-30 - 2026-08-30	68	7	91	1	Private
54020124 - Agri Guarantee USAID_Zanaco	2012-10-01 - 2020-01-31	26	3	46	5	Private
54020084 - Guarantee BiH Sberbank (formerly Volksbank) in cooperation with USAID	2010-09-01 - 2020-09-30	25	3	42	5	Private
54020179 - Zambia, bioenergy Madison Finance LPG guarantee	2015-09-01 - 2022-09-30	26	3	33	4	Private
54020125 - Loan Portfolio Guarantee for Sustainable Energy Moldova	2014-04-01 - 2029-04-30	9	1	15	2	Private
Total		**5 006**	**543**	**14 668**	**1 593**	

Sida implements the methodology for calculating mobilized private capital outlined in the DAC directives: In the case of guarantees, the mobilized amount is attributed to guarantors pro-rata, i.e. according to the amounts guaranteed by each guarantor. The reporting is made on commitment basis. Sida reports subsidies separately, as ODA grants. While the relevance of guarantees and any other reported instruments is made based on the Rio markers for climate change adaptation and climate change mitigation, the amounts guaranteed and mobilized are not (contrary to the reporting of ODA flows) weighted according to the levels of the markers.

Sida continuously works to enhance mobilisation of additional climate finance and is currently leading a project with the objective to increase access and implementation of innovative partnership- and financing methods and tools, as well as increasing the knowledge and engagement around innovative financing amongst a broad network of actors. The project supports the Global Innovation Lab for Climate Finance – an incubator which works with identifying and strengthening innovative financing instruments that mobilise capital within climate finance, including sectors such as sustainable cities, renewable energy and sustainable food systems.

In addition to guarantees, Sida also mobilises climate finance through other instruments such as Public Private Development Partnerships (PPDPs) and challenge funds in which funding from Sida enables mobilisation of private capital.

7.5.2 Mobilisation of private capital through Swedfund

Swedfund International Ltd is Sweden's development finance institution. It is a limited liability company entirely owned by the Swedish state. The Ministry of Enterprise and Innovation assumes responsibility for administration of the Swedish state's ownership of Swedfund, whereas the Ministry of Foreign Affairs is responsible for the company's development policy mission and financial contributions. Swedfund's mission is to contribute to the goal of Sweden's development policy and Sweden´s Policy for Global Development. Swedfund's mission is to contribute to poverty reduction by sustainable investments in developing countries - investments that are financially, environmentally and climate related, and socially sustainable. Since 1979, Swedfund has invested in companies and funds located in Africa, Asia, Latin America, Eastern Europe and the Middle East. At the end of 2020 Swedfund had 65 investments in businesses, financial institutions and funds in 17 countries, of which 54 percent of investments were located in Africa.

Environmental, climate and social aspects are of paramount importance in all Swedfund's investments, as established in the owner's instruction for Swedfund and demonstrated in Swedfund's business model and comprehensive Policy for Sustainable Development. In order to measure performance, the ownership instruction includes mission goals linked to certain targets, within which the Swedish government's strong focus on climate is clearly expressed. By 2045, Swedfund shall have a climate-neutral portfolio, and green-house gas emissions from the portfolio per invested Swedish krona shall decrease with 2020 as the base year.

Swedfund is always a minority investor, thereby ensuring that an investment made by Swedfund is catalytic and leads to financial commitments from both industrial and financial partners. In line with OECD/DAC criteria for additionality, Swedfund's additionality as an investor is viewed not only in financial terms, but also in terms of knowledge transfer, e.g. with respect to climate and environmental impact, social impact and other sustainability criteria such as good governance and anti-corruption.

In recent years, Swedfund has increased its investments substantially in the energy and climate sector. In accordance with the owner's instruction, Swedfund only invests in renewable energy. For example, in 2019, Swedfund invested in JCM Power. JCM Power is an independent power producer dedicated to accelerating social, economic and environmental sustainability in growth markets through the development, construction and operation of renewable energy infrastructure.

In 2020, Swedfund invested 12 million USD in the Solar Energy Transformation Fund, which is managed by SunFunder. SunFunder is a leading provider of loans, with the aim of financing the off-grid solar sector in sub-Saharan Africa, where over half of the population has no access to electricity. Swedfund's investment will contribute to increased access to electricity, as well as the increased generation of renewable energy.

In 2018, Swedfund analysed how climate and environmental risks impact on Swedfund's investments and how, in turn, these risks can impact on Swedfund's financial position. To conduct the analysis, Swedfund developed a method to take account of the climate risks and the requirements concerning mitigation that Swedfund imposes on portfolio holdings. In 2020, Swedfund analysed how well the portfolio is aligned with the Paris Agreement. The results shows an alignment of 90 % of Swedfund's portfolio with the Paris Agreement. In order to increase alignment, Swedfund provides training to the portfolio companies to give them the tools needed to advance the climate agenda.

In addition to financial commitments, Swedfund has continued to contribute to renewable energy in developing countries by, for example, cooperating with the wider European development community within the realm of ElectriFI, a facility set up to develop early-stage electrification projects using renewable resources.

In 2019 and 2020, Swedfund made the investments and helped mobilise the amounts of capital listed below. The table includes climate investments contracted in 2019 and 2020 (The World Bank definition of mobilized capital is used).

Table 7.8 Swedfund - New investments 2019 and 2020 (Contracted)

Portfolio company	Swedfund's investment	Mobilized capital	Source of capital	Sector
GEF South Asia Growth Fund II	14.26 MUSD	1,60 MUSD	Equity (Fund)	Energy & Climate
JCM Power Corporation	9,47 MUSD	4,79 MUSD	Equity (Direct)	Energy & Climate
Greenteco SES (Chigirin Solar Projekt)	10,64 MUSD	6,92 MUSD	Debt	Energy & Climate
SunFunder	10,43 MUSD	1,92 MUSD	Debt	Energy & Climate
Co-operative Bank of Kenya	12.98 MUSD	2,02 MUSD	Debt	Financial Inclusion
Interact Climate Change Facility	15,96 MUSD	n.a	Debt	Various

7.6 Capacity building

7.6.1 Capacity building through official development assistance (ODA)

Capacity and institutional development is central for development, and is a fundamental entry point in all of Sweden's development cooperation. The majority of the climate finance support that Sweden provides through Sida therefore has capacity building integrated into the core of its operations. Capacity building takes place at the organisational level, individual level, level of institutional frameworks, and often a combination of the three. In order to identify and address the specific capacity building needs of partner countries or organisations, their nationally determined contributions and national adaptation plans, as well as key development plans, are important sources of information.

Examples of Sweden's support to building climate change capacity are provided in CTF table 11 and the boxes below. The examples represent different types of capacity building support that Sida provides. These include initiatives where building climate change capacity is the main objective, other contributions where climate is part of contributions aiming to develop negotiating skills in international fora, and contributions where climate change is integrated in operations building capacity in areas such as agriculture, forestry or water and sanitation.

It may include support directly to low-income country government institutions or support via multilateral institutions, as in the case of the initiative together with the World Food Programme in Kenya, focusing on strengthening the capacity of national and county institutions in managing food insecurity in arid and semi-arid lands. It includes support to regionally active organisations, such as the Regional Community Forestry Training Center for Asia and the Pacific (RECOFTC); to civil society-based organisations, for example through the Pan African Climate Justice Alliance (PACJA), which works with the participation of African CSOs in the climate governance discourse and strengthening their ability to follow up on national commitments, compliance and implementation of the Paris Agreement, including NDCs; and in cooperation with Swedish authorities, such as the preparatory support to the Swedish Environmental Protection Agency ahead of the collaboration with UNICEF on air quality and children/youth's health in the Western Balkans.

BOX 7.5

Sida provides support to the global project Poverty-Environment Action for Sustainable Development Goals (PEA), a joint initiative between the UNDP and UNEP. The initiative aims at mainstreaming environmental sustainability and climate objectives for poverty eradication into development planning, budgeting and monitoring systems, public and private finance, and investment - in order to accelerate delivery of the 2030 Agenda and the SDGs. This is achieved through capacity building and technical assistance to national and sub-national governments to mainstream and align finance and investment with poverty, environment and climate change objectives, in the face of the changing forms and conditions of poverty found in the world today.

In Mozambique, training-of-trainer sessions on implementation of environmental and climate change elements of the reformed Sub-system for Planning and Budgeting (SPO) were conducted. A total of 52 technical and planning staff at the central level were trained and received information on the new law package on decentralization, the new sub-system, the module on planning and budgeting, and integration of NDCs and the SDGs.

In Rwanda, an environmental and climate change assessment was conducted, informing 16 sector plans and 30 district single action plans. This information was crucial in supporting the national planning and budget consultations for fiscal year 2020/21 in all sectors at the Ministry of Finance and Economic Planning. PEA also supported revision of the budget checklist for all budget agencies to include gender, environmental and natural resource indicators to enhance monitoring. Additionally, PEA Rwanda, in close collaboration with the Rwanda Environment Management Authority and the Ministry of Infrastructure, conducted a strategic environmental assessment for urbanization policy. The assessment was aimed at providing sustainable and inclusive guidance on implementation of the recently enacted PEA-supported National Land Use and Development Master Plan. Particular attention was given to conservation; integrated water resource management; agriculture; and population, urbanization, settlement and housing, especially with regard to projected long-term environmental impacts.

BOX 7.6

The Global Facility for Disaster Reduction and Recovery (GFDRR) is a global partnership that helps developing countries better understand and reduce their vulnerability to natural hazards and climate change. GFDRR is a grant-funding mechanism, managed by the World Bank and engaging over 400 local, national, regional, and international partners. GFDRR provides knowledge, funding, and technical assistance in order to build capacity and to help vulnerable nations improve resilience and reduce risk. In 2020, more than 130 countries were supported for improved government institutional capacity in disaster and climate risk–informed policy design and analysis. The contribution is considered to have climate change adaptation as principal objective, hence Sida's total disbursement in 2020 of approximately 25 MSEK is identified as climate finance.

BOX 7.7

Global Programme on Strengthened institutions for a sustainable climate, a 4-year International Training (ITP) programme (2019-2022) that aspires to enhance institutional capacity in developing countries in Africa on climate mitigation and adaptation, including sustainable urbanisation. The Swedish Environmental Protection Agency implements the capacity development program "Strengthening Institutions for Sustainable Climate and Cities" together with 6 other Swedish authorities in several countries in Africa. In Uganda and in Rwanda, they are working together with Statistics Sweden to build the capacity of the Ministry of Climate and Enterprise in its reporting of NDCs. In Kenya, SMHI supports local environmental planning committee understanding of climate change and planning of climate adaptation activities. The Programme aims to tackle challenges posed by climate change, sustainable urbanisation, growing emissions and explore viable adaptation potentials.

Sida's work for the implementation of Agenda 2030 and to deliver on the Paris agreement has a strong focus on capacity development, strengthened institutions and innovative solutions with broader partnerships. Sida starts from a systems approach where each actor has an important role and the interaction between the actors (e.g. authorities, academia, private sector, civil society organizations) enables development in the desired direction such as e.g. reduced environmental impact, energy efficiency or strengthened resilience to the effects of climate change. Capacity development is a foundation of almost all development cooperation. Stronger capacity improves the possibilities of working through countries' own systems and lays the foundation for lasting results that go beyond development cooperation. International Training Programs (ITP) is a method where participating organizations at central, regional and/or local level and other relevant partners use new capacities and new contacts to jointly formulate change projects for their respective countries, as well as create professional networks for the exchange of experience. The strengthening of formal structures and institutions through individual and organizational capacity development has positive effects on recipient countries' capacity to implement the Paris Agreement such as technology transfer including support to endogenous capacities and technologies and contributes to better planning, implementation and monitoring of climate adaptation and emission reduction measures. Several of the ITP programmes includes aspects of technology transfer in the sense that capacity building contributes to countries readiness to e.g. make use of available technology or undertake procurement of technics that are suitable and prioritised by themselves.

In summary, Sweden provides extensive support to climate change capacity building, with different approaches and in cooperation with different types of actors. This diversity is needed to respond to different partner countries' or organisations' specific needs and contexts.

7.6.2 Capacity building through other official flows (OOF)

Many of today's environmental challenges are transboundary and cannot be solved only within the borders of Sweden. The major emerging national economies of Brazil, Russia, India, Indonesia, China and South Africa (BRIICS) have extensive manufacturing industries that provide products to both the domestic and global market. These populous countries have a major impact on global resource use and environmental performance, and are therefore key players in global environmental and climate cooperation.

Developing relationships with strategic countries is positive for tackling environmental challenges but also in terms of industry, export trade, foreign policy and security policy.

The Swedish Environmental Protection Agency (Swedish EPA) is recipient of a fund from the Swedish Ministry for Environment totalling ca SEK 34 M per year allocated to support countries that have strategic importance to the global environment and climate. The partnerships with the project countries are based on mutual interest to reach environmental objectives. Four Swedish government agencies are involved to carry out this bilateral cooperation: the Swedish EPA, the Swedish Agency for Marine and Water Management, the Swedish Chemicals Agency and the Swedish Meteorological and Hydrological Institute (SMHI).

The EPA is for example supporting South Africa to develop a national strategy for hazardous waste from households. The EPA works with Brazilian authorities and institutions to implement initiatives on food waste prevention and municipal waste planning. During 2020 the EPA engaged in dialogue with the Climate Center under the Chinese Ministry of the Environment on emissions pricing and emissions trading, to create incentives for industrial change in China. The EPA has also supported China by sharing experiences related to permits for industrial plants. The EPA also supported Russia to further develop and deepen the work on waste management, climate and air policies and integrated environmental permits based on best available technology (BAT).

To increase the competence of environmental officials at the state level in India, the Swedish EPA collaborates with the environmental organization Center for Science and Environment (CSE) and has helped arranging trainings regarding waste management. Within the Arctic Council the EPA has contributed to knowledge building on climate change and its effects. Furthermore, the EPA has been active in the revision of the climate plan for the Barents region. Note that these are examples only and not an exhaustive list.

7.7 Technology development and technology transfer

7.7.1 Technology development through official development assistance (ODA)

A large proportion of Sweden’s development cooperation includes climate-friendly technology development or technology transfer. The projects stem from countries’ and organisations’ own needs, priorities and strategies and are designed through a collaboration between Sida and the implementing partner. Transfer of technology is often combined in an integrated way with capacity building to ensure long-term sustainability. Examples are presented in CTF table 10 and in the boxes below. The examples represent different types of contributions, including mitigation and adaptation technologies, and are from a range of actors and contexts in Africa, Asia and Europe and global partnerships, soft as well as hard technologies, and within a number of different sectors, including energy, agriculture and disaster risk reduction. Note that these are examples only and not an exhaustive list.

BOX 7.10

As part of Power Africa, the Beyond the Grid Fund Zambia aims to allow for clean energy access and accelerate private-sector growth in energy generation and distribution. The contribution includes support and advise to contracted companies, and advisory support to the Zambian government in managing a coordination platform for off-grid energy, the "Off-Grid Task Force". Since 2017, the Beyond the Grid Fund has brought clean, affordable off-grid energy access to over 800,000 Zambians, and in 2020 the fund expanded to four new countries, with an expanded partnership managed by Nordic Environment Finance Corporation. Beyond the Grid Fund has also won the prestigious Ashden Award for Innovative Finance, and the 2019 UN Climate Action Award.

BOX 7.11

The Beog-Puuto Family Farming project aims at restoring eroded abandoned farmland, increasing productivity in family farms and strengthening resilience of 50,000 vulnerable households in dry areas in northern and eastern Burkina Faso. The impact is expected to be increased productivity in family farms through a positive systems change, stronger resilience of vulnerable households to climate change, higher income, improved situation for women and strengthened incentives to young men to refuse militant extremism. The project aims to i) recover eroded farmland and increase productivity; and to ii) sustainably improve the soil status and increase productivity in family farms through a broad application of traditional water and soil conservation techniques. Groups of farmers are trained in running the agro-ecology pilot farms as well as farmer schools on their own.

7.7.2 Technology development through other official flows (OOF)

In accordance with Article 10 of the Paris Agreement, parties have a shared responsibility to strengthen technology development and transfer in order to improve resilience to climate change and to reduce greenhouse gas emissions. Much of Sweden's climate related finance includes elements of technology development and/or technology transfer. This section presents a set of examples on such cooperation.

Support to the technology mechanism under the UNFCCC and Paris Agreement

According to Article 10 of the Paris Agreement, parties shall strengthen cooperative action on technology development and transfer, and the Technology Mechanism established under the UNFCCC shall also serve as a mechanism under the Paris Agreement. Sweden supports climate technology cooperation through to the UNFCCCs technology mechanism, the Technology Executive Committee (TEC) and the Climate Technology Centre and Network (CTCN).

The CTCN promotes the accelerated transfer of environmentally sound technologies for low carbon and climate resilient development at the request of developing countries. CTCN provides technology solutions, capacity building and advice on policy, legal and regulatory frameworks tailored to the needs of individual countries.[81] CTCN reports annually to COP and CMA on the progress.

Sweden has supported the CTCN with SEK 6 million in total for 2017-2020. The Swedish Energy Agency is Sweden’s focal point (National Designated Entity) to the technology mechanism together with focal points from 160 other countries. Sweden also contributes to the CTCN through active participation in the CTCN Advisory Board. During 2020-2021, the representative from Sweden served as co-chair for the CTCN Advisory Board together with a representative from China. In 2021-2022, the Swedish representative will serve as chair of the board.

Enhanced cooperative action on technology transfer

The Swedish Energy Agency (SEA) supports several programs and initiatives that enhance technology development and transfer. One example is the various accelerator programs for Swedish small and medium-sized enterprises (SMEs) where cutting-edge energy solutions get disseminated to other countries, such as India and Indonesia. Other programs have a sectoral

[81] Joint annual report of the Technology Executive Committee and the Climate Technology Centre and Network for 2020: https://unfccc.int/documents/267476ommittee and the Climate Technology Centre and Network for 2020 | UNFCCC.

focus, such as promoting sustainable heating and cooling in China. A key component in these programs is to encourage Swedish and local private sector activities that support the countries to access sustainable technologies, contributing to an accelerated green transition in the energy sector.

Technology development and transfer cooperation in India

The SEA has been active in India since 2009. The overall objective is to build long-term relationships based on trade, research cooperation and knowledge development. Since 2013, the SEA has participated in the program India-Sweden Innovations Accelerator (ISIA). The program supports business-oriented innovation development and dissemination by promoting networking and knowledge sharing between Swedish and Indian actors active in innovative technologies for sustainable energy systems.

By 2020, more than 50 Swedish SMEs have been introduced through the ISIA program to the Indian market. In 2017-2020, 15 new Swedish innovations were introduced to the Indian market through the ISIA.

In December 2018, the cleantech showroom Sustainability by Sweden – Showroom India was established as a part of ISIA at The Trade Commissioner´s office at the Embassy of Sweden in New Delhi, India. The showroom has organized several digital workshops to showcase Swedish innovative green energy solutions with a focus on how these can be implemented to the context in India. One example is the workshop on smart grids that was held in August 2019 in preparation for up-coming collaborations.

In November 2020, a new program was launched to promote research and innovations; India-Sweden Collaborative Industrial Research & Development Programme 2020. The program is a collaboration between the Swedish Energy Agency and the Indian Department of Science and Technology. The program focuses on the development of smart grid technologies, recognizing the importance of efficient electricity distribution as demand for electricity grows. Jointly, the Swedish and Indian authorities will support industry led projects to develop smart grid solutions.

Technology transfer in Indonesia

In 2015, the SEA set up a continuous program for transferring technology to Indonesia: the so-called Business Accelerator Program Indonesia (BAPI). The program provides support to Swedish SMEs to enter the Indonesian market through the means of matchmaking with Indonesian stakeholders and market knowledge support. In 2017-2020, 15 Swedish companies were introduced to the Indonesian market through the BAPI program, offering technologies within energy efficiency, renewable energy and smart grid solutions. Since 2017, there is a Memorandum of Understanding (MoU) on energy cooperation between the governments of Sweden and Indonesia.

Waste management and waste-to-energy is another field of cooperation between Sweden and Indonesia. The SEA supported the city of Probolinggo to develop an action plan for their waste management in 2018. Since 2020, Sweden and the Province of West Java are exploring the possibility for technology transfer on energy recovery from waste.

Technology transfer cooperation with China

The Swedish Energy Agency is working to strengthen the long-term cooperation with China in the cleantech sector. In 2017, a Memorandum of Understanding (MoU) was signed by the energy ministers on Swedish-Chinese cooperation in the energy area. The Swedish Energy Agency's efforts to promote collaboration and sustainability include setting up a Cleantech Hub program in Shanghai, which was inaugurated by the energy minister of Sweden in 2017. The program's long-term vision is to accelerate the expansion of cleantech innovations in order to decrease CO2-emissions and increase energy efficiency and security.

Another outcome of the MoU from 2017 is a focused effort on the promotion of sustainable heating and cooling techniques in China, initiated in 2019. In 2019, Business Sweden was assigned by the Swedish Energy Agency to perform promotion activities in the Chinese district energy market in close collaboration with the Embassy of Sweden in Beijing and the export-oriented industry organization SweHeat & Cooling. Several activities promoting Swedish district energy solutions were performed in 2019-2020, including roadshows to different cities. Some of the activities were also in cooperation with the China District Heating Association. The overall aim is to mitigate emissions of greenhouse gases from the heating and cooling sectors through the uptake of Swedish innovative technologies.

Smart City Sweden

Smart City Sweden (SCS) is a Swedish state-funded platform for sustainable city solutions that opened in 2017. SCS builds collaborations between Sweden and other countries interested in implementing smart and sustainable city solutions from Sweden. SCS supports Swedish companies in responding to requests for collaboration, where a significant increase in requests from Africa and South America shows that SCS is starting to reach these markets. Around 20 pre-feasibility studies have been funded through SCS (typically amounting to SEK 300.000 per study) as a way of doing follow-up activities on promising incoming delegations where technology transfer seems viable. The receiving countries include Bolivia, Colombia, Peru, Gambia, Senegal and the Somaliland province. The most prevalent topics are waste management including biogas and renewable energy implementation. SCS also has a virtual showroom and has organized study visits in virtual format during the COVID-19-pandemic.

Global Innovation Accelerator

Since 2017, the Swedish Energy Agency has been running Cleantech Hubs – Energy Innovations by Sweden, a program that facilitates the introduction of Swedish innovations to markets across Europe, Asia and America. The program was built up around three footholds in China, USA and United Kingdom, but was not restricted to these countries.

However, at the end of the program in 2021, results did not meet the expectations of the program. The needs and starting points of participating companies were found to have varied widely, and combined with a pandemic, the setup could not fully deal with the combined challenges. A revised approach is under development and is expected to start before the end of 2021. By applying increased flexibility towards the participating companies regardless of geographical focus in the upcoming project, the ambition is to facilitate easier access not only to mature markets but also less developed ones.

Multilateral cooperation for technology development and transfer

Sweden participates in several multilateral initiatives that support and facilitate technology development and transfer, especially within the energy sector. A few examples are found below, highlighting Swedish contributions to the initiatives in 2017-2020.

Clean Energy Ministerial

The Clean Energy Ministerial (CEM) is a high-level global forum that brings together a community of the world's leading countries, companies and international experts with the mission to accelerate the transition to a global clean energy economy. Together, CEM members account for 90% of the world's clean power production and 80% of global clean energy investment. CEM members (28 member countries spread globally plus EU) collaborate to establish policies and programs that enhance clean energy supply and expand clean energy access.

Sweden has been a member of CEM since it started in 2011 as a 5-year collaboration. The second phase of CEM - CEM 2.0, 2016-2021 - is currently being concluded. Sweden is committed to continue within the next 5-year phase of CEM, i.e. CEM 3.0. (2021-2026). This involves active participation in different initiatives and campaigns. By the end of 2020, Sweden participates in 8 out of 22 Campaigns and Initiatives.

In 2018, Sweden also co-hosted the 10th Clean Energy Ministerial and 3rd Mission Innovation Ministerial meetings together with Denmark, the Council of Nordic States and the European Commission. The funding from Sweden to the CEM secretariat amounted to SEK 2,4 million in 2017-2020.

Mission Innovation

Launched at the Paris Climate Conference in 2015, Mission Innovation (MI) is a global initiative of 24 governments and the European Commission on behalf of the European Union. These members have committed to greater action to make clean energy affordable, attractive, and accessible to all this decade. This is to be achieved by engaging with the private sector, fostering international collaboration and celebrating innovators. Specifically, Mission Innovation encourages private sector activities to boost investment and demand for clean energy technologies, supporting developing as well as developed countries to plan their green energy transitions.

The support to MI is in the form of funding for the secretariat, paid by the Swedish Government, and through participation in the workstreams and Innovation Challenges. During the first phase of MI in 2015-2020, Sweden participated in roughly 10 Innovation Challenges supporting clean energy RD&D. Sweden co-hosted the third Ministerial meeting in Malmö in 2018 and was vice-chair of the steering committee in 2019-2020.

International Renewable Energy Agency

With 164 Member Countries, the International Renewable Energy Agency (IRENA) plays a leading role in the energy transformation as a center of excellence for knowledge and innovation, a global voice for renewables, a network hub and a source of advice and support for countries.

Counteracting climate change is in the forefront of IRENAs objectives. Sweden has been a member since IRENA's founding in 2009. The annual membership fee is approx. SEK 1.7 million. In 2019, Sweden provided a voluntary contribution of SEK 2 million for a pilot study on innovations for a 100% renewable electricity system and workshops with other member countries with similar ambitions, such as Costa Rica and Uruguay.

8. Research and systematic observation

8.1 Key developments in research initiatives since NC7

Strategic innovation programmes (SIP)[82] are an effort by three public agencies - Vinnova, the Swedish Energy Agency and the Research Council Formas - on actor-driven programmes through collaboration in areas that are strategically important for Sweden. Starting in 2014, it is an effort of a total of 8 billion SEK on programmes that can receive funding for up to 12 years, where the business community and other actors contribute the same amount. The SIP's main activity are research and innovation (R&I) projects conducted in cooperation between actors, but they have complementary instruments that are important in taking a holistic approach to needs within the field. The SIPs are implemented in public-private collaboration where the role of formulating needs and programme management is outsourced to programme actors, and the government agencies are responsible for exercising their formally authorised tasks. The basis for the SIPs is the investment in strategic research and innovation agendas 2012 – 2016, where the actors in a certain area formulated a common vision and goals, and defined needs and strategies for the development of an innovation area.

Another initiative, the government's innovation partnership programmes, was introduced in 2019. The objective is to identify innovative solutions to major challenges facing society and to contribute to Sweden's competitiveness. Four themes, based on Sweden's strengths and on the 2030 Agenda for Sustainable Development, form the basis for the partnership programmes in 2019–2022: Climate-neutral industry; Skills supply and lifelong learning; Digital transformation of industry; and Health and life sciences. The innovation partnership programmes bring together small and large companies, universities and higher education institutions, civil society and public-sector actors to jointly set priorities for what needs to be done to meet the challenges within the four themes.

8.2 Policy and funding in research, development and systematic observation

In 2017, the Swedish Parliament adopted a proposal on a national climate policy framework for Sweden (Government Bill 2016/17:146). The climate

[82] https://www.vinnova.se/en/m/strategic-innovation-programmes/

policy framework consists of a climate act, new national climate targets and a climate policy council. The framework creates order and stability in climate policy and sets long-term conditions for the business sector and society.

8.2.1 Climate research policy

The societal impacts of the COVID-19-pandemic have resulted in companies and foundations who normally invest heavily in R&D reducing their R&D budgets. The Swedish government has therefore decided to significantly increase public R&D funding as part of the government's latest Research and Innovation bill for the period 2021–2024, "Research, Freedom, Future – knowledge and innovation for Sweden", presented to Parliament on 17 December 2020.[83]

The bill proposes to strengthen the seven national ten-year research programmes (an outcome of the previous research and innovation bill, "Collaborating for knowledge – for society's challenges and strengthened competitiveness") and invest in some new national programmes. Most of these programmes are relevant to the UN Sustainable Development Goals. The national research programme for the climate ("Ett nationellt forskningsprogram för klimatet")[84], coordinated by Formas, will contribute to achieving Sweden's objective to become a fossil-fuel-free society and the ambition is to be a leading participant in global efforts to achieve the goals of the Paris Agreement. This programme will receive a considerable budget reinforcement and distribute 230 million SEK during 2021. The government points to further research on how the design of climate-related policy instruments can become more effective from a socio-economic perspective to better manage conflicting goals and increase goal completion. 50 million SEK will be allocated to research on biodiversity and ecosystem services, and increased research efforts will be directed to how climate change affects the emergence and transmission patterns of infectious diseases. The bill increases funding for the national research programmes for food ("Det nationella forskningsprogrammet för livsmedel") and on building a sustainable society ("Ett nationellt forskningsprogram för att bygga ett hållbart samhälle"), both coordinated by Formas. Formas has also been tasked with launching a new national research programme on oceans and

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[83] https://www.regeringen.se/4af915/contentassets/da8732af87a14b689658dadcfb2d3777/forskning-frihet-framtid--kunskap-och-innovation-for-sverige.pdf

[84] https://formas.se/om-formas/vad-vi-gor/nationella-forskningsprogram/klimat.html

water, "Ett nationellt forskningsprogram om hav och vatten", which will take a comprehensive approach to all challenges related to seas and water, "from source to sea" with the aim to facilitate close collaboration between academia and stakeholders.

In 2020, the government adopted a national strategy for a circular economy[85] as well as initiated a process to develop a bioeconomy strategy. According to this strategy, new funds should be allocated to strengthen research and innovation in bio-based materials and technology that generate profitability from recovery of products from, for example, agriculture, forestry and aquaculture. Further, the strategy directs increased funding towards research on sustainable growth and development of the green and blue bio-based economy.

8.3 International collaboration

8.3.1 Nordic collaboration

In January 2019, the Nordic Prime Ministers issued a joint commitment to work towards a carbon-neutral Nordic region and to demonstrate leadership in the fight against global warming. This joint effort underpins much of the Nordic collaboration in research initiatives. Sweden collaborates within the framework of the Nordic Council of Ministers (NCM)[86], where the Nordic countries work together in various policy areas, among them environment and climate, sustainable development and energy. The NCM action plan for Vision 2030, running from 2021 to 2024, focuses on carbon neutrality and climate adaptation; sustainable production; sustainable consumption; and international co-operation on climate change and the environment.[87] Nordic Innovation, part of the NCM, initiates and funds activities enhancing innovation for small and medium-sized businesses in the Nordic region.

The Nordic Sustainable Business Transformation programme (2018-2021) directly supports the NCM action plan for Vision 2030 and is built on four actions areas: *competence* – build networks and connect competences and people; *new solutions* – accelerate business through innovation; *circular cities* –

[85] https://www.government.se/press-releases/2020/11/swedish-strategy-for-circular-economy-accelerates-the-transition-to-sustainability/

[86] https://www.norden.org/en

[87] https://www.norden.org/en/publication/nordic-region-towards-being-most-sustainable-and-integrated-region-world

public private collaboration; and *ecosystems* – building networks and connecting competences and people. The NCM platform for cooperative energy research and policy development, Nordic Energy Research (NER), identifies four areas of research collaboration in its 2018-2021 research strategy: clean energy for electricity, heating and transport; regional grids; active end users; and Nordic energy system studies. Although none of these exclusively address climate related issues, NER funds research of joint Nordic interest which supports the ambition to reduce carbon emissions and the dependence of fossil fuels, and at the same time creates new industries based on green technology. The common Nordic research body, Nordforsk, facilitates cooperation between researchers, researcher groups and institutions in the Nordic countries through its funding instrument Nordic Centre of Excellence (NCoE). "Responsible Development of the Arctic: Opportunities and Challenges - Pathways to Action" is a cross-disciplinary programme consisting of four NCoEs, and another three NCoEs are funded through the "Nordic Bioeconomy Programme".

8.3.2 European cooperation

Sweden participates in the EU Research and Innovation programme Horizon Europe (2021 - 2027), the world's largest research and innovation initiative with a total budget of around €100 billion. Horizon Europe aims to strengthen green growth and competitiveness, and has clear global objectives to combat climate change and contribute to sustainable development. In 2020, Forte, Formas, the Swedish National Space Agency, the Swedish Energy Agency, the Swedish Research Council and Vinnova were asked to develop a strategy for how Sweden should strengthen its participation in Horizon Europe (until then, Sweden had no specific strategy for participation in the European research and innovation programmes). [88]

Sweden participates in the European Strategy Forum on Research Infrastructure (ESFRI), European Polar Board, European Incoherent Scatter Scientific Association – Tromsö (EISCAT) and several EU projects via various funders and providers. Through its participation in the European Research Area networks ERA-NET, ERA-NET+ and ERA-NET Cofund, Sweden contributes to strengthening European funding and cooperation in

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[88] https://www.vr.se/download/18.68c009f71769c7698a4c04/1611684269750/2020%20Gathering%20Forces%20for%20Horizon%20Europe_Proposal_MB.pdf

research and long-term development. Within the context of climate research, Sweden participates in the Joint Programming Initiative JPI Climate, where Swedish funding agencies and researchers actively contribute to a common strategic research agenda. Formas and the Swedish Research Council have funded Arctic climate research as well as social sciences and humanities research on climate change within the framework of JPI Climate.

Via Stockholm University, Sweden leads the EU-funded Horizon 2020 project FORCeS, carried out during the period 2019 to 2023 through a consortium of 22 partners from 12 countries [89]. FORCeS aims to study the magnitude of aerosol radiative forcing caused by anthropogenic emissions, which is crucial in order to increase confidence in climate projections.

The Belmont Forum[90] is an international partnership that mobilizes funding of environmental change research and accelerates its delivery to remove critical barriers to sustainability. In 2019, the Belmont Forum, in collaboration with Future Earth, announced a Collaborative Research Action for transdisciplinary research, which will improve understanding of the pathways between climate, environment and health to protect and promote human health and well-being in the face of climate challenges. Sweden is one of nine funders that committed resources for this call.

Sweden participates in several collaborative projects and programmes, such as EC-Earth, the collaboration between some 30 different institutes and universities in Europe. Within EC-Earth, the Swedish Meteorological and Hydrological Institute[91] (SMHI) (through the Rossby Centre[92], one of the leading centres for producing and publishing regional climate change projections, see section 8.6) has worked with the universities of Lund, Stockholm, Gothenburg, and Uppsala to develop and launch the new earth-system model which is part of the global climate modelling project CMIP6 (Coupled Model Intercomparison Project phase 6). The EC-Earth climate model is used to carry out climate calculations coordinated within CMIP6.

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89 https://forces-project.eu/

90 https://www.belmontforum.org/

91 https://www.smhi.se/en/about-smhi

92 https://www.smhi.se/forskning/forskningsenheter/klimatforskning

The Swedish Energy Agency supports research for strengthening Sweden's expertise in climate policy research of high relevance for current and future global energy systems. The research is often aimed at increasing understanding of complex dynamics between people and technology in energy systems, and at creating synergies and identifying conflicts between actors. Chalmers University of Technology, Lund University, two Swedish cities and several Swedish businesses cooperate on innovations for climate solutions in Europe's largest public-private partnership, the Climate Knowledge and Innovation Community (Climate-KIC).

8.3.3 Global collaboration

Most important for climate research is Sweden's participation in the Intergovernmental Panel on Climate Change (IPCC). Swedish researchers and organisations are participants or partners in global research activities and organisations. SMHI acts as Sweden's focal point for the IPCC. Furthermore, Swedish researchers participate in the World Climate Research Program (WCRP), International Science Council (ISC), International Arctic Science Committee (IASC), Science Committee on Antarctic Research (SCAR), International Ocean Discovery/Drilling Program (IODP), Global Biodiversity Information Facility (GBIF)[93], US National Science Foundation (in bilateral collaboration with the Swedish Polar Secretariat on the NSF's research icebreaker Oden), Future Earth, Science Europe, Global Research Council (GRC) and International Institute for Applied Systems Analysis (IIASA).

SMHI is the International Project Office (IPOC) for the Coordinated Regional Downscaling Experiment (CORDEX), on behalf of WCRP. The IPOC is responsible for providing strong global coordination, together with the appropriate administrative, scientific, and technical support, to respond to CORDEX's rapidly expanding worldwide activities. The Rossby Centre at SMHI has made projections for many different world regions (Europe, Africa, the Arctic, the Middle East and North Africa, South Asia as well as South, Central and North America). Results from these scenarios are used by climate scientists and for work related to climate change adaptation in

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[93] https://www.gbif.org/

Sweden and Europe but also on other continents including developing countries.

Through the collaborative initiative Intsam, Swedish research efforts are coordinated to strengthen collaboration outside the EU. The Swedish research funding bodies Vinnova, Forte, Formas, the Swedish Energy Agency and the Swedish Research Council are members.

As knowledge-action networks become increasingly important, Sweden will continue to support these collaborations. Through Formas, Sweden is a member of the Global Research Alliance on Agricultural Greenhouse Gases since 2008. Together with the Swedish Energy Agency, Formas represents Sweden in the International Energy Agency under OECD, where Swedish scientists participate in several ongoing projects.

Within the Arctic Council, Sweden is active in most of the assessments that are produced by the Arctic Monitoring Assessment Program (AMAP) in collaboration with the Arctic countries. In 2017, a Nordic programme to reduce the environmental impact of plastic pollution in the Arctic (PAME) was launched where Sweden and many other countries are involved.

Another significant climate-related effort is the Intergovernmental Science-Policy Platform on Biodiversity and Ecosystem Services (IPBES) concerning nature and people. The Swedish Environmental Protection Agency (EPA))[94] is Sweden's national contact point for IPBES. Since biodiversity loss and climate change are inseparable threats to humanity, the two areas must be addressed together. They are also deeply interconnected in ways that pose complex challenges to effective policy making and action. In 2020, the Swedish EPA and SMHI published a synthesis report, "Climate change and biodiversity – conclusions from the IPCC and IPBES in a Swedish perspective".[95]

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

[95] https://www.smhi.se/polopoly_fs/1.163955!/Klimatologi_56%20Klimatf%C3%B6r%C3%A4ndringar%20och%20biologisk%20m%C3%A5ngfald.pdf

8.4 Organisation

8.4.1 Government research funding

Alongside the direct appropriations to universities and university colleges, the most important public research funders are research councils, but there are also research foundations that provide significant funding for research.[96]

As mentioned earlier, Vinnova, the Swedish Energy Agency and Formas jointly co-finance a total of 17 strategic innovation programmes where businesses, academia and organisations join forces to develop the sustainable products and services of the future. Several of these SIPs are in climate and sustainability related fields.[97]

Formas funds basic and needs-driven research within the areas of environment, agricultural sciences and spatial planning. In 2020, its research and innovation funding amounted to 1.7 billion SEK, of which almost two thirds (949 million SEK) was allocated from The *Ministry* of the *Environment.* During the period 2018-2020, the largest share (45%) of Formas' total funding was allocated to projects in the environment and climate area. The main part of the climate research is funded through open, bottom-up calls, but Formas also funds climate research through planned calls. Formas participates to a large extent in international calls for research in which their funding is allocated to Swedish researchers who are part of international research consortia and other collaborations. Examples of thematic calls for research that Formas have been involved in during 2020 are ERA-Net Biodiversa – Biodiversity and Climate Change and Belmont Forum Collaborative Research Action – Transdisciplinary Research for Ocean Sustainability. In 2020, Formas was responsible for the joint government research call International network for Agenda 2030 ("Internationellt nätverk för agenda 2030"), to promote collaborative projects outside of the EU. As part of pillar two (Global challenges and European industrial competitiveness) in Horizon Europe, Formas has been assigned as the expert authority for two clusters: climate, energy and mobility; as well as food, bioeconomy, natural resources, agriculture and environment.

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[96] A large part of the research efforts in the country is carried out in the private sector, indeed making the business sector the largest funder of R&D.

[97] https://www.vinnova.se/en/m/strategic-innovation-programmes/

Vinnova funds needs-driven multidisciplinary and interdisciplinary research that promotes sustainable growth and stimulates collaborations between companies, universities, research institutes and the public sector. Vinnova has an annual research budget of around 3 billion SEK and is the focal point for EU research collaboration on . Around half of the funding is allocated to initiatives and projects related to the climate. In recent years, the research funded by Vinnova has focused on climate change mitigation, often with new technology such as AI. Adaptation and climate resilience are areas that have gained increasingly more research attention in recent years. Vinnova is currently in a strategy development process and has identified solutions related to system impact and circular business models as key areas for the following years.

The Swedish Research Council has no special mission for climate research funding, but its open calls attract applications that address climate-related research questions. In a joint effort with Formas and the Swedish EPA, the council was tasked via a government mandate in 2019 to establish a visiting researcher programme within climate and environment, with the purpose to strengthen Swedish research in the area through collaboration with prominent US researchers. The programme has had two calls, one in 2019 and one in 2020 with grant periods of 6-24 months.[98]

The Swedish National Space Agency (SNSA)[99] distributes government grants for space research, technology development and remote sensing activities. The SNSA and RISE Research Institutes of Sweden have signed an agreement for a long-term and strategic co-operation, developing the Swedish Space Data Lab (a collaboration between the Space Agency, RISE, Lindholmen Science Park, and Luleå University of Technology) to use Earth observation data for weather forecasts and for analysing climate trends.

The research foundation Mistra[100] annually invests around 250 million SEK in various research initiatives, and these are to a large extent climate-related research (annual funding dedicated to climate change research is roughly 80 million SEK). Key climate-related programmes[101] include Mistra

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[98] https://www.vr.se/english/applying-for-funding/calls/2018-11-07-visiting-researcher-programme-within-climate-and-environment.html

[99] https://www.rymdstyrelsen.se/en/space-data-and-services2/

[100] https://www.mistra.org/en/

[101] https://www.mistra.org/forskningsprogram

Electrification, (2021-2025), Mistra Food Futures (2020-2024), Mistra Carbon Exit (2017-2021), Mistra Sams (2016-2024) and Mistra Geopolitics (2017-2024). Mistra has recently granted funding (40 million SEK) for the research programme Fair Transformations to a Fossil Free Future (FAIRTRANS), to use the experience and dedication from civil society to accelerate a fair climate change transition.

A few government agencies fund research in support of their own operations, including climate-related ones, and thus enable climate research on specific areas. Among these, The Swedish Energy Agency is one of the largest R&D funders, allocating 1.6 billion SEK per year during the reporting period to efforts in research, development, demonstration, commercialisation and innovation in the energy sector. Areas that are prioritised for funding are those which have good growth and export potential. Interdisciplinary collaborations and initiatives that compare gender equality in academia are also emphasised as important. The Energy Agency has identified six research areas that need further focus from 2021 and onwards: housing, bioenergy, renewable energy, industry, transport and the energy system in society. Several of the funded projects are interdisciplinary and consider political and economic effects and consequences of changes in the energy system and address necessary changes to achieve climate solutions. The Agency also funds research projects that address the Paris Agreement through focusing on mechanisms (NDCs).

The Swedish EPA funds research for identified knowledge gaps within the Swedish EPA and the Swedish Agency for Marine and Water Management (SwAM)[102]. Roughly 95 million SEK per year is allocated to research, and part of it addresses climate change issues in support of the Swedish climate policy framework and the climate targets. In the climate research area, the Swedish EPA collaborates closely with Formas and their national research programme for the climate. The Swedish EPA is currently in the process of announcing a large research programme on multifunctionality in landscapes, where climate adaptation is a part. A larger climate programme is planned for 2022.

The Swedish Civil Contingencies Agency (MSB) has an annual research budget of about 121 million SEK. A smaller part, annually about 10.1

[102] https://www.havochvatten.se/en

million SEK, is earmarked for robust decision-making around environment-related issues and climate risks. The bulk of the funding is for disaster and resilience research to prevent and manage accidents and emergencies including climate impacts and adaptation, for example forest fires.

The Swedish Geological Survey (SGU) has an annual budget of 5.9 million SEK to support geoscientific-oriented basic and applied research at universities and other research institutions. In general, research topics include ore geology, geochemistry, sedimentology, ground water issues, bedrock properties and geomorphology. The research is often connected to climate trends as the basis for a variety of applications in mineral extraction, hydrogeology, engineering geology, ground water contamination and geothermal energy. SGU may also ask for research aimed at new methods to better understand and predict coastal processes in general, and geological risks such as natural pollutants, flooding, erosion and landslides in a changing climate. SGU is currently working on a new research agenda and specific topics are yet to be decided.

The Swedish Geotechnical Institute (SGI) conducts applied research that addresses societal challenges in the following areas: more effective ground construction, management of contaminated sites and climate change adaptation. Their research is funded through government appropriation and contributions from the research council, authorities, and the EU.

Some other government agencies that fund research, such as The Swedish Transport Administration and SwAM, also fund some climate-related projects. The Swedish Transport Administration has allocated 80 million SEK to climate-related research the last three years on focus areas including a fossil-free transport system (e.g. autonomous vehicles), accessibility in a sustainable society, environmental sustainability and climate adaptation, development of construction technology in environmental and climate research and streamlining train traffic to reduce unnecessary emissions. The focus areas will be similar for the next three years. The administration's research budget includes the research and innovation initiative Triple F, contributing to the transition to fossil-free freight transport in Sweden. Triple F runs 2019-2030 with an annual budget of 20-25 million SEK.

8.4.2 Performers

Around half of the publicly funded research activities in Sweden are conducted at universities and university colleges. These organisations have their own research resources (core funding from the government), complemented by competitive research funding from national, Nordic, European and international mechanisms. The recent government research and innovation bill ("Research, Freedom, Future – knowledge and innovation for Sweden") suggests a ten-percent increase in core funding over the period 2021 to 2024. Other public research performers include industrial research institutes and some government sector agencies.

SMHI and its Rossby Centre play a central role for climate research in areas such as climate models and scenarios (see section 8.6). The Stockholm Environment Institute (SEI)[103] is an international research institute that builds bridges between research and policies. SEI has identified three areas of crucial importance in their 2021 - 2024 strategy: reduced climate risk; sustainable resource use and resilient ecosystems; as well as improved health and well-being.

The Swedish Environmental Research Institute (IVL) has a total research budget of 84 million SEK (out of which 37 million SEK through government grants to Swedish EPA and Formas) and conducts research co-funded by the state and the business community. IVL carries out research within the entire environment and sustainability field. The research is conducted in three areas: sustainable environment, sustainable transition and sustainable society. All three include research related to climate mitigation and adaptation.

8.5 Systematic observation

Systematic climate observation includes various measurements in meteorology, hydrology, terrestrial aspects and oceanography. SMHI operates networks for these on a national level in Sweden. In addition, other monitoring research infrastructures exist that can contribute to more systematic and coherent information on the changes in marine and land-based systems.

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[103] https://www.sei.org/

Through the Swedish Research Council, Sweden participates in several international research infrastructures related to climate, such as the Integrated Carbon Climate Observing System - European Research Infrastructure (ICOS-ERIC)[104], GBIF, the Integrated Ocean Drilling Program, (IODP)[105], through the European Consortium for Ocean Research Drilling (ECORD)[106], International Continental Scientific Drilling Program (ICDP)[107] and Life Watch. A national organisation is the National Rig which is funded by the Swedish Research Council and supported by the Swedish Scientific Drilling Programme[108].

The national research infrastructure ICOS Sweden[109] is a national research infrastructure within the European ICOS network, operating stations for greenhouse gas measurements in Sweden. ICOS Sweden aims to provide free-to-use, accessible, high-quality data to improve knowledge of greenhouse balances and linked measurements of ocean, atmosphere, and land to understand gas sinks and emissions. The Swedish Infrastructure for Ecosystem Science (SITES)[110] is a nationally coordinated infrastructure for terrestrial and limnological field research that performs systematic observations on land and land use related to climate. SITES has nine field research stations and aims to promote high-quality research through long-term field measurements and field experiments, and by making data available.

The Aerosol, Clouds and Trace Gases Research Infrastructure (ACTRIS) Sweden[111] is the national part of the pan-European research infrastructure ACTRIS. ACTRIS Sweden is linked to ICOS Sweden and collaborates with SITES.

Sweden also participates in coordinating observations in the Arctic and Antarctic through the organisations Inter-Agency Standing Committee

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[104] https://www.icos-cp.eu/

[105] https://www.iodp.org/

[106] https://www.ecord.org/

[107] https://www.icdp-online.org/home/

[108] http://www.riksriggen.se/www/short-summary-in-english/

[109] https://www.icos-sweden.se/

[110] https://www.fieldsites.se/en-GB

[111] https://www.actris.se/

(IASC)[112] and the Scientific Committee on Antarctic Research (SCAR)[113]. SMHI and SU participates in the Integrated Arctic Observation System (INTAROS)[114], funded by Horizon 2020. The overall objective of the project is to build an efficient integrated Arctic Observation System (iAOS) by extending, improving and unifying existing observation systems in the different regions of the Arctic.

8.6 Programmes and funding of climate research, including international cooperation

The Bolin Centre[115] at Stockholm University is a multi-disciplinary consortium of over 400 scientists in Sweden that conduct research and graduate education related to the Earth's climate. The research at the Bolin Centre is structured into multi-disciplinary research areas: oceans-atmosphere dynamics and climate; clouds, aerosols, turbulence and climate; hydrosphere, cryosphere and climate; biogeochemical cycles and climate; historical to millennial climate variability; deep time climate variability; landscape processes and climate; and biodiversity and climate.

BECC is a collaboration between Lund University and University of Gothenburg and strives for a better understanding of the impacts of climate change and land use decisions on terrestrial ecosystems and biodiversity, addressing the consequences of ecosystem changes for human beings and socio-economic systems[116].

Formas and the Swedish Research council, among others, finances Future Earth[117], a hub initiating and supporting international collaboration between researchers and stakeholders within climate and sustainability.

8.6.1 Research on policies and socio-economic relationships

At the Beijer Institute[118], two research programmes are relevant for policy and economics research: urban social-ecological systems; and behaviour,

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112 https://interagencystandingcommittee.org/

113 https://www.scar.org/

114 http://www.intaros.eu/

115 https://bolin.su.se/

116 https://www.becc.lu.se/

117 https://futureearth.org/

118 https://beijer.kva.se/

economics and nature. These programmes are funded by core funding of the Beijer Institute, Mistra, the University of Gävle, Formas and the URBAND-NET/ERA-NET initiative among others.

Mistra has several ongoing programmes with relevance for socio-economic analysis: Mistra Food Future, for a sustainable food system; Mistra Resource-Efficient and Effective Solutions, on policies for solutions based on circular economy; and Mistra Carbon Exit, on policies and other aspects on the road to net-zero products and services. The Mistra Center for Sustainable Markets (MISUM) focuses on increasing the understanding of the role of markets in sustainable development. Mistra has recently funded programs such as Mistra Financial Systems (how financial markets can contribute to sustainable development, 2016-2020), and Mistra's largest investment , Stockholm Resilience Centre (2007-2018, 198 million SEK), which focuses on the human impact on the dynamics of the ecosystems. A new programme is the Mistra and Formas call Social Transformations for Climate Action focusing on the civil society for societal transformation towards a fossil-free economy.

The Swedish EPA funds several research projects within socio-economic analysis and policy: research on the application of socio-economic analyses (2021-2023), policy instruments and consumption (2016-2020), synthesis analyses on sustainable consumption (2021-2022) and sustainable transports, ending in 2020 and 2021. Other research projects focus on effects and measures for follow-up, such as research on air pollution, or follow-up on social change.

The Centre for Climate Science and Policy Research (CSPR)[119] is an example of local collaboration on socio-economic analyses between Linköping University and SMHI. Its research focuses on climate change linked to transformation, vulnerability, adaptation and change, but also visualisation, communication, the impact of culture and different methods for carbon monitoring.

[119] https://liu.se/en/research/centre-for-climate-science-and-policy-research-cspr

Via the Arctic Council[120], several projects are funded on how to address the changing Arctic climate and its effect.

SEI runs the Mistra-financed programme Mistra Geopolitics (2017-2024) which examines the dynamics of geopolitics, human security, and environmental change.

The research program Humans, energy systems and society (MESAM)[121] is one of the Swedish Energy Agency´s initiatives in social sciences, humanities and interdisciplinary research. The agency also funds the project Roads from fossil dependence: a study of the impact of the Paris Agreement and the global sustainability goals on reforms of climate-damaging subsidies 2020-2022.

8.6.2 Research and development of measures for reducing emissions and adapting to climate change, including technology

SMHI houses The Swedish National Knowledge Centre for Climate Change Adaptation[122]. The centre collects, develops, and shares research, information from authorities and educative examples to facilitate sound decision making. IVL (see section 8.3.3) carries out research within the entire environment and sustainability field, such as survey of carbon dioxide emissions, energy scenarios, and climate effects on ecosystems.

Of the 17 SIPs, Viable Cities, Strim, RE:Source, Innovair, InfraSweden 2030, Drive Sweden, and Bioinnovation are relevant for reducing climate impacts. STandUP for energy[123] on energy supply from sustainable and renewable sources is a collaboration between Uppsala University, KTH, Luleå University and The Swedish University of Agricultural Sciences. Bio4Energy[124], started in 2009, is a collaboration on bioenergy and biorefinery research and development between Umeå University, Luleå University of Technology, The Swedish University of Agricultural Sciences, and RISE.

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120 https://arctic-council.org/en/

121 https://www.energimyndigheten.se/utlysningar/sok-stod-for-forskning-om-manniska-energisystem-och-samhalle2/

122 https://www.smhi.se/en/theme/climate-centre

123 https://www.standupforenergy.se/

124 https://www.bio4energy.se/

The Swedish Energy Agency funds research that contributes to the transition to a sustainable energy system. The agency funds many projects that bring together universities, industry owners and business owners, to achieve common goals. Much of this research focuses on innovation in energy-related products and services. An example is A Challenge from Sweden, a programme aimed at accelerating transformative system change in society, in relation to energy and climate goals.

Swedish LifeWatch (SLW)[125] is located at the Swedish University of Agricultural Sciences (SLU)[126], and Biodiversity Atlas Sweden (BAS)[127] at the Swedish Museum of Natural History, but the consortia are made up of a number of Higher Education Institutions (HEIs) and research institutions. BAS also forms the Swedish node for the international infrastructure GBIF. All these networks provide open access to data.

8.6.3 Support for global climate-related research

In 2018, Sweden launched a hub to explore the linkages between climate change and conflict. The Stockholm Climate Security Hub[128] provides evidence-based insights on fostering security and prosperity and strengthening resilience in the face of a changing climate. It combines the strengths of four leading research institutes: SEI, Stockholm International Water Institute (SIWI), Stockholm International Peace Research Institute (SIPRI) and Stockholm Resilience Centre at Stockholm University. The hub is funded by the Swedish Ministry for Foreign Affairs.

The Swedish International Development Cooperation Agency (Sida)[129] supports actors in low-income countries who both can produce new research and participate in international activities within transdisciplinary research on global sustainability, including climate issues. Sida cooperates with civil society, multilateral organisations, public agencies, and the private sector for sustainable development and to help people in poverty and oppression to improve living conditions. As a part of this, Sida supports

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[125] https://www.slu.se/en/subweb/swedish-lifewatch/

[126] https://www.slu.se/en/

[127] https://bioatlas.se/

[128] https://www.climatesecurityhub.org/

[129] https://www.sida.se/en

research projects in developing countries and a part of these are related to climate issues.

Via Sida, Sweden supports the CGIAR[130], which is a global research partnership working with adapting agriculture to climate change, and the Consortium of Humanities Centre and Institutes (CHCI)[131] which provides support for research within humanities such as how culture affects and is affected by climate change in Tanzania. Sida funds RECOFTS[132] and the initiative Research Forested Landscape Network Governance[133] on forest management and climate in Southeast Asia. Together with the Swedish Research Council, Formas and Forte, Sida provides funding for multidisciplinary research on the understanding and handling of consequences in complex systems due to climate change. Sida co-funds the Economy and Environment Partnership for Southeast Asia (EEPSEA Partnership), a regional research network with the vision to be a regional platform for environmental economics and transdisciplinary research to address global environmental challenges.

Sida also participates in research collaborations via funding to calls such as Belmont Forum on Ocean Sustainability, International Science Programme[134], Grand Challenges in Africa[135] within the African Academy of Sciences (AAS)[136], Science Granting Councils Initiative in Africa[137], The World Academy of Sciences (TWAS)[138], and the Organisation for Women in Science for the Developing World (OSWD)[139] (within TWAS).

Via Sida, Sweden provides funding for The Biosciences Eastern and Central Africa – International Livestock Research Institute (BecA-ILRI)[140] Hub which is a collaboration with the National Agricultural Research Institutions

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[130] https://www.cgiar.org/

[131] https://chcinetwork.org/

[132] https://www.recoftc.org/

[133] https://www.recoftc.org/news/recoftc-cifor-and-sweden-launch-forest-landscape-governance-research-network

[134] https://www.isp.uu.se/about-isp/#about

[135] https://www.aasciences.africa/aesa/programmes/grand-challenges-africa

[136] https://www.aasciences.africa/

[137] https://www.idrc.ca/en/initiative/science-granting-councils-initiative-sub-saharan-africa

[138] https://twas.org/

[139] https://owsd.net/

[140] https://hub.africabiosciences.org/

(NARIs), African universities and regulatory bodies, private sector, international research institutes, foreign universities, CGIAR and other participants. The aim is to support specific projects, capacity building, and support for the bioinformatics platform.

The Royal Swedish Academy of Sciences (KVA)[141] is a member of the program Leading Integrated Research for Agenda 2030 in Africa (LIRA)[142] which is funded by the International Council for Science (ICSU). There is ongoing collaboration with the International Social Science Council (ISSC)[143] and the International Council for Science (ICS)[144].

SEI coordinates a regional research network in southeast Asia, The Sustainable Mekong Research Network (SUMERNET)[145] on sustainability research. Most of the projects have a climate focus, and between 2019-2028, the network will focus on water insecurity throughout the Mekong Region by linking evidence-based research on regionally relevant water issues and engaging with policy, local community and vulnerable groups across the region.

The African marine research organisation (WIOMSA)[146] supports researchers in modelling the effects of climate change on the distribution of shared fishery species in the subtropical Western Indian Ocean. WIOMSA is co-funded by the Swedish Government.

8.7 Modelling and prediction, including global and regional models

The Rossby Centre was part of the international effort to develop a new version of the global Earth system model, EC-Earth, that has been complemented with several additional processes, such as dynamic vegetation as well as components for interactive atmospheric chemistry and ocean biogeochemistry. Data from this effort is available via the Swedish Earth System Grid Federation node (ESGF)[147] which is the international standard

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[141] https://www.kva.se/en/startsida

[142] https://council.science/what-we-do/funding-programmes/lira2030/

[143] http://www.worldsocialscience.org/

[144] https://council.science/

[145] https://www.sei.org/projects-and-tools/projects/sumernet/

[146] https://www.wiomsa.org/

[147] https://esgf.llnl.gov/

for sharing climate model data. SMHI Hydrology Research unit[148] studies how future climate change may affect water availability and flow dynamics in river systems and ocean climate research is conducted mainly with regional climate models for the Baltic Sea, the North Sea and the Arctic.

The Centre for Environmental and Climate Research (CEC)[149] at Lund University coordinates two national strategic research areas; Biodiversity and Ecosystem services in Changing Climate (BECC) and ModElling the Regional and Global Earth System (MERGE). Modelling the regional and global Earth system (MERGE)[150] is a collaboration between Lund University, University of Gothenburg, Rossby Centre/SMHI, Linnaeus University, Chalmers University of Technology, and The Royal Institute of Technology (KTH) aiming at creating reliable modelling of the climate system.

The Centre for Societal Risk Research, (CSR)[151] at Karlstad University, funded by the Swedish Civil Contingencies Agency (MSB), supports research in the field of climate adaptation, and modelling is one part of the research.

8.8 Programmes and funding for systematic monitoring, including international cooperation

Sweden has an extensive national environmental monitoring system. The national environmental monitoring aim is to provide a holistic view of the environmental status in Sweden. The national environmental monitoring is separated into ten programme areas and the Swedish EPA is responsible for eight programme areas: air, forest, farmland, mountains, landscapes, wetlands, toxic substances coordination, and health-related environmental monitoring.[152]

Within the national air-monitoring program[153], pollutants in air and precipitation are monitored, mainly on a regional background level. What

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[148] https://www.smhi.se/en/research/research-departments/hydrology

[149] https://www.cec.lu.se/

[150] https://www.merge.lu.se/merge-startpage

[151] https://www.kau.se/en/csr

[152] http://www.swedishepa.se/Environmental-objectives-and-cooperation/Swedish-environmental-work/Environmental-monitoring-describes-the-state-of-the-environment/

[153] https://www.naturvardsverket.se/Miljoarbete-i-samhallet/Miljoarbete-i-Sverige/Uppdelat-efter-omrade/Luft/Luftovervakning/

substances to monitor are decided in conventions such as the Convention on Long-Range Transboundary Air Pollution (CLRTAP) and its monitoring programme European Monitoring and Evaluation Programme (EMEP).

SwAM is responsible for two programme areas: sea and coastal areas, and freshwater.[154]

On a European scale, SMHI takes part in the European Global Ocean Observing System (EuroGOOS)[155] which is the European component of the Global Ocean Observing System of the Intergovernmental Oceanographic Commission of UNESCO (IOC GOOS). The aim is to enhance cooperation and to ensure sustained observations. Further, SMHI is a member of the Baltic sub-group, Baltic Operational Oceanographic System (BOOS)[156]. SGU, Swedish Maritime Administration, SU, and SMHI are all partners of the European Marine Observation and Data Network (EMODnet) providing data and collaborates with the Copernicus Marine Monitoring Service[157].

As the contact point for the IPCC, SMHI coordinates the Swedish IPCC work. SMHI represents Sweden in the World Meteorological Organization (WMO)[158], Intergovernmental Oceanographic Commission (IOC)[159], Group on Earth Observations (GEO)[160], European Centre for Medium Range Weather Forecasts (ECMWF)[161], and in the European Common satellite programs of the European Organization for the Exploitation of Meteorological Satellites (EUMETSAT)[162], where climate monitoring has become increasingly important. SMHI is also the Swedish representative in the Copernicus User Forum, the European Union's Earth observation programme. The cooperation between the weather services in Europe,

[154] http://www.naturvardsverket.se/Documents/publikationer/978-91-620-8388-5.pdf

[155] https://eurogoos.eu/

[156] https://eurogoos.eu/roos/baltic-operational-oceanographic-system-boos/

[157] https://marine.copernicus.eu/

[158] https://public.wmo.int/en

[159] https://ioc.unesco.org/

[160] https://earthobservations.org/index.php

[161] https://www.ecmwf.int/

[162] https://www.eumetsat.int/

EUMETNET[163], provides a framework to organise co-operative programs between its members in the various fields of basic meteorological activities.

The Swedish Polar Research Secretariat[164] is a government agency that promotes and co-ordinates Swedish polar research. Polar research focus on the Arctic, Antarctica, the sub-polar regions and the Swedish mountain areas. Abisko Scientific Research Station in northern Sweden and the Wasa and Svea research stations in Dronning Maud Land in Antarctica are part of the Swedish Polar Research Secretariat's permanent infrastructure for research. Another example is the Icebreaker Oden that is one of the world's most powerful icebreakers and one of the world's premier platforms for conducting research in polar regions.

The Swedish National Space Agency (SNSA) coordinates Swedish participation in Copernicus, the EU Earth Observation Programme[165] , represents Sweden in the European Space Agency (ESA)[166], participates in the ESA programme for Global Monitoring of Essential Climate Variables (ESA CCI)[167] and the Copernicus Committee, as well as works on bilateral and multilateral satellite projects such as Europe's Copernicus Sentinel[168] satellite program. SLU has an assignment from the government to manage and implement the Environmental Monitoring and Assessment (EMA)[169] and also hosts the Swedish National Inventory of Forests[170], which comprises statistics about the status and change in Sweden's forests.

SMHI conducts monitoring in the field of atmospheric remote sensing with focus on cloud and precipitation retrievals using satellite and radar measurements. SMHI contributes with atmospheric data to the World Meteorological Organisation's (WMO) World Weather Watch (WWW)[171], which are reported further to the Global Climate Observing System

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163 https://www.eumetnet.eu/

164 https://www.polar.se/en/

165 https://www.copernicus.eu/sv

166 http://www.esa.int/Space_in_Member_States/Sweden

167 http://www.esa.int/Applications/Observing_the_Earth/Space_for_our_climate/Space_agencies_join_forces_to_systematically_observe_climate_variables

168 https://sentinels.copernicus.eu/web/sentinel/home

169 https://www.slu.se/en/Collaborative-Centres-and-Projects/slu-water-forum/environmental-monitoring-and-assessment/environmental-monitoring/

170 https://www.slu.se/en/Collaborative-Centres-and-Projects/the-swedish-national-forest-inventory/

171 https://public.wmo.int/en/programmes/world-weather-watch

(GCOS)[172]. Through the European Meteorological Network EUMETNET, Sweden contributes with data on wind and temperature obtained at various levels by civil aviation and with integrated humidity in the atmosphere from GPS measurements.

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[172] https://gcos.wmo.int/en/home

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Mistra FAIRTRANS https://www.mistra.org/en/news/sek-40-million-for-research-on-how-to-achieve-a-fossil-free-future/

Mistra Food Futures https://mistrafoodfutures.se/

Mistra Center for Sustainable Markets (Misum) https://www.hhs.se/misum

Mistra Resource Efficient and Effective Solutions REES https://mistrarees.se/home/

Mistra Carbon Exit https://www.mistracarbonexit.com/

Mistra Stockholm Recilience Centre https://www.mistra.org/forskningsprogram/stockholm-resilience-centre/

Mistra Financial Systems https://www.mistra.org/forskningsprogram/mistra-financial-systems/

Mistra Geopolitics https://www.mistra-geopolitics.se/

NordForsk https://www.nordforsk.org/about

Nordic Council of Ministers https://www.norden.org/en

Nordic Energy Research https://www.nordicenergy.org/

SMHI https://www.smhi.se/forskning

STandUP för Energy https://www.standupforenergy.se/

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Swedish Environmental Protection Agency: http://www.naturvardsverket.se/Miljoarbete-i-samhallet/Miljoarbete-i-Sverige/Forskning/Forskning-for-miljomalen/

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The Swedish International Development Cooperation Agency https://www.sida.se/en

9. Education, training and public awareness

Achieving the goals of the Paris Agreement will require major structural changes and the participation of the whole of society in climate change transition. This presupposes that there is a strong commitment and a broad understanding of the climate issue among the public. It also presupposes that people from all parts of society are enabled to contribute. The possibility of achieving the goals of the Paris Agreement is therefore strongly linked to increased awareness and participation in issues related to climate change.[173]

In the year 2020 the Swedish government made a national stocktake of opportunities and conditions for Sweden's implementation of Article 12 of the Paris Agreement. The stocktake was performed in line with the UNFCCC ACE Guidelines[174] as a step towards forming a national strategy on ACE, actions for climate empowerment. The national stocktake and the surveys and analysis conducted serves as useful sources of knowledge on education, training, public awareness, public participation, public access to information and international cooperation in climate change issues in Sweden.

This chapter describes actions relating to education, training and public awareness in Sweden. The structure is mainly organised in line with the suggested guidelines FCCC/CP/2019/13/Add.1, point 69.

9.1 Education and training

Education and learning play a key role in strengthening society's preparedness and ability to take action to combat climate change. The challenge of solving climate issues in society requires new and innovative solutions. Sweden like every country needs to continue building the necessary knowledge to solve the climate challenges of limiting emissions and adapting society to a changing climate.

9.1.1 General policy on education and training

The Government has a very high ambition for the implementation of Agenda 2030 for sustainable development at local, regional and national level

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[173] Mission M2020/00157 /Kl, Swedish Environmental Ministry 2020

[174]https://unfccc.int/files/cooperation_and_support/education_and_outreach/application/pdf/action_for_climate_empowerment_guidelines.pdf

and all authorities within their respective areas of responsibility and on the basis of their assignments.

Sustainable development is well integrated into syllabuses and curricula for preschool, primary school and upper secondary school. The environment and the conditions for sustainable development, which includes climate related issues, must permeate all course and subject plans in the governing documents for preschool up to and including adult education.

The higher education institutions' assignments for education and practical learning in climate related issues are partly expressed in the Higher Education Act and the Higher Education Ordinance, which state that they must promote sustainable development in their activities, and that sustainable development must be part of various educations.

The Swedish National Agency for Education as the administrative authority in the school area with the task of working for the generational goal and the environmental quality goals, gender equality and human rights.

9.1.2 Primary, secondary and higher education

There is strong support for sustainability issues including climate related issues in the governing documents. In addition many schools have a strong comittment to environmental issues. The schools have access to a large variety of education materials that holds high standard. The Swedish National Agency for Education works to support schools in their work in several ways, including providing competence for materials for teachers and school leaders.[175]

To strengthen the development of didactical tools and use of methods in education for ESD (education for sustainable development), the Swedish National Agency for Education offers on line-based in service training in the area for teachers from pre-school up to upper secondary level. In cooperation, the Swedish National Agency for Education and five Swedish Universities offer in service traing for school management staff on how to manage schools from a sutatainable perspective. Reports from the Swedish

[175] https://www.skolverket.se/andra-sprak-other-languages/english-engelska

Schools Inspectorate shows the importance of the management in the work to implement ESD in daily school life.

The Swedish National Agency for Education has the task of promoting integration of Agenda 2030 and the Swedish environmental goals in the educational system. In 2019 and 2020, the agency was commissioned to increase awareness of how Agenda 2030 and the national environmental goals are linked to teaching. The National Agency for Education also participates in several forms of collaboration around sustainable development in education, both nationally and internationally, including in the network Learning for Sustainable Development, LHU, and The Global School, which is run by the Swedish Council for Higher Education. The Swedish National Agency for Education also cooperates with other Swedish agencies concerning implementation of Agenda 2030.

Several higher education institutions have also adopted their own governing documents, for example on how climate related issues are being included as part of compulsory or elective courses in programs.

Teachers also highlight young people's climate concern or anxiety as a challenge in education regarding climate. Surveys on the public awareness and access to information in Sweden also shows that young people have a very strong commitment to climate and environmental issues. This implicates that the there is a need to continue developing policy and education around climate change issues.

BOX 91. The Swedish School System

In Sweden, the state governs the school through laws, ordinances, curricula and syllabi. These set goals and guidelines for all activities in the schools. The municipalities have the main responsibility for compulsory school, upper secondary school and municipal adult education. The National Agency for Education is the national school authority with responsibility for evaluation, development and supervision of school activities. Sweden has a nine-year compulsory primary school. All children and young people between the ages of seven and 16 are required to attend school. Swedish schools are mainly publicly funded and free of charge. 3.5 percent of students go to independent schools that are also publicly funded.

9.2 Training programmes

This section provides an overview of some of the training programmes in Sweden. It is based on two surveys conducted in 2020 and 2021.

Cohort Programme

Stockholm Environmental Institute worked with the Cohort Program to enable young people to work closely with members of the Advisory Committee identify global momentum to promote sustainable lifestyles under the 10YFP Sustainable Lifestyles and Education (SLE) program.

Junior Academy

Junior Academy – is an international program for young people within science, technology, engineering, mathemathics, giving youth the chance to work with societal challenges and innovation. (collaboration between the Royal Swedish Academy of Engineering Sciences (IVA) the New York Academy of Sciences (NYAS) and Chalmers University of Technology)

Climate Framework for Swedish universities

Chalmers University of Technology and KTH Royal Institute of Technology have initiated a national climate framework to contribute to climate change in line with national and international commitments. The focus of the Climate Framework is mainly on their direct climate impact, but does also focus on the core business of education, research and collaboration. So far 38 universities and colleges have joined the Climate Framework.

Eco-schools, Green Flag and YRE

The Keep Sweden Tidy Foundation runs the Eco School Program in Sweden that is a global network offered by FEE (Foundation for Environmental Education) for education for sutainable development recognized by the UN[176]. Schools and pre-schools put up own sustainable goals and the work is lead by the enviromental council on the school consisting of both teachers and pupils. Schools working succefully gets the Green Flag. The Keep Sweden Tidy Foundation also runs the FEE-project

[176] https://hsr.se/keep-sweden-tidy-foundation

Young Reporters for the Environment (YRE)-. Pupils writes articles concerning sutainable development.[177]

The Sustainable Schools Award

The Swedish National Agency of Education runs the The Sustainable Schools Award. Schools and pre-schools that report their work in the area of ESD and fullfill the criterias concerning staff and pupils involvement in the work with sustainable development can apply to The Swedish National Agency and get the award from the agency.

Baltic Sea Science Center

The Baltic Sea Science Center is a cooperation to educate high school students on the effects of warming oceans. The film "Meet a researcher" is produces both for the public and schools the effects of global warming on fish.

The Bohlin Climate Festival

The Bohlin Climate Festival is annual events for children and young people aged 10-20 offers activities and lectures with a clear scientific connection. The Climate Festival both 2020 and 2021 were digital events. (the Bolin Center)

Citizen science the Climate call

The Swedish University of Agricultural Sciences, SLU, has several climate-related projects in citizen science, including “The species portal” and “Klimatkollen”, which register climate change in flora and fauna.

9.3 Education material

Education materials are developed both by government agencies and other actors for the Swedish Ecucation system. Here are some examples:

The forest in the school

Nationwide activities and a national collaboration between the school and Sweden's forestry stakeholders (authorities, universities, organizations and

[177] https://www.yre.global/

business) provide materials about forest inventory and the role of the forest in climate work. (SLU)

Forests and sustainable development

A new webbased material on forests for highschool students will also be launched in 2022 align with a webbbased climate-education-portal for High schools with instructions for field-excursions and classroom-education. (SLU, Formas)

ReGeneration 2030

Curriculum development and lectures on sustainable lifestyle and education for hundreds of young people at ReGeneration Week 2021. (SEI)

Sustainable of course!

A school material for home and consumer knowledge teachers, grades 7-9. The material consists of films, lessons and digital quizzes. The film episodes were shown 52,200 times in 2020. (Swedish Consumer Agency)

Sustainable comsumtion

30 complete lessons according to the curriculum for compulsory school teaching in home and consumer knowledge and upper secondary school teaching in social studies. The lessons are available through a digital lesson bank. In 2020 the lesson bank had approximately 65,700 visits. (the Swedish Consumer Agency)

Sustainable production and consumption of food

Lessons, films and posters aimed at children and young people are available via the website Free in School. (the Swedish Board of Agriculture)[178]

Geoschool

A digital learning environment with lessons and map application for teachers and students in primary and secondary school on climate impact, rising water levels and risks of rising sea levels. (the Swedish mapping, cadastral and land registration authority)

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[178] https://jordbruksverket.se/mat-och-drycker/hallbar-produktion-och-konsumtion-av-mat/hallbar-mat---en-komplicerad-fraga#h-Dukanskeocksaarintresseradavdethar

https://gratisiskolan.se/all-products?avsandare=418%252F

Transforming the Swedish Industry

Educational material for upper secondary school within the project the Global School. (Government iniative Fossilfree Sweden)

Ambio

A Journal of environment and society, with several focu-editions on climate has been published since 1972 (by the Royal Swedish Academy of Sciences)

Passion for Climate

A project to canalize climate engagement among yoth in higher education. (Chalmers University of Technology)

Swedish Life Cycle Center

Is a competence center that arranges webinar with themes linked to climate, e.g. the environmental footprint of EU, biodiversity, climate and construction, plant-based consumer guides and the climate impact on the transport system. The films are also used in education and by companies. Some education is open to the public. (Chalmers University of Technology in cooperation)

9.4 Public awareness, public participation and access to information

Awareness of climate change is generally very high in Sweden. A vast majority of the Swedish public also state that it is very, or quite important, to take societal actions to reduce the impacts of climate change. The Swedish people are interested in information about climate change, and a recently conducted survey show that they to a large extent want the information to come from authorities, researchers or news media.

A large majority of the Swedish public also state that they themselves can act to reduce climate change. On a question on how a climate climate-adapted society would affect their quality of life, a majority of Swedes think it will be in a positive or neutral way.

In Sweden, just over a quarter of the population is highly educated. Of the population aged 25–64, 43 per cent have some form of post-secondary education. 28 percent, have at least three years of post-secondary education, which corresponds to 1,442,000 people. In recent years, the proportion of highly educated people has increased by just over half a percentage point per year.[179]

Sweden has a very high degree of digitalization in an international comparison. 95 percent of the Swedes from the age of 8 and up use internet. 9 out of 10 Swedes do it daily.[180]

The high level of knowledge, the large interest and the attitude towards a climate-adapted society gives a central role to actions for climate empowerment for both government, authorities, companies and the civil society in Sweden.

9.4.1 General policy on public awareness, participation and access to information

Some of the government Agencies in Sweden have an appointed commission to work for public participation and access to information on climate related issues. For exemple, the Swedish Energy Agency, the Climate Policy Council, the Swedish Consumer Agency, the Swedish Food Safety Authority, the Swedish Environmental Protection Agency, the Swedish Forest Agency, the Swedish Hydrological and Metreological Agency (SMHI) and the Swedish Transport Administration. In addition to these, many other government agencies have an appointed basic obligation to provide information, guidance, advice and other assistance within their area of responsibility under the Public Administration Act, as well as to other related assignments.

9.4.2 Public access to information through digitalisation and the Aarhus Convention

In Sweden, public access to the administrative authorities' geographical environmental information is specifically regulated in the Act on Geographical Environmental Information. In order to increase the pace of digitalization in the public sector, the Swedish government implemented an initiative where authorities were commissioned to lead the digital transformation within their areas. In 2017, a national digitalization strategy

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[179] https://www.scb.se/hitta-statistik/statistik-efter-amne/utbildning-och-forskning/befolkningens-utbildning/befolkningens-utbildning/pong/statistiknyhet/befolkningens-utbildning-2018/

[180] https://svenskarnaochinternet.se/english/

was adopted with the overall goal for Sweden to be at the front in using the possibilities of digitalization.

The Swedish Environmental Protection Agency is the Swedish node for the Aarhus Convention, with the task of being a hub that matches the needs and demands of various stakeholders. The Aarhus Convention includes the so-called PRTR protocol. In Sweden, the protocol has been implemented through the emissions register *Emissions in figures*, which is available on the Swedish Environmental Protection Agency's website.[181]

9.5 Public information campaigns and public participation

The principle of openness is central to the Swedish legal system. It implies that the public, both individuals and representatives of the media, have the right to insight into and access to information about the state's and municipalities' activities. The principle of openness is expressed in various ways in Sweden's constitutional laws. For example, through the right to freedom of expression, the freedom of information for civil servants and through public access to public documents.

Public participation and access to information on climate related issues are granted by allowing the public to access information on authorities websites and via social media.

Several agencies regularly publish knowledge and statistics around environmental issues such as emissions, and also work actively with the Swedish media to increase the public access to the information.

This chapter gives an overview on actions to enhance the public awareness and the access to information on climate related issues.

Hello Consumer!

Hello Consumer! is an nation wide information service with the aim to make it easier for consumers to make well-balanced choices in relation to their carbon footprints. It also includes information on environmentally sustainable consumption related to the generational goal for the environmental work and the environmental quality goals, as well as

[181] https://utslappisiffror.naturvardsverket.se/en/Search/?selectedCountryCode=en&currentPage=999

information on other sustainability aspects when deemed appropriate. The service has been improved to make more consumers aware of environmental aspects[182] (the Swedish Consumer Agency).

Fuels for cars and environmental impact from leisure boats

Easy-to-understand information about the fuels available at service stations. for vehicle users, with the long-term goal to contribute to a positive attitude towards the introduction of new fuels with lower greenhouse gas emissions on the market. This together with an information campaign about the environmental impact of recreational boats to facilitate the transition of the transport sector (The Swedish Transport Agency).

From October 1st 2021, there is a national requirement for environmental information about fuels must be presented at the fuel pumps. The information is provided with the help of a sticker that informs the consumer about the fuel's greenhouse gas emissions, which fossil raw materials or renewable raw materials that are included in the fuel and the country of origin of the raw materials (The Swedish Energy Agency).

Car-choice-information service

The tool bilsvar.se is an information service for consumers coosing a car based on their economy, practical needs and sustainability. The service is based on assignments in the EU directive 1994/94 / EC.[183] (The Swedish Environmental Protection Agency, the Swedish Energy Agency and the Swedish Transport Agency.)

"What should we eat today"

The menu "What should we eat today" is a collaboration between the Swedish Consumer Agency and the National Food Administration, was launched in 2020. The new menu is more sustainable from a climate perspective and makes it easier for the public to see the climate footprint of different dishes.

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[182] https://www.hallakonsument.se/en/engelska/

[183] https://www.bilsvar.se/

Energy and climate advice service in every municipality

Energy and climate advice is a free service for questions about energy use and climate impact, which is aimed at individuals, associations and organizations. The service is provided by all municipalities and financed by the Swedish Energy Agency.

The Swedish web portal for climate change adaptation, Klimatanpassning.se

The purpose of the web portal Klimatanpassning.se is to support various actors in society in the work with climate adaptation. The portal is run jointly by 27 Swedish authorities and managed by the National Knowledge Center for Climate Adaptation at SMHI. The portal offers comprehensive information and support that is easily accessible for the public.[184]

The Climate Adaptation Game in Minecraft

The Climate Adaptation Game is available both in Minecraft and on the web-site, and can be played in Swedish or English. The aim is to increase the understanding of what a warmer climate implicates and how we can adapt to it. The game is suitable for education in sustainable development and when starting to work with climate adaptation.[185]

New scenario service for historical and future climate change

New scenario service was launched 2021 on smhi.se, is based on new observation data and new climate model data. Both individuals, authorities and the business community can find climate information in a new interactive web-service. The service is available in English and Swedish.[186]

The rural network

The rural network is a national network with organizations, associations and authorities that in various ways are important for rural development. During 2020 the network had a campaign on how the countryside can deliver fossil-free energy. The board of the network also produces seminars and podcasts[187]. (The Swedish Board of Agriculture)

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[184] http://www.klimatanpassning.se/en

[185] https://www.smhi.se/en/climate/education/adaptation-game-1.153788

[186] https://www.smhi.se/klimat/framtidens-klimat/framtidens-klimat

[187] https://www.landsbygdsnatverket.se/2.2e7051841506a4adf404a58.html

Green light 2030

Green light is an annual concference for the transport sector around the 2030 and 2045 climate goals arranged by the The Swedish Transport Administration.

Win-win-award

The WIN WIN Gothenburg Sustainability Award is a non-profit organization funded by the City of Gothenburg, The Region Västra Götaland and several other member organizations and companies. During the WIN WIN Awards prize week, several talks, workshops and exhibitions were carried out for the public. The WIN WIN Sustainability Adventure is an initiative for young people who are committed to creating a more sustainable world by creating a forum for networking, skills development and exchange of ideas.[188]

COP 26 Hub

Researchers from the Bolin Center were on site at Stockholm House of Culture & City Theatre, October 31st - November 12th 2021, to answer questions related to climate and the UN Climate Conference. The public was also invited to watch live broadcasts from COP26, see a photo exhibition, and discuss climate-related issues with researchers (Bohlin Center).

The Bolin Center also arranged several Journalist Meetings for the exchange of knowledge for journalists and researchers.

Panorama

Panorama is a digital collaboration tool that visualizes climate change in Sweden. Panorama gives the user an overview of the current situation and what needs to be done to achieve the Swedish climate goals. The tool visualizes the climate emissions that occur within Sweden's borders, how they can be reduced, what policy instruments are in place together with information on how the change is going.

[188] http://winwingothenburgaward.com/

The Climate Policy Council, the Swedish Environmental Protection Agency and the Swedish Energy Agency run and develop Panorama together, and many other actors have contributed their expertise.[189]

9.6 Resource or information centres

The following examples presents some of the resources and information centres for climate related issues in Sweden.

Samtinget, the Sami parliament of Sweden

The Sami Parliament is both a publically-elected parliament and a State agency. The tasks of the Parliament are regulated by the Swedish Sami Parliament Act.

The Sami Parliament's has adopted an action plan for climate adaptation. The Sami Parliament, in collaboration with the county administrative boards in the reindeer husbandry area, have made climate and vulnerability analyzes and action plans for climate adaptation. The purpose is to take stock of how climate change affects the conditions for reindeer husbandry in the Sami village, identify problems and analyze possible proposals for measures.[190]

SMHI, the Swedish Meteorological and Hydrological Institute

SMHI, the Swedish Meteorological and Hydrological Institute, is an expert authority under the Ministry of the Environment. SMHI has a global outlook and a vital mission to forecast changes in weather, water and climate. SMHI has a lot of contact with the public through its customer service and answers many questions from the public about climate on a daily basis.

SMHI is the Swedish Focal Point for IPCC and works actively to make information from the IPCC available and relevant for the public, news media and other relevant stakeholders. SMHI regularly gives lectures and hold seminars around climate change and adaptation for students on different levels.

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[189] https://app.climateview.global/public/board/48023530-bb99-4a82-a00e-c9e7aad71f5d

[190] https://www.sametinget.se/lang/english

The agency uses several methods such as films, webcasts, art-exhibitions and games to enhane the public access to information on climate change.[191]

Statistics Sweden, SCB

Statistics Sweden, SCB, is responsible for official statistics and for other government statistics, in practice to develop, produce and disseminate the statistics. SCB has participated in a number of development projects within environmental economics and environmental statistics, for example. Prince[192]. SCB regularly publish environmental statistic accessible for the public, organisations and companies in both website, databases and on social media.[193]

The Swedish Civil Contingencies Agency (MSB)

MSB is responsible for supporting society's preparedness for accidents, crises and civil defense. This assignment includes coordinating the various actors' communication and collective information to the public.

Krisinformation.se is a service for Sweden's collective crisis information. The purpose of the service is to make it easier for the public to find confirmed information from Swedish authorities by collecting it in one place and to reduce the risk of incorrect information being disseminated.[194]

The mobile-app "Fire risk Outside" shows the risk of fire in forests and land to the public and contains advice on to prevent vegetation fires. The flood portal shows maps of flood risks at watercourses, lakes and coasts in a future climate.

MSB also educates local and regional authorities in climate risks, prevention and adaption.[195]

The Swedish Climate Policy Council

The mission of the Swedish Climate Policy Council is to evaluate the Goverments overall policies including the bases and methods on which they

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[191] https://www.smhi.se/en/about-smhi/who-we-are/who-we-are-1.83748

[192] https://www.prince-project.se/

[193] https://www.scb.se/en/

[194] https://www.krisinformation.se/en

[195] https://www.msb.se/en/

are built. The council also fosters debate in society on climate policy. The members of the Council represent several research disciplines and universities of Sweden.[196]

The Swedish Consumer Agency

The Swedish Consumer Agency is a government agency to safeguard consumer interests. One special mission is to identify significant barriers to sustainable consumption. The work was limited to obstacles that to a large extent make it difficult for consumers to make environmentally sustainable choices.

The Agency also works to enhance information on sustainable consumption on the service Hello Customer both in the website, chatt, phone and mail.[197]

The Geological Survey of Sweden, SGU

The Geological Survey of Sweden, SGU, is the expert agency for issues relating to bedrock, soil and groundwater in Sweden. SGU educates other state actors in the UN classification of nature resources, UNFC. In 2021 SGU focused on increasing knowledge around CCS, carbon capture and storage.[198]

The Swedish Energy Agency

The Swedish Energy Agency is leading society's transition to a sustainable energy system with facts, knowledge, and analysis of supply and use of energy in the society, as well as work towards security of energy supply. The agency funds research on new and renewable energy technologies, smart grids and vehicles and future transport fuels.

The Swedish Energy Agency guides the public in energy efficiency for homes and provide tips and advice on the purchase of various products such as lighting, white goods, home electronics and heating systems. A testlab performs tests of products in lighting, white goods, heating and hot water, consumer electronics and solar energy and the tests are available on the website.

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[196] https://www.klimatpolitiskaradet.se/en/uppdrag/

[197] https://www.konsumentverket.se/languages/english-engelska/

[198] https://www.sgu.se/en/

The Swedish Energy Agency also has a portal with information for the purchase of solar cells.

The Swedish Environmental Protection Agency

The Swedish Environmental Protection Agency is driving and coordinating the environmental work in Sweden. The assignment includes distributing government grants to other actors who work with, for example, protection and management of valuable nature, remediation and after-treatment of contaminated areas and compensation for game damage. The Swedish EPA also provides support to outdoor organizations.

The Swedish EPA is responsible for statistics and knowledge on the Swedish emissions, and works actively to enhance public access to information. The agency is also responsible for the web-site that describes the Swedish Environmental Objectives[199].

The Agency regularly holds webinars[200] on climate related issues open to the public and works actively with social media and educations for journalists.

Since 2020 the Swedish Environmental Protection Agency has a specific task to provide digital information about the Paris Agreement to the public. The information is compatible the Language Act, and websites also includes comprehensive information on climate work from a social perspective such as gender equality, indigenous peoples and human rights. [201]

The Swedish Geotechnical Institute (SGI)

The Swedish Geotechnical Institute (SGI) is an expert agency for an efficient and sustainable use of land and natural resources. The mission includes the prevention of landslides and coastal erosion, sustainable and effective soil works, know-how and methods to remediate contaminated sites and climate adaptation.

SGI works actively with both schools and the public for example in the story-mapping projects EVOKED and the research-projcect Sea-Rims in

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[199] https://www.sverigesmiljomal.se/environmental-objectives/

[200] https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/sveriges-klimatarbete/webbinarier-om-klimat-och-luft

[201] https://www.naturvardsverket.se/amnesomraden/klimatomstallningen/det-globala-klimatarbetet/parisavtalet

collaboration with KTH Royal Institute of Technology in Stockholm and several municipalities. An new interactive webbsite with the aim to raise awareness and ethical issues around rising sea-levels is launched in januari 2022. The agency also participates in annual conferences and meetings open for the public around practical measures for climate adaptation on the coast.

The Swedish Food Agency

The Swedish Food Agency work towards the following healthy dietary habits, safe foods and fair practices in the food trade. The Swedish Food Agency encourage the public to learn more about eco-smart food choices and how to minimize food waste.

The national food database is run by the agency and contains just over 2,200 foods and dishes. The database is used by companies in the food industry, actors in the health care system and teachers and students in education and research.

On food waste agency conducted a survey about consumer behavior and perceptions. Fruit and vegetables are the most thrown away in the home and rended the information campaign "Take care of fruit and vegetables".[202]

The Swedish National Board of Housing, Building and Planning, Boverket

Boverket – the Swedish National Board of Housing, Building and Planning – is a central government authority assorted under the Ministry of Finance. We review developments within the fields of housing, building and planning.

Boverket mainly guides other state actors for example in climate risks, climate declaration and adaption. The agency has a new mission to start an information center for sustainable construction with a focus on energy-efficient renovation.[203]

The Swedish National Heritage Board

The Swedish National Heritage Board is Sweden's central administrative agency in the area of cultural heritage. The board regularly gathers actors from the civil society such as building care associations, homesteads and smaller museums. An example from the cultural heritage sector is the web

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[202] https://www.livsmedelsverket.se/en

[203] https://www.boverket.se/en/start/about/about-boverket/

exhibition “Klimatklokt” (Climate-wise), which advises homeowners on how to save energy.[204]

The Swedish Transport Administration

Trafikverket, The Swedish Transport Administration is responsible for long-term planning of the transport system for all types of traffic, as well as for building, operating and maintaining public roads and railways.

During 2021 the administration has worked to increase the public knowledge of owning and driving rechargeable vehicles through website, webinars and social media.

The Swedish Transport Agency

The Swedish Transport Agency is working to achieve good accessibility, high quality, secure and environmentally aware rail, air, sea and road transport.

The agency is a well-used source of knowledge for the public for example around environmental issues in shipping and aviation, with links to ICAO:s Carbon Calculator.

The Bohlin Center

The Bolin Centre focuses on extending and disseminating knowledge about the Earth’s natural climate system, climate variations, climate impacting processes, climate modelling, human impact on the climate and climate impacts on ecosystems, biodiversity and human conditions as well as how society can minimize negative impacts. The centre was formed in 2006 by Stockholm University, the Swedish Royal Institute of Technology (KTH) and the Swedish Meteorological and Hydrological Institute (SMHI).

The Bohlin Center regularly holds lecures for students at different levels and for the public and participating in the open course Taking on the Climate Crisis with Social Change[205], is developed by Stockholm University.[206]

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[204] https://www.raa.se/in-english/

[205] https://www.futurelearn.com/courses/taking-on-the-climate-crisis

[206] https://bolin.su.se/

Mistra Environmetal communication

Mistra Environmental Communication is a four-year research programme that aims to reframe environmental communication, to mainstream an advanced and inclusive understanding of environmental communication in research, policy and practice such that it can effectively underpin and foster sustainability transformations. The programme is funded by Mistra, which is an independent research-foundation.[207]

Stockholm Environental insitute, SEI

The main task fro SEI is to initiate, carry out and disseminate knowledge from research in the environmental field. Reduced climate risks are one of three main focus areas. Centret arbetar både nationellt och internationellt genom sju center utanför Sverige.

SEI currently has just over twenty tools for increasing knowledge and capaciybuilding, e.g. energy system planning, water management, climate footprint (eg WWF's climate calculator). SEI has an ongoing project that aims to develop a tool that can break down the national consumption-based calculations to the local level. In the autumn of 2021, SEI researchers conducted an experiment to test how different types of information linked to sustainability may affect consumers' purchases of food.

SEI has a role in the coordination function for the 10YFP Sustainable Lifestyles and Education Program. Several seminars and lectures available to the public.[208]

Stockholm Resilience Center

Stockholm Resilience Centre (SRC) is an international research centre on resilience and sustainability science. SRC is a joint initiative between Stockholm University and the Beijer Institute of Ecological Economics at The Royal Swedish Academy Sciences.[209]

The Royal Swedish Academy of Agriculture and Forestry KSLA

The Royal Swedish Academy of Agriculture and Forestry is a free and independent organization that works with issues of agriculture, horticulture,

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[207] https://www.slu.se/en/subweb/mistra-ec/

[208] https://www.sei.org/

[209] https://www.stockholmresilience.org/about-us.html

food, forest and forest products, fishing and aquaculture, the environment and natural resources.

Climate related issues is central, and the Academy has formes focus-areas around Bioenergy, Climate and agriculture and Use without exhauste.[210]

SWEDESD

As one of the leading countries of the UN Decade of Education for Sustainable Development (2005-2014), the Swedish government established the Swedish International Centre of Education for Sustainable Development (SWEDESD). Today, SWEDESD is a well-established research and development environment at Uppsala University that offers reflexive tools for ESD implementation and scaling. SWEDESD run integrated collaborative research and development projects in Sweden and abroad. SWEDESD also offers training courses, among others, for active teachers in schools and at universities, as well as for teacher educators, policy makers and project leaders dealing with wicked problems.[211]

United Nations Association of Sweden

Is non-profit member-organization and umbrella organization for almost 80 national organizations. Climate is one of the focus-areas. Through school operations, there are now also 37 UN schools around Sweden which involves around 10,000 students.

In 2021, the association together with LSU - Sweden's youth organizations conducted a youth consultation prior to Sweden's Voluntary Review of Agenda 2030, where climate was one of the focus areas.[212]

As an accredited organization at UNEP, the association also follow the work within UNEP and participate in various types of consultation meetings and as an observer during UNEP's formal meetings.[213]

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[210] https://www.ksla.se/en/

[211] https://www.swedesd.uu.se/

[212] https://fn.se/wp-content/uploads/2021/06/Hoj-rostenfor-hallbar-utveckling-slutlig-210429.pdf

[213] https://fn.se/

9.7 Involvement of the public and non-governmental organizations

Several organizations of the civil society in Sweden gather a large member base and state that the climate is one of their main questions, and that the the public is one of their main target groups. Some examples are: The Swedish Society for Nature Conservation, Friends of the Earth, WWF, PUSH Sweden and the Climate Parliament.

All of them give examples of how they work for public participation and access to information on climate issues, including participation among young people, social media, websites and media, and to run larger campaigns and organize and participate in various public events. Some also work to support schools with skills development and teaching materials.[214]

The Swedish government har regular interactions with the civil society, and supports the civil society in various ways, for example financially and through cooperations like Drive for Democracy[215]. In relation to the upcoming UN World Environmental Day and the conference Stockholm +50 the Swedish Government has increaseda financial support to NGO:s.

Sweden is also a part of the EU-initiative European Climate Pact which aims to increase the public participation in climate action.[216]

9.8 Participation in international activities

9.8.1 ACE-negotioations and National Focal Point for Sweden

Sweden is participating actively in the international preparations and negotionations around ACE (Actions for Climate Empowerment) in relation to article 6 of the Convention and article 12 of the Paris Agreement. That includes the review of the Doha Work Programme and the preparation of the Glasgow Work Programme adopted at COP 26.

Sweden has a designated focal point for ACE at the Swedish Environmental Protection Agency.

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[214] Survey within mission on stocktaking of Swedens possibilities and conditions on Article 12 in 2020.

[215] https://www.government.se/articles/2019/11/drive-for-democracy-takes-shape/

[216] https://europa.eu/climate-pact/index_en

9.8.2 Sweden's work with capacity building

Today's environmental challenges are largely cross-border. Sweden's long experience and expertise in environmental management and governance implies that Sweden can support and participate in development work in other countries and contribute with expert knowledge within multilateral institutions and organisations. Today, Sweden participates in, and leads, several projects that have a bearing on the implementation of the Paris Agreement. One example is the Strengthened institutions for a sustainable climate program that the Swedish Environmental Protection Agency leads with the aim of, among other things, strengthening the transparency framework under the Paris Agreement in a number of countries. Another example is the Swedish Environmental Protection Agency's and UNDP's Environmental Governance Program, which works to integrate the environment and human rights into the environmental management in mining. Results from this type of project are regularly reported to Sida and, when appropriate, also in Sweden's Biennial Report.

When Sweden participates in both bi- and multilateral collaborations and activities, Sweden do not only contribute with Swedish knowledge and Swedish experience to solve global climate challenges. In collaborations, knowledge and experience flow in both directions and strengthen not only the partner countries' ability to solve environmental problems, but also our own. This creates the conditions for the international work to also strengthen national implementation, which applies to both international environmental work financed by the Ministry of the Environment and to international development work with the EU and / or Sida as the financier.

9.9 Monitoring, review and evaluation of the implementation of Article 6 of the Convention

9.9.1 Assessing public awareness since 2002

The Swedish Environmental Protection Agency regularly investigates the Swedish people's knowledge of and attitudes to climate related issues. The survey has been regularly conducted since 2002 and is used to develop and adapt policy.

The latest survey from 2021 shows a generally high level of awareness of climate related issues. The proportion of people who believe that Sweden will be affected by climate change is 93 percent. 85 percent of the Swedish public agree that it is very, or quite, important to take societal action on climate change. 81 percent believe that Sweden can act to slow down climate change and 79 percent state that they themselves can act to reduce climate change. The survey also shows that the Swedish people are prepared to take several different measures to reduce their own climate impact such as spending their vacation near home instead of flying abroad, change consumer habits or to eat less meat.

In a new issue in the 2021 survey, the public was asked how they believe that a completely climate-adapted society would affect their own quality of life. 38 percent believe that a climate-adapted society would have had a positive effect on the quality of life, 33 percent that there had been no change and 18 percent that the quality of life had been affected for the worse. See figure 9.1.

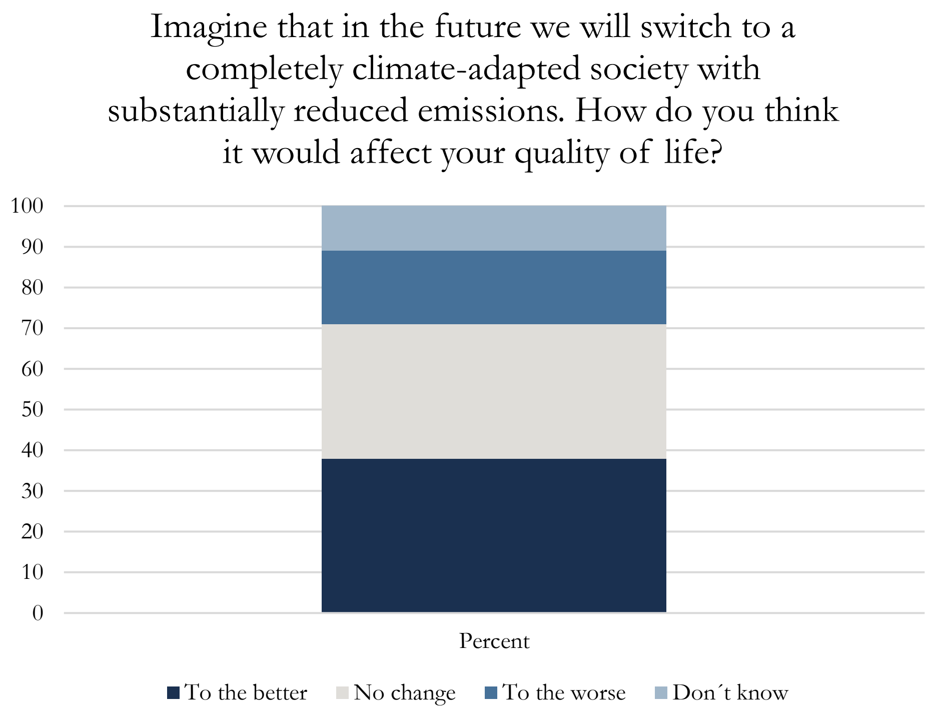

Figure 9.1 Results from a survey conducted among Swedish population on how they believe that a completely climate-adapted society would affect their own quality of life.

In general, women and youth in the ages 18–29 years show a higher level of awareness and show stronger support for societal actions.

The SOM Institute regularly assess the Swedish people's concerns about various societal events. In the latest survey from 2019, environmental and climate related issues continue to be at the top the list regarding what is considered worrying about the future.

9.9.2 New survey of public needs and access to information on climate related issues

The Swedish Environmental Protection Agency carried a survey in 2020 that assess the public's needs for information on climate related issues. The survey complements previous surveys on awareness by also asking questions about what the Swedish people want to know, from whom and in what way they want the information.

An overwhelming majority in the survey are interested in climate related issues (76 %). A large proportion also state that they are worried about climate change (70 %). A main result of the survey is that a majority of the Swedish people want information on climate related issues from authorities, researchers or news media. Very few were interested in recieving information from influencers in social media or from friends, colleagues or family.

Another central result from the survey concerns channels for receiving information. Newspapers, TV and internet search function were the most popular channels for recieving information on climate related issues.

The survey stated questions related to whether one knows about the Paris Agreement. 92 percent answered that they have heard of or know about the Paris Agreement. Of them, 69 percent stated that the Paris Agreement is very important, or quite important.

9.9.3 Media coverage

The Swedish Environmental Protection Agency regularly measures the media-coverage for climate related issues in Swedish media. The data is used to secure the public´s access to information on climate change issues.

The latest analysis shows that the media coverage was increasing in 2018 and 2019, but decreased in 2020 and 2021. One likely explanation is the COVID-19pandemic.

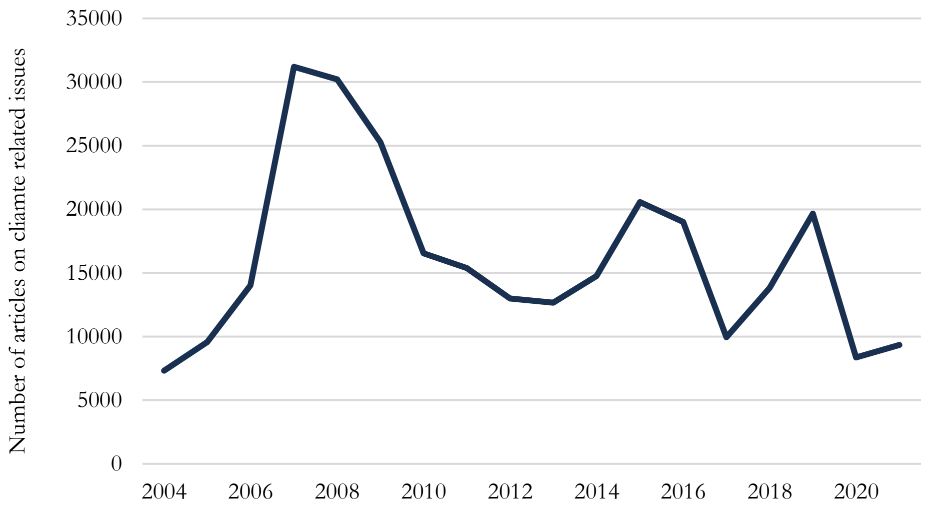

Figure 9.2 Number of articles on climate related issues in Swedish media 2004-2021.

9.9.4 Government Agencies information on websites

In autumn 2019, the Swedish Environmental Protection Agency carried out a survey of 20 authorities' climate communication. The analysis shows that the authorities that have a more pronounced task within the climate area, take greater responsibility and raise the climate issue to a greater extent in their communication. These authorities also put the climate issue in a larger context and emphasize the challenges of climate change in a broader perspective with links to the overall climate change work that is taking place in society and globally. The survey contributed with valuable knowledge on the continous work on general on policy public access to information on climate change issues.

9.9.5 Annual reputation measure

Several Swedish Agencies are annualy assess regarding the confidence and reputation within the public. Since two years, the Swedish Environmental Protection Agency has included a question related to the publics' confidence in the agency in climate related issues. 46 percent of the Swedish Public has a high or relatively high confidence in the Swedish EPA in climate related issues. The numbers are higher among women than men.

9.9.6 Government commission appointed to the Swedish EPA on article Paris Agreement article 12

In 2020 the Swedish Environmental Protection Agency completed an appointed commissionof taking stock of opportunities and conditions for Sweden's implementation of Article 12 of the Paris Agreement. Within the commission the Swedish EPA conducted a survey on actions for climate empowerment that was handed out to just over 50 government agencies and organisations.

Annex 1 Acronyms and abbreviations

%	Percent
€	Euro(s)
°C	Degree(s) Celsius
3C	Combating Climate Change
AAUs	Assigned amount units
ADB	Asian Development Bank
AfDB	African Development Bank Program (Ch. 7)
BECC	Biodiversity and Ecosystem Services in a Changing Climate
bn	Billion (1,000 million)
BONUS	Joint Baltic Sea Research and Development Program
BOOS	Baltic Operational Oceanographic System
C	Manufacturing (Swedish Standard Industrial Classification SNI 2007)
CAB	County administrative board
CCAC	Climate and Clean Air Coalition
CCI	Climate Change Initiative
CDM	Clean Development Mechanism
CER	Certified emission reduction
CGIAR	Consultative Group on International Agricultural Research
CH4	Methane
CHP	Combined heat and power
CMIP5	Coupled Model Intercomparison Project, Phase 5
CMIP6	Coupled Model Intercomparison Project, Phase 6
CO2	Carbon dioxide
CO_2-eq.	Carbon dioxide equivalent
COP	Conference of the Parties
CPF	Carbon Partnership Facility
CRF	Common Reporting Format
CTF	Clean Technology Fund
DAC	Development Assistance Committee of the OECD
E85	Fuel blend of about 85 % denatured ethanol and 15 % petrol (gasoline) or other hydrocarbon
ECDS	Environment Climate Data Sweden
EC	Earth system model of the European Centre for Medium-Range Weather Forecasts
ECMWF	European Centre for Medium-Range Weather Forecasts
ECVs	Essential climate variables
EEA	European Environment Agency
EEDI	Energy Efficiency Design Index
EEOI	Energy Efficiency Operational Indicator
EIS	Environmental impact statement
EMAS	Eco-Management and Audit Scheme
EMODNET	European Marine Observation and Data Network
EPD	Environmental Product Declaration
ERA-NET	European Research Area Networks
ERU	Emission reduction unit
ESA	European Space Agency
ESD	Effort Sharing Decision
EU ETS	European Union Emissions Trading System
EUMETSAT	European Organisation for the Exploitation of Meteorological Satellites
EuroGOOS	European Global Ocean Observing System
FAME	Fatty acid methyl ester
F-gases	Fluorinated greenhouse gases
FIP	Forest Investment Program
FOI	Swedish Defence Research Agency
GCF	Green Climate Fund
GCM	Global climate model, or general circulation model
GCOS	Global Climate Observing System GDP
GEF	Global Environment Facility
GEOSS	Global Earth Observation System of Systems
GMES	Global Monitoring for Environment and Security
GNI	Gross national income
GPS	Global Positioning System
GRDC	Global Runoff Data Centre

GTOS	Global Terrestrial Observing System GWh ha Hectare(s)
HFCs	Hydrofluorocarbons´
HVO	Hydrotreated (hydrogenated) vegetable oil(s)
ICAO	International Civil Aviation Organisation
ICOS	Integrated Carbon Observation System
ICSU	International Council for Science
IDB	Inter-American Development Bank
IMO	International Maritime Organisation
IPCC	Intergovernmental Panel on Climate Change
ISDR	International Strategy for Disaster Reduction
ISO	International Organisation for Standardisation
IVL	IVL Swedish Environmental Research Institute
JI	Joint Implementation
JPI	Joint Programming Initiative
KLIMP	Local climate investment programs
Km_2	Square kilometre(s)
KVA	Royal Swedish Academy of Sciences
kWh	Kilowatt-hour(s)
LDCs	Least developed countries
LIP	Local investment programs for ecologically sustainable development
LPG	Liquefied petroleum gas
LULUCF	Land use, land-use change and forestry
m_2	Square metre(s)
m_3	Cubic metre(s)
MERGE	ModElling the Regional and Global Earth system
MISU	Department of Meteorology at Stockholm University
mm	Millimetre(s)
MSB	Swedish Civil Contingencies Agency
Mt	Million tonnes
Mt CO_2-eq.	Million tonnes of carbon dioxide equivalent
N_2O	Nitrous oxide
NC8	Eitght National Communication on Climate Change
NFI	National Forest Inventory
NILS	National Inventory of Landscapes in Sweden
OECD	Organisation for Economic Cooperation and Development
PFCs	Perfluorocarbons
PGD	Sweden's Policy for Global Development
PMR	Partnership for Market Readiness
ppm	Parts per million
R&D	Research and development
RCP	Representative Concentration Pathway
REDD+	Reducing Emissions from Deforestation and Forest Degradation
SEEMP	Ship Energy Efficiency Management Plan
SEI	Stockholm Environment Institute
SEK	Swedish kronor
SEK m	Million Swedish kronor
SF6	Sulphur hexafluoride
SFS	Swedish Code of Statutes
SGI	Swedish Geotechnical Institute
Sida	Swedish International Development Cooperation Agency
SIDS	Small island developing states
SIK	Swedish Institute for Food and Biotechnology
SLCPs	Short-lived climate pollutants
SMHI	Swedish Meteorological and Hydrological Institute
SNI	Swedish Standard Industrial Classification
SSNC	Swedish Society for Nature Conservation
TBE	Tick-borne encephalitis
TPES	Total primary energy supply
TWh	Terawatt-hour(s)
UCF T2	Umbrella Carbon Facility Tranche 2
UN	United Nations
UNECE	United Nations Economic Commission for Europe
UNFCCC	United Nations Framework Convention on Climate Change

US$	US dollars
VAT	Value added tax
VINNOVA	Swedish Governmental Agency for Innovation Systems
WCRP	World Climate Research Program WFP World Food Program
WMO	World Meteorological Organisation
WWF	World Wide Fund for Nature

Annex 2 Summary emissions and removals tables[217][218]

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1990
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	19319,06	7878,35	6976,09	6,49	568,78	101,73	NO	NO	34850,48
1. Energy	51347,34	402,32	617,90						52367,56
A. Fuel combustion (sectoral approach)	51011,11	322,74	616,63						51950,48
1. Energy industries	9791,91	16,63	119,60						9928,14
2. Manufacturing industries and construction	10656,74	23,93	137,22						10817,90
3. Transport	19690,03	163,86	192,40						20046,30
4. Other sectors	10872,42	118,31	167,40						11158,14
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	336,22	79,58	1,27						417,08
1. Solid fuels	5,32	0,00	0,00						5,32
2. Oil and natural gas	330,91	79,58	1,27						411,76
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6011,15	26,25	953,38	6,49	568,78	101,73	NO	NO	7667,77
A. Mineral industry	1672,50								1672,50
B. Chemical industry	666,45	0,71	802,97						1470,13
C. Metal industry	3260,19	19,46	NA	NO	568,78	22,80			3871,23
D. Non-energy products from fuels and solvent use	392,98	NA	NA						392,98
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				6,49	NO		NO	NO	6,49
G. Other product manufacture and use	NE,NA	NA	86,73		NO	78,93			165,66
H. Other	19,02	6,08	63,67						88,78
3. Agriculture	177,75	3519,85	3966,69						7664,29
A. Enteric fermentation		3274,59							3274,59
B. Manure management		245,26	369,43						614,70
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3597,26						3597,26
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	173,40								173,40
H. Urea application	4,35								4,35
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-38261,03	463,53	1206,43						-36591,07
A. Forest land	-40033,77	223,51	1158,47						-38651,80
B. Cropland	3866,25	226,43	1,30						4093,98
C. Grassland	-94,30	8,27	0,17						-85,86
D. Wetlands	73,38	5,33	0,93						79,63
E. Settlements	2518,80	IE	37,85						2556,66
F. Other land	223,52	NO	NO,NA						223,52
G. Harvested wood products	-4814,91								-4814,91
H. Other	NO	NO	NO						NO
5. Waste	43,85	3466,39	231,69						3741,94
A. Solid waste disposal	NO,NA	3421,70							3421,70
B. Biological treatment of solid waste		7,36	5,07						12,44
C. Incineration and open burning of waste	43,85	0,01	0,99						44,85
D. Waste water treatment and discharge		37,33	225,63						262,96
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	3668,44	0,83	55,90						3725,16
Aviation	1334,94	0,44	18,59						1353,98
Navigation	2333,50	0,38	37,30						2371,18
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	21027,89								21027,89
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			416,28						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									71441,55
Total CO_2 equivalent emissions with land use, land-use change and forestry									34850,48
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

217 Sweden. 2022 National Inventory Report (NIR)

218 Sweden. 2022 Common Reporting Format (CRF) Table

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1991
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	20236,47	7868,86	6836,58	11,14	573,84	102,69	NO	NO	35629,57
1. Energy	52029,77	425,99	650,35						53106,11
A. Fuel combustion (sectoral approach)	51746,04	334,53	649,26						52729,83
1. Energy industries	10759,22	18,99	145,81						10924,02
2. Manufacturing industries and construction	10635,42	23,66	143,16						10802,24
3. Transport	19814,73	171,11	194,39						20180,23
4. Other sectors	10536,68	120,77	165,91						10823,35
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	283,73	91,45	1,09						376,28
1. Solid fuels	5,18	0,00	0,00						5,19
2. Oil and natural gas	278,56	91,45	1,09						371,09
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5728,10	28,37	997,92	11,14	573,84	102,69	NO	NO	7442,06
A. Mineral industry	1536,71								1536,71
B. Chemical industry	661,61	0,70	844,25						1506,56
C. Metal industry	3179,89	21,20	NA	NO	572,88	22,80			3796,76
D. Non-energy products from fuels and solvent use	331,21	NA	NA						331,21
E. Electronic Industry				0,24	0,97	0,77			1,98
F. Product uses as ODS substitutes				10,90	NO		NO	NO	10,90
G. Other product manufacture and use	NE,NA	NA	85,61		NO	79,12			164,73
H. Other	18,67	6,48	68,06						93,21
3. Agriculture	140,48	3429,15	3763,27						7332,89
A. Enteric fermentation		3191,50							3191,50
B. Manure management		237,65	359,50						597,16
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3403,77						3403,77
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	137,04								137,04
H. Urea application	3,43								3,43
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-37714,08	462,96	1192,19						-36058,94
A. Forest land	-39916,64	223,54	1140,93						-38552,18
B. Cropland	3824,31	225,85	1,67						4051,82
C. Grassland	-446,20	8,64	0,18						-437,38
D. Wetlands	70,66	4,93	0,86						76,44
E. Settlements	2905,18	IE	44,08						2949,26
F. Other land	0,17	NO	NO,NA						0,17
G. Harvested wood products	-4151,56								-4151,56
H. Other	NO	NO	NO						NO
5. Waste	52,20	3522,39	232,85						3807,45
A. Solid waste disposal	NO,NA	3473,82							3473,82
B. Biological treatment of solid waste		10,96	7,58						18,54
C. Incineration and open burning of waste	52,20	0,01	1,15						53,36
D. Waste water treatment and discharge		37,60	224,12						261,72
E. Other	NO	NO	NO						NO
6. Other ***(as specified in summary 1.A)***									

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
Memo items:[(2)]									
International bunkers	3697,12	0,79	57,03						3754,94
Aviation	1087,92	0,35	16,11						1104,38
Navigation	2609,20	0,44	40,92						2650,56
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	23523,60								23523,60
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			422,80						
Indirect CO_2 [(3)]	NO								

Total CO_2 equivalent emissions without land use, land-use change and forestry	71688,52
Total CO_2 equivalent emissions with land use, land-use change and forestry	35629,57
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1992
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	20682,79	7995,40	6674,71	12,81	389,48	102,58	NO	NO	35857,77
1. Energy	52111,02	413,95	668,29						53193,26
A. Fuel combustion (sectoral approach)	51799,74	322,77	667,07						52789,58
1. Energy industries	11360,01	15,39	152,41						11527,81
2. Manufacturing industries and construction	9692,77	26,33	149,65						9868,75
3. Transport	20791,31	160,00	209,95						21161,26
4. Other sectors	9955,65	121,05	155,06						10231,76
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	311,28	91,18	1,22						403,68
1. Solid fuels	4,57	0,00	0,00						4,58
2. Oil and natural gas	306,71	91,18	1,22						399,10
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5406,70	27,31	984,19	12,81	389,48	102,58	NO	NO	6923,06
A. Mineral industry	1452,56								1452,56
B. Chemical industry	668,27	0,73	813,00						1482,00
C. Metal industry	2972,08	20,12	NA	NO	388,51	22,80			3403,51
D. Non-energy products from fuels and solvent use	294,95	NA	NA						294,95
E. Electronic Industry				0,24	0,97	0,77			1,98
F. Product uses as ODS substitutes				12,57	NO		NO	NO	12,57
G. Other product manufacture and use	NE,NA	NA	103,41		NO	79,01			182,41
H. Other	18,85	6,45	67,78						93,08
3. Agriculture	112,86	3564,26	3600,37						7277,49
A. Enteric fermentation		3320,15							3320,15
B. Manure management		244,11	369,09						613,20
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3231,28						3231,28
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	110,68								110,68
H. Urea application	2,19								2,19
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-37006,11	462,61	1188,02						-35355,49
A. Forest land	-39078,55	223,56	1132,70						-37722,29
B. Cropland	3880,46	225,07	1,80						4107,33
C. Grassland	-268,23	8,64	0,23						-259,35
D. Wetlands	78,99	5,33	0,93						85,25
E. Settlements	1836,76	IE	49,16						1885,92
F. Other land	33,40	NO	NO,NA						33,40
G. Harvested wood products	-3488,93								-3488,93
H. Other	NO	NO	NO						NO
5. Waste	58,33	3527,29	233,84						3819,45
A. Solid waste disposal	NO,NA	3474,86							3474,86
B. Biological treatment of solid waste		14,56	10,08						24,64
C. Incineration and open burning of waste	58,33	0,01	1,15						59,48
D. Waste water treatment and discharge		37,87	222,61						260,47
E. Other	NO	NO	NO						NO
6. Other ***(as specified in summary 1.A)***									

Memo items:[2]									
International bunkers	3843,73	0,77	61,30						3905,80
Aviation	899,49	0,28	15,03						914,79
Navigation	2944,24	0,50	46,27						2991,00
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	24285,31								24285,31
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			406,64						
Indirect CO_2 [3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									71213,26
Total CO_2 equivalent emissions with land use, land-use change and forestry									35857,77
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1993
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	24587,12	7968,31	6890,19	30,20	453,21	99,35	NO	NO	40028,37
1. Energy	52044,76	399,01	687,63						53131,39
A. Fuel combustion (sectoral approach)	51700,06	306,74	686,28						52693,08
1. Energy industries	11498,21	18,58	160,86						11677,65
2. Manufacturing industries and construction	10506,23	26,39	151,10						10683,72
3. Transport	19778,35	140,01	217,08						20135,44
4. Other sectors	9917,27	121,76	157,25						10196,27
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	344,69	92,27	1,35						438,31
1. Solid fuels	4,72	0,00	0,00						4,73
2. Oil and natural gas	339,97	92,27	1,34						433,58
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5498,77	27,51	963,17	30,20	453,21	99,35	NO	NO	7072,21
A. Mineral industry	1474,80								1474,80
B. Chemical industry	636,32	0,68	790,37						1427,37
C. Metal industry	3065,53	20,19	NA	NO	449,96	22,80			3558,49
D. Non-energy products from fuels and solvent use	307,25	NA	NA						307,25
E. Electronic Industry				0,28	3,25	0,77			4,30
F. Product uses as ODS substitutes				29,91	NO		NO	NO	29,91
G. Other product manufacture and use	NE,NA	NA	103,11		NO	75,78			178,89
H. Other	14,87	6,64	69,69						91,19
3. Agriculture	134,44	3664,43	3809,01						7607,88
A. Enteric fermentation		3410,12							3410,12
B. Manure management		254,31	370,18						624,49
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3438,83						3438,83
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	131,87								131,87
H. Urea application	2,57								2,57
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry [(1)]	-33138,87	463,21	1193,85						-31481,82
A. Forest land	-35474,67	223,62	1131,99						-34119,06
B. Cropland	3775,55	225,72	2,04						4003,31
C. Grassland	-335,32	8,70	0,25						-326,37
D. Wetlands	79,83	5,17	0,90						85,90
E. Settlements	3918,53	IE	55,78						3974,31
F. Other land	0,34	NO	NO,NA						0,34
G. Harvested wood products	-5103,12								-5103,12
H. Other	NO	NO	NO						NO
5. Waste	48,02	3414,15	236,54						3698,71
A. Solid waste disposal	NO,NA	3357,87							3357,87
B. Biological treatment of solid waste		18,15	12,59						30,74
C. Incineration and open burning of waste	48,02	0,01	1,03						49,05
D. Waste water treatment and discharge		38,12	222,92						261,04
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items: [(2)]									
International bunkers	4090,40	0,85	62,84						4154,09
Aviation	1229,76	0,36	18,04						1248,17
Navigation	2860,64	0,48	44,80						2905,92
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	25842,49								25842,49
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			388,55						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									71510,19
Total CO_2 equivalent emissions with land use, land-use change and forestry									40028,37
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1994
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	24884,64	7902,90	6920,76	73,26	485,08	106,37	NO	NO	40373,02
1. Energy	54040,59	408,43	693,96						55142,97
A. Fuel combustion (sectoral approach)	53745,47	314,68	692,83						54752,98
1. Energy industries	11980,75	21,11	161,36						12163,22
2. Manufacturing industries and construction	11510,45	29,44	163,85						11703,74
3. Transport	20275,44	145,05	214,49						20634,98
4. Other sectors	9978,84	119,08	153,13						10251,04
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	295,12	93,75	1,13						390,00
1. Solid fuels	5,56	0,00	0,00						5,57
2. Oil and natural gas	289,55	93,74	1,13						384,43
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5935,70	27,74	925,86	73,26	485,08	106,37	NO	NO	7554,01
A. Mineral industry	1562,93								1562,93
B. Chemical industry	707,91	0,79	764,71						1473,41
C. Metal industry	3392,93	20,37	NA	NO	480,50	25,08			3918,87
D. Non-energy products from fuels and solvent use	257,02	NA	NA						257,02
E. Electronic Industry				0,46	4,59	1,54			6,58
F. Product uses as ODS substitutes				72,80	NO		NO	NO	72,80
G. Other product manufacture and use	NE,NA	NA	92,08		NO	79,76			171,84
H. Other	14,92	6,58	69,07						90,57
3. Agriculture	161,20	3724,42	3865,81						7751,43
A. Enteric fermentation		3468,41							3468,41
B. Manure management		256,00	376,41						632,41
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3489,40						3489,40
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	158,96								158,96
H. Urea application	2,24								2,24
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-35301,94	463,14	1195,70						-33643,10
A. Forest land	-35577,07	223,54	1130,19						-34223,35
B. Cropland	4111,15	225,25	2,28						4338,68
C. Grassland	-508,76	8,70	0,28						-499,78
D. Wetlands	89,70	5,65	0,98						96,33
E. Settlements	2086,51	IE	59,45						2145,96
F. Other land	0,34	NO	NO,NA						0,34
G. Harvested wood products	-5503,80								-5503,80
H. Other	NO	NO	NO						NO
5. Waste	49,08	3279,18	239,43						3567,69
A. Solid waste disposal	NO,NA	3219,00							3219,00
B. Biological treatment of solid waste		21,75	15,09						36,84
C. Incineration and open burning of waste	49,08	0,01	1,11						50,19
D. Waste water treatment and discharge		38,43	223,23						261,66
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	4719,53	0,95	71,92						4792,41
Aviation	1350,46	0,38	19,30						1370,14
Navigation	3369,07	0,57	52,62						3422,27
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	27961,46								27961,46
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			392,58						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									74016,11
Total CO_2 equivalent emissions with land use, land-use change and forestry									40373,02
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1995
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	21458,94	7815,52	6809,37	135,76	532,35	135,19	NO	NO	36887,13
1. Energy	53152,03	400,59	710,05						54262,67
A. Fuel combustion (sectoral approach)	52815,26	309,18	708,75						53833,18
1. Energy industries	11142,20	21,71	168,47						11332,38
2. Manufacturing industries and construction	11882,84	28,76	159,64						12071,23
3. Transport	20298,84	133,38	229,91						20662,12
4. Other sectors	9491,39	125,33	150,73						9767,45
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	336,78	91,42	1,30						429,49
1. Solid fuels	6,06	0,00	0,00						6,06
2. Oil and natural gas	330,72	91,41	1,30						423,43
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6237,41	18,39	890,30	135,76	532,35	135,19	NO	NO	7949,40
A. Mineral industry	1689,20								1689,20
B. Chemical industry	733,83	0,83	701,89						1436,56
C. Metal industry	3514,35	10,93	NA	NO	521,15	25,08			4071,51
D. Non-energy products from fuels and solvent use	284,87	NA	NA						284,87
E. Electronic Industry				0,46	10,83	2,37			13,66
F. Product uses as ODS substitutes				135,30	0,37		NO	NO	135,68
G. Other product manufacture and use	NE,NA	NA	118,90		NO	107,74			226,64
H. Other	15,16	6,63	69,51						91,30
3. Agriculture	172,89	3658,06	3758,88						7589,82
A. Enteric fermentation		3401,81							3401,81
B. Manure management		256,25	370,52						626,77
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3388,36						3388,36
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	171,45								171,45
H. Urea application	1,43								1,43
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry [(1)]	-38146,13	463,83	1205,92						-36476,38
A. Forest land	-38616,62	223,85	1134,30						-37258,47
B. Cropland	4034,39	225,06	2,84						4262,29
C. Grassland	-503,53	8,70	0,31						-494,51
D. Wetlands	100,54	6,22	1,08						107,84
E. Settlements	2889,32	IE	64,11						2953,44
F. Other land	0,34	NO	NO,NA						0,34
G. Harvested wood products	-6050,57								-6050,57
H. Other	NO	NO	NO						NO
5. Waste	42,74	3274,64	244,22						3561,61
A. Solid waste disposal	NO,NA	3210,60							3210,60
B. Biological treatment of solid waste		25,49	17,59						43,09
C. Incineration and open burning of waste	42,74	0,01	1,08						43,82
D. Waste water treatment and discharge		38,54	225,55						264,10
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items: [(2)]									
International bunkers	4796,44	1,16	73,07						4870,67
Aviation	1436,78	0,59	20,51						1457,87
Navigation	3359,67	0,57	52,56						3412,80
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	28843,45								28843,45
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			380,21						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									73363,50
Total CO_2 equivalent emissions with land use, land-use change and forestry									36887,13
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1996
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	23382,19	7826,03	6822,43	226,86	469,72	116,88	NO	NO	38844,10
1. Energy	57251,37	410,50	714,67						58376,54
A. Fuel combustion (sectoral approach)	56929,38	312,49	713,34						57955,21
1. Energy industries	15602,80	28,94	180,76						15812,50
2. Manufacturing industries and construction	11797,76	28,01	154,75						11980,51
3. Transport	19971,36	129,53	225,75						20326,64
4. Other sectors	9557,46	126,02	152,08						9835,56
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	321,98	98,01	1,33						421,33
1. Solid fuels	5,89	0,00	0,00						5,89
2. Oil and natural gas	316,10	98,01	1,33						415,43
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6024,02	8,42	875,13	226,86	469,72	116,88	NO	NO	7721,02
A. Mineral industry	1615,88								1615,88
B. Chemical industry	794,76	0,86	674,67						1470,28
C. Metal industry	3329,18	1,03	NA	NO	452,36	29,64			3812,21
D. Non-energy products from fuels and solvent use	268,98	NA	NA						268,98
E. Electronic Industry				0,72	15,65	2,37			18,74
F. Product uses as ODS substitutes				226,14	1,71		NO	NO	227,85
G. Other product manufacture and use	NE,NA	NA	132,01		NO	84,87			216,88
H. Other	15,22	6,53	68,45						90,20
3. Agriculture	197,33	3697,89	3785,24						7680,45
A. Enteric fermentation		3438,50							3438,50
B. Manure management		259,39	374,66						634,05
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3410,58						3410,58
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	196,25								196,25
H. Urea application	1,08								1,08
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-40139,65	462,64	1207,90						-38469,11
A. Forest land	-40648,05	224,21	1134,40						-39289,44
B. Cropland	4065,58	224,24	2,84						4292,66
C. Grassland	-622,74	8,70	0,31						-613,72
D. Wetlands	94,29	5,49	0,96						100,73
E. Settlements	2501,83	IE	66,74						2568,57
F. Other land	0,34	NO	NO,NA						0,34
G. Harvested wood products	-5530,89								-5530,89
H. Other	NO	NO	NO						NO
5. Waste	49,12	3246,59	239,49						3535,19
A. Solid waste disposal	NO,NA	3183,05							3183,05
B. Biological treatment of solid waste		25,39	17,16						42,56
C. Incineration and open burning of waste	49,12	0,00	0,81						49,93
D. Waste water treatment and discharge		38,14	221,51						259,66
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items:[(2)]									
International bunkers	5020,73	1,06	77,25						5099,04
Aviation	1475,28	0,46	21,47						1497,21
Navigation	3545,45	0,60	55,78						3601,83
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	30676,40								30676,40
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			372,03						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									77313,20
Total CO_2 equivalent emissions with land use, land-use change and forestry									38844,10
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [1]	17207,38	7771,49	6827,48	371,93	433,75	159,59	NO	NO	32771,62
1. Energy	52268,30	382,79	673,42						53324,51
A. Fuel combustion (sectoral approach)	51910,47	286,54	672,09						52869,10
1. Energy industries	10914,42	24,12	143,83						11082,38
2. Manufacturing industries and construction	12194,64	27,43	152,39						12374,46
3. Transport	19992,94	116,76	234,52						20344,22
4. Other sectors	8808,47	118,22	141,35						9068,04
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	357,82	96,25	1,33						455,41
1. Solid fuels	5,70	0,00	0,00						5,71
2. Oil and natural gas	352,12	96,25	1,33						449,70
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5928,10	8,90	876,28	371,93	433,75	159,59	NO	NO	7778,55
A. Mineral industry	1528,36								1528,36
B. Chemical industry	797,05	0,85	666,85						1464,75
C. Metal industry	3280,70	1,06	NA	NO	413,87	38,76			3734,39
D. Non-energy products from fuels and solvent use	309,63	NA	NA						309,63
E. Electronic Industry				0,55	16,89	3,17			20,60
F. Product uses as ODS substitutes				371,39	2,99		NO	NO	374,38
G. Other product manufacture and use	NE,NA	NA	136,19		NO	117,66			253,85
H. Other	12,36	6,98	73,25						92,59
3. Agriculture	178,37	3693,16	3834,88						7706,41
A. Enteric fermentation		3434,81							3434,81
B. Manure management		258,35	376,36						634,71
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3458,51						3458,51
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	177,56								177,56
H. Urea application	0,81								0,81
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry [1]	-41217,99	471,63	1207,67						-39538,69
A. Forest land	-40540,13	232,46	1132,02						-39175,65
B. Cropland	4129,19	223,76	2,98						4355,94
C. Grassland	-260,84	8,86	0,32						-251,66
D. Wetlands	111,94	6,54	1,14						119,62
E. Settlements	2685,96	IE	68,94						2754,89
F. Other land	0,34	NO	NO,NA						0,34
G. Harvested wood products	-7344,44								-7344,44
H. Other	NO	NO	NO						NO
5. Waste	50,60	3215,01	235,22						3500,84
A. Solid waste disposal	NO,NA	3151,89							3151,89
B. Biological treatment of solid waste		25,40	16,81						42,20
C. Incineration and open burning of waste	50,60	0,01	0,94						51,55
D. Waste water treatment and discharge		37,72	217,48						255,19
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items: [2]									
International bunkers	5825,26	1,16	89,91						5916,34
Aviation	1560,09	0,45	22,83						1583,37
Navigation	4265,17	0,72	67,08						4332,97
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	30440,58								30440,58
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			357,69						
Indirect CO_2 [3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									72310,30
Total CO_2 equivalent emissions with land use, land-use change and forestry									32771,62
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1998
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	16674,25	7655,79	6868,79	483,44	420,81	111,22	NO	NO	32214,30
1. Energy	52716,25	376,28	654,82						53747,35
A. Fuel combustion (sectoral approach)	52351,23	276,08	653,47						53280,78
1. Energy industries	11980,54	25,64	154,38						12160,56
2. Manufacturing industries and construction	11603,55	27,23	154,03						11784,82
3. Transport	20033,34	110,40	213,09						20356,83
4. Other sectors	8733,80	112,80	131,97						8978,57
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	365,02	100,19	1,34						466,56
1. Solid fuels	5,54	0,00	0,00						5,54
2. Oil and natural gas	359,49	100,19	1,34						461,02
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5994,02	8,71	958,68	483,44	420,81	111,22	NO	NO	7976,89
A. Mineral industry	1656,35								1656,35
B. Chemical industry	789,84	0,87	748,25						1538,96
C. Metal industry	3238,47	0,99	NA	NO	401,51	36,48			3677,45
D. Non-energy products from fuels and solvent use	300,80	NA	NA						300,80
E. Electronic Industry				0,58	15,96	1,60			18,14
F. Product uses as ODS substitutes				482,86	3,34		NO	NO	486,20
G. Other product manufacture and use	NE,NA	NA	138,57		NO	73,14			211,71
H. Other	8,57	6,86	71,86						87,29
3. Agriculture	133,78	3644,33	3808,85						7586,96
A. Enteric fermentation		3391,76							3391,76
B. Manure management		252,58	369,60						622,17
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3439,25						3439,25
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	133,13								133,13
H. Urea application	0,65								0,65
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry [(1)]	-42218,98	460,50	1213,46						-40545,02
A. Forest land	-41862,94	223,23	1134,51						-40505,21
B. Cropland	4510,45	223,06	2,98						4736,49
C. Grassland	-600,07	8,80	0,32						-590,95
D. Wetlands	98,80	5,41	0,94						105,15
E. Settlements	2632,18	IE	72,49						2704,67
F. Other land	0,34	NO	NO,NA						0,34
G. Harvested wood products	-6997,72								-6997,72
H. Other	NO	NO	NO						NO
5. Waste	49,16	3165,97	232,99						3448,12
A. Solid waste disposal	NO,NA	3100,52							3100,52
B. Biological treatment of solid waste		28,15	18,42						46,57
C. Incineration and open burning of waste	49,16	0,01	0,95						50,12
D. Waste water treatment and discharge		37,30	213,62						250,92
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items: [(2)]									
International bunkers	6688,78	1,35	103,65						6793,79
Aviation	1672,90	0,51	24,59						1698,01
Navigation	5015,89	0,84	79,06						5095,78
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	30646,56								30646,56
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			345,00						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									72759,32
Total CO_2 equivalent emissions with land use, land-use change and forestry									32214,30
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 1999
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	14111,04	7466,95	6663,61	638,96	454,24	121,21	NO	NO	29456,02
1. Energy	50001,29	353,54	639,90						50994,73
A. Fuel combustion (sectoral approach)	49626,13	255,97	638,51						50520,60
1. Energy industries	10252,80	25,38	146,01						10424,19
2. Manufacturing industries and construction	10859,92	25,83	145,46						11031,20
3. Transport	20317,75	102,20	219,33						20639,28
4. Other sectors	8195,65	102,56	127,72						8425,93
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	375,16	97,58	1,39						474,13
1. Solid fuels	5,61	0,00	0,00						5,62
2. Oil and natural gas	369,55	97,58	1,39						468,52
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5822,07	8,50	866,00	638,96	454,24	121,21	NO	NO	7910,99
A. Mineral industry	1642,78								1642,78
B. Chemical industry	569,91	0,52	663,80						1234,24
C. Metal industry	3232,51	1,03	NA	NO	441,03	36,48			3711,05
D. Non-energy products from fuels and solvent use	367,87	NA	NA						367,87
E. Electronic Industry				0,22	9,30	1,57			11,10
F. Product uses as ODS substitutes				638,74	3,91		NO	NO	642,64
G. Other product manufacture and use	NE,NA	NA	129,33		NO	83,16			212,50
H. Other	9,00	6,95	72,86						88,82
3. Agriculture	160,29	3603,50	3697,15						7460,94
A. Enteric fermentation		3356,47							3356,47
B. Manure management		247,03	358,70						605,74
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3338,45						3338,45
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	159,74								159,74
H. Urea application	0,55								0,55
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-41920,80	465,86	1226,90						-40228,04
A. Forest land	-41479,32	226,95	1142,65						-40109,72
B. Cropland	4589,26	222,27	2,98						4814,51
C. Grassland	-590,62	8,81	0,33						-581,49
D. Wetlands	135,43	7,83	1,36						144,62
E. Settlements	2317,55	IE	76,51						2394,06
F. Other land	0,34	NO	NO,NA						0,34
G. Harvested wood products	-6893,45								-6893,45
H. Other	NO	NO	NO						NO
5. Waste	48,20	3035,54	233,66						3317,40
A. Solid waste disposal	NO,NA	2967,77							2967,77
B. Biological treatment of solid waste		30,90	20,03						50,93
C. Incineration and open burning of waste	48,20	0,01	0,95						49,16
D. Waste water treatment and discharge		36,87	212,68						249,54
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	6848,76	1,37	104,90						6955,02
Aviation	1879,19	0,52	27,27						1906,98
Navigation	4969,57	0,84	77,63						5048,04
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	30521,45								30521,45
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			338,75						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									69684,06
Total CO_2 equivalent emissions with land use, land-use change and forestry									29456,02
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2000
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	11448,01	7302,51	6582,86	769,64	375,93	118,78	NO	NO	26597,73
1. Energy	48394,86	334,13	556,76						49285,74
A. Fuel combustion (sectoral approach)	48020,52	239,31	555,39						48815,22
1. Energy industries	8760,88	24,25	142,72						8927,84
2. Manufacturing industries and construction	11058,49	22,45	129,26						11210,21
3. Transport	20205,13	90,57	155,58						20451,28
4. Other sectors	7996,02	102,04	127,83						8225,89
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	374,34	94,82	1,37						470,53
1. Solid fuels	5,52	0,00	0,00						5,53
2. Oil and natural gas	368,83	94,81	1,36						465,00
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6291,69	9,45	830,29	769,64	375,93	118,78	NO	NO	8395,78
A. Mineral industry	1767,72								1767,72
B. Chemical industry	821,37	0,76	631,76						1453,89
C. Metal industry	3307,46	0,94	NA	NO	363,16	50,16			3721,73
D. Non-energy products from fuels and solvent use	381,27	NA	NA						381,27
E. Electronic Industry				0,22	8,21	1,57			10,01
F. Product uses as ODS substitutes				769,42	4,56		NO	NO	773,97
G. Other product manufacture and use	NE,NA	NA	117,41		NO	67,05			184,46
H. Other	13,85	7,75	81,12						102,73
3. Agriculture	159,68	3549,55	3724,74						7433,97
A. Enteric fermentation		3311,34							3311,34
B. Manure management		238,21	351,48						589,69
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3373,26						3373,26
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	159,20								159,20
H. Urea application	0,48								0,48
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-43442,65	466,14	1236,59						-41739,91
A. Forest land	-42673,59	227,09	1143,51						-41302,99
B. Cropland	4617,78	221,79	3,28						4842,84
C. Grassland	-566,94	8,86	0,34						-557,74
D. Wetlands	145,78	8,40	1,46						155,64
E. Settlements	2914,07	IE	84,88						2998,95
F. Other land	0,38	NO	NO,NA						0,38
G. Harvested wood products	-7880,13								-7880,13
H. Other	NO	NO	NO						NO
5. Waste	44,44	2943,24	234,48						3222,15
A. Solid waste disposal	NO,NA	2874,35							2874,35
B. Biological treatment of solid waste		32,40	20,74						53,14
C. Incineration and open burning of waste	44,44	0,01	0,92						45,36
D. Waste water treatment and discharge		36,48	212,82						249,29
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
Memo items:[2]									
International bunkers	6751,88	1,28	102,94						6856,10
Aviation	1926,23	0,45	27,99						1954,67
Navigation	4825,65	0,83	74,95						4901,43
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	29004,05								29004,05
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			335,34						
Indirect CO_2 [3]	NO								

Total CO_2 equivalent emissions without land use, land-use change and forestry	68337,64
Total CO_2 equivalent emissions with land use, land-use change and forestry	26597,73
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2001
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	11524,31	7231,74	6466,40	851,95	368,89	122,78	NO	NO	26566,08
1. Energy	49178,14	337,74	583,45						50099,32
A. Fuel combustion (sectoral approach)	48805,48	236,58	582,09						49624,15
1. Energy industries	10270,88	29,40	166,00						10466,28
2. Manufacturing industries and construction	11095,41	27,59	156,85						11279,84
3. Transport	20262,77	83,82	140,69						20487,28
4. Other sectors	7176,43	95,76	118,56						7390,75
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	372,66	101,16	1,35						475,17
1. Solid fuels	5,91	0,00	0,00						5,92
2. Oil and natural gas	366,75	101,16	1,35						469,26
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6456,39	9,69	671,01	851,95	368,89	122,78	NO	NO	8480,72
A. Mineral industry	1810,56								1810,56
B. Chemical industry	846,02	1,00	477,08						1324,11
C. Metal industry	3381,96	1,03	NA	NO	355,16	52,94			3791,09
D. Non-energy products from fuels and solvent use	404,33	NA	NA						404,33
E. Electronic Industry				0,39	9,19	2,71			12,29
F. Product uses as ODS substitutes				851,57	4,54		NO	NO	856,11
G. Other product manufacture and use	NE,NA	NA	113,84		NO	67,12			180,96
H. Other	13,52	7,66	80,09						101,27
3. Agriculture	139,96	3527,03	3738,09						7405,08
A. Enteric fermentation		3276,57							3276,57
B. Manure management		250,46	350,55						601,02
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3387,53						3387,53
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	139,56								139,56
H. Urea application	0,40								0,40
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-44297,65	466,37	1240,83						-42590,44
A. Forest land	-44096,39	227,75	1143,99						-42724,65
B. Cropland	4465,74	221,24	3,44						4690,42
C. Grassland	-548,06	8,90	0,34						-538,83
D. Wetlands	151,03	8,48	1,48						160,99
E. Settlements	2300,16	IE	89,27						2389,43
F. Other land	0,96	NO	NO,NA						0,96
G. Harvested wood products	-6571,08								-6571,08
H. Other	NO	NO	NO						NO
5. Waste	47,47	2890,91	233,02						3171,40
A. Solid waste disposal	NO,NA	2822,15							2822,15
B. Biological treatment of solid waste		33,48	21,15						54,63
C. Incineration and open burning of waste	47,47	0,01	1,02						48,50
D. Waste water treatment and discharge		35,27	210,85						246,12
E. Other	NO	NO	NO						NO
6. Other ***(as specified in summary 1.A)***									

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
Memo items:[(2)]									
International bunkers	6587,49	1,21	100,00						6688,70
Aviation	1870,75	0,39	27,15						1898,30
Navigation	4716,74	0,81	72,85						4790,41
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	32609,34								32609,34
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			320,46						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									69156,52
Total CO_2 equivalent emissions with land use, land-use change and forestry									26566,08
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2002
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	13154,30	6981,42	6350,25	934,62	407,54	119,60	NO	NO	27947,73
1. Energy	49980,20	327,61	572,58						50880,40
A. Fuel combustion (sectoral approach)	49612,39	231,73	571,31						50415,44
1. Energy industries	11202,09	32,67	178,80						11413,57
2. Manufacturing industries and construction	10921,47	24,63	141,50						11087,60
3. Transport	20780,02	77,59	132,95						20990,55
4. Other sectors	6708,81	96,84	118,06						6923,71
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	367,81	95,88	1,27						464,96
1. Solid fuels	6,11	0,00	0,00						6,12
2. Oil and natural gas	361,69	95,88	1,27						458,84
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6617,36	9,64	641,07	934,62	407,54	119,60	NO	NO	8729,82
A. Mineral industry	1828,09								1828,09
B. Chemical industry	881,11	0,99	439,69						1321,79
C. Metal industry	3496,95	1,05	NA	NO	387,30	62,84			3948,14
D. Non-energy products from fuels and solvent use	400,08	NA	NA						400,08
E. Electronic Industry				0,46	14,73	1,81			16,99
F. Product uses as ODS substitutes				934,16	5,51		NO	NO	939,68
G. Other product manufacture and use	NE,NA	NA	122,22		NO	54,96			177,17
H. Other	11,13	7,59	79,16						97,88
3. Agriculture	133,31	3471,81	3658,99						7264,12
A. Enteric fermentation		3223,26							3223,26
B. Manure management		248,56	352,61						601,17
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3306,38						3306,38
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	132,95								132,95
H. Urea application	0,36								0,36
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry [(1)]	-43637,30	467,97	1245,20						-41924,13
A. Forest land	-42801,09	230,39	1143,18						-41427,52
B. Cropland	4534,44	220,22	3,51						4758,16
C. Grassland	-291,47	9,12	0,39						-281,95
D. Wetlands	153,29	8,24	1,43						162,96
E. Settlements	1986,57	IE	94,86						2081,43
F. Other land	1,02	NO	NO,NA						1,02
G. Harvested wood products	-7220,06								-7220,06
H. Other	NO	NO	NO						NO
5. Waste	60,73	2704,39	232,41						2997,53
A. Solid waste disposal	NO,NA	2635,73							2635,73
B. Biological treatment of solid waste		34,56	21,57						56,12
C. Incineration and open burning of waste	60,73	0,01	1,08						61,81
D. Waste water treatment and discharge		34,09	209,77						243,86
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items: [(2)]									
International bunkers	5756,61	1,02	87,99						5845,62
Aviation	1611,26	0,31	23,74						1635,30
Navigation	4145,35	0,71	64,26						4210,32
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	34071,14								34071,14
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			310,00						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									69871,86
Total CO_2 equivalent emissions with land use, land-use change and forestry									27947,73
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2003
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	17145,65	6765,35	6309,55	1003,37	404,87	85,13	NO	NO	31713,92
1. Energy	50936,66	309,75	570,79						51817,20
A. Fuel combustion (sectoral approach)	50540,94	228,92	569,38						51339,24
1. Energy industries	12325,00	35,55	190,62						12551,17
2. Manufacturing industries and construction	10804,02	23,40	129,32						10956,74
3. Transport	20988,65	72,08	126,81						21187,55
4. Other sectors	6423,27	97,89	122,62						6643,78
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	395,72	80,83	1,41						477,96
1. Solid fuels	5,00	0,00	0,00						5,00
2. Oil and natural gas	390,73	80,82	1,41						472,96
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6223,59	9,94	643,62	1003,37	404,87	85,13	NO	NO	8370,51
A. Mineral industry	1741,93								1741,93
B. Chemical industry	836,04	1,00	428,51						1265,55
C. Metal industry	3246,82	0,87	NA	NO	388,77	33,45			3669,91
D. Non-energy products from fuels and solvent use	388,40	NA	NA						388,40
E. Electronic Industry				0,20	9,92	2,02			12,13
F. Product uses as ODS substitutes				1003,18	6,18		NO	NO	1009,36
G. Other product manufacture and use	NE,NA	NA	131,10		NO	49,66			180,76
H. Other	10,39	8,07	84,01						102,47
3. Agriculture	129,93	3428,01	3617,06						7175,00
A. Enteric fermentation		3172,58							3172,58
B. Manure management		255,43	351,15						606,58
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3265,91						3265,91
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	129,65								129,65
H. Urea application	0,28								0,28
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-40225,85	465,47	1243,18						-38517,21
A. Forest land	-39688,74	231,59	1137,19						-38319,95
B. Cropland	4425,52	218,58	3,58						4647,68
C. Grassland	-242,81	7,71	0,44						-234,66
D. Wetlands	149,08	7,59	1,32						157,99
E. Settlements	3026,00	IE	98,43						3124,44
F. Other land	1,02	NO	NO,NA						1,02
G. Harvested wood products	-7895,92								-7895,92
H. Other	NO	NO	NO						NO
5. Waste	81,32	2552,18	234,91						2868,41
A. Solid waste disposal	NO,NA	2485,44							2485,44
B. Biological treatment of solid waste		33,79	20,97						54,76
C. Incineration and open burning of waste	81,32	0,02	3,53						84,87
D. Waste water treatment and discharge		32,93	210,41						243,35
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	7179,63	1,26	109,34						7290,23
Aviation	1566,46	0,29	23,01						1589,75
Navigation	5613,18	0,97	86,33						5700,48
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	34229,62								34229,62
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			305,78						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									70231,12
Total CO_2 equivalent emissions with land use, land-use change and forestry									31713,92
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2004
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	22737,73	6781,19	6318,19	1085,13	401,05	94,69	NO	NO	37417,97
1. Energy	49757,39	315,60	585,37						50658,36
A. Fuel combustion (sectoral approach)	49370,45	222,59	583,95						50176,99
1. Energy industries	11417,68	35,34	215,56						11668,58
2. Manufacturing industries and construction	10472,94	23,15	127,93						10624,02
3. Transport	21323,54	66,25	121,79						21511,58
4. Other sectors	6156,29	97,85	118,67						6372,81
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	386,94	93,01	1,42						481,36
1. Solid fuels	7,30	0,00	0,00						7,31
2. Oil and natural gas	379,63	93,01	1,41						474,05
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6707,93	9,91	650,10	1085,13	401,05	94,69	NO	NO	8948,81
A. Mineral industry	1821,25								1821,25
B. Chemical industry	920,43	1,03	427,12						1348,59
C. Metal industry	3492,88	0,95	NA	NO	390,97	38,58			3923,38
D. Non-energy products from fuels and solvent use	462,74	NA	NA						462,74
E. Electronic Industry				0,07	3,92	1,04			5,03
F. Product uses as ODS substitutes				1085,06	6,16		NO	NO	1091,22
G. Other product manufacture and use	NE,NA	NA	140,52		NO	55,07			195,59
H. Other	10,63	7,93	82,46						101,01
3. Agriculture	123,23	3469,48	3603,54						7196,25
A. Enteric fermentation		3214,01							3214,01
B. Manure management		255,47	352,59						608,06
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3250,95						3250,95
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	122,88								122,88
H. Urea application	0,35								0,35
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-33945,15	461,43	1244,85						-32238,87
A. Forest land	-32838,30	229,36	1134,61						-31474,33
B. Cropland	4330,41	218,25	3,82						4552,48
C. Grassland	-281,90	7,36	0,43						-274,11
D. Wetlands	137,02	6,46	1,12						144,60
E. Settlements	3245,03	IE	102,49						3347,52
F. Other land	-0,17	NO	NO,NA						-0,17
G. Harvested wood products	-8537,23								-8537,23
H. Other	NO	NO	NO						NO
5. Waste	94,33	2524,77	234,32						2853,42
A. Solid waste disposal	NO,NA	2460,67							2460,67
B. Biological treatment of solid waste		32,28	19,59						51,88
C. Incineration and open burning of waste	94,33	0,03	3,94						98,29
D. Waste water treatment and discharge		31,78	210,79						242,57
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[2]									
International bunkers	8288,18	1,48	124,42						8414,08
Aviation	1771,55	0,33	25,48						1797,37
Navigation	6516,63	1,15	98,93						6616,72
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	35436,58								35436,58
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			300,49						
Indirect CO_2 [3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									69656,84
Total CO_2 equivalent emissions with land use, land-use change and forestry									37417,97
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS

(Sheet 1 of 1)

Inventory 2005
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	20355,85	6588,95	6210,43	1110,20	406,31	151,59	NO	NO	34823,34
1. Energy	47313,96	304,85	583,05						48201,86
A. Fuel combustion (sectoral approach)	46949,79	220,40	581,72						47751,92
1. Energy industries	10548,58	38,87	222,47						10809,92
2. Manufacturing industries and construction	9848,89	22,51	127,03						9998,43
3. Transport	21527,81	62,76	119,71						21710,28
4. Other sectors	5024,52	96,26	112,51						5233,30
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	364,16	84,45	1,33						449,94
1. Solid fuels	5,39	0,00	0,00						5,40
2. Oil and natural gas	358,77	84,45	1,32						444,54
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6540,78	9,41	644,84	1110,20	406,31	151,59	NO	NO	8863,13
A. Mineral industry	1947,36								1947,36
B. Chemical industry	912,15	0,86	431,42						1344,43
C. Metal industry	3217,10	0,65	NA	NO	400,86	95,26			3713,86
D. Non-energy products from fuels and solvent use	452,60	NA	NA						452,60
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1110,20	5,45		NO	NO	1115,65
G. Other product manufacture and use	NE,NA	NA	131,18		NO	56,33			187,51
H. Other	11,58	7,91	82,24						101,73
3. Agriculture	116,50	3441,64	3487,21						7045,36
A. Enteric fermentation		3176,98							3176,98
B. Manure management		264,66	349,95						614,61
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3137,26						3137,26
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	116,12								116,12
H. Urea application	0,38								0,38
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry [(1)]	-33710,23	461,14	1244,90						-32004,19
A. Forest land	-29246,58	227,08	1131,45						-27888,05
B. Cropland	3947,19	217,73	3,96						4168,88
C. Grassland	-65,98	8,01	0,43						-57,54
D. Wetlands	166,02	8,32	1,45						175,79
E. Settlements	1814,51	IE	104,01						1918,52
F. Other land	-0,17	NO	NO,NA						-0,17
G. Harvested wood products	-10325,22								-10325,22
H. Other	NO	NO	NO						NO
5. Waste	94,85	2371,90	250,43						2717,19
A. Solid waste disposal	NO,NA	2288,83							2288,83
B. Biological treatment of solid waste		52,43	32,89						85,32
C. Incineration and open burning of waste	94,85	0,02	4,91						99,79
D. Waste water treatment and discharge		30,61	212,63						243,24
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items: [(2)]									
International bunkers	8563,52	1,53	129,35						8694,40
Aviation	1935,72	0,36	27,75						1963,83
Navigation	6627,79	1,17	101,60						6730,57
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	36402,04								36402,04
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			295,84						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									66827,53
Total CO_2 equivalent emissions with land use, land-use change and forestry									34823,34
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2006
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	10816,92	6473,81	6150,98	1134,96	392,16	112,64	NO	NO	25081,48
1. Energy	47183,11	301,09	592,54						48076,75
A. Fuel combustion (sectoral approach)	46371,33	219,09	590,91						47181,34
1. Energy industries	10579,04	42,20	227,98						10849,22
2. Manufacturing industries and construction	9878,48	24,80	142,85						10046,12
3. Transport	21505,61	58,15	117,07						21680,83
4. Other sectors	4408,19	93,95	103,02						4605,16
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	811,79	82,00	1,63						895,41
1. Solid fuels	5,14	0,00	0,00						5,15
2. Oil and natural gas	806,64	81,99	1,62						890,26
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6523,51	9,45	657,24	1134,96	392,16	112,64	NO	NO	8829,97
A. Mineral industry	2025,58								2025,58
B. Chemical industry	907,43	1,03	448,07						1356,53
C. Metal industry	3152,54	0,44	NA	NO	382,05	73,40			3608,43
D. Non-energy products from fuels and solvent use	425,50	NA	NA						425,50
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1134,96	5,26		NO	NO	1140,22
G. Other product manufacture and use	NE,NA	NA	126,20		4,86	39,24			170,30
H. Other	12,46	7,97	82,97						103,41
3. Agriculture	89,61	3417,70	3407,14						6914,46
A. Enteric fermentation		3157,62							3157,62
B. Manure management		260,09	344,53						604,62
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3062,61						3062,61
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	89,45								89,45
H. Urea application	0,17								0,17
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-43068,17	464,61	1243,68						-41359,89
A. Forest land	-37809,25	235,31	1128,19						-36445,75
B. Cropland	3736,08	216,46	3,75						3956,29
C. Grassland	-0,15	7,83	0,50						8,18
D. Wetlands	127,01	5,01	0,87						132,88
E. Settlements	2251,15	IE	106,31						2357,46
F. Other land	-0,14	NO	NO,NA						-0,14
G. Harvested wood products	-11372,87								-11372,87
H. Other	NO	NO	NO						NO
5. Waste	88,86	2280,96	250,37						2620,20
A. Solid waste disposal	NO,NA	2198,45							2198,45
B. Biological treatment of solid waste		53,04	32,35						85,40
C. Incineration and open burning of waste	88,86	0,02	4,03						92,92
D. Waste water treatment and discharge		29,44	213,99						243,43
E. Other	NO	NO	NO						NO
6. Other ***(as specified in summary 1.A)***									

Memo items:[2]									
International bunkers	9065,85	1,67	136,78						9204,30
Aviation	2006,28	0,42	28,83						2035,53
Navigation	7059,57	1,25	107,95						7168,77
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	38152,11								38152,11
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			292,12						
Indirect CO_2 [3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									66441,37
Total CO_2 equivalent emissions with land use, land-use change and forestry									25081,48
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2007
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	16166,48	6201,88	6003,13	1140,47	400,11	137,38	NO	NO	30049,45
1. Energy	46309,96	292,72	596,87						47199,56
A. Fuel combustion (sectoral approach)	45461,93	209,36	595,53						46266,82
1. Energy industries	10041,79	41,89	236,49						10320,17
2. Manufacturing industries and construction	9456,22	23,74	138,21						9618,16
3. Transport	21812,24	54,14	114,22						21980,60
4. Other sectors	4151,69	89,60	106,61						4347,90
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	848,03	83,36	1,34						932,73
1. Solid fuels	4,59	0,00	0,00						4,59
2. Oil and natural gas	843,44	83,35	1,34						928,14
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6627,92	9,39	435,90	1140,47	400,11	137,38	NO	NO	8751,17
A. Mineral industry	1971,70								1971,70
B. Chemical industry	875,37	1,02	242,49						1118,87
C. Metal industry	3318,44	0,41	NA	NO	385,55	107,96			3812,36
D. Non-energy products from fuels and solvent use	450,11	NA	NA						450,11
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1140,47	4,85		NO	NO	1145,31
G. Other product manufacture and use	NE,NA	NA	110,48		9,71	29,42			149,61
H. Other	12,30	7,97	82,93						103,20
3. Agriculture	115,58	3355,45	3459,28						6930,31
A. Enteric fermentation		3098,40							3098,40
B. Manure management		257,05	345,55						602,60
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3113,73						3113,73
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	115,38								115,38
H. Urea application	0,20								0,20
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-36985,49	452,59	1258,33						-35274,57
A. Forest land	-32776,71	220,49	1117,57						-31438,65
B. Cropland	3720,95	216,03	3,97						3940,96
C. Grassland	438,70	7,75	24,21						470,66
D. Wetlands	174,29	8,32	1,45						184,05
E. Settlements	3019,94	IE	105,91						3125,85
F. Other land	0,65	NO	NO,NA						0,65
G. Harvested wood products	-11563,31								-11563,31
H. Other	NO	NO	NO						NO
5. Waste	98,50	2091,73	252,75						2442,98
A. Solid waste disposal	NO,NA	2001,90							2001,90
B. Biological treatment of solid waste		59,54	36,85						96,39
C. Incineration and open burning of waste	98,50	0,03	4,09						102,62
D. Waste water treatment and discharge		30,26	211,80						242,06
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[2]									
International bunkers	9184,92	1,64	137,01						9323,57
Aviation	2194,68	0,40	30,32						2225,40
Navigation	6990,24	1,24	106,68						7098,16
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	39500,91								39500,91
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			284,30						
Indirect CO_2[3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									65324,02
Total CO_2 equivalent emissions with land use, land-use change and forestry									30049,45
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2008
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	8259,09	5934,57	6047,41	1155,93	350,24	72,85	NO	NO	21820,08
1. Energy	44491,59	277,47	606,98						45376,04
A. Fuel combustion (sectoral approach)	43630,17	206,80	605,52						44442,49
1. Energy industries	9943,70	44,84	244,78						10233,32
2. Manufacturing industries and construction	8859,14	24,05	140,52						9023,71
3. Transport	21224,72	50,46	115,46						21390,64
4. Other sectors	3602,62	87,44	104,76						3794,82
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	861,41	70,67	1,46						933,55
1. Solid fuels	4,45	0,00	0,00						4,45
2. Oil and natural gas	856,96	70,67	1,45						929,09
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6371,57	8,87	463,89	1155,93	350,24	72,85	NO	NO	8423,34
A. Mineral industry	1993,67								1993,67
B. Chemical industry	798,62	0,89	265,25						1064,76
C. Metal industry	3089,56	0,26	NA	NO	335,83	45,63			3471,27
D. Non-energy products from fuels and solvent use	476,25	NA	NA						476,25
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1155,93	4,70		NO	NO	1160,63
G. Other product manufacture and use	NE,NA	NA	118,27		9,71	27,22			155,21
H. Other	13,47	7,73	80,36						101,56
3. Agriculture	104,59	3364,29	3500,24						6969,12
A. Enteric fermentation		3109,64							3109,64
B. Manure management		254,65	345,88						600,53
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3154,36						3154,36
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	104,42								104,42
H. Urea application	0,17								0,17
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-42811,38	459,13	1219,81						-41132,44
A. Forest land	-39489,42	228,66	1094,77						-38165,99
B. Cropland	3309,64	215,26	4,11						3529,02
C. Grassland	149,20	7,81	6,73						163,74
D. Wetlands	165,84	7,40	1,29						174,53
E. Settlements	2702,56	IE	106,25						2808,81
F. Other land	0,65	NO	NO,NA						0,65
G. Harvested wood products	-9649,85								-9649,85
H. Other	NO	NO	NO						NO
5. Waste	102,72	1824,80	256,50						2184,02
A. Solid waste disposal	NO,NA	1724,38							1724,38
B. Biological treatment of solid waste		71,07	40,67						111,74
C. Incineration and open burning of waste	102,72	0,03	5,32						108,06
D. Waste water treatment and discharge		29,33	210,51						239,84
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	9243,34	1,83	136,01						9381,19
Aviation	2456,84	0,61	33,11						2490,57
Navigation	6786,50	1,22	102,90						6890,62
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	40711,55								40711,55
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			270,66						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									62952,52
Total CO_2 equivalent emissions with land use, land-use change and forestry									21820,08
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2009
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	4582,32	5766,55	5851,93	1154,25	48,68	70,01	NO	NO	17473,73
1. Energy	42577,67	274,89	622,43						43474,99
A. Fuel combustion (sectoral approach)	41713,26	208,13	620,96						42542,36
1. Energy industries	10317,09	49,91	258,58						10625,58
2. Manufacturing industries and construction	7192,73	23,59	137,43						7353,75
3. Transport	20870,04	46,80	117,72						21034,57
4. Other sectors	3333,40	87,83	107,23						3528,45
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	864,41	66,76	1,47						932,63
1. Solid fuels	14,54	0,01	0,01						14,56
2. Oil and natural gas	849,86	66,75	1,46						918,07
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	4623,77	8,47	481,90	1154,25	48,68	70,01	NO	NO	6387,09
A. Mineral industry	1698,00								1698,00
B. Chemical industry	709,97	0,84	299,98						1010,78
C. Metal industry	1791,64	0,17	NA	NO	39,45	27,87			1859,13
D. Non-energy products from fuels and solvent use	414,17	NA	NA						414,17
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1154,25	4,37		NO	NO	1158,62
G. Other product manufacture and use	NE,NA	NA	104,30		4,86	42,14			151,30
H. Other	10,01	7,46	77,63						95,09
3. Agriculture	114,54	3316,03	3295,20						6725,77
A. Enteric fermentation		3064,63							3064,63
B. Manure management		251,39	340,12						591,52
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	2955,08						2955,08
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	113,74								113,74
H. Urea application	0,80								0,80
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-42839,14	440,63	1192,07						-41206,44
A. Forest land	-42680,31	211,82	1068,07						-41400,42
B. Cropland	3203,41	213,88	4,37						3421,67
C. Grassland	263,98	8,05	6,76						278,79
D. Wetlands	161,85	6,88	1,20						169,92
E. Settlements	3446,02	IE	105,47						3551,49
F. Other land	64,16	NO	NO,NA						64,16
G. Harvested wood products	-7298,25								-7298,25
H. Other	NO	NO	NO						NO
5. Waste	105,47	1726,53	260,32						2092,33
A. Solid waste disposal	NO,NA	1620,23							1620,23
B. Biological treatment of solid waste		79,13	45,09						124,22
C. Incineration and open burning of waste	105,47	0,02	4,95						110,45
D. Waste water treatment and discharge		27,16	210,28						237,43
E. Other	NO	NO	NO						NO
6. Other ***(as specified in summary 1.A)***									

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
Memo items:[(2)]									
International bunkers	9321,25	1,83	137,85						9460,93
Aviation	2088,05	0,52	28,41						2116,99
Navigation	7233,19	1,31	109,44						7343,94
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	41340,28								41340,28
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			253,60						
Indirect CO_2 [(3)]	NO								

Total CO_2 equivalent emissions without land use, land-use change and forestry	58680,17
Total CO_2 equivalent emissions with land use, land-use change and forestry	17473,73
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2010
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	8595,06	5650,30	6040,32	1133,81	187,79	63,46	NO	NO	21670,73
1. Energy	46546,01	271,41	663,15						47480,57
A. Fuel combustion (sectoral approach)	45720,67	210,55	661,72						46592,94
1. Energy industries	12785,11	55,98	284,17						13125,27
2. Manufacturing industries and construction	8387,42	25,17	146,84						8559,42
3. Transport	20956,06	43,07	124,04						21123,17
4. Other sectors	3592,08	86,34	106,67						3785,08
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	825,34	60,85	1,44						887,63
1. Solid fuels	5,01	0,00	0,00						5,01
2. Oil and natural gas	820,33	60,85	1,43						882,61
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6517,31	8,73	506,50	1133,81	187,79	63,46	NO	NO	8417,59
A. Mineral industry	1901,49								1901,49
B. Chemical industry	907,74	0,84	306,63						1215,21
C. Metal industry	3253,60	0,25	NA	NO	184,38	32,69			3470,92
D. Non-energy products from fuels and solvent use	441,71	NA	NA						441,71
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1133,81	3,41		NO	NO	1137,22
G. Other product manufacture and use	NE,NA	NA	120,41		NO	30,77			151,18
H. Other	12,76	7,63	79,47						99,86
3. Agriculture	123,80	3317,07	3404,04						6844,91
A. Enteric fermentation		3065,40							3065,40
B. Manure management		251,67	341,85						593,51
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3062,20						3062,20
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	123,06								123,06
H. Urea application	0,74								0,74
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry [(1)]	-44692,28	438,30	1211,07						-43042,91
A. Forest land	-44707,93	211,93	1088,44						-43407,56
B. Cropland	3514,05	212,11	4,02						3730,18
C. Grassland	667,05	8,13	6,08						681,26
D. Wetlands	155,05	6,13	1,07						162,25
E. Settlements	3140,99	IE	102,57						3243,56
F. Other land	4,00	NO	NO,NA						4,00
G. Harvested wood products	-7465,50								-7465,50
H. Other	NO	NO	NO						NO
5. Waste	100,23	1614,79	255,56						1970,58
A. Solid waste disposal	NO,NA	1510,27							1510,27
B. Biological treatment of solid waste		78,12	40,50						118,62
C. Incineration and open burning of waste	100,23	0,02	4,50						104,75
D. Waste water treatment and discharge		26,37	210,56						236,93
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items: [(2)]									
International bunkers	8944,80	1,73	133,79						9080,31
Aviation	2110,19	0,51	29,06						2139,76
Navigation	6834,61	1,21	104,73						6940,55
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	45895,88								45895,88
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			257,20						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									64713,64
Total CO_2 equivalent emissions with land use, land-use change and forestry									21670,73
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2011
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	4797,11	5488,20	5692,30	1105,94	215,08	55,44	NO	NO	17354,07
1. Energy	42862,76	252,32	625,28						43740,36
A. Fuel combustion (sectoral approach)	42029,17	193,64	624,02						42846,83
1. Energy industries	10475,58	46,69	249,46						10771,73
2. Manufacturing industries and construction	7769,17	23,57	139,89						7932,63
3. Transport	20563,60	38,30	127,57						20729,47
4. Other sectors	3220,82	85,08	107,10						3413,00
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	833,58	58,68	1,26						893,52
1. Solid fuels	5,85	0,00	0,00						5,86
2. Oil and natural gas	827,74	58,68	1,26						887,67
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6313,13	8,54	218,83	1105,94	215,08	55,44	NO	NO	7916,97
A. Mineral industry	1936,79								1936,79
B. Chemical industry	859,95	0,84	46,79						907,57
C. Metal industry	3088,12	0,25	NA	NO	212,76	25,05			3326,18
D. Non-energy products from fuels and solvent use	417,35	NA	NA						417,35
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1105,94	2,32		NO	NO	1108,26
G. Other product manufacture and use	NE,NA	NA	94,49		NO	30,39			124,87
H. Other	10,92	7,45	77,56						95,93
3. Agriculture	123,87	3288,15	3426,34						6838,35
A. Enteric fermentation		3034,84							3034,84
B. Manure management		253,30	338,33						591,64
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3088,00						3088,00
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	123,06								123,06
H. Urea application	0,80								0,80
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-44608,06	432,87	1157,64						-43017,56
A. Forest land	-44501,52	207,91	1035,23						-43258,38
B. Cropland	3748,39	210,49	4,27						3963,16
C. Grassland	248,30	7,70	6,16						262,17
D. Wetlands	167,49	6,76	1,18						175,42
E. Settlements	2754,23	IE	104,58						2858,81
F. Other land	3,02	NO	NO,NA						3,02
G. Harvested wood products	-7027,99								-7027,99
H. Other	NO	NO	NO						NO
5. Waste	105,43	1506,32	264,21						1875,96
A. Solid waste disposal	NO,NA	1388,00							1388,00
B. Biological treatment of solid waste		91,21	49,36						140,57
C. Incineration and open burning of waste	105,43	0,02	5,50						110,95
D. Waste water treatment and discharge		27,09	209,35						236,44
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	8011,46	1,59	119,92						8132,96
Aviation	2273,83	0,58	31,30						2305,71
Navigation	5737,63	1,01	88,62						5827,26
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	41902,81								41902,81
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			245,36						
Indirect CO_2[(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									60371,63
Total CO_2 equivalent emissions with land use, land-use change and forestry									17354,07
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2012
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	1916,64	5298,30	5610,14	1087,92	78,68	53,13	NO	NO	14044,81
1. Energy	40561,01	246,53	627,73						41435,26
A. Fuel combustion (sectoral approach)	39722,70	181,51	626,38						40530,59
1. Energy industries	10095,89	48,02	242,57						10386,47
2. Manufacturing industries and construction	7219,14	23,54	139,93						7382,60
3. Transport	19410,08	30,32	138,39						19578,80
4. Other sectors	2997,59	79,63	105,50						3182,73
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	838,31	65,02	1,35						904,67
1. Solid fuels	8,65	0,00	0,01						8,66
2. Oil and natural gas	829,66	65,01	1,34						896,01
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6089,15	9,15	244,42	1087,92	78,68	53,13	NO	NO	7562,45
A. Mineral industry	2003,11								2003,11
B. Chemical industry	831,96	0,85	71,13						903,94
C. Metal industry	2754,41	0,52	NA	0,27	76,93	24,44			2856,57
D. Non-energy products from fuels and solvent use	488,07	NA	NA						488,07
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1087,65	1,75		NO	NO	1089,40
G. Other product manufacture and use	NE,NA	NA	92,31		NO	28,69			120,99
H. Other	11,59	7,78	80,99						100,36
3. Agriculture	142,12	3252,81	3369,72						6764,65
A. Enteric fermentation		3002,92							3002,92
B. Manure management		249,89	331,48						581,38
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3038,23						3038,23
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	141,65								141,65
H. Urea application	0,47								0,47
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-45001,94	423,71	1114,47						-43463,76
A. Forest land	-45490,17	201,03	985,89						-44303,25
B. Cropland	4033,49	208,33	4,12						4245,94
C. Grassland	208,49	7,33	12,07						227,89
D. Wetlands	172,96	7,02	1,22						181,20
E. Settlements	2883,98	IE	106,04						2990,02
F. Other land	2,63	NO	NO,NA						2,63
G. Harvested wood products	-6813,31								-6813,31
H. Other	NO	NO	NO						NO
5. Waste	126,31	1366,09	253,81						1746,21
A. Solid waste disposal	NO,NA	1260,58							1260,58
B. Biological treatment of solid waste		78,50	39,97						118,47
C. Incineration and open burning of waste	126,31	0,03	5,34						131,68
D. Waste water treatment and discharge		26,98	208,50						235,48
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	7657,98	1,52	115,28						7774,78
Aviation	2164,92	0,56	30,12						2195,59
Navigation	5493,07	0,96	85,16						5579,19
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	42971,49								42971,49
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			236,37						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									57508,57
Total CO_2 equivalent emissions with land use, land-use change and forestry									14044,81
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	2489,28	5208,52	5654,53	1076,73	51,22	42,06	NO	NO	14522,34
1. Energy	38969,38	238,66	650,18						39858,22
A. Fuel combustion (sectoral approach)	38270,46	181,27	649,01						39100,74
1. Energy industries	9583,26	48,50	259,05						9890,81
2. Manufacturing industries and construction	6931,15	25,28	143,77						7100,21
3. Transport	18939,59	29,30	144,94						19113,83
4. Other sectors	2816,46	78,18	101,25						2995,90
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	698,92	57,39	1,18						757,49
1. Solid fuels	3,30	0,00	0,00						3,30
2. Oil and natural gas	695,62	57,39	1,18						754,19
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6115,64	8,80	212,10	1076,73	51,22	42,06	NO	NO	7506,55
A. Mineral industry	1920,23								1920,23
B. Chemical industry	884,58	0,80	54,52						939,89
C. Metal industry	2804,75	0,25	NA	0,18	49,83	11,19			2866,20
D. Non-energy products from fuels and solvent use	495,06	NA	NA						495,06
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1076,55	1,40		NO	NO	1077,95
G. Other product manufacture and use	NE,NA	NA	76,95		NO	30,87			107,82
H. Other	11,02	7,76	80,63						99,40
3. Agriculture	142,56	3272,21	3426,16						6840,93
A. Enteric fermentation		3009,09							3009,09
B. Manure management		263,11	341,87						604,98
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3084,29						3084,29
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	141,65								141,65
H. Urea application	0,91								0,91
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-42862,06	425,02	1116,39						-41320,64
A. Forest land	-43863,03	204,80	984,54						-42673,69
B. Cropland	3884,71	206,40	4,01						4095,12
C. Grassland	353,72	7,23	13,87						374,82
D. Wetlands	172,01	6,59	1,15						179,74
E. Settlements	2797,67	IE	109,97						2907,64
F. Other land	0,84	NO	NO,NA						0,84
G. Harvested wood products	-6207,97								-6207,97
H. Other	NO	NO	NO						NO
5. Waste	123,76	1263,83	249,69						1637,28
A. Solid waste disposal	NO,NA	1164,99							1164,99
B. Biological treatment of solid waste		71,76	37,80						109,55
C. Incineration and open burning of waste	123,76	0,03	5,05						128,83
D. Waste water treatment and discharge		27,05	206,85						233,90
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[2]									
International bunkers	7409,29	1,47	111,34						7522,10
Aviation	2239,82	0,57	30,99						2271,39
Navigation	5169,47	0,90	80,34						5250,71
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	43854,53								43854,53
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			229,25						
Indirect CO_2 [3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									55842,98
Total CO_2 equivalent emissions with land use, land-use change and forestry									14522,34
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2014
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	746,68	5089,74	5728,73	1103,09	82,02	45,88	NO	NO	12796,14
1. Energy	37309,70	218,80	617,47						38145,96
A. Fuel combustion (sectoral approach)	36537,08	168,07	616,11						37321,25
1. Energy industries	8553,02	42,54	231,10						8826,66
2. Manufacturing industries and construction	6787,44	23,34	136,08						6946,85
3. Transport	18521,20	28,18	153,10						18702,48
4. Other sectors	2675,43	74,01	95,82						2845,26
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	772,62	50,73	1,36						824,71
1. Solid fuels	7,11	0,00	0,00						7,11
2. Oil and natural gas	765,51	50,73	1,36						817,60
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5922,74	8,94	229,77	1103,09	82,02	45,88	NO	NO	7392,44
A. Mineral industry	1850,39								1850,39
B. Chemical industry	829,56	0,83	62,37						892,77
C. Metal industry	2749,48	0,23	NA	NO	80,89	15,75			2846,35
D. Non-energy products from fuels and solvent use	482,96	NA	NA						482,96
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1103,09	1,14		NO	NO	1104,23
G. Other product manufacture and use	NE,NA	NA	85,47		NO	30,13			115,60
H. Other	10,34	7,88	81,93						100,14
3. Agriculture	123,33	3268,35	3507,03						6898,71
A. Enteric fermentation		3010,60							3010,60
B. Manure management		257,75	340,10						597,85
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3166,93						3166,93
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	123,12								123,12
H. Urea application	0,21								0,21
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-42731,25	453,84	1129,53						-41147,88
A. Forest land	-42137,82	234,90	1005,44						-40897,48
B. Cropland	3347,74	203,65	4,29						3555,68
C. Grassland	-130,74	7,56	5,04						-118,15
D. Wetlands	190,98	7,74	1,35						200,07
E. Settlements	3436,86	IE	110,73						3547,59
F. Other land	0,35	NO	NO,NA						0,35
G. Harvested wood products	-7438,61								-7438,61
H. Other	NO	NO	NO						NO
5. Waste	122,17	1139,81	244,93						1506,91
A. Solid waste disposal	NO,NA	1043,99							1043,99
B. Biological treatment of solid waste		68,28	33,47						101,75
C. Incineration and open burning of waste	122,17	0,02	5,37						127,56
D. Waste water treatment and discharge		27,52	206,09						233,61
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	7868,77	1,53	119,34						7989,64
Aviation	2268,65	0,57	31,39						2300,62
Navigation	5600,12	0,96	87,94						5689,02
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	42642,46								42642,46
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			224,09						
Indirect CO_2[(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									53944,02
Total CO_2 equivalent emissions with land use, land-use change and forestry									12796,14
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

Inventory 2015
Submission 2022 v2
SWEDEN

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	3682,52	4948,95	5798,34	1121,70	35,13	53,14	NO	NO	15639,77
1. Energy	37580,93	213,03	642,64						38436,60
A. Fuel combustion (sectoral approach)	36759,14	164,93	641,16						37565,23
1. Energy industries	8638,36	42,91	242,72						8924,00
2. Manufacturing industries and construction	6925,07	24,17	137,93						7087,17
3. Transport	18608,90	27,70	165,31						18801,92
4. Other sectors	2586,80	70,15	95,19						2752,14
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	821,79	48,09	1,48						871,37
1. Solid fuels	23,72	0,01	0,02						23,75
2. Oil and natural gas	798,07	48,08	1,47						847,62
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5917,52	8,93	211,52	1121,70	35,13	53,14	NO	NO	7347,93
A. Mineral industry	1994,44								1994,44
B. Chemical industry	782,12	0,80	41,01						823,93
C. Metal industry	2692,84	0,22	NA	NO	34,20	17,22			2744,49
D. Non-energy products from fuels and solvent use	439,71	NA	NA						439,71
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1121,70	0,93		NO	NO	1122,63
G. Other product manufacture and use	NE,NA	NA	88,37		NO	35,91			124,28
H. Other	8,41	7,90	82,15						98,46
3. Agriculture	124,48	3255,88	3542,96						6923,32
A. Enteric fermentation		2999,11							2999,11
B. Manure management		256,78	340,74						597,51
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3202,22						3202,22
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	123,12								123,12
H. Urea application	1,36								1,36
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-40059,21	430,18	1162,80						-38466,23
A. Forest land	-40615,30	211,26	1037,64						-39366,40
B. Cropland	3589,46	203,06	4,17						3796,70
C. Grassland	223,98	7,68	4,94						236,60
D. Wetlands	199,56	8,18	1,42						209,16
E. Settlements	3905,07	IE	110,85						4015,92
F. Other land	-7,81	NO	NO,NA						-7,81
G. Harvested wood products	-7354,17								-7354,17
H. Other	NO	NO	NO						NO
5. Waste	118,80	1040,93	238,42						1398,15
A. Solid waste disposal	NO,NA	943,10							943,10
B. Biological treatment of solid waste		70,12	29,92						100,04
C. Incineration and open burning of waste	118,80	0,01	5,20						124,01
D. Waste water treatment and discharge		27,70	203,30						231,00
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[(2)]									
International bunkers	7918,02	1,32	127,42						8046,76
Aviation	2167,66	0,45	30,62						2198,74
Navigation	5750,35	0,87	96,80						5848,03
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	44072,72								44072,72
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			217,03						
Indirect CO_2[(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									54106,00
Total CO_2 equivalent emissions with land use, land-use change and forestry									15639,77
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	2928,59	4875,13	5797,00	1138,52	31,18	57,46	NO	NO	14827,88
1. Energy	36727,70	217,63	653,33						37598,67
A. Fuel combustion (sectoral approach)	36088,09	170,38	651,90						36910,37
1. Energy industries	9063,57	46,61	233,23						9343,41
2. Manufacturing industries and construction	6709,92	24,18	141,59						6875,69
3. Transport	17893,24	28,14	179,94						18101,32
4. Other sectors	2421,36	71,45	97,15						2589,95
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	639,62	47,25	1,43						688,29
1. Solid fuels	9,74	0,01	0,01						9,75
2. Oil and natural gas	629,88	47,24	1,42						678,54
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6436,85	8,93	216,47	1138,52	31,18	57,46	NO	NO	7889,41
A. Mineral industry	2011,82								2011,82
B. Chemical industry	894,18	0,78	58,18						953,14
C. Metal industry	3071,68	0,26	NA	NO	30,45	19,80			3122,20
D. Non-energy products from fuels and solvent use	449,68	NA	NA						449,68
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1138,52	0,72		NO	NO	1139,24
G. Other product manufacture and use	NE,NA	NA	76,26		NO	37,66			113,93
H. Other	9,50	7,89	82,02						99,41
3. Agriculture	128,12	3253,13	3509,03						6890,27
A. Enteric fermentation		2990,87							2990,87
B. Manure management		262,26	333,93						596,19
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3175,11						3175,11
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	126,70								126,70
H. Urea application	1,41								1,41
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-40487,39	434,01	1179,58						-38873,80
A. Forest land	-39057,12	215,71	1058,06						-37783,35
B. Cropland	3530,39	201,95	3,73						3736,07
C. Grassland	125,83	7,97	4,27						138,08
D. Wetlands	206,35	8,38	1,46						216,18
E. Settlements	2918,47	IE	108,67						3027,14
F. Other land	-7,77	NO	NO,NA						-7,77
G. Harvested wood products	-8203,54								-8203,54
H. Other	NO	NO	NO						NO
5. Waste	123,31	961,43	238,59						1323,33
A. Solid waste disposal	NO,NA	853,19							853,19
B. Biological treatment of solid waste		79,91	34,05						113,97
C. Incineration and open burning of waste	123,31	0,02	5,07						128,40
D. Waste water treatment and discharge		28,31	199,46						227,78
E. Other	NO	NO	NO						NO
6. Other ***(as specified in summary 1.A)***									

	CO_2	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
Memo items:[2]									
International bunkers	8840,07	1,52	138,25						8979,85
Aviation	2527,87	0,52	34,35						2562,75
Navigation	6312,20	1,00	103,90						6417,10
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	46282,11								46282,11
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			213,35						
Indirect CO_2 [3]	NO								

Total CO_2 equivalent emissions without land use, land-use change and forestry	53701,68
Total CO_2 equivalent emissions with land use, land-use change and forestry	14827,88
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry	NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry	NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	6292,40	4843,57	6016,16	1100,43	36,58	45,81	NO	NO	18334,96
1. Energy	36246,27	214,24	678,80						37139,32
A. Fuel combustion (sectoral approach)	35445,60	169,07	677,52						36292,19
1. Energy industries	8997,32	46,55	247,13						9291,00
2. Manufacturing industries and construction	6629,88	24,56	143,82						6798,26
3. Transport	17474,10	27,83	188,27						17690,20
4. Other sectors	2344,30	70,13	98,30						2512,73
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	800,68	45,17	1,28						847,13
1. Solid fuels	5,32	0,00	0,00						5,33
2. Oil and natural gas	795,35	45,17	1,28						841,80
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6198,13	9,10	249,01	1100,43	36,58	45,81	NO	NO	7639,07
A. Mineral industry	1984,14								1984,14
B. Chemical industry	875,91	0,78	47,99						924,68
C. Metal industry	2878,93	0,23	NA	0,33	36,06	12,85			2928,40
D. Non-energy products from fuels and solvent use	447,03	NA	NA						447,03
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1100,10	0,52		NO	NO	1100,62
G. Other product manufacture and use	NE,NA	NA	116,92		NO	32,97			149,89
H. Other	12,11	8,09	84,10						104,31
3. Agriculture	127,54	3284,30	3642,07						7053,90
A. Enteric fermentation		3020,92							3020,92
B. Manure management		263,38	334,44						597,82
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3307,63						3307,63
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	126,70								126,70
H. Urea application	0,84								0,84
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-36411,83	436,48	1209,79						-34765,56
A. Forest land	-36883,48	220,02	1088,47						-35574,99
B. Cropland	3912,80	201,07	3,69						4117,56
C. Grassland	124,05	8,13	7,03						139,21
D. Wetlands	195,48	7,26	1,26						204,00
E. Settlements	2732,11	IE	106,40						2838,51
F. Other land	-7,75	NO	NO,NA						-7,75
G. Harvested wood products	-6485,04								-6485,04
H. Other	NO	NO	NO						NO
5. Waste	132,29	899,46	236,49						1268,24
A. Solid waste disposal	NO,NA	794,64							794,64
B. Biological treatment of solid waste		76,28	32,21						108,49
C. Incineration and open burning of waste	132,29	0,03	5,18						137,50
D. Waste water treatment and discharge		28,51	199,10						227,61
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items:[2]									
International bunkers	10042,45	1,67	156,03						10200,14
Aviation	2753,34	0,49	37,24						2791,07
Navigation	7289,11	1,17	118,79						7409,08
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	47845,50								47845,50
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			204,78						
Indirect CO_2 [3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									53100,52
Total CO_2 equivalent emissions with land use, land-use change and forestry									18334,96
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

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GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2 [(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions) [(1)]	5815,42	4819,61	5861,70	1043,18	61,87	32,98	NO	NO	17634,76
1. Energy	35863,29	204,05	683,49						36750,84
A. Fuel combustion (sectoral approach)	35038,26	162,34	682,07						35882,67
1. Energy industries	9127,03	48,07	250,38						9425,47
2. Manufacturing industries and construction	6709,96	25,02	143,71						6878,69
3. Transport	17002,84	28,16	199,48						17230,48
4. Other sectors	2198,43	61,10	88,50						2348,02
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	825,03	41,71	1,42						868,17
1. Solid fuels	4,44	0,00	0,00						4,44
2. Oil and natural gas	820,60	41,71	1,42						863,72
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5975,20	9,17	205,33	1043,18	61,87	32,98	NO	NO	7327,72
A. Mineral industry	2030,11								2030,11
B. Chemical industry	903,89	0,77	31,75						936,42
C. Metal industry	2616,27	0,22	NA	0,41	61,56	NO			2678,46
D. Non-energy products from fuels and solvent use	411,57	NA	NA						411,57
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				1042,77	0,31		NO	NO	1043,08
G. Other product manufacture and use	NE,NA	NA	88,59		NO	32,98			121,57
H. Other	13,34	8,18	84,99						106,51
3. Agriculture	128,55	3271,61	3478,68						6878,85
A. Enteric fermentation		3008,88							3008,88
B. Manure management		262,73	332,58						595,32
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3146,10						3146,10
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	126,70								126,70
H. Urea application	1,85								1,85
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry [(1)]	-36279,49	498,78	1265,64						-34515,06
A. Forest land	-37881,46	280,37	1140,96						-36460,13
B. Cropland	4276,29	200,52	4,02						4480,83
C. Grassland	240,12	8,28	5,45						253,85
D. Wetlands	230,47	9,61	1,67						241,75
E. Settlements	2801,43	IE	110,06						2911,49
F. Other land	18,56	NO	NO,NA						18,56
G. Harvested wood products	-5964,90								-5964,90
H. Other	NO	NO	NO						NO
5. Waste	127,87	836,00	228,55						1192,42
A. Solid waste disposal	NO,NA	738,72							738,72
B. Biological treatment of solid waste		67,80	25,16						92,96
C. Incineration and open burning of waste	127,87	0,04	5,29						133,20
D. Waste water treatment and discharge		29,44	198,10						227,54
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									
Memo items: [(2)]									
International bunkers	8428,35	10,15	127,73						8566,23
Aviation	2788,46	0,51	37,63						2826,59
Navigation	5639,89	9,64	90,10						5739,63
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	47225,55								47225,55
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			199,18						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									52149,83
Total CO_2 equivalent emissions with land use, land-use change and forestry									17634,76
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[1]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[1]	2526,44	4627,22	5845,98	991,08	49,39	34,13	NO	NO	14074,24
1. Energy	34119,53	212,64	663,71						34995,89
A. Fuel combustion (sectoral approach)	33583,35	171,55	662,73						34417,63
1. Energy industries	7858,65	47,64	231,46						8137,76
2. Manufacturing industries and construction	6706,11	25,18	144,64						6875,93
3. Transport	16754,39	37,71	198,69						16990,79
4. Other sectors	2264,19	61,02	87,93						2413,15
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	536,19	41,09	0,98						578,26
1. Solid fuels	7,47	0,00	0,00						7,48
2. Oil and natural gas	528,72	41,08	0,98						570,78
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	6620,29	9,56	205,45	991,08	49,39	34,13	NO	NO	7909,90
A. Mineral industry	1748,79								1748,79
B. Chemical industry	902,37	0,78	28,80						931,95
C. Metal industry	3585,76	0,30	NA	1,04	49,29	NO			3636,39
D. Non-energy products from fuels and solvent use	372,42	NA	NA						372,42
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				990,04	0,10		NO	NO	990,15
G. Other product manufacture and use	NE,NA	NA	88,59		NO	34,13			122,72
H. Other	10,95	8,48	88,06						107,49
3. Agriculture	122,85	3223,80	3476,99						6823,64
A. Enteric fermentation		2957,76							2957,76
B. Manure management		266,04	329,96						596,00
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3147,03						3147,03
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	122,44								122,44
H. Urea application	0,41								0,41
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[1]	-38456,05	447,58	1272,12						-36736,35
A. Forest land	-38117,52	233,77	1150,55						-36733,20
B. Cropland	2752,87	199,51	3,90						2956,29
C. Grassland	419,07	8,11	5,35						432,54
D. Wetlands	184,95	6,18	1,08						192,21
E. Settlements	2781,25	IE	107,18						2888,44
F. Other land	12,99	NO	NO,NA						12,99
G. Harvested wood products	-6489,68								-6489,68
H. Other	NO	NO	NO						NO
5. Waste	119,82	733,64	227,70						1081,17
A. Solid waste disposal	NO,NA	634,29							634,29
B. Biological treatment of solid waste		69,68	25,38						95,06
C. Incineration and open burning of waste	119,82	0,03	5,22						125,07
D. Waste water treatment and discharge		29,64	197,11						226,75
E. Other	NO	NO	NO						NO
6. Other *(as specified in summary 1.A)*									

Memo items:[2]									
International bunkers	9481,50	11,83	144,29						9637,62
Aviation	2644,74	0,45	35,78						2680,97
Navigation	6836,76	11,38	108,51						6956,65
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	47837,62								47837,62
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			187,69						
Indirect CO_2 [3]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									50810,59
Total CO_2 equivalent emissions with land use, land-use change and forestry									14074,24
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

SUMMARY 2 SUMMARY REPORT FOR CO_2 EQUIVALENT EMISSIONS
(Sheet 1 of 1)

GREENHOUSE GAS SOURCE AND SINK CATEGORIES	CO_2[(1)]	CH_4	N_2O	HFCs	PFCs	SF_6	Unspecified mix of HFCs and PFCs	NF_3	Total
	CO_2 equivalent (kt)								
Total (net emissions)[(1)]	-4960,60	4552,66	5885,39	938,61	65,22	38,93	NO	NO	6520,21
1. Energy	30943,78	219,66	599,90						31763,34
A. Fuel combustion (sectoral approach)	30498,83	175,67	599,49						31273,99
1. Energy industries	7265,82	46,44	184,85						7497,11
2. Manufacturing industries and construction	5914,35	23,67	136,29						6074,32
3. Transport	15155,18	46,10	189,50						15390,79
4. Other sectors	2163,47	59,46	88,84						2311,77
5. Other	NO,IE	NO,IE	NO,IE						NO,IE
B. Fugitive emissions from fuels	444,96	43,98	0,42						489,36
1. Solid fuels	6,57	0,00	0,00						6,57
2. Oil and natural gas	438,39	43,98	0,41						482,78
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	5335,83	9,76	185,50	938,61	65,22	38,93	NO	NO	6573,86
A. Mineral industry	1681,45								1681,45
B. Chemical industry	590,52	0,80	6,23						597,56
C. Metal industry	2683,51	0,23	NA	0,57	65,22	NO			2749,53
D. Non-energy products from fuels and solvent use	370,10	NA	NA						370,10
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				938,04	NO		NO	NO	938,04
G. Other product manufacture and use	NE,NA	NA	88,59		NO	38,93			127,52
H. Other	10,25	8,73	90,67						109,66
3. Agriculture	122,57	3202,67	3605,25						6930,49
A. Enteric fermentation		2937,26							2937,26
B. Manure management		265,41	329,08						594,49
C. Rice cultivation		NO							NO
D. Agricultural soils		NO	3276,17						3276,17
E. Prescribed burning of savannas		NO	NO						NO
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	122,44								122,44
H. Urea application	0,13								0,13
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry[(1)]	-41475,70	442,47	1268,70						-39764,54
A. Forest land	-39660,56	231,98	1148,23						-38280,35
B. Cropland	2561,34	198,43	3,81						2763,58
C. Grassland	293,63	6,97	5,44						306,04
D. Wetlands	175,17	5,09	0,89						181,14
E. Settlements	2508,07	IE	105,58						2613,65
F. Other land	22,03	NO	NO,NA						22,03
G. Harvested wood products	-7375,37								-7375,37
H. Other	NO	NO	NO						NO
5. Waste	112,91	678,11	226,04						1017,06
A. Solid waste disposal	NO,NA	577,98							577,98
B. Biological treatment of solid waste		70,59	25,27						95,85
C. Incineration and open burning of waste	112,91	0,04	3,67						116,61
D. Waste water treatment and discharge		29,51	197,11						226,62
E. Other	NO	NO	NO						NO
6. Other ***(as specified in summary 1.A)***									

Memo items:[(2)]									
International bunkers	9104,92	12,08	144,00						9261,00
Aviation	928,32	0,15	12,56						941,03
Navigation	8176,60	11,93	131,44						8319,97
Multilateral operations	NO	NO	NO						NO
CO_2 emissions from biomass	47323,23								47323,23
CO_2 captured	NO,NE,IE,NA								NO,NE,IE,NA
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			173,50						
Indirect CO_2 [(3)]	NO								
Total CO_2 equivalent emissions without land use, land-use change and forestry									46284,75
Total CO_2 equivalent emissions with land use, land-use change and forestry									6520,21
Total CO_2 equivalent emissions, including indirect CO_2, without land use, land-use change and forestry									NA
Total CO_2 equivalent emissions, including indirect CO_2, with land use, land-use change and forestry									NA

(1) For carbon dioxide (CO_2) from land use, land-use change and forestry the net emissions/removals are to be reported. For the purposes of reporting, the signs for removals are always negative (-) and for

(2) See footnote 7 to table Summary 1.A.

(3) In accordance with the UNFCCC Annex I inventory reporting guidelines, for Parties that decide to report indirect CO_2, the national totals shall be provided with and without indirect CO_2.

Annex 3 The national system for the GHG inventory and for policies, measures and projections

In accordance with the Kyoto Protocol, as well as the associated Decision 24/CP.19, as well as EU Monitoring Mechanism Regulation (EU/No/525/2013), Sweden has established a national system for greenhouse gas inventory. The Swedish national system for policies and measures and projections aims to ensure that the policies, and measures and projections to the Secretariat of the Convention (UNFCCC), the Kyoto Protocol and the European Commission are reported in compliance with specified requirements.

The Swedish national system for GHG inventory came into force on 1 January 2006, and a national system for policies and measures and projections was set up in 2015. In relation to legal arrangements, the information is the same for the two systems.

On 29 December 2014, the Ordinance on Climate Reporting (SFS 2014:1434) came into force in Sweden. The ordinance describes the roles and responsibilities of government agencies in the context of climate reporting and concerns both the GHG inventory and the reporting of policies, measures and projections. This led to several changes in Swedish reporting such as enlarging the national system, adding other agencies, as well as adding responsibilities for agencies already included. The ordinance requires that sufficient capacity be available for timely reporting.

9.10 The national system for preparing the Swedish GHG inventory

The Swedish national system for GHG inventory was established in 2006 in accordance with 19/CMP.1, 20/CP.7 and decision 280/2004/EC. In 2013, EU decision No 280/2004/EC was replaced by the Monitoring Mechanism Regulation 525/2013/EC. The Monitoring Mechanism Regulation has the same demands for national systems as the Monitoring Mechanism decision. The aim is to ensure that climate reporting to the secretariat of the Convention (UNFCCC), the Kyoto Protocol, and the European Commission complies with specified requirements. The national system for GHG inventory is described in detail every year in Sweden’s annual National Inventory Report, submitted to the UNFCCC Secretariat. The KP reporting of LULUCF uses the same institutional arrangements, national system and corresponding QA/QC procedures as for the UNFCCC reporting.

9.10.1 Legal arrangements

The legal basis for Sweden's national system is provided by the Ordinance on Climate Reporting (2014:1434), which describes the roles and responsibilities of the relevant government agencies in this area. The ordinance ensures that sufficient capacity is available for reporting. The previous ordinance concerning climate reporting (2005:626) was updated and expanded to fulfil the reporting requirements under the second commitment period under the Kyoto Protocol and the EU Monitoring Mechanism Regulation 525/2013/EC. It also includes other improvements needed on the national level. The new ordinance came into force in December 2014, superseding the previous ordinance.

Supplemental to the new ordinance, formal agreements between the Swedish Environmental Protection Agency and other national agencies have been signed, listing in detail what is required regarding content and timetable from each responsible agency. Sweden also has legislation indirectly supporting climate reporting efforts by providing a basis for estimating greenhouse gas emissions and removals.

Environmental reports are submitted under the Environmental Code (SFS 1998:808), and the Official Statistics Act (SFS 2001:99) imposes an obligation for large industries to submit annual data. In addition, government agencies in Sweden must comply by the Information and Secrecy Act (SFS 2009:400).

The General Statistics Act (SFS 2001: 99) and the associated Ordinance (2001:100) Concerning Official Statistics impose an obligation on companies and other organizations to submit annual data. The data then serve as a basis for estimating greenhouse gas emissions and removals in several sectors.

According to Directive 2003/87/EC and national Act (2004:1199) on emission trading, emission data for plants included in the emission trading system should be reported annually. These data are used as a supplementary source within this greenhouse gas inventory.

9.10.2 Insitutional arrangements

Preparing the annual inventory and other reports is done in collaboration between the Ministry of Climate and Enterprise, the Swedish Environmental

Protection Agency and other government agencies and consultants. Sections 13-27 of the Ordinance on Climate Reporting (2014:1434) describe the tasks of the government agencies in the context of the yearly inventory and reporting activity. The illustration in Figure A3.1 and the associated text below describe in broad terms which organizations are involved in the work of compiling documentation for the yearly inventory report and for other reporting to the European Commission and the UNFCCC.

Depending on the role of the government agencies in climate-reporting activity, this responsibility may range for example from supplying data and producing emission factors/calorific values to carrying out calculations to estimate emissions. Agencies that have a responsibility to participate in the national peer review are indicated in bold text in Figure A3.1 In addition to what is described in the Ordinance, the Swedish Environmental Protection Agency (Swedish EPA) engages the SMED[219] consortium as consultants to conduct the greenhouse gas inventory.

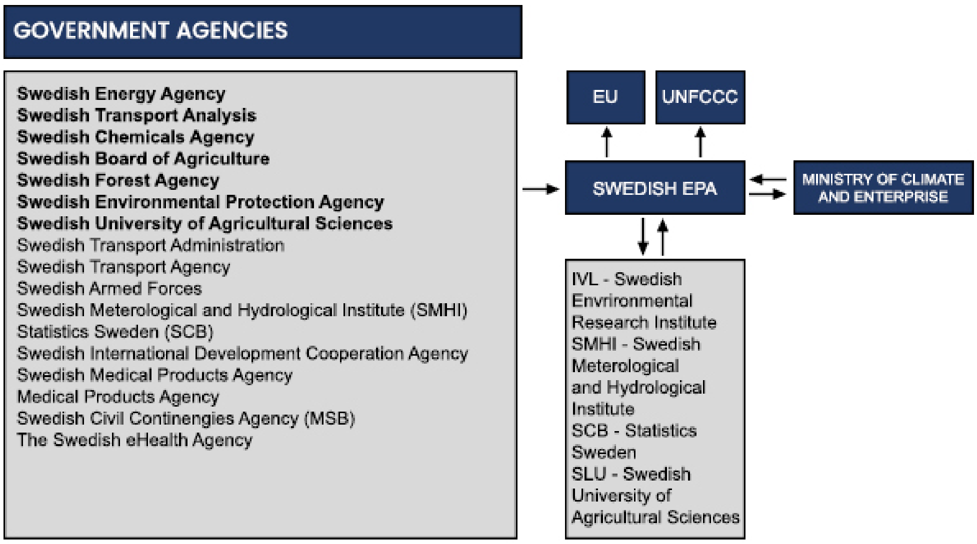

Figure A3.1. The Swedish national system for GHG inventory.

[219] SMED = Svenska MiljöEmissionsData (Swedish Environmental Emissions Data), a consortium comprising Statistics Sweden (SCB), the Swedish Meteorological and Hydrological Institute (SMHI), IVL Swedish Environmental Research Institute and the Swedish University of Agricultural Sciences (SLU).

To be able to report according to decision 24/CP.19 and IPCC methodology guidelines from 2006 and in accordance with 525/2013/EC the national system has been enlarged by three governmental agencies; the Medical Products Agency, the Swedish Civil Contingencies Agency and the Geological Survey of Sweden.

9.10.3 Contact details or organisation responsible

The Swedish Ministry of Climate and Enterprise is the single national entity and has overall responsibility for the inventory.

Postal address	SE 103 33 Stockholm, Sweden
telephone	+46 8 405 10 00

UNFCCC focal point:
Mr. Mattias Frumerie
M.climate@regeringskansliet.se

9.10.4 Inventory planning, preparation and management

The Swedish greenhouse gas inventory is compiled in accordance with the reporting guidelines drawn up by the Intergovernmental Panel on Climate Change (IPCC), KP and the UNFCCC. The national system is designed to ensure the quality of the inventory, i.e. to ensure its transparency, consistency, comparability, completeness and accuracy. The Swedish quality system is based on the structure described in UNFCCC decision 20/CP.7 and applies a PDCA (plan–do–check–act) approach. This is an adopted model for how systematic quality and environmental management activity is to be undertaken according to international standards to ensure that quality is maintained and developed.

9.10.4.1 Planning and development

In any given year, priorities are set since recommendations received from international and national reviews, the results of key category analysis, uncertainty analysis, ideas for improvements from the Swedish EPA and SMED consultants, and new requirements arising from international decisions, amongst others.

Based on these criteria, the Swedish EPA commissions development projects, which are undertaken by SMED consultants. On completion of these projects, the results are implemented in the inventory.

9.10.4.2 Preparation

Government agencies supply activity data to the Swedish EPA and SMED, which also gather activity data from companies and sectoral organisations, and from environmental reports. Emission factors may be plant-specific, developed at a national level, or IPCC default factors. Methods used to estimate emissions comply with current requirements and guidelines.

9.10.4.3 Quality control and quality assurance

All data are subjected to general inventory quality control (Tier 1), as described in the IPCC Good Practice Guidance (2000), Table 8.1. Certain sources also undergo additional checks (Tier 2). All quality control is documented by SMED in checklists. Data are also validated using the checks built into the CRF Reporter tool.

Quality assurance is carried out in the form of a national peer review by government agencies, as provided in the Ordinance on Climate Reporting (2014:1434). This national review covers choice of methods, emission factors and activity data and is a guarantee of politically independent figures. The reviewers also identify potential areas for improvement in future reporting. Their findings are documented in review reports. The timetables for quality assurance are included in the agreements between the government agencies and the Swedish EPA. The government authorities conducting the national review are marked in bold in Figure 1.19. From the 2016 submission, quality assurance is conducted in two steps, with an annual quality control and verification of the trends, national statistics used and changes in methods, if any. Every year there is also an in-depth review of one sector. In addition, reporting is reviewed annually by the EU and UNFCCC.

An in-depth review of each sector will take place every five years as long as there are no specific recommendations from the EU or UNFCCC reviews, there were no changes in methodology, or the first-step review did not signal any problems. Sweden has also initiated meetings with experts from

Denmark, Finland and Norway where GHG inventory compilers discuss problems, the need for revised methods and other relevant matters.

9.10.4.4 Finalisation, publication and submission

The results are published nationally by the Swedish Environmental Protection Agency in late November or early December each year. The Swedish EPA delivers the greenhouse gas inventory to the Ministry of Climate and Enterprise five working days before the preliminary reporting to European Commission (January 15th).

The Swedish EPA, on behalf of the Ministry of Climate and Enterprise, submits the inventory to the European Commission on January and March 15th and to the UNFCCC on April 15th. Reported data in the submission of year *t* relates to the series of emissions years from 1990 up to and including year *t*-2, in other words emissions which took place during 2019 are reported in early 2021.

9.10.4.5 Follow up improvements

Each year, all comments received from national and international reviews that are not already addressed and also ideas from SMED and the Swedish EPA are compiled into a list for suggestions on improvements. From this list, development projects are formed each year. All suggestions not implemented one year is kept on the list for next year. In addition, improvements related to transparency of the NIR are continuously addressed in response to questions raised by national experts during the national peer review, and in response to previous ERT recommendations.

9.10.5 Description of process and methodology for key source identification

The process and methodology for identifying Key Categories (including and excluding LULUCF) are presented below.

The analysis has been made for the base year and the latest year using the approach 1 and approach 2 levels and trend assessment according to the methods described in the 2006 IPCC guidelines. The approach 1 method assesses the impacts of various source/sink categories on the level and the trend of the national emission inventory. The approach 2 method includes information on uncertainties.

In the approach 1 analysis key categories are the aggregated categories that together contribute up to either 95% of the level or 95% of the overall contribution to trend of all greenhouse gas emissions in Sweden. In the approach 2 analysis, information about the sources' uncertainties are also included in the analysis. Approach 2 key categories are those that add up to 90% of the contribution to level and trend in the national inventory.

The analysis is performed for all direct greenhouse gases, i.e. CO2, CH4, N2O, HFCs, PFCs and SF6, with all emissions converted to CO2-eq.

Approach 1 level assessment

The contribution of each source or sink category to the total national inventory level is calculated as:

$$L_{x,t} = \left|E_{x,t}\right| / \sum_{y} \left|E_{y,t}\right|$$

Lx,t= level assessment for source or sink x in latest inventory year (year t).

│Ex,t│ = absolute value of emission or removal estimate of source or sink category x in year t

∑│Ey,t│= total contribution, which is the sum of the absolute values of emissions and removals in year t calculated using the aktregation level chosen by the country for key category analysis. Because both emissions and removals are entered as absolute values, the total contribution/level can be larger than a country's total emissions minus removals.

Key categories are those that, when summed together in descending order of magnitude, add up to 95% of the sum of all $L_{x,t}$.

Approach 1 trend assessment

For the latest inventory year (year t), the trend assessment is calculated for each source or sink category and each GHG. If inventory data are available for both the base year and year t the trend assessment is calculated as (in accordance with the 2006 IPCC guidelines):

$$T_{x,t} = \frac{|E_{x,0}|}{\sum_y |E_{y,0}|} = \left| \left[\frac{(E_{x,t} - E_{x,0})}{|E_{x,0}|} \right] - \frac{\left(\sum_y E_{y,t} - \sum_y E_{y,0} \right)}{\left| \sum_y E_{y,0} \right|} \right|$$

$T_{x,t}$= trend assessment of source or sink category *x* in year *t* as compared to the base year (year 0)

$|E_{x,0}|$ = absolute value of emission or removal estimate of source or sink category *x* in year 0

$E_{x,t}$ and $E_{x,0}$ = real values of estimates of source or sink category *x* in years *t* and 0, respectively

$\sum E_{y,t}$ and $\sum E_{y,0}$ = total inventory estimates in years *t* and 0, respectively

If there is no base year emission for a given category the trend assessment is instead calculated as:

$$T_{x,t} = \left| E_{x,t} / \sum_y |E_{y,0}| \right|$$

Approach 2 level and trend assessments

When the information from the approach 1 key categories analysis is combined with the outcome from the uncertainty analysis, it results in an approach 2 key category analysis. IPCC encourages inventory compilers to use this approach if possible. It will provide additional insight into the reasons why particular categories are key and will assist in prioritizing activities to improve inventory quality and reduce overall uncertainty. The level and trend assessment including uncertainty is calculated as:

$$LU_{x,t} = (L_{x,t} \times U_{x,t}) \quad , \quad TU_{x,t} = (T_{x,t} \times U_{x,t})$$

Where $L_{x,t}$ and $T_{x,t}$ are the results from the approach 1 level and trend analysis, respectively. $U_{x,t}$ is the category percentage uncertainty in year *t* calculated as described in Annex 7. The key categories are those that add up to 90% of the sum of all $LU_{x,t}$ or 90% of the contribution to trend and $TU_{x,t}$, respectively, when ranked by decreasing order of magnitude.

Results

The results if key categories can be found in Sweden's National Inventory Report 2023[220] in Annex: 1: Key Categories chapter 1.2 Results.

9.10.6 Information on changes in the national system for GHG inventory

There have been no changes in the Swedish national system since the previous Biennial Report or National Communication.

9.11 The national system for policies and measures and projections

According to Article 39 of Regulation (EU) No 2018/1999 of the European Parliament and the Council on Governance of the Energy Union and Climate action, every member state needs to have a national system for policies and measures and projections. The Swedish national system for policies and measures and projections was established in 2015[221]. Its aim is to ensure that policies and measures and projections are reported in compliance with specified requirements to the Secretariat of the Convention (UNFCCC), the Kyoto Protocol (19/CMP.1) and the European Commission.

9.11.1 Legal arrangements

The legal basis for Sweden's national system for policies and measures and projections is the same as for the annual greenhouse gas inventory and is provided by the Ordinance on Climate Reporting (SFS 2014:1434). See more information on the Ordinance under section 1.2.1.1. The Ordinance includes all reporting on policies and measures and projections according to EU/No 2018/1999 of the European Parliament and the Council on Governance of the Energy Union and Climate action.

Accompanying the Ordinance on Climate Reporting, formal agreements between the Swedish EPA and the agencies concerned have been established, specifying in detail the content and timeframe for each agency for providing information on policies and measures and projections.

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[220] https://unfccc.int/documents/627663

[221] Regulation (EU) No 525/2013 on a mechanism for monitoring and reporting greenhouse gases.

9.11.2 Insitutional arrangements

To prepare the reporting on policies and measures and projections, cooperation takes place between the Ministry of the Environment, the Swedish EPA and other government agencies, see Figure A3.2).

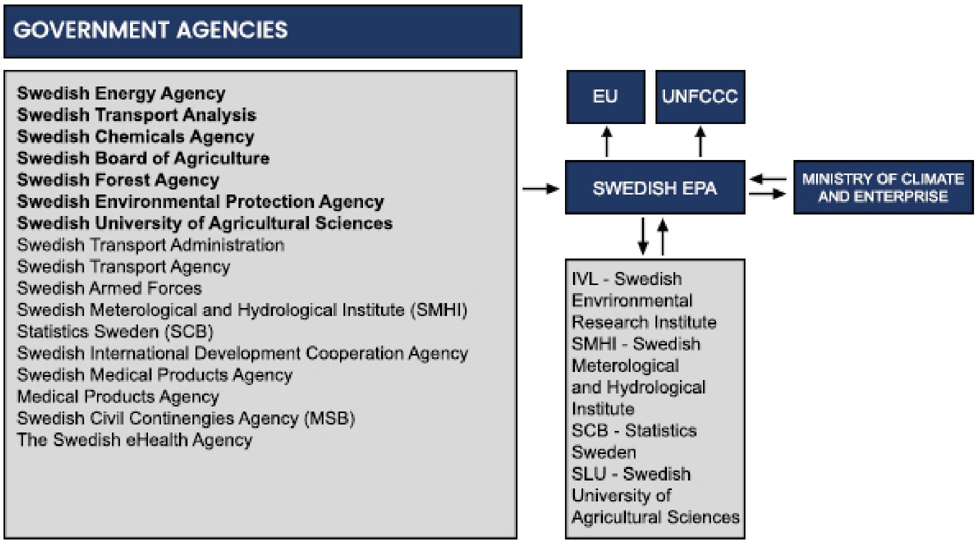

Figure A3.2 Government agencies included in the Swedish national system for reporting on policies, measures and projections.

The Ministry of the Environment is responsible for the national system and for ensuring that Sweden meets international reporting requirements in the area of climate change.

The Swedish EPA is responsible for producing the reports for the required reporting. The agency is thus responsible for coordinating Sweden's national system and for maintaining the necessary reporting system.

The other government agencies are responsible for providing the data and documentation necessary for reporting. In some cases, the agencies are responsible for peer review of different sectors.

The same contract with consultants (SMED[222]) as for the GHG inventory is used in the institutional process of policies and measures and projections.

9.11.3 Contact details or organisation responsible

The contact details are the same as for Sweden's national system for the GHG inventory (section 9.10.3).

9.11.4 Inventory planning, preparation and management

The national system is designed to ensure the quality of the reporting on policies and measures and projections, i.e. to ensure its transparency, consistency, comparability, completeness, accuracy and timeliness. The process for reporting applies a plan-do-check-act approach.

9.11.4.1 Planning and development

The national system is designed to ensure the quality of the reporting on policies and measures and projections, i.e. to ensure its transparency, consistency, comparability, completeness, accuracy and timeliness. The process for reporting applies a plan-do-check-act approach.

The report on policies and measures and projections is planned in due time before reporting. The report is compiled and includes quality control activities.

Work on the report on projections starts one year ahead of submission and includes planning and defining assumptions and sensitivity analysis. Underlying projections on activity data are provided by several government agencies. The projections on emissions are then produced and compiled by the Swedish EPA.

Work on the policies and measures (PaMs) report starts one year before submission and includes planning activities. The information on policies and measures is gathered by the Swedish EPA. Government agencies, in accordance with the Ordinance, then perform quality assurance activities.

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[222] SMED = Svenska MiljöEmissionsData (Swedish Environmental Emissions Data), a consortium comprising Statistics Sweden (SCB), the Swedish Meteorological and Hydrological Institute (SMHI), IVL Swedish Environmental Research Institute and the Swedish University of Agricultural Sciences (SLU).

9.11.4.2 Preparation

The relevant assumptions, methodologies and models for producing the report on policies and measures and projections, are selected when planning the report. The work is based on established methods and models that have been used for many years and assessed to be the most relevant and suitable. The methodologies and models are continuously assessed and improved. Assumptions are made based on available data and on expert knowledge. Several government agencies are responsible for providing data according to the Ordinance and agreements. The Swedish EPA collects the additional data needed for reporting on policies, measures and projections and produces the reports.

9.11.4.3 Quality control and quality assurance

To ensure timeliness, transparency, accuracy, consistency, comparability and completeness, quality control activities are performed in parallel with work on projections and compilation of the information on policies and measures. Quality assurance activities are then performed according to the Ordinance before the report is finalised and submitted.

The timetables for quality assurance are included in the agreements between the government agencies and the Swedish EPA.

All data are subjected to general quality control activities throughout the process before submission. Quality assurance is carried out in the form of a national peer review by relevant government agencies, as provided in the Ordinance. The national review covers transparency, completeness, consistency, accuracy and comparability.

9.11.4.4 Finalisation and submission

After quality assurance activities and, if necessary, adjustments of the report, the Swedish EPA submits the reports to the EU on 15 March biennially.

9.11.4.5 Follow-up and improvements

The review identifies potential areas for improvement in future reporting. The findings are documented in the review report. For projections, sensitivity analysis are performed by applying a range of lower and higher estimates to the key assumptions.

9.11.5 Information on changes in the national system

There have been no changes in the Swedish national system since the previous National Communication.

9.12 References

19/CMP.1, Guidelines for national systems under Article 5, paragraph 1, of the Kyoto Protocol

24/CP.19, Revision of the UNFCCC reporting guidelines on annual inventories for Parties included in Annex I to the Convention

EU/No/525/2013, Regulation No 525/2013/EC on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information and Union level relevant to climate change and repealing decision No 280/2004/EC

National Inventory Report Sweden 2022, Greenhouse gas emission Inventory 1990–2020, Submitted under UNFCCC and the Kyoto Protocol.

SFS 2009:400, Svensk författningssamling, Offentlighets- och sekretesslag,

SFS 2009:400. SFS 2014:1434, Svensk författningssamling; Klimatrapporteringsförordning, 2014:1434

Annex 4 The national registry

Contact details The Swedish Emission Registry Team	
Phone	+46 16 544 2300
Email	emissiontrading@swedishenergyagency.se
The Internet address of the interface to Sweden's national registry	https://unionregistry.ec.europa.eu/euregistry/SE/index.xhtml

Public information on the national registry is available on the webpage of the Swedish Energy Agency that can be accessed online.[223]

According to EU directive 2003/87/EG, each Member State is required to establish and operate a national registry for transactions of allowances in the EU's Emissions Trading System (EU ETS). The registries system ensures the accurate accounting of transactions in emission allowances under the EU Emissions Trading System (EU ETS).

On 16 October 2008, all the registries set up under the EU ETS established a direct connection to the UN's International Transaction Log (ITL). This made possible transfers of international emission units (assigned amount units, AAUs) and reduction units (certified emission reductions, CERs, and emission reduction units, ERUs) between registries operating under the Kyoto Protocol.

Since 20 June 2012, the EU has used a single, consolidated IT platform for the EU ETS, known as the Union Registry. Responsibility for hosting the registry and developing the associated software rests with the EU Commission. All registries are located on a consolidated IT platform that shares the same infrastructure technology. The chosen architecture implements methods to ensure that the consolidated national registries are uniquely identifiable, protected and distinguishable from each other. All the

[223] https://www.energimyndigheten.se/en/sustainability/emissions-trading/about-emissions-trading/public-information-in-emissions-trading/

national registries within the EU are thus identical in terms of maintenance and basic security standards.

The change to a consolidated system of EU registries triggered changes to data integrity measures to safeguard, maintain and recover data, as reflected in the updated disaster recovery plan. The complete description of the consolidated registry is provided in the common readiness documentation and specific readiness documentation for the national registry of EU and all consolidating national registries.

The functions of the registry are governed by a special EU Regulation. The Union Registry conforms to UN and European Commission technical data exchange standards (UNFCCC Data Exchange Standard (DES version 1.1.9) and Commission Regulation (EU) No 389/2013 establishing a Union Registry – the Registry Regulation), and has advanced functions for issuance, external transactions, cancellation and retirement, and for reconciliation of data with the ITL.

The Swedish Energy Agency, as the national administrator, is responsible for all administration for users on behalf of the Swedish section of the Union Registry. Processes are performed by three national administrators at the Swedish Energy Agency. Each member state's registry administrators are mainly responsible for acting as the contact point with their respective account holders in the Union Registry and performing all operations involving direct contact with them. The registry administrator is also a point of contact with the EU Commission and its helpdesk.

The changes introduced since version 8.0.8 of the national registry are listed in Annex B in NIR. Both regression testing and tests on the new functionality were successfully carried out prior to release of the version to Production. The site acceptance test was carried out by quality assurance consultants on behalf of and assisted by the European Commission.

To minimise the risk of inconsistencies in data between the Swedish Union registry, the ITL and the European Union Transaction Log (EUTL), a transaction is always executed in accordance with the requirements of the DES. A transaction is not completed until all the registries have received confirmation that it is recorded on the servers concerned. If a transaction initiated in the Swedish section of the registry contains a deviation, this will be identified by the ITL or EUTL sending a message with an error code. If an error code is sent, the transaction is terminated in the registry. An error message is presented to the person initiating the transaction. If the registry fails to terminate the transaction, the registry administrator notifies the central administrator of this, with a view to obtaining instructions on any action to be taken. Each member state's registry administrator can make manual corrections on behalf of the central administrator of the ITL or EUTL.

Annex 5 Projections methodology and calculations assumptions

Methodology

Different projection methods are used for different sectors. The methods that have been used to draw up the projections in this report are described in this section.

Energy sector

Projections for greenhouse gases for the energy sector are based on projections for the whole energy system. Projections for carbon dioxide emissions from the energy sector are drawn up by multiplying the total consumption of each fuel by the corresponding emissions factors. The energy projections, together with expert assessments of future emissions factors, have provided the basis for the projections of methane and nitrous oxide from incinerators.

Different models are used for each sub-sector in drawing up projections of trends in the energy system. The Times-Nordic model is used to make projections for electricity and heating production. Demand in the sub-sectors, taxes and other policy instruments, fuel prices and economic and technical development are used as input data for Times-Nordic. Times-Nordic is a dynamic optimization model. Most of the methods and models used to project development in the energy sector are based on a bottom-up perspective. Model results for different sub-sectors are coordinated so that weighted projections for the whole energy system are finally obtained. The process is described in Figure A.1. Expert assessments are an important element in all stages of the process.

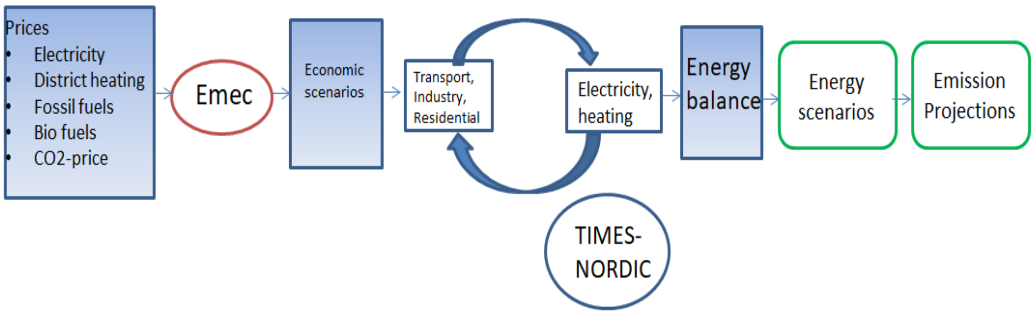

Figure A.1 Projection process for emissions from the energy sector.

A starting point in the projection work on the development of the energy system in the short and long-term is assumptions on economic trends, both in Sweden and internationally. The economic variables included in the work on energy projections mainly consist of estimates of the trend in gross domestic product, private and public consumption, disposable income and trends in value-added for industry and commerce. For industry, estimates of economic development at the level of individual branches of industries are included.

Projections on economic development are drawn up using a general equilibrium model, EMEC, by the National Institute of Economic Research. Input data for projections on economic development are harmonized with projections on the development of the energy system by the National Institute of Economic Research and the Swedish Energy Agency. The economic growth generated by the EMEC model is governed firstly by access to production factors such as labor and capital and secondly by technical development, which are given exogenically in the model. The advantage in using this type of model is that it encompasses the whole economy. The model is therefore able to capture repercussions between sectors, for example a change of tax or the introduction of emission caps. The total economic impact is therefore captured in a more complete way than in partial models.

Another important basis for projections on trends in the energy system is the fossil fuel prices received from the EU. A model is used to convert international fossil-fuel prices for crude oil and coal to domestic user prices, paid by the final consumer, as crude oil has to be refined into finished motor fuels and fuels for heating before it can be used on the Swedish market.

Electricity and district-heating production

The projections on fuel use for electricity and district-heating production are based on the Times-Nordic model. The demand for electricity and district heating is exogenic data for the model which, through its optimisation algorithm, works out the most cost-effective fuel mix for the whole energy system, i.e. including energy use in the user sectors. Times-Nordic represents all Nordic countries (excluding Iceland) and permits electricity trade between neighboring countries. Not just the Swedish energy system, but the Nordic energy system, is therefore optimised.

Residential and commercial/institutional sectors

The projections of energy use in the residential and commercial/institutional sectors are drawn up by combining the model results from Times-Nordic and assessments by experts. Times-Nordic also models the competition for different heating systems in buildings. Different variables such as electricity and fuel prices, population development, potential for different heating systems, investment costs of heating systems, levels of efficiency and energy efficiency improvement are assumed.

Industry sector

The projections on energy use in the industry sector come from an Excel-based model with the energy use in industries linked to economic relations (value added and production value) and energy prices. The energy use is primarily based on assumptions of economic development and energy prices. This result is harmonised through contacts with energy-intensive companies and industry organisations. Account is also taken of the results of the Times-Nordic energy system model.

Transport sector

The projections on carbon dioxide emissions from the transport sector are calculated on the basis of projections of energy use in the transport sector. The calculation of emissions of other greenhouse gases is based on the change in transport activity, number of vehicles in different vehicle types (e.g. fitted with catalytic converter) and emissions factors. The transport sector has been divided into four sub-sectors: road traffic, air traffic, rail traffic and shipping.

The projections for road transport are based on assessments on transport demand and on the development of the vehicle fleet. The demand for transport with passenger cars is expected to be mainly influenced by demography, fuel prices and income in households, while the demand for freight transport is based on assumptions on economic development and trading overseas. The development of the vehicle fleet is based on the assumptions on the allocations of fuels and annual efficiency, which are a result of existing instruments and historical trends. The projections for aviation, navigation and railways are based on assumptions on transport demand and future efficiency.

Industrial processes

Carbon dioxide emissions from industrial processes have been calculated using an Excel-based trend analysis of historical emissions. In addition to official statistics, data and other information from industry organisations and companies have been used to obtain more detailed knowledge on the industries and emissions concerned.

Waste sector

Emissions from landfills in the waste sector are calculated using a model developed by the IPCC that has been partially modified to better represent conditions in Sweden. Results from the model calculations are also compared with results from field measurements. The method is based on figures on quantities of landfilled waste from 1952, the organic content of waste, the gas potentials of different types of waste and emissions factors.

Agricultural sector

Projections of activity data for the agricultural sector are based on results from an economic equilibrium model; the Swedish Agricultural Sector model (SASM), which is based on assumptions on production and future agriculture policy. The projected activity data is used to calculate future emissions in the same way as is done for current emissions within the climate reporting process. Activity data includes figures related to numbers of livestock, manure production, stable period, methods for manure management and annual balances of nitrogen flows to and from agricultural land.

Land Use, Land-Use Change and Forestry sector

The projections for net removals in *Forest land* in the Land Use, Land-Use Change and Forestry sector are mainly estimated using the Heureka Regwise modelling tool. The model simulates the future development of the forests based on assumptions on how they are managed and harvested. The calculations encompass biomass in living trees and dead wood on forest soil in productive forests. In the projection, net removal in these pools are calculated as the difference between the stocks at different times. The emissions/removals in the soil organic carbon pool and the dead organic matter pool are based on the trend in these pools as reported in the latest submission.

For *Cropland* and *Grassland*, the average net annual emissions/removals per hectare for each carbon pool for the latest ten reported years are used together with the projected area of these land use categories. The projected emissions/removals for each reported carbon pool for *Wetlands* and *Settlements* are assumed to be constant and estimated as the mean over the latest ten years as reported in the latest submission. The net removals for HWP are estimated based on the projected harvest from the Heureka-Regwise-model and the assumption that available biomass is distributed to the different product groups in the same way as in current distribution, i.e. as an average of the five latest years in the latest submission.

Assumptions underlying the calculations

Calculation assumptions for energy sector

General assumptions on which estimates for the energy sector are based:

- Within the EU emissions trading scheme, a price of 30 euros was assumed per tonne of carbon dioxide 2030 and 53 euros per tonne 2040 (in 2016 price).
- Based on the decision in force regarding the Swedish-Norwegian electricity certificate system, it was assumed that the system is operational during the whole projection period and will lead to an increase of 28.4 TWh of new renewable electric power production in 2020 compared to 2012's level. This production goal is considered consistent after year 2020 and the system operational until 2040.
- In general, current taxes and other instruments (in place first of July 2020) are assumed to remain unchanged until 2040.
- National Institute of Economic Research estimates of economic development (%/year):

	Reference	
	2015-2035	2035-2040
GDP	1.72	1.76
Private consumption	1.87	2.22
Export	2.58	2.59
Import	2.60	2.70

- The trends in fossil fuel prices are given by the European Commission (2016 prices)

	Base year	Reference		
	2018	2020	2030	2040
Crude oil (USD/barrel)	68	42	89	103
Coal (USD/tonnes)	93	53	86	98
Natural gas (USD/Mbtu)	6	4	6	8

Assumptions on which estimates for energy industries are based:

- 2 of Sweden's 8 reactors have shut down until 2020. This leads to a decrease of the nuclear capacity in Sweden. The remaining nuclear power plants are assumed to have an economic working life of 60 years, which means no decommission during the projection period.
- Projections of the Swedish sector price for electricity for the years 2030 and 2040. (Annual average, 2016 price level in SEK/kWh)

	2018	2030	2040
Electricity price	0.46	0.33	0.50

- Electricity production from hydropower (incl. small-scale hydropower) and nuclear power production has been assumed to be, in TWh:

	2018	2030	2040
Hydropower	62	67	68
Nuclear power production	66	52	52

- For the refinery sector, the emissions are assumed to increase during the projection period, in accordance with the expansion plans of this sector. Counteracting measures for higher efficiency of 5 % in 2040 compared to 2019 are assumed.
- A shift to fossil-free technology is assumed for a part of the manufacturing of solid fuels

Assumptions on which estimates for residential, commercial/institutional and combustion in agricultural, forestry and fishing sectors are based:

- The projections on energy use in households, premises and combustion in the agricultural, forestry and fishing sectors are based on assumptions on future temperature conditions, population trend, stock of housing and commercial premises, energy prices, investment costs, technological development and economic development.
- Future temperature conditions are based on IPCC scenario RCP 4.5.[224]
- Population growth (Statistics Sweden)

	2018	2030	2040
Population	10 230 185	11 094 873	11 529 973

- The number of new apartments in single-dwelling houses and multi-dwelling houses in the projection is assumed to increase by 295 000 from 2019 to 2025 and by 526 000 from 2025 to 2050.
- Heated area of new single dwelling houses and new apartment buildings is assumed to be 150 m^2 and 65 m^2 respectively.
- The projections for energy use from working machinery in agricultural sector are based on the projections in the agriculture sector. For working machinery in forestry the projections are based on projections of different processes in forest management.

Calculation assumptions for industry

Assumptions on which estimates for industrial combustion are based:

- The projection for manufacturing industries is based on assumptions on the economic development for the respective industry, the extent of energy efficiency efforts and assumptions on future fuel and energy prices.
- Annual growth in value-added between 2015-2035 and 2035-2040 (National Institute of Economic Research):

Industry	Annual growth (%) 2015-2035	Annual growth (%) 2035-2040
Pulp and paper industry	2.05	1.33
Chemical industry	1.80	2.05

[224] RCP : Reference Concentration Pathway

Iron and steel industry	0.29	0.16
Manufacture of non-metallic mineral products	1.20	1.21
Non-ferrous metalworks	1.07	0.83
Engineering industry	1.33	1.55

Assumptions on which estimates for industrial processes and product use are based:

- The projection is based on historical trends as well as economic projections for each industry.
- The assumption on projected value added is the same as those for manufacturing industries.

Assumptions on which estimates for transport are based:

- The transport projections are based on several assumptions regarding number of inhabitants, disposable income of households, GDP, fuel price, exports and imports. Of importance are also assumptions regarding technical development, energy efficiency, mileage and introduction of renewable fuels.
- Traffic volume for cars in the projections is based on the historical relationships between traffic volume trends, GDP and cost of driving.
- Traffic volumes for light-duty lorries and heavy-duty lorries in the projection are based on the respective relationships between the traffic volume trends and GDP.
- The tax exemption for pure and high-blended biofuels is enforced from 2018-2020, after 2020 no decision on its future has been made meaning the competitiveness for high-blended biofuels and pure biofuels is worsened, meaning less of these fuels (E85, ED95, FAME100 and HVO100) is used.
- EU emission regulations set for cars, heavy-duty vehicles and light duty vehicles respectively.
- Fuel prices, SEK/litre, including tax and excluding VAT, 2018-year fixed prices

Fuel prices, SEK/litre, including tax and excluding VAT, 2018-year fixed prices	2018	2040
Petrol, with low-blend ethanol	12.3	17.7
Diesel, with low blend biodiesel	12.3	19.4

- Since July 1st 2018 there is no exemption from carbon and energy tax on bio-diesel and bio-petrol that is blended with components from non-renewable sources, no matter the level of renewable content. The same tax levels as of today are assumed during the whole period. The low blending of HVO and ethanol is assumed to increase aligned with the emission reduction obligation until 2020. After 2020 the level of low-blending of HVO in diesel is assumed to be unchanged and the volume of low-blended HVO is thus solely dependent on the diesel usage and the same assumption is made for low-blending of ethanol in petrol. Renewable fuel (except biogas) that is sold without being blended with non-renewable fuel is fully exempted from tax in 2020, where after the exemption is removed.

Calculation assumptions for the waste sector

Assumptions on which estimates the waste sector are based:

- The projections are based on the existing policies and measures for reduced landfilling of organic waste, such as the prohibition of landfilling and landfill tax, and have been calculated partly on the basis of estimates of future quantities of landfilled waste, the emergence of alternative treatment capacity and future efficiency in gas recovery at landfills.
- The projections of emissions from biological treatment of solid waste are based on assumed continued increasing production.

Calculation assumptions for the agriculture sector

Assumptions on which estimates the agriculture sector are based:

- The projections are based on assumptions on prices, productivity and available areas and buildings.
- The prices are based on average prices for 2013-2017 in Sweden and price projections from OECD/FAO[225], extrapolated to 2040.
- Assumed growth in productivity per year:

	Change per year
Harvest	+0.5%

[225] OECD/FAO. 2018. OECD-FAO Agricultural outlook 2018-2027. OECD Publishing.

Milk yield	+1%
Swine per sow	+1,5%
Supplies	-0.5%
Labour	-1.5%

- Assumed availability of buildings: 35 % of current buildings are assumed to be in use in 2030 with only maintenance needed, 13% are disposed and 52 % can be used if renovations are made.
- The common agricultural policy (CAP) in 2019 is assumed to continue until 2040.

Calculation assumptions for the LULUCF sector

Assumptions on which estimates the LULUCF sector are based:

Forest land

- The reported projection is based on a projection assuming that current harvest intensity (2015-2019) persist over time. The harvest level was estimated to 84% of the growth available for harvest on productive forest land.
- Other settings are based on the projection in an analysis of the forest development (SKA-15) in terms of management, climate effect and nature conservation.[226]
- The reported projection is based on a projection in which felling is assumed to not be higher than what is considered as sustainable in the long term.
- The structure of the standing stock at the start of the model simulation is based on the Swedish National Forest Inventory (NFI) which also forms the base for the annual reporting under the UNFCCC and the Kyoto protocol.
- In the projection current forest management practices are assumed, including environmental measures in forestry and environmental policy aimed at preserving biological diversity. This means that a total of 848 000 ha is set aside for nature conservation through legal protection and 1 332 000 ha is voluntary set aside by forest owners. Further 1 468 000 ha is left as retention patches within the forest used for timber production. The total forest land area used for

[226] Claesson, S., Duvemo, K., Lundström, A., & Wikberg, P.E. 2015. Skogliga konsekvensanalyser 2015 – SKA 15. Skogsstyrelsen. Rapport 10/2015.

timber production is 21 349 000 ha. The total simulated area consisted of productive forest land of 23 497 000 ha (including legally or voluntary set-aside areas and forest land used for timber production) and low-production forest land of 4 474 000 ha.

- In the projection a climate effect is included, based on the RCP 4.5 scenario (IPCC 2013) which gives a positive effect on the annual gross increment by 21 % 2070-2100 compared to 1970-2000.

Cropland, Grassland, Wetlands

- The projections for each carbon pool are based on the mean net annual carbon stock change for the period 2010-2019 as reported in the National Inventory Report, submission 2021.
- The mean annual carbon stock change per area is multiplied with the projected area. The projection assumes that the area continues to decrease at the same rate as the last 30 years period.

Settlements

- The projected emissions/removals for each reported carbon pool are assumed to be constant and estimated as a mean for the period 2010-2019 as reported in the National Inventory Report, submission 2021.

Harvested Wood Products (HWP)

- The net removals for HWP is estimated based on the projected harvest and the assumption that the available biomass is distributed on the different product groups equally as today.

Assumptions on which estimsates for the sensitive alternatives for the energy sector are based:

- Estimates of economic development (%/year):

	Reference		Lower GDP		Lower fossil fuel prices	
	2015-2035	2035-2040	2015-2035	2035-2040	2015-2035	2035-2040
GDP	1.72	1.76	1.42	1.26	1.77	1.84
Private consumption	1.87	2.22	1.43	1.57	2.02	2.26
Export	2.58	2.59	2.12	1.81	2.54	2.72
Import	2.60	2.70	2.14	1.94	2.64	2.75

- Import prices on fossil fuels and exchange rates, 2016 prices

	Base year	Reference and Lower GDP	Lower fossil fuel prices
	2018	2040	2040
Crude oil (USD/barrel)	68	103	45
Coal (USD/tonnes)	93	98	64
Natural gas (USD/Mbtu)	6	8	5

Annex 6 Financial, technological and capacity-building support

See the Additional tables to Sweden's Eighth National Communication (NC) on Climate Change under UNFCCC – Annex 6 (NC); Provision of financial, technological and capacity-building support.[227]

[227] https://unfccc.int/NC8

Annex 7 Information in accordance with Article 7.2 of the Kyoto Protocol

Reported information	NC8
National system for inventory of emissions and removals	Annex 3
National registry	Annex 4
Supplementary related to mechanisms under Article 6,12 and 17	Chapter 4.3
Policy instruments implemented to promote sustainable development (art 2)	Chapter 4.2
Initiatives in IMO and ICAO to reduce emissions from international transports	Chapter 4.2.8
Minimise adverse effects	Chapter 4.2.9
Minimise adverse effectsPrograms, legislative arrangements and administration procedures for implementation of the Kyoto Protocol	Chapter 4.1
Implementation of article 3.3 and 3.4 and contribution to conservation of biodiversity and of natural resources	Chapter 4.2.7
Information in accordance to article 10	Annex 3
a) Improve data for inventory of emissions	Annex 3
b) activities for emission limitation and adaptation	Chapter 4.2, 4.3
c) Activities for technical transfer and capacity building	Chapter 7.6 and 7.7
d) Cooperation in research and systematic observation	Chapter 8.2-8.5
e) International participation in information of training	Chapter 9.7
Finance resources and capacity building	Chapter 7.3 – 7.7