Sweden's Seventh National Communication on Climate Change

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Preface

Climate change poses an unprecedented threat to our lives and societies. It has immense consequences for human security across the globe. It is obvious that the way we organise our society and make use of natural resources are having a global long term impact on the ecosystem of our planet. The old model of achieving wealth through excessive use of natural resources has proved to be outdated. Some may argue that the call for a paradigm shift of development is too challenging. Sweden, however, sees a land of opportunities in transforming Sweden and the world towards sustainable development.

It falls on governments to demonstrate political leadership to realize the Paris Agreement. As governments, we should introduce the necessary legislation to provide a long-term and predictable environment for society. Sweden is willing to show leadership. The policy instruments introduced have had a significant effect so far, and emissions have fallen by around 25% in absolute numbers between 1990 and 2015, while the economy has grown by 75%. That is good, but far from enough. With broad support from the parliament the government introduced a climate policy framework with a climate act for Sweden in June 2017. This framework is the most important climate reform in Sweden's history and sets out implementation of the Paris Agreement in Sweden. The framework contains new ambitious climate goals, a climate act and plans for a new climate policy council. The framework contains the following climate goals for Sweden:

- Net zero emissions of greenhouse gases into the atmosphere by 2045, and thereafter negative emissions. Emissions from activities in Sweden must be at least 85% lower than in 1990. Based on current population forecasts for Sweden, this means that emissions in Sweden will be less than one tonne per person by 2045.
- By 2030, emissions from domestic transport, excluding domestic aviation, shall be reduced by at least 70% compared with 2010.
- Emissions in the sectors outside the EU emission trading scheme should be at least 63% lower in 2030 and at least 75% lower in 2040, as compared to 1990.

These goals mean Sweden undertakes to achieve emission reductions that far exceed Sweden's required emission reductions under EU legislation. Sweden therefore is already moving beyond the commitment by the EU within the Paris Agreement, and encourages other countries to do the same.

In this seventh Swedish National Communication 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 2020 and 2030. According to these projections, emissions will continue to decrease, and the national target for 2020 is within reach with national measures alone.

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

Stockholm, December 2017.

Isabella Lövin

Minister for International Development Cooperation and Climate

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1. Executive summary

1.1. Introduction

This is Sweden's Seventh National Communication (NC7), 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), fell by 25 % over the period 1990–2015 and are expected to continue to decrease. By 2020, aggregate emissions are projected to be 30 % below the 1990 level. By 2030 we expect a further reduction to 36 % below the 1990 level.

As part of the EU-28, 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 as a whole, 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. Sweden's population is 10 million and most people live in urban areas. Considering that Sweden is the fifth largest country in Europe, the population density is low with an average of 24.5 inhabitants per km^2. However, most people live in the southern part of the country and so the population density ranges from 3 per km^2 in the north to 121 per km^2 in the south.

Sweden has a land area of approximately 408,000 km^2 (excluding inland waters). Productive forest is the predominant land type (58 %), followed by wetlands (13 %), high mountains (12 %) and farmland (8 %). Settled areas account for 3 % of the total land area. Inland water systems total more than 40,000 km^2, or 9 % of the total area.

Most of Sweden has a temperate climate despite its northern latitude, with largely four distinct seasons and mild temperatures throughout the year. 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 reported –17°C. The maximum 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°C higher in the years 1991–2016 than in 1961–90. The largest rise, over 2°C, took place in the northern parts of Sweden in winter and the smallest was in the autumn, when the temperature in south-west Sweden remained almost unchanged.

Sweden has an open economy with exports accounting for 46 % of GDP. Natural resources, such as forest and iron ore, form the basis for Sweden's industrial production and have, along with the engineering industry, brought about a strong export-oriented economy. The service sector is important, accounting for 65 % of the economy in terms of value added. This is approximately three times the size of the manufacturing industry.

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. Of total electricity production in 2015 hydropower accounted for 47 %, nuclear power 34 % and

wind power 10 %, while biofuels and fossil-based production made up the remaining 9 %.

Between 1970 and 2015 the Swedish economy grew 155 % while total energy use only increased by 22 %. For instance, industrial production volume almost doubled, but industrial energy use rose by only just over 4 %. The residential and service sector reduced its energy use while the aggregate heated floor space both of homes and of commercial and institutional premises increased. In total, the overall energy intensity of the economy more than halved during the period.

Domestic transport is dominated by road traffic. Transport activity for passengers and goods alike has increased since 1970, but the trends are somewhat different. Passenger transports more than doubled, while goods transports grew by 28 %. For goods transport, road transport and shipping account for roughly equal proportions while rail represents a smaller share. Passenger transports are dominated by road transports (84 %), followed by rail (10 %). In 2015 fossil fuels accounted for 82 % of the energy used by transport, while the remainder consisted of biofuels and electricity.

With 63 % of Sweden being (productive and unproductive) forest land, forests (trees and soil) account for a significant uptake of carbon dioxide emissions. The size of the sink fluctuates over time but has nevertheless increased by approximately 20 % between 1990 and 2015. In 2015 it accounted for an uptake of 46.6 Mt CO_2-eq. This can be compared to the total Swedish greenhouse gas emissions of 53.7 Mt CO_2-eq.

1.3. Greenhouse gas inventory

In 2015, greenhouse gas emissions (excluding LULUCF) in Sweden totalled 53.7 Mt CO_2-eq. Total emissions decreased by 18.2 Mt CO_2-eq., or 25 %, between 1990 and 2015. Emission levels have varied between a low of 53.7 Mt CO_2-eq. in 2015 and a high of 77.3 Mt CO_2-eq. in 1996. The net sink attributable to the LULUCF sector has varied over the period. In 2015 it amounted to 50.5 Mt CO_2-eq., which corresponds to 94 % of total greenhouse gas emissions.

In 2015, emissions of carbon dioxide (excluding LULUCF) amounted to 43.1 Mt in total, equivalent to 81 % of total greenhouse gas emissions, calculated as CO_2-eq. Emissions of methane (CH_4) accounted for 4.9 Mt of CO_2-eq. (about 9 % of total emissions), emissions of nitrous oxide (N_2O) 4.6 Mt (9 %) and fluorinated greenhouse gases 0.9 Mt (2 %).

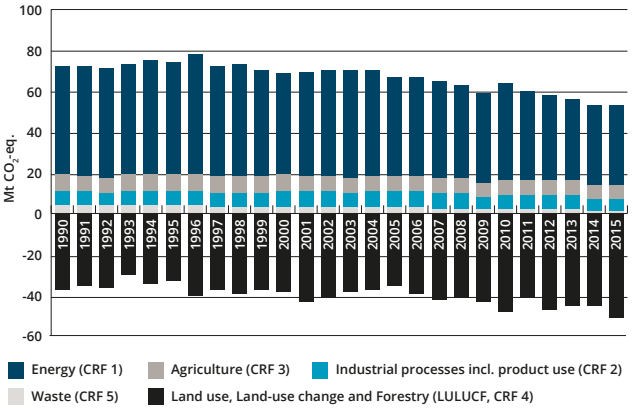


Figure 1.1 Total greenhouse gas emissions and removals in Sweden 2015.

Recent years have seen a downward trend in emissions. The largest reductions in absolute terms are due to a transition from oil-fuelled heating of homes and commercial and institutional premises to electricity, e.g. heat pumps, and district heating. Increased use of biofuels in district heating generation and industry has also contributed to the reductions together with reductions in landfilling of waste.

Total emissions from energy industries were approximately 9.0 Mt CO_2-eq. in 2015, a 10 % decrease compared with 1990. The production of electricity and district heating accounts for the larger part of the emissions at 71 % (6.4 Mt CO_2-eq.) in 2015.

Greenhouse gas emissions from fuel combustion in the residential, commercial and institutional sectors were 72 % lower in 2015 compared to 1990 due to a strong decrease in combustion of fossil fuels for heating.

Emissions from combustion in manufacturing industries and construction were 7.6 Mt CO_2-eq. in 2015, 33 % lower than in 1990. The decreasing trend of emissions in the sector is primarily related to a lower use of oil, as oil has been replaced by electricity or biomass.

Fugitive emissions were around 0.9 Mt CO_2-eq. in 2015. In total, fugitive emissions have increased by 125 % compared with 1990. The increase of fugitive emissions from oil is related to the establishment of hydrogen production facilities at two oil refineries in 2006.

Emissions from the industrial processes and product use sector represented 12 % of total national emissions in 2015. The emissions were 10 % lower in 2015 compared with 1990, equivalent to 0.7 Mt CO_2-eq. The main sources of emissions in this sector are the production of iron and steel as well as the cement and lime industries.

In 2015, emissions of greenhouse gases from domestic transport totalled 18 Mt CO_2-eq. The majority of the transport-related greenhouse gas emissions in Sweden come from road traffic, mainly from cars and heavy-duty vehicles. The decrease in emissions from cars, a decrease that started in 2007, has slowed down since 2013.

Emissions from the waste sector totalled 1.4 Mt CO_2-eq. in 2015, or about 2.6 % of the national total of greenhouse gas emissions. More than two thirds of the emissions from the waste sector come from solid waste disposal in landfills, which generates methane emissions and corresponded to 79 % of the sector in 2015. Methane emissions decreased by 68 % in the period 1990–2015.

In 2015, emissions from the agricultural sector were about 6.9 Mt CO_2-eq., about 10 % lower compared with 1990. The long-term trend is decreasing emissions, although emissions have levelled out over the last few years due to an increased use of fertilisers.

The largest removals of carbon dioxide in Sweden occur in forest land, totalling about 50 Mt CO_2-eq. in 2015, followed by harvested wood products with removals of nearly 7 Mt CO_2-eq. During the period 1990–2015 net removals varied between roughly 31 to 50 Mt CO_2-eq. Net removals in this sector are heavily influenced by harvests and natural disturbances such as storms on forest land.

In 2015, greenhouse emissions from international bunkering totalled 8.4 Mt CO_2-eq., 132 % higher than in 1990. Emissions from international shipping reached a total of 6.2 Mt CO_2-eq. in 2015. This is an increase of 8 % compared with 2015 and 173 % higher than in 1990.

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."

Recently, in June 2017, the Riksdag adopted a national climate policy framework for Sweden. The climate policy framework consists of a Climate Act, new 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. The Act will impose responsibility on the current Government, and on future governments, to pursue a climate policy that is based on the national climate targets and to provide clear feedback on the progress. Sweden will have long-term climate targets beyond 2020 (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.

The climate policy is also set out in two previous Government Bills, entitled *An Integrated Climate and Energy Policy*, passed by the Riksdag in June 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. This target applies to activities not included in the EU Emissions Trading System (EU ETS). It is more 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, but in many cases these are supplemented with targeted instruments, for example to support the development and market introduction of technology and eliminate barriers to energy efficiency and other measures.

Since the early 1990s, two key instruments in reducing Swedish emissions have been the energy and carbon dioxide 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 related to bans, standards and urban planning also plays a part in curbing emissions. EU-wide policy instruments, in particular emission standards for new vehicles and the EU ETS, are also important in Sweden.

In the budget proposal for 2018, the Government proposes to strengthen existing policy instruments and to introduce a range of new policy instruments as a step to meet the new climate targets set by the Parliament. Cross sectoral

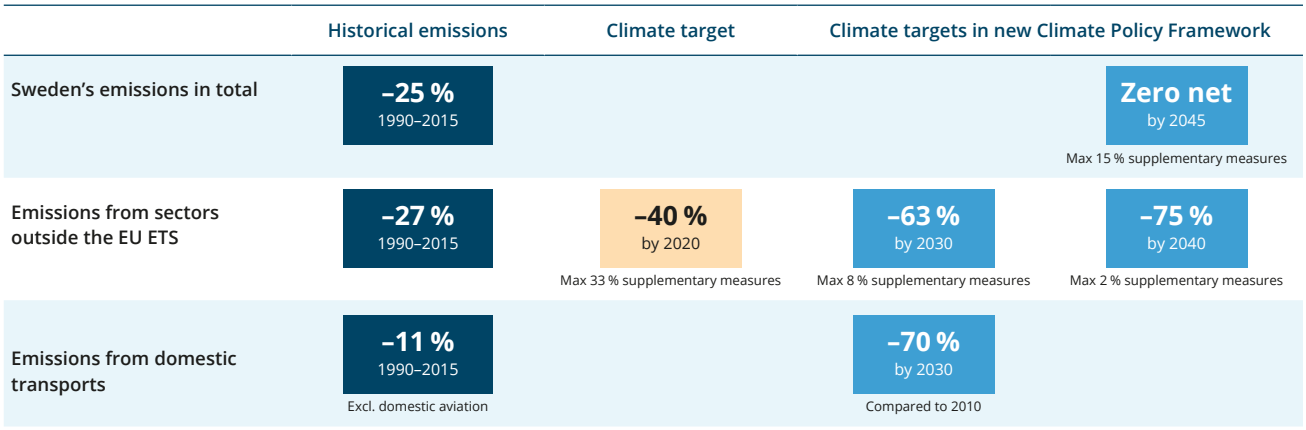


Figure 1.2 Sweden's national climate targets.

instruments as well as sector targeted instruments are proposed. The Governments notes that reducing transport-related emissions is essential and consequently proposes several policy instruments aimed at the transport sector.

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-sectorial 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. The total effect of the investments that will receive support during 2015–2020 is estimated to be 1.4 Mt CO_2-eq. annually over the technical lifespan of the investments.

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

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. It is furthermore an arena where difficulties and complications can be discussed and brought to the government's attention.

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

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.

1.4.2. Energy sector

Since 1990, the production of electricity and district heating has been marked by a very substantial expansion of renewable fuels. The use of fossil fuels in this sector has in recent decades been affected by energy and carbon dioxide taxes. The aggregate level of taxes on fossil fuel use in the sector has risen steadily since 1990, making it considerably more expensive to use these fuels than it would have been if energy taxation had been kept at its 1990 level. Since 2005, most combustion installations for power and heat production have been included in the EU ETS, which is a key policy instrument for the sector. Model estimates show that emissions from the electricity and district heating sector (including industrial back-pressure power) could have been almost 18 Mt CO_2-eq. higher in 2015 if policy instruments had remained at their 1990 levels. The difference in modelled emissions is due above all to the significantly greater use of coal in the scenario based on 1990 instruments than in the one based on current levels of instruments.

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. In addition, there are instruments such as technology procurement, network initiatives and information campaigns at the local, regional and national levels.

1.4.3. Industrial sector

Total emissions from combustion in manufacturing industries are trending downward. The instruments primarily affecting combustion emissions from the industrial sector are the EU ETS, energy and carbon dioxide taxes, the electricity certificates system and the Environmental Code. Industrial process emissions have come almost entirely within the scope of the EU ETS since its expansion for the third trading period (2013–2020). These processes are also regulated by the Environmental Code's requirement to use the best available technology. Recently the initiative 'Hydrogen Breakthrough Iron-making Technology' was granted support to find solutions to the issue of CO_2 emissions in the steel industry.

1.4.4. Transport sector

Emissions from domestic transport, where road transport dominates, increased after 1990, reaching a peak in 2006–2007. They have been declining since then, but this decline has slowed since 2013. The decrease in emissions since 2006 can be attributed to policy instruments introduced both nationally and at the EU level. The most significant ones include emission performance standards for new vehicles, vehicle taxes and vehicle fuel taxes. These have resulted in more energy-efficient vehicles and a greater use of renewable fuels. Lately the local climate investment program has granted support for infrastructure for the introduction of electrical vehicles. In the budget proposal for 2018, the Government proposes the introduction of a bonusmalus-system for new light vehicles and an emission reduction obligation for petrol and diesel to further spur emission reductions in the sector. The proposals will be applied from the first of July 2018. Moreover, the Government proposes that a tax on air travel will be introduced with the aim to reduce the climate impact of aviation. The tax is proposed to enter into force on 1 April 2018. In addition, support for research,

development and demonstration in the transport sector is important. 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.

The overall emissions impact of tax increases on diesel and petrol was estimated to total about 2 Mt CO_2/year in 2010 and for both years 2015 and 2020 have an effect of approximately 2.3 Mt CO_2/year lower emissions compared to a scenario that retained the 1990 nominal tax level.

The effect of the tax exemption for biofuels in 2010 totalled about 1 Mt CO_2/year, 2.5 Mt CO_2/year for 2015, and for 2020 is estimated to have an effect of about 4.2 Mt CO_2/year[1] lower emissions than if no biofuels had been used.

The Swedish Transport Agency has estimated the effect on national emissions of the EU CO_2 requirements for new vehicles and the national instruments introduced since 2005 that affect car choices. If neither EU requirements nor the national instruments were in place in 2015, emissions would have been 1.3 Mt CO_2 higher/year. The effect increases over time and in 2030, the effect is estimated to 4.3 Mt CO_2/year. The analysis also shows that the short-term impact of emissions is largely due to national incentives, while the long-term impact largely depends on EU requirements.

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. The factors behind this decline include an expansion of methane recovery from landfills and reduced landfill disposal of organic material, combined with increases in recovery of materials and waste incineration with energy recovery. These measures are a consequence of a series of policy instruments at both national and EU levels, specifically the ban on landfilling combustible and organic materials and regulation for methane collection. 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 1.7 Mt CO_2-eq. lower in 2015 than in a scenario based on 1990 instruments. By 2020, the difference was projected to be 1.9 Mt CO_2-eq.

1.4.6. Agriculture and forestry

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.

Investments in the agricultural sector have been granted from the Local Climate Investment Program and a new Rural Development Program for 2014–2020, which includes investment grants for environmental and climate actions. The Government has also introduced a support scheme for biogas production through anaerobic digestion of manure.

The Swedish Forestry Act (as of 1993) has two overarching, equal objectives: support production and protect the environment. Existing legislation indirectly affects trends in carbon dioxide removals in various ways, in particular through provisions on forest management in the Forestry Act, the land drainage provisions of the Environmental Code, site protection and nature conservation agreements. As part of the 'Forest Kingdom' initiative, the Government allocated SEK 10 million each year during 2012–2015 to strengthen governmental advice and training for increased production and to promote environmental awareness in order to increase the uptake of carbon.

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. Sweden has committed SEK 2.4 billion to support climate initiatives. As of the end of 2016 the program has supported and been active in 11 multilateral carbon funds, 96 individual CDM projects and programs, and 2 JI projects, as well as numerous international collaborations. At the end of 2016, SEK 1.3 billion had been granted, corresponding to approximately 15 Mt CO_2-eq. The program contains legally binding agreements of further financial support totalling approximately SEK 1.1 billion, or approximately 25 Mt CO_2-eq. for the period up to 2022.

All the projects are being carried out in developing countries, and priority has been given to projects in least developed countries (LDCs), small island developing states (SIDS) and in 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.

In 2016 the Swedish Parliament decided that international credits generated during the first commitment period of the Kyoto Protocol should be cancelled. The cancellation was conducted in 2017.

1.5. Projections and the total effect 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

1 With existing decided policy instruments.

the projection period. By 2020 and 2030, aggregate emissions are projected to be 30 % and 36 % lower respectively, than in 1990. The LULUCF sector contributed to an annual net removal of carbon dioxide in Sweden during the period 1990–2015 and is expected to continue to do so during the projection period.

Over the projection period, the emissions from energy, transport, industrial processes and product use, agriculture and waste are expected to decrease until 2035. The projected trend in emissions differs between sectors.

Emissions from the energy industries (electricity and heat production, refineries and manufacture of solid fuels) are projected to increase slightly until 2020 and then decrease until 2035. Until 2035, production of electricity is assumed to grow more than consumption, resulting in a projected export of about 12 TWh by 2020 and 34 TWh by 2030.

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 2035, 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 2035 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 2030. 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 2035 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 decrease until 2035, mainly due to a decrease in removals from forest land. The projected decrease in removals of carbon dioxide from forest land is based on the assumption that the harvest level will continue to gradually increase at about the same pace as in recent years.

1.5.1. Progress towards meeting Sweden's commitment under the Kyoto Protocol

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 year 2013 and 2014 Sweden's ESD emissions were lower than the ESD target. The surplus amount of AEAs was over 6 million per year compared to the Swedish ESD target. The surplus for 2013 was deleted in December 2016 and the surplus for 2014 will be deleted when the Compliance Account for 2014 is closed. Sweden has already taken a decision to delete the ESD surplus for 2015 and the Government has proposed to the Parliament that also the surplus for 2016 shall be deleted.

The projections indicate an overachievement in relation to the ESD target. The ESD emissions are projected to decrease to 29.7 million tonnes in 2020. The overachievement between the projected trend and the Swedish target in 2020 is estimated to be over 6 million tonnes, without the use of international credits. However, all necessary preparations are made to enable investment in

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

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Energy excl. transport	33.8	20.8	20.7	20.2	19.3	18.4	-39 %	-43 %
Transport	19.3	18.2	15.4	14.3	13.6	13.1	-20 %	-30 %
Industrial processes and product use	7.2	6.4	6.3	6.2	6.1	6.0	-12 %	-15 %
Agriculture	7.6	6.9	6.4	6.1	5.9	5.4	-17 %	-23 %
Waste	3.7	1.4	1.1	0.9	0.7	0.7	-72 %	-81 %
Total emissions	**71.6**	**53.7**	**49.9**	**47.7**	**45.6**	**43.6**	**-30 %**	**-36 %**
LULUCF	-36.7	-45.2	-43.3	-44.3	-42.2	-40.5	18 %	15 %

international projects if required to meet the ESD target. The projections also indicate that Sweden will have a surplus of Annual Emissions Allocations during 2016–2020. Note that these figures are uncertain and preliminary.

1.6. Vulnerability assessment, climate change impacts and adaptation measure

In Sweden, plenty of research is carried out on climate change and its effects. The information from Swedish authorities is freely available to all, but not always easy to use or understand for the uninitiated user. But efforts are being made to ensure that stakeholders receive relevant and useable information.

As a result of climate change, temperatures in Sweden will increase by 2–7 degrees by the end of the century, depending on the scenario used. The greatest increase is expected in the north, and the increase will be greater in the winter than in the summer. This will mean milder winters with decreasing snow cover. Precipitation patterns will also change, and are expected to increase by 0–40 % by 2100. The greatest increase will be during the winter. During the summer, precipitation for southern Sweden is expected to decrease, and increased transpiration may lead to a shortage of drinking water in some areas.

Many aspects of Swedish society will be affected by climate change. Heavy rainfall is already causing significant economic damage, and the occurrence of these types of events is expected to increase. That climate change affects human health is well known; however, the magnitude is hard to predict with precision, and varies with local preconditions and vulnerability. In addition, there are important impacts on infrastructure, agriculture, cultural heritage and other areas.

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

Adaptation to climate change spans many different fields, and it is therefore important to consider areas with multiple benefits as well as conflicting targets.

1.7. Financial resources and transfer of 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.

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.

In December 2016, the Government adopted a new policy framework outlining the direction of Swedish development cooperation and humanitarian aid. 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.

Over the period 2013–2016, Sweden provided almost SEK 12 billion of public climate finance for developing countries. Sweden is 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's bilateral climate change efforts focus on climate-vulnerable countries, such as Bangladesh, Bolivia, Burkina Faso, Kenya, Mali, Mozambique, Somalia, Tanzania and Zambia.

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.

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. In 2016 Sweden was one of the first donors to provide support to the Capacity Building Initiative for Transparency (CBIT), which aims to strengthen the institutional and technical capacities of developing countries to meet the enhanced transparency requirements of the Paris Agreement.

Several Swedish government agencies and institutions, such as the Swedish International Development Cooperation Agency (Sida), Swedish Energy Agency, Swedish Agency for Economic and Regional Growth, Swedfund and Business Sweden, are also involved in technology transfer to developing countries and economies in transition. This includes soft as well as hard technologies, and within a number of different sectors, such as energy, agriculture and disaster risk reduction. Transfer of technology is often combined in an integrated way with capacity building, to ensure long-term sustainability.

1.8. Research and systematic observation

The Government's latest Research Bill increases funding for climate change research. A special focus is on the UN

Sustainable Goals and the Paris Agreement through the support of six National Research programs, especially 'A national research program for the climate'. Support for the ten-year Strategic Research Areas (SRAs), introduced in 2008 and now being continued for another five years, constitutes a large part of the Swedish research system. There are eleven climate-related initiatives centred on modelling, climate processes, effects and energy.

Sweden participates in many international projects and initiatives. The Swedish Meteorological and Hydrological Institute (SMHI) hosts the international project office for the Coordinated Regional Climate Downscaling Experiment (CORDEX) on behalf of World Climate Research Program (WCRP). Through the Nordic Council of Ministers, Sweden participates in the Nordic Center of Excellence, which has an initiative on Arctic climate and adaptation. Sweden contributes to the assessments by sub-groups under the Arctic Council; one such group on resilience was initiated and funded by Sweden during the reporting period. On the European level, Sweden is active within the Horizon 2014–2020 and its three strategic objectives: excellent science, industrial leadership and societal challenges. Especially relevant are the Joint Program Initiatives (JPI-Climate) and Climate Knowledge and Innovation (Climate KIC). Sweden has been an active supporter of the Intergovernmental Panel on Climate Change (IPCC) from its start. The research initiative Future Earth has five of its core projects secretariats in Sweden. The Swedish Environmental Protection Agency provided support to the flagship project of the Global Commission on the new climate economy.

Sweden supports research in developing countries through the Swedish International Development Cooperation Agency (Sida). All regions are supported, but a strong focus is on Sub-Saharan Africa. Support is mainly geared towards the natural sciences, but the social and economic dimensions of environment and climate change are gaining more attention. Another growing area is solution-oriented, trans-disciplinary global sustainability research. This includes environment, climate, natural resources, energy and other relevant areas, both from a natural science and a social science perspective in support of capacity building. Support is also available directly to regional universities and networks as well as through Swedish universities and institutes.

Climate research is becoming more trans-disciplinary and integrated with society. Research on energy and societal issues is relevant for meeting the goals of mitigation and adaptation to climate change, but it might not be labelled climate research. Research on circular economy and transformative changes in society to achieve challenging climate goals and geopolitics are increasing, so also research on socio-political conditions and social-ecological aspects. Research that contributes to the transition to a sustainable energy system commands the largest budget. Technical focus is increasingly strengthened with the perspective of the users, behaviour, marketing, instruments affairs, and business models related to the energy sector. This means a holistic approach where different parts and sectors are analysed in relation to the actors, decisions, political goals and other objectives. Except for the Strategic Research Areas, which have projects within all categories requested by the UNFCCC, there are no new larger national efforts during the reporting period. The new national research program for the climate starts next year (2018).

1.8.1. Systematic observation

Systematic observation includes various measures in meteorology, hydrology and oceanography that are mainly provided by (SMHI), which represents Sweden in the World Meteorological Organization (WMO), the European network for Meteorological Weather Services (EUMETNET) and other international organisations. Sweden contributes to the Global Climate Observing System (GCOS) Essential Climate Variables (ECVs), which include the long-term observations and measurements of temperature, precipitation, wave height, icing, variations in glaciers, and satellite-based observations. Sweden contributes to the development of a new infrastructure for global observation system, mainly through the Copernicus Sentinel satellites. Sweden participates in several international research infrastructures such as ICOS-ERIC (Integrated Carbon Observing System – European Research Infrastructure Cooperation). Sweden hosts the ICOS Carbon Portal, where verified carbon data can contribute to better knowledge of carbon flow in the natural environment. Monitoring of changes in carbon balance, biomass and land use is performed through the National Forest Inventory (NFI). These data are reported to the UNFCCC.

1.9. Education, training and public awareness

In Sweden, communicating climate change knowledge is a key part of efforts to achieve emissions reductions and to carry out adaptation activities. Public awareness, public access to information, public participation, education and training on climate change are encouraged as actions for climate empowerment. Current positions as reflected in the The Climate Act 2017 for a climate policy framework, reflects a broad national support for climate action. The public awareness on climate change is generally high in Sweden. The vast majority, almost 8 out of 10, believe it is possible to reduce Sweden's climate impact and more than 7 out of 10 think they can contribute themselves. Media coverage describes climate change as an ongoing reality, not a distant threat, and the debate focuses on advantages and disadvantages of proposed solutions.

In Sweden, preschools, schools and adult education institutes have a clear remit to understand the requirements for sustainable development, formulated in the Education Act, curricula and syllabuses. In-depth teaching on climate issues is common at the upper secondary level. Teaching

manuals adapted for compulsory schools, a wide variety of films and other teaching material on climate and climate-friendly consumption, energy and transport, are produced by government agencies and non-government actors. The permanent exhibition 'Mission: Climate Earth' has been up and running since 2005.

Swedish government agencies communicate on climate issues based on their extensive experience of using knowledge and communication as policy instruments. The agencies involve all relevant stakeholders in activities on climate change education, training and public awareness. Non-government organisations, networks and knowledge centres help to build awareness by promoting dialogue on climate change solutions. Generous material on various climate scenarios is provided, including maps, tools and information that helps different stakeholders to reduce emissions and cope with a changing climate. A majority of municipalities have energy and climate advisers who support households and businesses. Numerous conferences and events are held annually, engaging stakeholders, policymakers, public agencies and private companies on action for climate empowerment. The Fossil-Free Sweden initiative, launched in 2015, highlights and promotes actors who help solve climate issues and achieve the goal of a fossil-free society. Increasing engagement is reflected in the growing numbers of business networks that promote business development within climate and environment.

In addition to national territorial statistics, Swedish agencies estimate and publicly communicate information on how Swedish consumption affects emissions in other countries. The Hello Consumer website was launched in 2016, and offers guidance on climate friendly choices and links to tools such as the 'Climate Account', the 'Ecolabel Guide' and online services on vehicles' carbon footprint.

Both government and non-government Swedish resources and information centres participate in numerous international activities on action for climate empowerment.

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 implement 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[2] 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 2016 was 10 million, with 23 % aged up to 19 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 11.5 million. Average population density is 24.5 inhabitants per km^2, ranging from 3 per km^2 in northern Sweden to 121 per km^2 in the south (Statistics Sweden 2017a).

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 408,150 km^2. Urban land make up 3 % of the land area, while productive forest land account for 58 %, farmland 8 %, wetlands 13 %, mires, rock surface, subalpine woodlands and high mountains 17 %, and other land 2 %. Inland water systems total more than 40,000 km^2, or more than 9 % of the total area (Swedish University of Agricultural Sciences, 2017). 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.

Table 2.1 Sweden's population profile, with projections (Statistics Sweden 2017a)

	1990	2000	2010	2014	2015	2016	Annual increase, 1990–2012, %	Annual increase, 2009–2012, %	2020	2030	2040
Population (million)	8.59	8.88	9.34	9.75	9.85	10.00	0.6	1.1	10.58	11.48	12.04
Aged up to 19 years (% of population)	24.6	24.1	23.2	22.7	22.7	22.9			22.7	22.7	22.0
Aged 65+ years (% of population)	17.8	17.2	18.5	19.6	19.8	19.8			19.9	21.2	22.6
Population density (inhabitants/km^2)	21.0	21.6	22.9	23.9	24.2	24.5			26.0	28.2	29.6

2 In 2017 there were 337 government agencies in Sweden (Statistics Sweden 2017b). There are also local authorities and various companies that exercise public authority.

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).

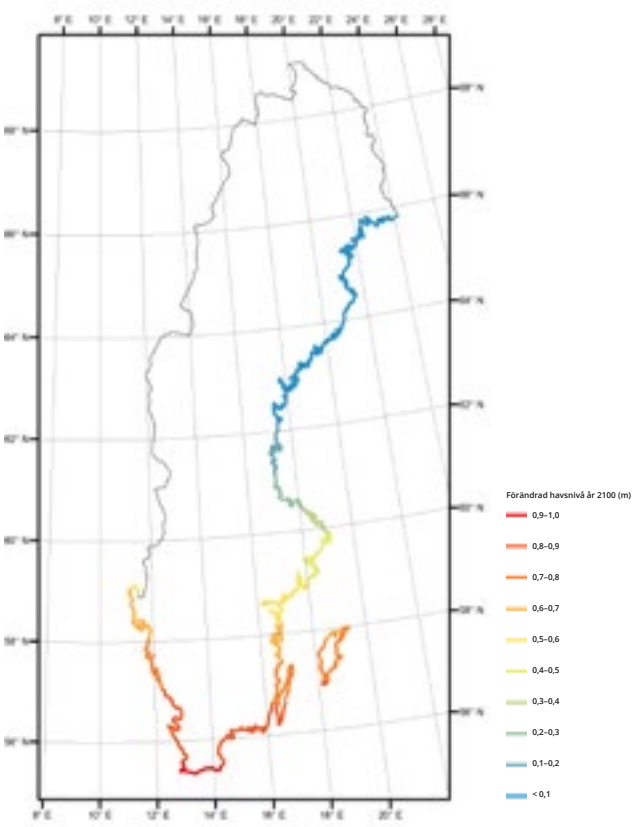


Figure 2.1 Net effect of rise in sea level (minus land rise) in Sweden, assuming a global sea level rise of 1 metre in 100 years. The land rise estimates are based on the Swedish National Land Survey's model NKG2005LU (Ågren & Svensson 2007).

Rising sea levels is 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 1991–2016 than in 1961–90. The largest rise, over 2°, took place in the northern parts of Sweden in winter and the smallest was in autumn, when the temperature in south-west Sweden remained almost unchanged. 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 2007/08 was the warmest of all winters since 1860, 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 2016 are illustrated in Figs. 2.2 to 2.4.

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 insolation, and vary from one year to the next. An energy index that takes these parameters into account and is weighted according to the geographical distribution of the population provides a picture of how heating needs have fluctuated from year to year (see Fig. 2.5). The years 1990 and 2000 were very warm, with heating requirements 13–14 % below the average for the reference period 1965–95, while 1996 and 2010 have been the only years since 1990 with greater heating requirements (+4 %) than in the reference period. Greenhouse gas emissions from heating, power production and district heating decreased by more than 60 % between 1990 and 2015.

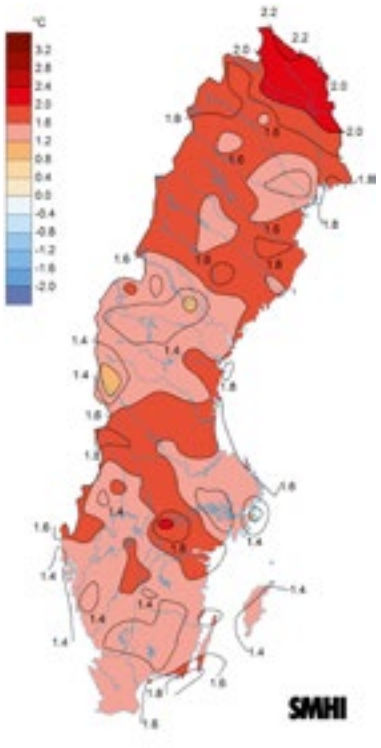


Figure 2.2 Difference in annual mean temperature between 2016 and 1961–90 (°C)

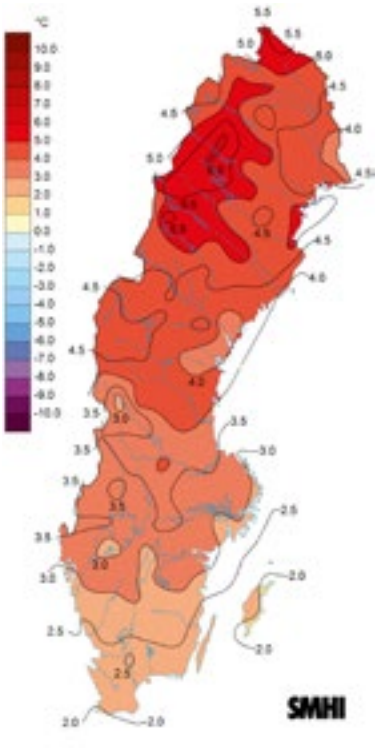


Figure 2.3 Difference in mean winter temperature between 2016/2017 and 1961–90 (°C)

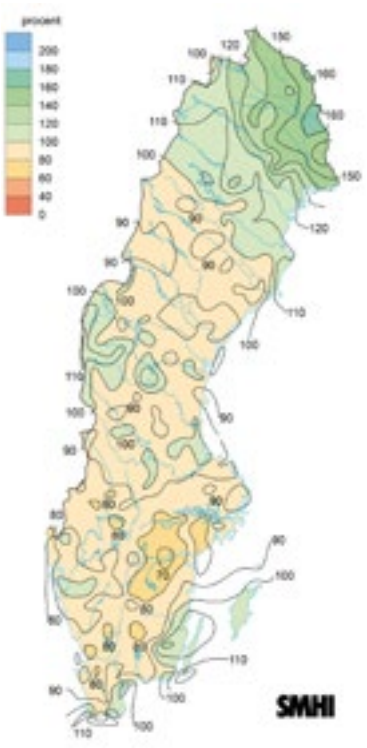


Figure 2.4 Difference in annual precipitation between 2016 and 1961–90 (%)

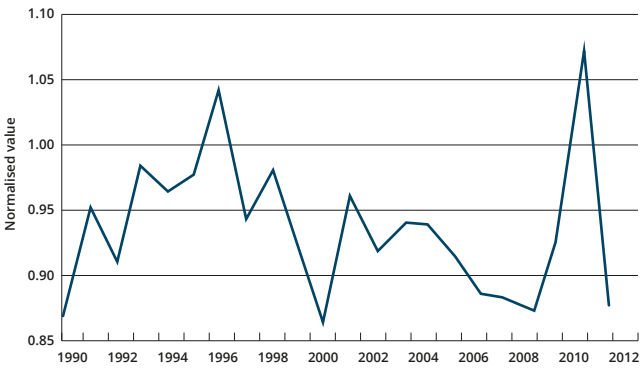


Figure 2.5 The Energy Index[3], weighted according to the geographical distribution of the population, showing variation in annual heating requirements in Sweden over the period 1990–2012.

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 2017a).

2.5. Economic profile

Sweden has an open, trade-oriented economy. In 2016 the nation's gross domestic production (GDP) was SEK 4,319 billion in 2016, or close to SEK 435,500 per capita, placing the nation among the richest countries in the world.

From 1990 to 2016, the economy grew by an average of 2.2% per year. During that period the economy has suffered from three 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. Finally, 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. Between 2014 and 2016 the average GDP growth rate has been 3.3%.

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 2016 exports accounted for 46% of GDP. Main export industries are machines, vehicles, pharmaceuticals and chemicals, wood products, electronics and minerals.

On the production side, two thirds of Swedish GDP stems from the private sector, whereas the public sector contributes with nearly one fifth. Within the private sector, services dominate with 65% of the value added, manufacturing industries 21% and construction 8%. Value added from primary production (agriculture, forestry, fishing and mineral extraction) is 2%.

2.6. Energy

The Swedish energy system is partly based on domestic sources of renewable energy such as water, wind and

3 The Energy Index weights the effects on heating requirements for buildings, over one year, of solar, wind and temperature conditions and the technical energy characteristics of buildings. Values below 1.00 represents lower heating requirements than during the reference period.

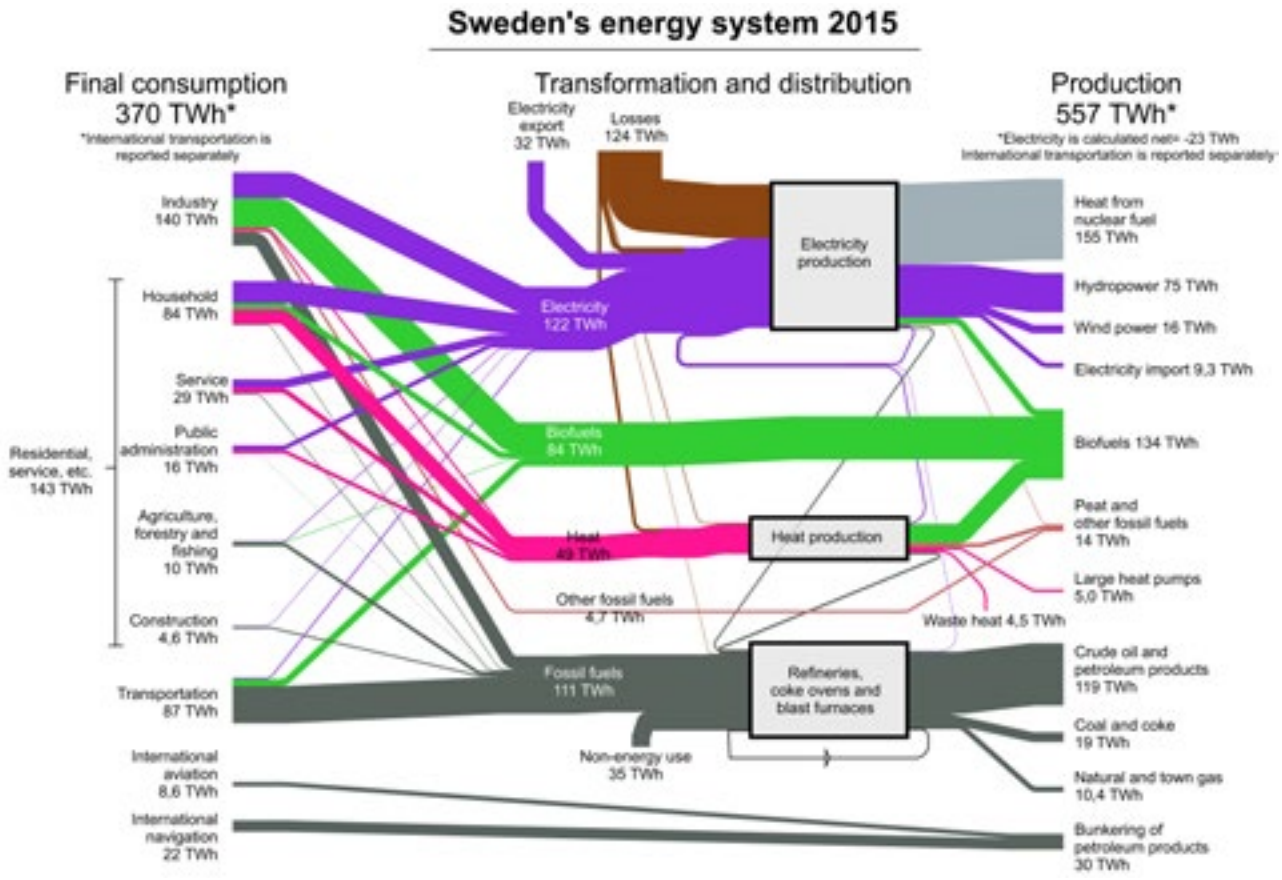


Figure 2.6 Sweden's energy system (Swedish Energy Agency)

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 biofuel 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.

Table 2.2 GDP by expenditure, at constant prices, reference year 2015 (National Institute of Economic Research 2017, OECD 2017)

	1990	1995	2000	2005	2010	2015	2016	Growth, 1990–2016 (%/year)	Growth, 2014–2016 (%/year)
GDP (SEK m)	2 473 109	2 573 055	3 067 065	3 491 833	3 777 507	4 181 103	4 319 502	2,20	3,33
GDP per capita (SEK)	288 954	291 500	345 697	386 711	402 800	426 679	435 491	1,62	2,22
GDP per capita (PPP)	19 923	22 774	29 258	33 968	41 668	47 823	49 077	3,57	2,43
Imports (SEK m)	607 413	690 459	1 050 118	1 206 823	1 413 888	1 707 708	1 770 622	4,39	5,15
Exports (SEK m)	550 152	749 590	1 159 609	1 455 041	1 612 716	1 906 170	1 970 046	5,20	4,74
Private consumption (SEK m)	1 180 403	1 166 225	1 380 717	1 542 362	1 717 497	1 884 169	1 926 249	1,92	2,36
Public consumption (SEK m)	830 533	878 957	914 453	942 856	1 010 831	1 086 360	1 119 950	1,17	2,38

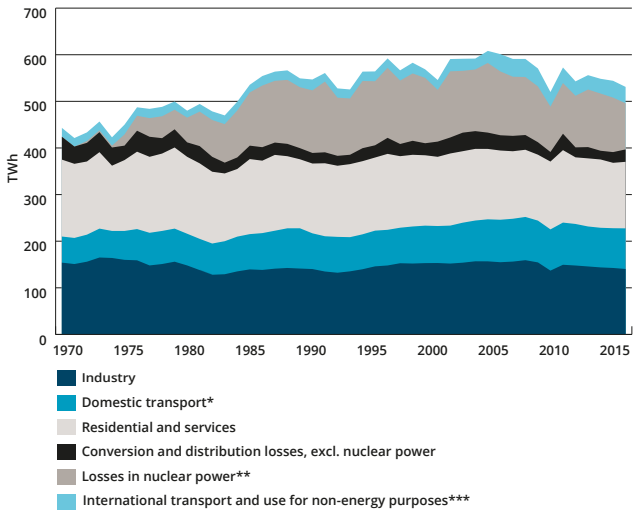
Table 2.3 Total primary energy supply (TPES) in TWh, 1990–2015

	1990	1995	2000	2005	2010	2011	2012	2013	2014	2015
TPES (TWh)	553	578	551	599	584	566	578	566	555	525
TPES (MWh) per capita	64	65	62	66	62	60	60	59	57	53

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 Fig. 2.6 and 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.

Total final energy use has increased by 20 % since 1970, and has been stable at approximately 550 TWh for the past five years. These figures relate to industry, domestic transport, residential property and services, international transport, use for non-energy purposes, and conversion and distribution losses. Despite the moderate overall increase in energy use during the period, some changes in use within the sectors have taken place. Industrial production volume has almost doubled, but industrial energy use has risen by only just over 4 %. The residential and service sector has reduced its energy use although the aggregate heated floor space both of homes and of commercial and institutional premises has increased. The rise in the volume of goods on the roads is what underlies the rise in energy use by transport (Swedish Transport Administration 2017).



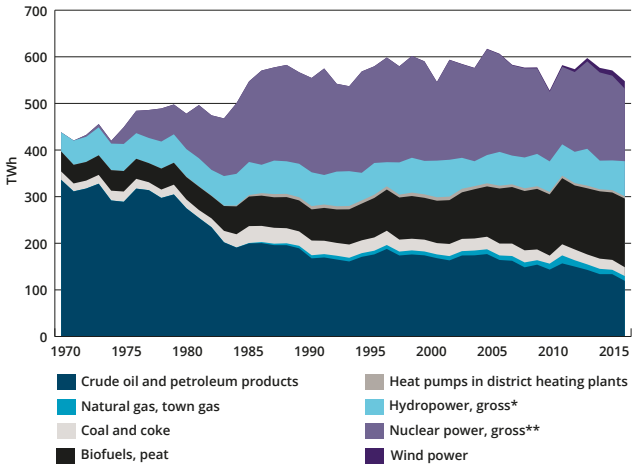
* Data up to and including 1989 include international flights.
** According to the method used by the United Nations Economic Commission for Europe (UNECE) to estimate supply from nuclear power.
*** From 1990, data include international flights.

Figure 2.7 Sweden's TPES in 1970–2015, including conversion and distribution losses (Swedish Energy Agency 2017a)

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.

Almost 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 25 %.



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

Figure 2.8 Sweden's energy supply in 1970–2015, excl. net electricity exports (Swedish Energy Agency 2017a)

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 2015, production of district heating had risen by 293 % since 1970 and 43 % since 1990 (see Fig. 2.8). At the same time, the share of biofuels in production had grown from 2 % to 25 % and 76 % in 1970–90 and 1970–2010 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.

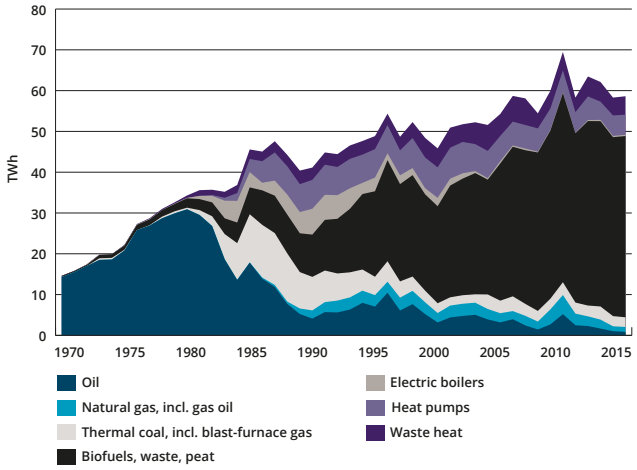


Figure 2.9 Energy supply for district heating, 1970–2015 (Swedish Energy Agency 2017a)

Between 1990 and 2014, the share of renewable energy in Sweden rose by 19 percentage points to 53 % (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.

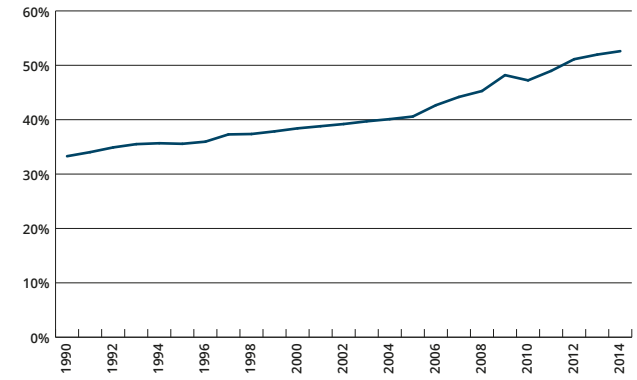


Figure 2.10 Share of renewable energy used in Sweden, 1990–2014 (Swedish Energy Agency 2017a)

Between 2000 and 2014, the price of fuel oil no.1 rose by 114 % and fuel oil no. 2–6 rose by 122 % while that of wood chips remained relatively stable at a low level (see Fig. 2.10)[4]. 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.

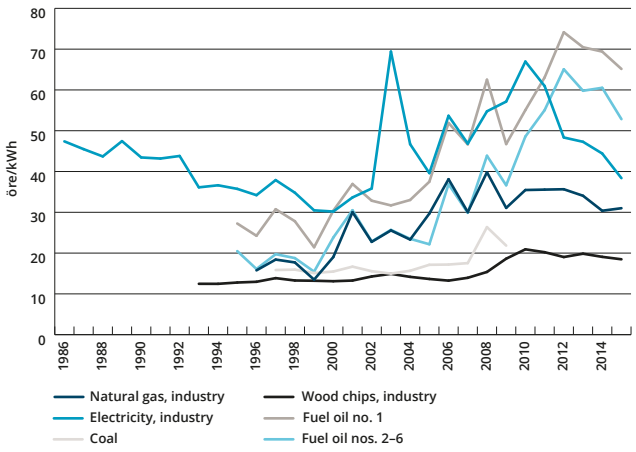
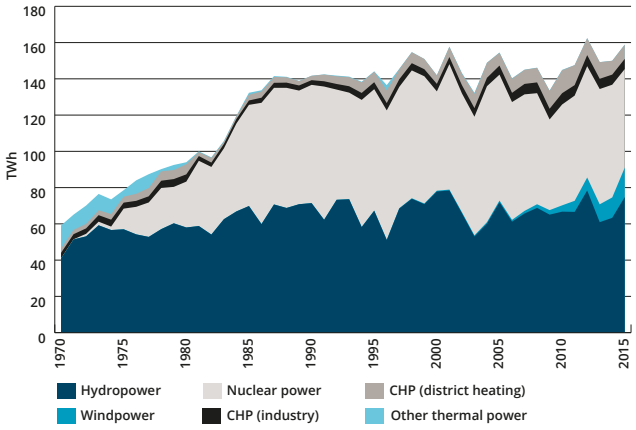


Figure 2.11 Real energy prices for industry in Sweden, including energy taxes, 1986–2015, expressed in SEK/kWh, 2016 prices (Swedish Energy Agency 2017a)

2.6.2. Electricity supply

Of total electricity production in 2015, hydropower accounted for 47 %, nuclear power 34 % and wind power 10 %, while biofuels and fossil-based production made up the remaining 9 % (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 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 2.12 Sweden's electricity production by power source, 1970–2015 (Swedish Energy Agency 2017a)

4 Fuel oil no 1 is used for heating purposes, while fuel oils no 2–6 are mainly used in larger heating plants and ships.

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.

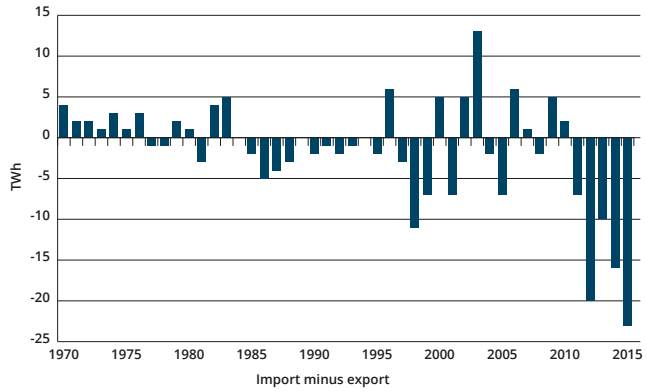


Figure 2.13 Sweden's annual net imports (+) and net exports (−) of electricity, 1970–2015 (Swedish Energy Agency 2017a)

2.7. Building stock and urban structure

2.7.1. Building stock and residential floor area

In 2016 there were 2,053,665 single-family houses for year-round occupation and 2,424,113 apartments in multi-dwelling buildings (Statistics Sweden 2017c). Of the current stock of apartments, 53 % were built before 1980. Average floor space in single-family houses, including weekend and holiday homes, is 122 m^2. For multi-dwelling buildings, floor area is on average 68 m^2.

A 2.7 % increase in the number of apartments and a 3.9 % increase in the number of single-family houses took place between 2013 and 2016, prior to 2013 the calculation of these two definitions were carried out differently and hence the numbers cannot be compared. In 2016, average living space was 42 m^2 per capita (Statistics Sweden 2017e). In 2016 industrial buildings contained floor space of 131 million m^2 (Statistics Sweden 2017d).

2.7.2. Energy use in buildings

Final energy use in residential and service-sector buildings, in which energy for heating predominates, decreased between 1990 and 2015 even after weather correction of energy use. On the other hand, use of electricity for non-heating purposes increased. Household electricity use increased slightly except in 2014 and 2015, while the increase in energy used for building services was relatively large also with the exception of 2014 and 2015 (Swedish Energy Agency 2017c).

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 2015 (Swedish Energy Agency 2016). For commercial and institutional premises, the proportion of district heating was 74 % in 2014 (Swedish Energy Agency 2015).

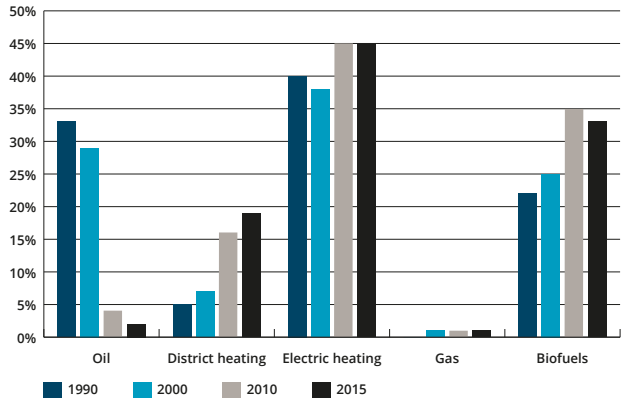


Figure 2.14 Use of energy for heating in single-family houses in 1990, 2000, 2010 and 2015 (Swedish Energy Agency 2016)

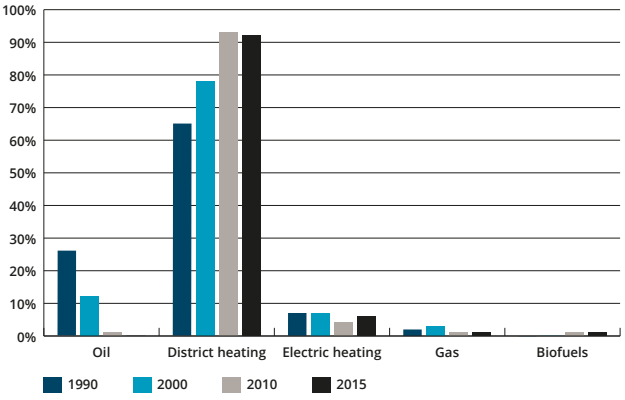


Figure 2.15 Use of energy for heating in multi-dwelling buildings in 1990, 2000, 2010 and 2015 (Swedish Energy Agency 2016)

Average energy efficiency of newly produced single-family houses has improved. In homes built in the period 2001–10, average energy use is 83 kWh/m^2. This may be compared with 96 kWh/m^2 in homes built in 1991–2000. In new multi-dwelling buildings built in 2001–2010 the figure is 107 kWh/m^2, slightly less as for this category of housing built in the 1980s and 1990s (see Fig. 2.16).

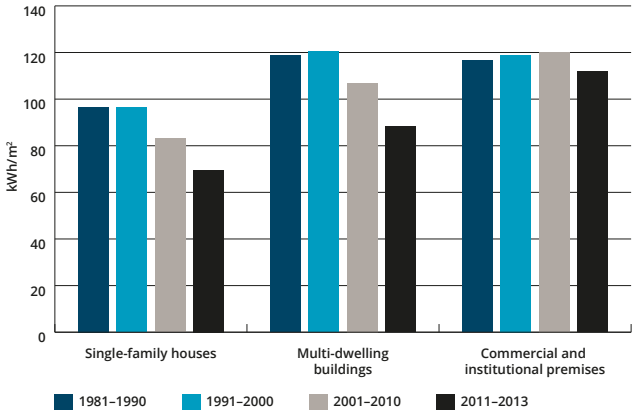


Figure 2.16 Use of energy for heating of residential and commercial/institutional premises built in 1981–90, 1991–2000, 2001–10 and 2011–2013 (Swedish Energy Agency 2016)

2.7.3. Urban structure

In Sweden, as in other countries, migration from rural to urban areas is under way. In 2015, 87% 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, 2016). Between 1960 and 2005, the urban area increased by 54% and the urban population by 47%. Accordingly, more land per capita was used for housing, infrastructure and services. Between 2010 and 2015, population density in towns and cities rose from 1,317 to 1,389 inhabitants per km^2.

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 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 industry is important to the economy, accounting for more than 20% of GDP in terms of value added. Machine manufacture, together with electric and electronic equipment are examples of important sectors. The latter in fact being the sector that has shown the most rapid growth in the past 25 years, due to the advances in telecommunication technology. More recently however, manufacture of motor vehicles that have increased in production the most. Different sectors' contribution to the value added in the manufacturing industry in 2016 is shown in Figure 2.17.

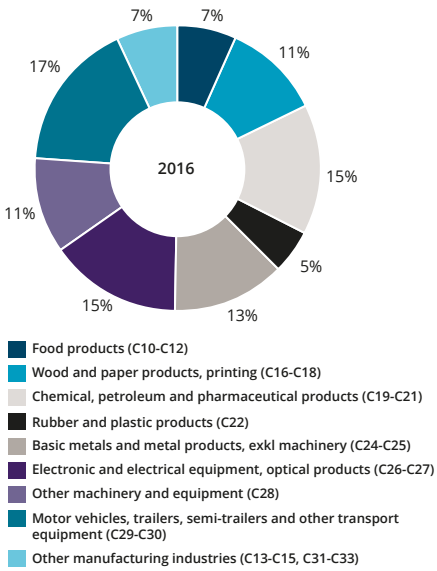


Figure 2.17 Distribution of value added in manufacturing industry, 2016. Swedish Standard Industrial Classification (SNI) designations in brackets (Statistics Sweden, 2017).

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, but the trends are somewhat different (see Figs. 2.17 and 2.18). For goods transport, road transport and shipping account for roughly equal proportions while rail represents a smaller share. The past few years' fluctuations in economic trends have exerted more influence on freight than on passenger transport activity.

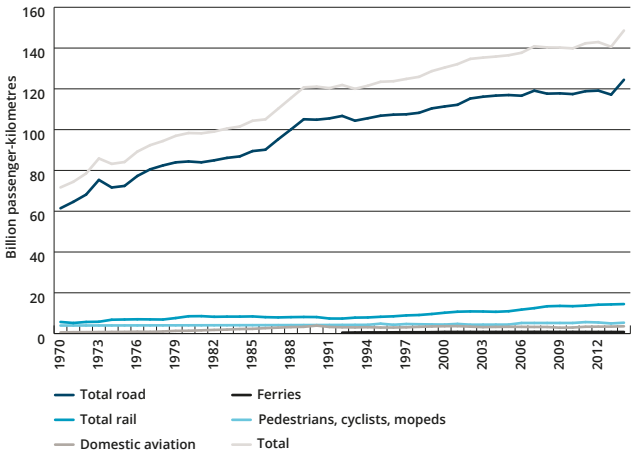


Figure 2.18 Trends in passenger transport activity, 1970–2014 (Transport Analysis 2016)

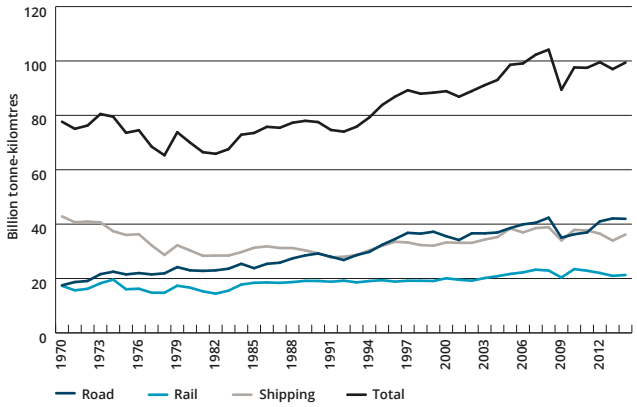


Figure 2.19 Trends in goods transport activity, 1970–2014 (Transport Analysis 2016)

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 leveled off and since 2000 the energy use and carbon dioxide emissions of freight transport have grown along with transport activity.

In 2015 fossil fuels accounted for 82 % of the energy used by 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 15.1 % of energy use by road transport in 2015. 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 E_{85} (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.

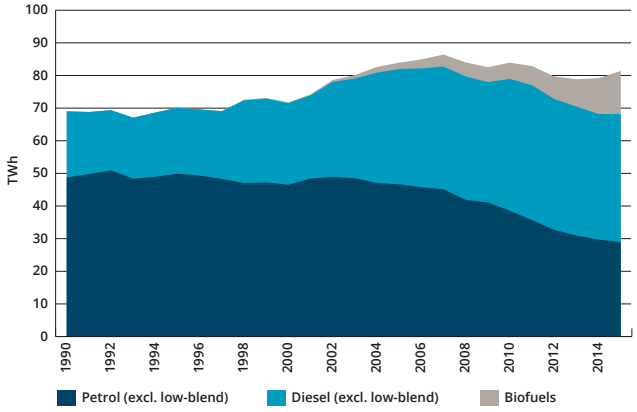


Figure 2.20 Use of petrol, diesel and biofuels by road transport in Sweden (Swedish Energy Agency 2017)

2.10. Waste

Approximately 168 million tonnes (Mt) of waste was generated in Sweden in 2014 (Swedish Environmental Protection Agency 2016). The categories with the largest volumes were the mining sector (139 Mt), construction sector (8.9 Mt), other industries (except mining) (5.7 Mt), households (4.2 Mt) and infrastructure and services (4.1 Mt). Accordingly, 82 % 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 waste has decreased sharply in the past decade to just under 1 % of household waste today (in 2001 the proportion was 23 %) (see Fig. 2.20). The remainder is sent for materials recovery, incinerated with energy recovery or treated biologically (composted or digested).

Household waste per capita in 2014 was approximately 430 kg. The share of this that goes to material recovery is 35 %, to incineration with energy recovery is 48 %, 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.

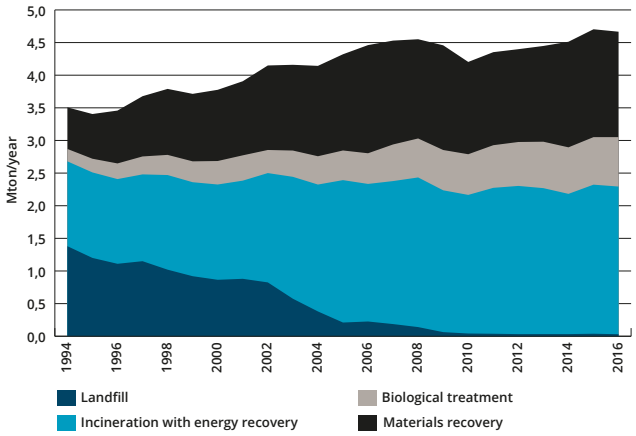


Figure 2.21 Volume trends of household waste treated in Sweden, 1992–2016

Materials recovery from household waste has increased by 13 % since 2001. In 2011, materials were recovered from 1.4 Mt (33 %) of household waste, of which just under 1.1 Mt consisted of packaging and recyclable paper (newspapers).

Biological treatment of waste, except for wastewater sludge, is increasing and takes place at 26 composting facilities and 21 mixed-waste digestion plants. The latter receive food and slaughter waste, in particular, and produce most biogas after sewage treatment plants. Smaller quantities of food waste are also received for digestion at sewage treatment plants.

In 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 594,000 tonnes, more than 90% was returned to farmland in 2011.

In 2011 there were 30 incineration plants for household waste outside industry. These plants produce both district heating and electricity. Half of the heating requirement in Sweden's building stock is met by district heating, and in 2011 waste incineration accounted for 9,600 GWh (18%) of the total heat energy supplied and a further 3,665 GWh of electric energy supplied.

Recovery of methane gas takes place from 46 active and 11 disused landfills. In 2011, 270 GWh of landfill gas (18% of total biogas energy) was collected and used mainly for heating, but also for electricity production and as a vehicle fuel. Some landfill gas is flared to further reduce emissions of methane due to its higher global warming potential compared to carbon dioxide.

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 2016 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 roughly 8% since 1990. The trend towards fewer, larger farming enterprises has been under way for many decades and the period 1990–2016 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 2016 than in 1990. Total crop production has fallen by some 18% since 1990 (see Table 2.5).

In 2016 there were 1.5 million cattle, 0.6 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 13% in the period 1990–2016. The number of dairy cows has fallen sharply, while that of cows used for calf rearing has risen. Sheep and lamb production has increased, especially in 2005–16. Pig numbers continue to decline, and have fallen by 40% since 1990.

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).

Total use of mineral fertiliser has decreased over a long period. Owing to rising cereal prices, a certain upturn may be noted in 2009–10 when applying more fertiliser became profitable and a downturn in 2013–2014. Since then, however, the long-term trend of declining sales has continued (see Table 2.8). 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 has been lower release of nitrous oxide.

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 28,2 million hectares hectares (ha), according to the Swedish Forestry Act. Of the total forest area, 23,6 million ha is regarded productive forest, corresponding to 58% of the total land area. Accordingly, there is also 7.0 million ha of unproductive forests (17% 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, 2017)

50% of forest land is owned by individuals, 25% by privately owned limited companies, 6% by other private owners and 19% by state-owned limited companies, the central government and other public owners (Swedish Forest Agency 2014).

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 1.24 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 2014).

Increased demand for forest raw materials from the forest industry has led to an increase in felling during the period 1990–2015 (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 some 2.8 billion m^3 in 1990 to 3.3 billion m^3 in 2009 and 3,5 billion m^3 in 2014 (Swedish University of Agricultural Sciences 2017).

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

Table 2.4 Breakdown of agricultural land for farms with more than 2 ha of arable land ('000 ha)

	1990	1995	2000	2005	2010	2014	2015	2016
Forage and green fodder crops	918	1059	921	1080	1195	1170	1135	1108
Cereals	1336	1105	1229	1024	963	1034	1034	1020
Fallow land	176	279	248	321	177	132	163	169
Oilseed rape and turnip rape	168	105	48	82	110	96	95	93
Potatoes	36	35	33	30	27	24	23	24
Sugar beet	50	58	56	49	38	34	19	31
Legumes	..	21	37	41	46	45	59	66
Other crops	..	46	55	42	67	55	56	58
Unspecified arable land	..	..	80	32	11	6	6	11
Unused arable land	46	60	..	2	..	..	..	..
Total area of arable land	2845	2767	2706	2703	2634	2597	2590	2580
Grazing land and hay meadows	332	425	..	513	452	436	450	452
Total area of farmland	3176	3192	..	3216	3085	3032	3040	3032

Table 2.5 Crop production in Sweden (tonnes)

	1990	2016	Change (tonnes)	Change, %
Forage and green fodder crops	5219000	4733700	-485300	-10
Cereals	6211300	5480500	-730800	-13
Oilseed rape and turnip rape	380110	268500	-111610	-42
Potatoes	1186100	861300	-324800	-38
Sugar beet	2775500	1988000	-787500	-40
Total crop production	15772010	13332000	-2440010	-18

Table 2.6 Livestock numbers ('000)

	1990	1995	2000	2005	2010	2014	2015	2016
Cows for milk production	576	482	428	393	348	344	340	331
Cows for calf rearing	75	157	167	177	197	186	184	194
Total, cows	651	639	595	570	545	531	524	525
Heifers, bulls and steers	543	596	589	527	513	491	488	489
Calves below 1 year	524	542	500	508	479	472	467	476
Total, cattle	1718	1777	1684	1605	1537	1493	1480	1490
Ewes and rams	162	195	198	222	273	287	289	281
Lambs	244	266	234	249	292	301	306	297
Total, sheep and lambs	406	462	432	471	565	589	595	578
Sows and gilts	230	245	206	188	156	145	142	140
Pigs for slaughter	1025	1300	1146	1085	937	857	830	835
Piglets	1009	768	566	538	427	376	384	378
Total, pigs	2264	2313	1918	1811	1520	1378	1356	1354
Horses				283	363			356

Table 2.7 Livestock production (tonnes)

	1990	2016	Change	Change, %
Milk	3432000	2862000	-570000	-17
Beef	143780	131250	-12530	-9
Pork	289150	232800	-56350	-19
Mutton, lamb	4880	4090	-790	-16

Table 2.8 Sales of mineral fertiliser expressed as nitrogen nutrient ('000 tonnes)

	1989/90	1994/95	1999/00	2004/05	2009/10	2013/14	2014/15	2015/16
Nitrogen (N)	225	198	189.4	161.6	168	114	128.2	121.9

expanded to some 80,000 ha in 2012. 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 2010, ash recycling was carried out on less than 10,000 ha (Swedish Forest Agency 2014).

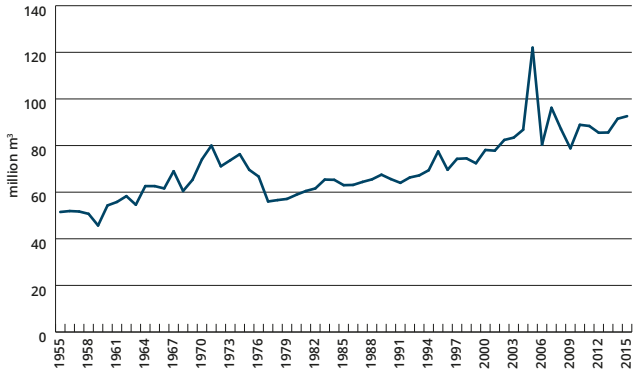


Figure 2.22 Estimated gross annual volume felled in Sweden (Swedish Forest Agency 2017)

2.13. References

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3. Greenhouse gas inventory information

The information in this chapter is a summary of the 2017 inventory of emissions and removals of greenhouse gases for the years 1990 to 2015, submitted under the UN Framework Convention on Climate Change and the Kyoto Protocol (National Inventory Report Sweden 2017).

3.1. Total emissions and removals of greenhouse gases

In 2015, greenhouse gas emissions (excluding LULUCF) in Sweden totalled 53.7 million tonnes of carbon dioxide equivalents (Mt CO_2-eq.), see Figure 3.1. Total emissions have decreased by 18.2 Mt, or 25 %, between 1990 and 2015. Emission levels have varied between a low of 53.7 Mt CO_2-eq. in 2015 and a high of 77.3 Mt CO_2-eq. in 1996. Annual variations are largely due to fluctuations in temperature and precipitation and to the economic situation. The net sink attributable to the land use, land-use change and forestry (LULUCF) sector has varied over the period. In 2015 it amounted to 50.5 Mt CO_2-eq., which corresponds to 94 % of total greenhouse gas emissions.

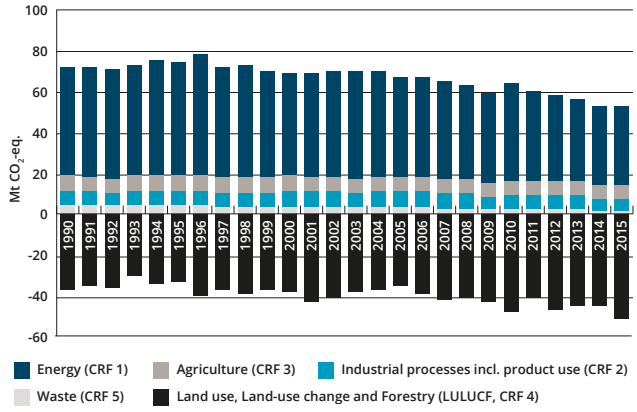


Figure 3.1 Total greenhouse gas emissions from different sectors.

In 2015, emissions (excl. LULUCF) of carbon dioxide (CO_2) amounted to 43.1 Mt in total, which is equivalent to 81 % of total greenhouse gas emissions, calculated as CO_2-eq. Emissions of methane (CH_4) accounted for 4.9 Mt of CO_2-eq. (about 9 % of total emissions), emissions of nitrous oxide (N_2O) 4.6 Mt (9 %), fluorinated greenhouse gases 0.9 Mt (2 %), see Figure 3.2. The shares of the different greenhouse gases have remained stable over the period 1990 to 2015.

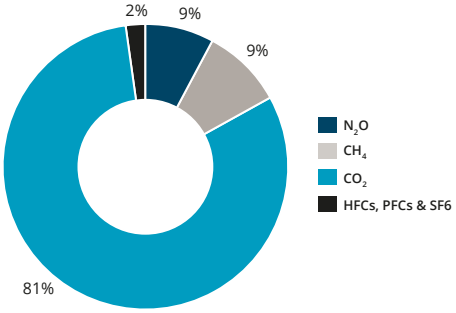


Figure 3.2 Greenhouse gas emissions in 2015 (excl. LULUCF) by gas, in carbon dioxide equivalent.

3.2. Emissions and removals of greenhouse gases by sector

The largest sources of emissions in 2015 was the energy sector (73 %), agriculture (13 %) and industrial processes and product use (12 %), as shown in Figure 3.3.

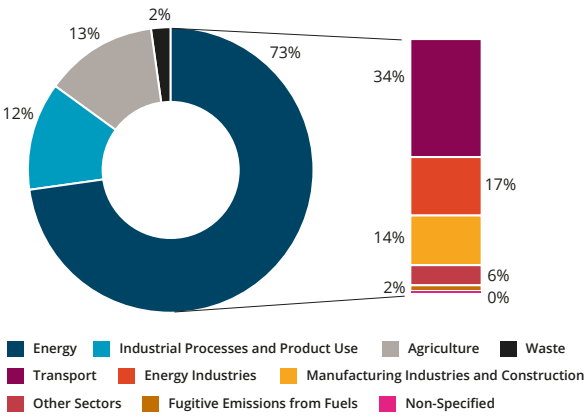


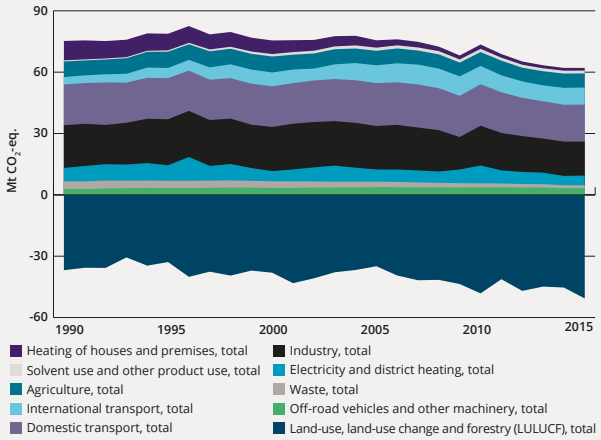
Figure 3.3 Greenhouse gas emissions in 2015 (excl. LULUCF), by sector.

In recent years there has been a downward trend in emissions. The largest reductions in absolute terms are due to a transition from oil-fuelled heating of homes and commercial and institutional premises to electricity, e.g. heat pumps, and district heating. Increased use of biofuels

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

BOX 3.1

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 Common Reporting Format.



The main emission sources in Sweden are domestic transport, industry, and electricity and district heating according to this breakdown.

Emissions from domestic transport respond to one third of Sweden's total emissions (excluding LULUCF and international transport). Although the emissions were 9 % lower in 2015 than in 1990, the decreasing trend seen in recent years has slowed down to a halt. The development in recent years can be explained by increased traffic on Swedish roads and the shift towards biofuels and increased energy efficiency not being strong enough to counteract that trend.

Emissions from industry respond to 31 % of Sweden's total emissions and have decreased by 20 % 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 also significantly impacts the trend.

Electricity and district heating shows a trend of decreasing emissions despite the increased demand for district heating due to increased combustion of waste and biofuels. 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:

Description of trends (in Swedish):
http://www.naturvardsverket.se/klimatutslapp

Detailed data and reference to CRF-categories (in English):
http://www.scb.se/mi0107-en

3.2.1. Energy industries

Total emissions from energy industries were approximately 9.0 Mt CO_2-eq. in 2015, a 10 % decrease compared with 1990. Production of electricity and district heating account for the larger part of the emissions with 71 % (6.4 Mt) in 2015. Emissions from refineries and the manufacture of solid fuels totalled 2.6 Mt in 2015.

Energy industries are dominated by electricity and heat production, where emissions fluctuate between the years due to the weather conditions' influence on the electricity and heat production, see Figure 3.4.The fluctuations seen for emission from coke production and refineries are primarily related to changes in production levels in response to the economic development of the industries. Emissions from Sweden's electricity and heat production mainly originate from combined heat and power plants that are to a large extent fuelled by waste and renewable resources with low emission factors, and industry-derived gases from the steel production. The use of coal, oil and gas are decreasing. Despite demand for district heating increasing by over 50 % since 1990, the emissions have remained at a level similar to 1990.

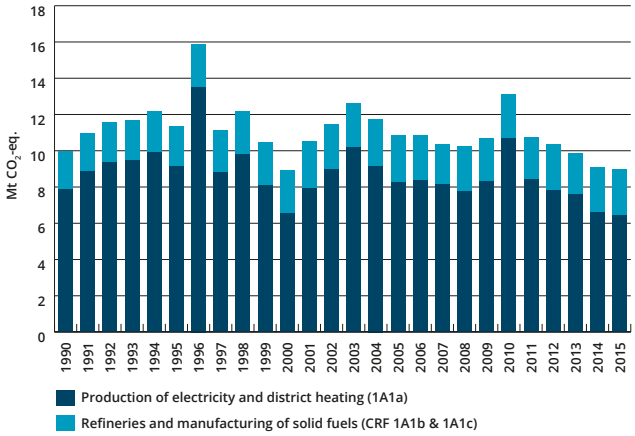


Figure 3.4 Greenhouse gas emissions from the energy industries (CRF 1A1).

3.2.2. Residential and commercial/institutional

Greenhouse gas emissions from fuel combustion in the residential, commercial and institutional sectors were 72 % lower in 2015 compared to 1990 due to a strong decrease in combustion of fossil fuels for heating, see Figure 3.5. The emissions primarily adhere 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-fuelled 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 working machinery and off-road vehicles.

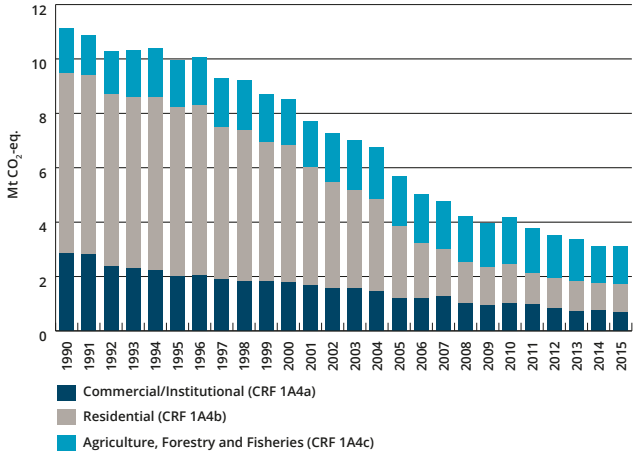


Figure 3.5 Greenhouse gas emissions from combustion in the commercial and institutional, residential, and agriculture, forestry and fisheries sectors.

3.2.3. Industrial combustion

To cover all industry-related emissions, account needs to be taken of process emissions, emissions from combustion and fugitive emissions, which according to UNFCCC guidelines are to be reported under separate CRF (Common Reporting Format) categories.

The mining, iron and steel industries, as well as the pulp and paper industry, are examples of historically important industries for Sweden. Emissions from combustion in manufacturing industries and construction were 7.6 Mt CO_2-eq. in 2015, see Figure 3.6. Emissions in 2015 were 33% lower than in 1990 and close to unchanged compared to 2014. Although increasing slightly up until 1997, the emissions show a decreasing trend since then. The lower emissions in 2009 and higher emissions in 2010 were caused by the impact of the financial crisis on production levels and their subsequent recovery. The decreasing trend is primarily related to a lower use of oil as oil has been replaced by electricity or biomass.

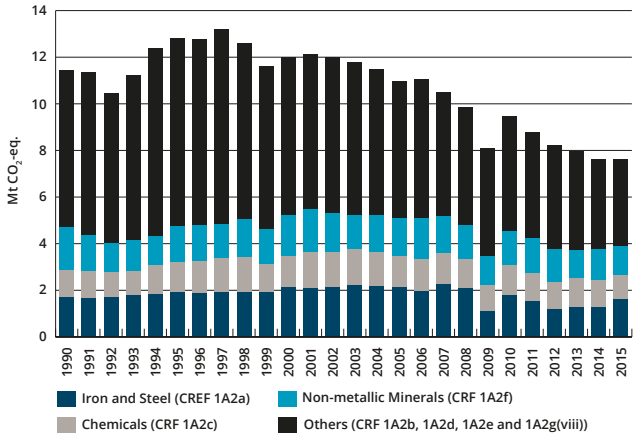


Figure 3.6 Greenhouse gas emissions from industrial combustion.

3.2.4. Fugitive emissions

Fugitive emissions come from sources like processing, storing and using fuels, gas flaring, and the transmission and distribution of gas. Emissions were around 0.9 Mt CO_2-eq. in 2015, see Figure 3.7, and have increased by 125% compared with 1990. The increase of fugitive emissions from oil, observed in the time series from 2006, is related to the establishment of hydrogen production facilities at two oil refineries.

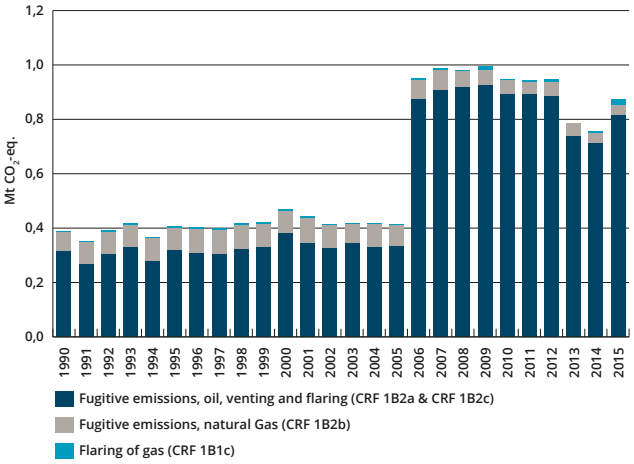


Figure 3.7 Fugitive emissions.

3.2.5. Industrial processes including product use

Emissions from the industrial processes and product use sector represented 12% of total national emissions in 2015. The main sources of emissions in this sector are the production of iron and steel as well as the cement and lime industries. Greenhouse gas emissions from industrial processes and product use were 10% lower in 2015 compared with 1990, equivalent to 0.7 Mt CO_2-eq. see Figure 3.8.

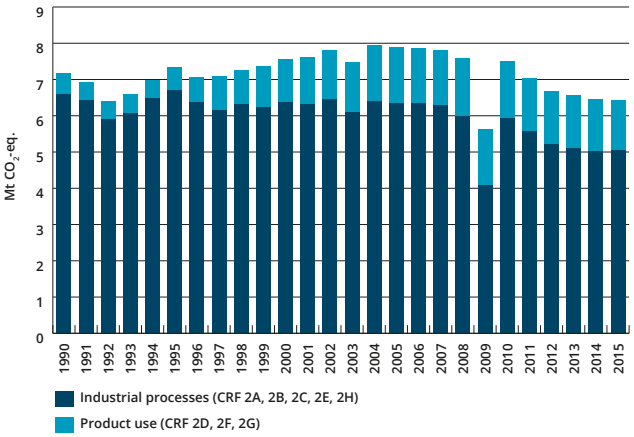


Figure 3.8 Emissions from the industrial processes and product use.

Greenhouse gas emissions from industrial processes and product use show an overall decreasing trend since 1995, with the exception of 2009 and 2010, and were 23% lower in 2015 compared with 1990. The trend of emissions from product use is mainly influenced by products used as substitutes for ozone depleting substances. The emissions

show an increasing trend that culminated in 2008–2010 and have been decreasing since 2010. Nevertheless, greenhouse gas emissions from product use were 142 % higher in 2015 compared with 1990. Products used as substitutes for ozone depleting substances responded to 57 % of the total emissions from product use in 2015.

3.2.6. Transport

In 2015, emissions of greenhouse gases from domestic transport totalled 18 Mt CO_2-eq., one third of the national total. The majority of the transport-related greenhouse gas emissions in Sweden come from road traffic, mainly from cars and heavy-duty vehicles. The decrease in emissions from cars, a decrease that started in 2007, has slowed down since 2013, see Figure 3.9. The switch from petrol-powered to diesel-powered cars has led to a more energy-efficient car fleet, which since the mid-2000s has been bolstered by a general improvement in fuel efficiency for new cars.

The emissions from heavy-duty vehicles follow the fluctuations of economic activity, and these emissions increased between 1996 and 2008. The decrease in emissions from heavy-duty vehicles that started in 2010 has slowed down since 2013.

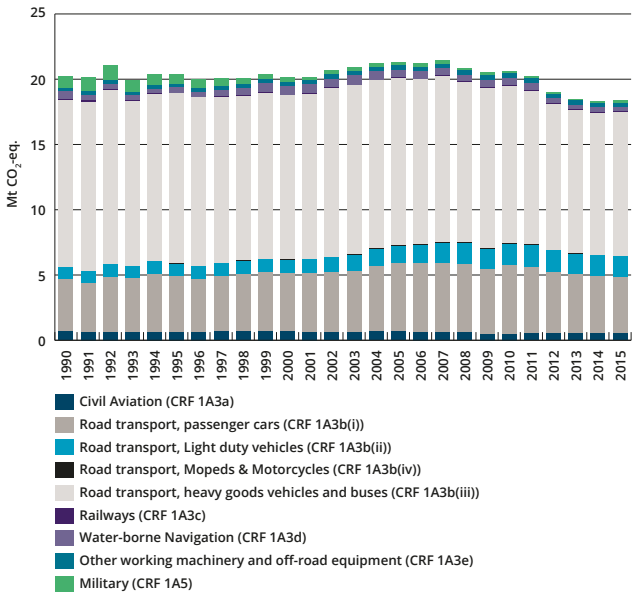


Figure 3.9 Greenhouse gas emissions from transport.

Except for emissions from road transport, emissions from transport include emissions from domestic aviation, railways, national navigation, other working machinery and off-road equipment as well as domestic military operations. In 2015, the greenhouse gas emissions from road transport were 17 Mt CO_2-eq., 0.5 Mt CO_2-eq. from domestic aviation, 0.4 Mt CO_2-eq. from domestic navigation, 0.1 Mt CO_2-eq. from railways, and 0.3 Mt CO_2-eq. from working machinery. Emissions from domestic military operations totalled 0.2 Mt CO_2-eq. in 2015.

3.2.7. Waste

Greenhouse gas emissions from the waste sector totalled 1.4 Mt CO_2-eq. in 2015, or about 2.6 % of the national total of greenhouse gas emissions. More than two thirds of the emissions from the waste sector come from solid waste disposal in landfills, which generates methane emissions and responded to 79 % of the sector in 2015, see Figure 3.10.

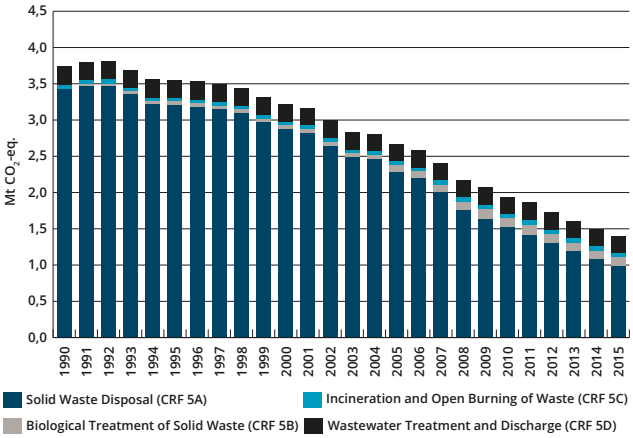


Figure 3.10 Greenhouse gas emissions from the waste sector, per subsector.

Methane emissions have decreased by 68 % in the period 1990–2015. The most important mitigation measures are the expansion of the methane recovery from landfills, the reduction of landfill disposal of organic material, the increased levels of recovery of materials, and waste incineration with energy recovery. The main reasons for the decrease in the quantities of waste sent to landfill are the bans on landfill disposal of combustible and organic material, introduced in 2002 and 2005 respectively. Producer responsibility, municipal waste plans and the waste tax have also contributed to the reduction of the amount of waste deposited in landfills.

3.2.8. Agriculture

In 2015, emissions from the agricultural sector were about 6.9 Mt CO_2-eq., which equals 12.5 % of the total national greenhouse gas emissions (excluding LULUCF).

The main sources of greenhouse gas emissions from the agricultural sector are methane emissions from cattle and nitrous oxide emissions from soil and manure, which are almost equal in size. In addition, there are small amounts of carbon dioxide emissions from liming and urea application. In 2015, agricultural emissions were about 10 % lower compared with 1990, see Figure 3.11.

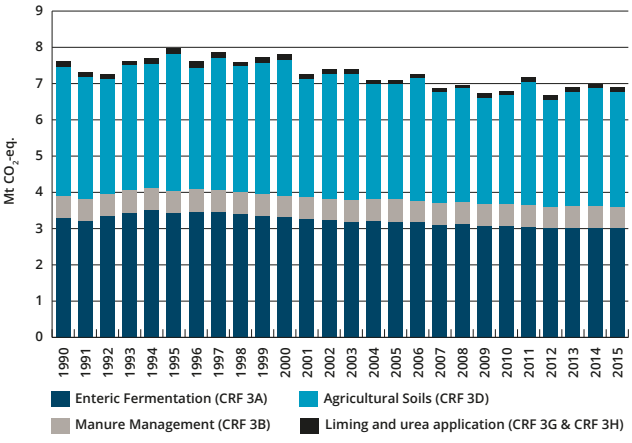


Figure 3.11 Greenhouse gas emissions from agriculture.

The decrease in emissions from agriculture is explained by a decline in livestock numbers and a decrease in emissions from agricultural soils. The long-term trend is decreasing emissions, although emissions have levelled out over the last few years due to an increased use of fertilisers. About half (51 %) of the sector's emissions consisted of N_2O, 47 % CH_4 and the rest is CO_2.

3.2.9. Land use, Land use change and Forestry

The largest removals of carbon dioxide in Sweden occur in forest land, totalling about 50 Mt CO_2-eq. in 2015, followed by harvested wood products with removals of nearly 7 Mt CO_2-eq, see Figure 3.12.

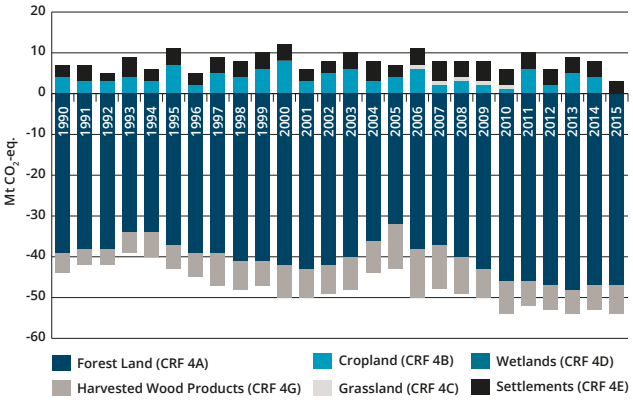


Figure 3.12 Greenhouse gas emissions and removals from land use, land-use change and forestry.

The largest emissions in this sector is due to settlements. Usually cropland is also an emitter, but was in 2015 a small sink. The estimated emissions and removals in the mineral soil give the annual variation for cropland. The annual variations depend on what is grown and how large areas of crops that are grown between years, together with the climatic conditions (air temperature and precipitations). The net emissions in 2015 were about 3 Mt CO_2-eq. as a mean value in these two categories. Sources and sinks in the LULUCF sector as a whole have resulted in net removals since 1990. During the period 1990–2015 net removals varied between roughly 31 to 50 Mt CO_2-eq. 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. Net removals in this sector are heavily influenced by harvests and natural disturbances such as storms on forest land. Two severe storms, in 2005 and 2007, had significant impacts on the trends of both forest land and harvested wood products. According to the Swedish National Board of Forestry, the felling, including wood felled by storms, was estimated at 122 Mm^3 stemwood in 2005. However, the decrease in the living biomass in 2005 resulted in a corresponding increase in the harvested wood products pool in 2006.

3.2.10. International transport

Greenhouse gas emissions from international shipping and aviation, known as international bunkering, are considerably larger than those from domestic shipping and aviation. In 2015 these emissions totalled 8.4 Mt CO_2-eq., a full 132 % higher than in 1990, see Figure 3.13.

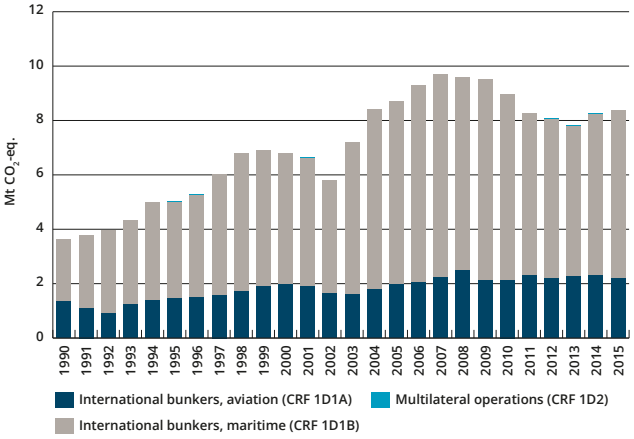


Figure 3.13 Greenhouse gas emissions from international bunkers.

Emissions from international shipping reached a total of 6.2 Mt CO_2-eq. in 2015. This is an increase of 8 % compared with 2015 and 173 % higher than in 1990. The increase may be a result of the production by Swedish refineries of low-sulphur marine fuels (fuel oil Nos. 2–5), which meet strict environmental standards. As a result, more shipping companies choose to refuel in Sweden. Another explanation may be the globalisation of trade and production systems, which has led to goods being transported over greater distances. Fluctuations in bunker volumes between years are also dependent on fuel prices in Sweden compared with the price at ports in other countries.

The Swedish Armed Forces bunker extremely small quantities of fuel in Sweden for operations abroad.

3.2.11. Reference list

National Inventory Report Sweden 2017, Greenhouse gas emission Inventory 1990 – 2015, Submitted under UNFCCC and the Kyoto Protocol.

4. Policies and measures

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[5]. 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. In addition, analysis linked to cost-effectiveness of policies and measures are presented in a specific section of the chapter. At the end of the chapter the policy instruments and their effects are summarized in a table.

4.1. 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. Recently, in June 2017, a new National Climate Policy Framework, ensuring long term order and stability in climate policy, was adopted by the Riksdag (Swedish Parliament).

4.1.1. 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)

4.1.2. Sweden's national climate policy framework

In June 2017, the Riksdag (Swedish Parliament) adopted a proposal on a national climate policy framework for Sweden (Govt. Bill 2016/17:146). The climate policy framework consists of a Climate Act, new 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. The climate act will impose responsibility on the current Government, and on future governments, to pursue a climate policy that is based on the national climate targets and to provide clear feedback on the progress. Sweden will have long-term climate targets beyond 2020 and a council that independently reviews climate policy. The reform is a key component of Sweden's efforts to live up to the Paris Agreement.

Targets

- By 2045, Sweden is to have no net emissions of greenhouse gases into the atmosphere and should

Figure 4.1. Sweden's national targets

	Historical emissions	Climate target	Climate targets in new Climate Policy Framework	
Sweden's emissions in total	**–25 %** 1990–2015			**Zero net** by 2045 Max 15 % supplementary measures
Emissions from sectors outside the EU ETS	**–27 %** 1990–2015	**–40 %** by 2020 Max 33 % supplementary measures	**–63 %** by 2030 Max 8 % supplementary measures	**–75 %** by 2040 Max 2 % supplementary measures
Emissions from domestic transports	**–11 %** 1990–2015 Excl. domestic aviation		**–70 %** by 2030 Compared to 2010	

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

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[6] is not included in the goal since this subsector is included in the EU ETS.

Climate Act

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

Climate Policy Council

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

4.1.3. 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. If the target in 2020 is met, greenhouse gas emissions from the non-ETS sector would be around 20 million tonnes of carbon dioxide equivalent lower than in 1990. This target applies to activities not included in the EU Emissions Trading System and does not include the LULUCF sector. In addition, the Bills also set targets for energy efficiency and renewable energy (see Boxes 4.1 and 4.2).

6 The emissions only includes CO_2.

Monitoring

Monitoring takes place at both the EU and the national level. Under the EU's monitoring mechanism (Regulation (EU) No 525/2013), Sweden reports every two years on policies and measures implemented and planned to achieve the climate target for 2020. At a national level regular evaluations have been performed of the country's climate policy. The first was a 'checkpoint' review started in 2004 (leading to a climate policy decision in 2006), and the second was initiated in 2007 (resulting in the 2009 climate policy decision). To analyze progress towards the objectives, as well as the state of knowledge, a further checkpoint review was undertaken in 2015.

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 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 inquiries has proved effective also for the purposes of fulfilling Sweden's commitments under the Protocol.

Box 4.1 Sweden's renewables target for 2020

The EU has adopted a mandatory target requiring a 20 % share of energy from renewable sources in overall energy consumption by 2020. Responsibility for meeting the target has been divided among the Member States. Based on the agreed burden sharing, the target for Sweden's renewable energy share in 2020 is 49 %. The Riksdag has decided that, by that year, renewable sources are to provide at least 50 % of total energy consumed. The share of renewable energy in the transport sector, meanwhile, is according to an EU target to be at least 10 %.

Box 4.2 Sweden's energy efficiency target for 2020

The EU has adopted a target of a 20 % improvement in energy efficiency by 2020. This target has not been broken down

among the individual Member States. Sweden has chosen to express its national target for improved energy efficiency by 2020 as a 20 % reduction in energy intensity between 2008 and 2020, which means that the energy supplied per unit of GDP at constant prices shall decrease over that period.

4.1.4. Framework agreement on the Swedish energy policy

In addition, in June 2016, a cross-party framework agreement on the Swedish energy policy was decided. The agreement sets out a target of 100 % renewable electricity production in Sweden by 2040. This is a target, not a deadline for banning nuclear power, nor does it mean closing nuclear power plants through political decisions. Moreover, in November 2016 a target of 50 % more efficient energy use by 2030 compared to 2005[7] was agreed.

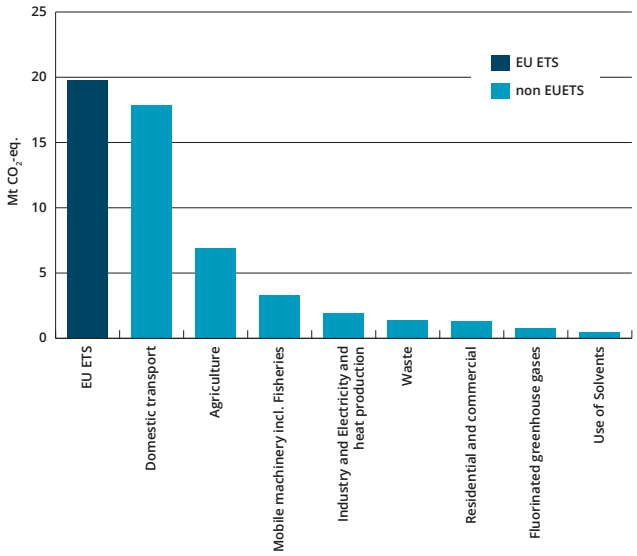


Figure 4.2 Emissions inside and outside the EU Emissions Trading System (Scope for period 2013–2020)

Box 4.3 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.
- 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 Riksdag has since approved, for example, Govt. Bill 2009/10:133, *A Higher Target and Further Development of the Electricity Certificates System*; Govt. Bill 2010/11:155, *A New Electricity Certificates Act – Simplified Rules and a Single Electricity Certificates Market;* Govt. Bill 2010/11:153, *Strengthening the Role of the Consumer for a Developed Electricity Market and Sustainable Energy System;* Govt. Bill 2010/11:70, *Third Internal Energy Market Package for Electricity and Natural Gas;* Govt. Bill 2011/12:98, *Hourly Metering for Active Electricity Consumers;* Govt. Bill 2012/13:70, *Consideration of Network Concessions;* and Govt. Bill 2012/13:21, *Research and Innovation for a Sustainable Energy System.*
- 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.

7 Expressed in terms of primary energy use in relation to gross domestic product (GDP).

4.1.5. 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.

An evaluation (Swedish Energy Agency 2015) shows that the efforts from regional climate and energy strategies have developed, albeit at different rates, in a positive direction. Concrete results are primarily relatable to methodological development, establishment of cooperative structures, knowledge building and knowledge transfer. Between 200 and 600 measures were implemented each year during 2010–2014 in the context of these strategies, and they exhibit a wide range and variety of initiatives and measures.

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.

Energy and climate change advisory services, which are partly funded by the Swedish state and municipalities, have been provided since 1998. A survey by Statistics Sweden (SCB 2015) commissioned by the Swedish Energy Agency posed a question about the impact of advice received from the energy and climate adviser on single-family house owners' decisions regarding investments. The survey revealed that 36 % of the owners themselves considered that the advice had a fairly large impact.

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

4.2.1. Background

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 dioxide 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 emission 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 objectives than climate mitigation, it can be difficult to evaluate the progress made towards the objective. As several instruments interact, it is also hard to distinguish the effect of a single instrument. Furthermore, picking out the effects of policy instruments from the impact of other, external changes, such as energy prices, is often complicated.

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 market is Nordic/north European and, moreover, has been covered by the EU ETS since 2005.

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, therefore, it may 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 tightened up.

Figure 4.3 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 4.4). The different sectors are described in more detail in the relevant sections of this chapter.

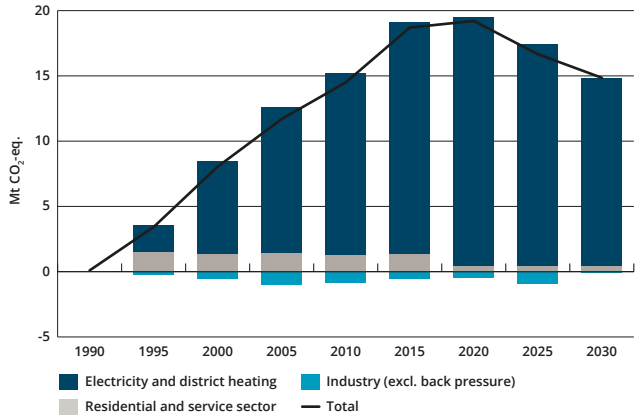


Figure 4.3 Difference in carbon dioxide emissions between a scenario based on 1990 policy instruments and actual development of policy instruments (Profu 2017a)

Box 4.4 TIMES-NORDIC modelling

To assess the effects of economic instruments on Sweden's stationary energy system, results of estimates made with the TIMES-NORDIC energy system model (Profu 2017a). The 'stationary energy system' comprises production of electricity, district heating and process steam, together with final energy consumption in the residential sector, services and industry. The estimates covered two cases:

1. Actual development of policy instruments from 1990 to 2015. Current instruments are subsequently assumed to remain in use up to and including 2030.
2. A '1990 scenario', using the policy instruments in place in 1990 throughout the period studied (1990–2030). In other respects, this case is identical to (1).

Modeling attempts to capture the most important variables that could conceivably influence the outcome we are interested in studying; all modeling therefore necessarily involves a simplification of reality and hence some uncertainty.

4.2.2. 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. Approximately half of the allowances are allocated for free to the covered installations, and the rest are auctioned. There is no free allocation for emissions from electricity production.

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 to include new greenhouse gases (nitrous oxide and perfluorocarbons) and some new industrial activities. At present, about 760 Swedish installations are included in the system. At the EU level in total, approximately 11,000 installations are covered.

Emissions from aviation were included in the system in 2012. Because of extensive protests from some countries outside the EU, and pending adoption by the International Civil Aviation Organization (ICAO) of a global market-based instrument, the EU decided on a temporary exemption until 31 December 2016 for flights to and from the EU. This means that the system includes only flights within EU. As ICAO in September 2016 decided to implement a global measure, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA), the EU Commission has proposed a continued exemption until the end of the current trading period 2020. Sweden is an Administering Member State for approximately 90 aircraft operators.

Energy tax and carbon dioxide tax

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

Carbon dioxide tax

A carbon dioxide tax, based on the fossil carbon content in the fuel, was introduced in 1991 and aims at reducing the emissions of carbon dioxide 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 1.13/kg (2017). In addition to specific tax increases stipulated in government bills, a yearly indexation of the tax level is applied.

The tax level is proportionate to the calculated amount of carbon dioxide emissions on the basis of the fuel's fossil carbon content. This means that biofuels currently are not subject to carbon taxation As regards motor fuels, the Government's budget proposal for 2018 includes changes to carbon taxation of biofuels (see separate section on carbon and energy taxation in the transport sector).

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

Energy tax

Taxes on energy have been used in Sweden for a long time.[8] 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 was initially fiscal. In more recent years, the aim has also been to steer energy use

8 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).

towards Sweden's energy efficiency and renewability targets[9]. The energy tax on motor fuels also aims at internalising 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 purposes. The tax level on heating fuels also varies between households, industry and the energy conversion sector.

Carbon dioxide tax and energy tax in the transport sector
Petrol and diesel are covered by both an energy tax and a carbon dioxide tax. In accordance with the climate policy decision in 2009, the energy tax on diesel has been raised in two stages, in 2011 and 2013, by a total of SEK 0.40 per litre (Govt. Bill 2008/09:162). As of January 2016, the energy tax on diesel was increased by another SEK 0.52 per litre and on petrol by SEK 0.47 per litre (Swedish Tax Agency 2016). Since 1994, both energy and carbon dioxide taxes on fuels and electricity are adjusted to changes in the consumer price index (CPI), to take into account inflation. As of 2017, tax rates on petrol and diesel are also adjusted to take into account the development of the gross domestic product (GDP).[10]Sweden applies tax reductions for sustainable biofuels. The energy tax reduction varies between different kinds of biofuels and is between 36 and 100% compared to fossil counterparts (2017). Since December 2015, sustainable biofuels are fully exempt from carbon dioxide tax. This is a change for blended fuels, such as ethanol blended in petrol and biodiesel blended in diesel, where the previous tax reduction was restricted to no more than 5% by volume.

Ethanol has 88–100% exemption from energy tax depending on whether it is used for low blending in petrol, high blending in petrol (E_{85}) or high blending in diesel (ED_{95}). For FAME in diesel, the deduction is 36% of the normal energy tax. For hydrogenated vegetable and animal oils and fats (HVO) and other biofuels classed as diesel or gasoline, the tax deduction is 100% for both the energy tax and the carbon dioxide tax. This applies to the portion of the fuel made from biomass (Swedish Tax Agency 2017a).

As noted in chapter 4.2.4, the Government's proposal in the Budget Bill for 2018 to introduce an emission reduction obligation scheme is 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 will be subject to carbon and energy tax rates that correspond to the rates of their fossil counterparts. At the same time, the carbon tax rates for petrol and diesel are adjusted downwards to take into account the share of low-blended biofuel per litre full blend, following from the emission reduction scheme. In this way, the basic logic behind the carbon tax – to only target *fossil* carbon emissions – is preserved. High-blended biofuels are not covered by the scheme and the proposal is to exempt all high-blended sustainable biofuels from both carbon and energy tax.

Carbon dioxide tax and energy tax for heat production
Heat production is subject to energy tax as well as carbon dioxide tax. Biofuels are exempt from energy tax (Swedish Tax Agency 2017b) and the carbon dioxide tax does not apply since it is based on the fossil carbon content. Since 2013, fuels used for heat production in combined heat and power plants (CHPs) within the EU ETS are no longer subject to the carbon dioxide tax, but pay 30% of the energy tax. Other heating plants within the EU ETS are subject to 100% of the energy tax and 80% of the carbon dioxide tax. CHPs outside the EU ETS pay 30% of the energy tax and 80% of the carbon dioxide tax on fuels used to produce heat (Swedish Tax Agency 2017c). No carbon dioxide tax is charged for fuels used for heat production and supplied to manufacturing processes in industries if the industrial activity is part of the EU ETS.

In the Government's budget proposal for 2018, the carbon dioxide tax on fuels used for heat production in CHP plants within the EU ETS is proposed to be increased from 0% to 11% of the general carbon tax rate. The carbon tax on fuels used for heat production within the EU ETS, other than heat production in CHP plants or in industrial manufacturing processes, is proposed to be increased from 80% to 91% of the general rate. The change is proposed to come into effect on 1 January 2018.

Carbon dioxide tax and energy tax for electricity production
Fuel used for electricity production is exempted from both energy and carbon dioxide taxes, but the use of electricity is generally subject to an energy tax.

Carbon dioxide tax and energy tax in the industrial sector
Industry is subject to some exemptions and reductions in energy and carbon dioxide taxes, basically 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. Moreover, reductions and exemptions are applied to avoid carbon leakage. The manufacturing industry covered by the EU ETS pays 30% of the general energy tax and, since 2011, is exempted from the carbon dioxide tax. The manufacturing industry not covered by the EU ETS also pays 30% of the general energy tax on fuels used in industrial manufacturing processes. Earlier, this part of industry had significant reductions in the carbon dioxide tax, but in recent years the tax has been raised. In January 2011 the carbon dioxide tax was raised from 21% to 30%, in January 2015 to 60%, and in January 2016 to 80% of the standard rate of carbon dioxide tax. The carbon dioxide tax reduction will be totally rescinded by 2018.

Carbon dioxide 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 dioxide tax rates for fossil fuel used for heating purposes. Since

9 The energy efficiency target and the renewable target for 2020 are part of Govt. Bills 2008/09:162 and 163.
10 This is achieved through a flat-rate increase of 2 % per year. The combined change in the carbon and energy tax rates is, however, added exclusively to the energy tax rate (i.e. the carbon tax rate is only directly affected by the indexation to CPI).

then, the carbon dioxide tax reduction in the sectors has been reduced in steps. As for industry, the tax was increased to 60 % of the standard rate in January 2015 and to 80 % in January 2016, and the reduction will be totally rescinded by 2018.

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

In addition to a general relief of the carbon dioxide tax, enterprises could up until 2014 claim a further reduction under what has been known as the 1.2-percent rule. This tax relief has primarily taken effect for enterprises in the greenhouse horticulture sector. This tax relief ended in January 2015.[11]

Local Climate Investment Program

To further stimulate the reduction of greenhouse gas emissions, a program for local investments was introduced in 2015 (the Climate Leap). 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. Investments in sectors included in the EU ETS may still be eligible for grants if these result in an increased utilisation of waste heat. Applicants compete based on the estimated greenhouse gas reduction of each investment program.

The program granted approximately SEK 2 billion during 2015–June 2017. The total allocated budget for 2016–2018 was SEK 600 million annually. In 2016 the Government decided to increase the budget and extend the program, totalling SEK 700 million annually for the period 2017–2020. In spring 2017, the budget was increased for the same year with an additional SEK 500 million. In the budget proposal for 2018 the Government proposes to increase the budget for 2018 with an additional SEK 800 million, and the indicative budget for 2019 and 2020 by SEK 1300 million and SEK 2300 million respectively.

During September 2015 through June 2017, the Swedish EPA made decisions on grants to 1035 investments totalling ca SEK 4.65 billion, of which 43 % were covered by the grants.

Effects of the Local Climate Investment Program

In total, the investments granted up until 20 June 2017 are expected to generate a reduction of approximately 0.7 Mt CO_2-eq. per year during the technical lifespan of the investments[12]. The total effect of these investments is estimated to be over 10 Mt CO_2-eq. during the technical lifespan of the investments. 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 and supply of biofuel. Hence, all emission reductions cannot not be attributed to this policy instrument alone, as other instruments will also affect the emissions. E.g. the electric vehicles need the infrastructure but are also affected by other national and EU policy instruments.

The Environmental Code and planning legislation

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

Measures in 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, as for major infrastructure projects, are also covered by the Environmental Code. Since May 2011, the Planning and Building Act introduced new requirements on considering the environmental and climate aspects of planning. 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 January 2017 for municipal structure planning, aimed at reducing greenhouse gas emissions.

In December 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.

Climate change communication

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

Communication on possible measures in different sectors is disseminated through several channels. The Swedish

11 The 1.2-percent rule included businesses for which the carbon dioxide tax exceeded 1.2 % of the company's sales value, despite the general reduction of the carbon dioxide tax taken. For the excess amount of tax, only 24 % of the tax that would otherwise have been paid was paid. (Govt. Bill 2009/10:41)

12 The technical lifespan of the investments is in average 16 years.

Environmental Protection Agency and the Swedish Meteorological and Hydrological Institute (SMHI) are responsible for gathering and communicating information on climate change, as mandated by the Government.

The Swedish Government has adopted the objective to make Sweden one of the world's first fossil-free welfare states. This ambition requires a mobilisation of the entire society, not least municipalities, cities and business. To that end the government has launched the Fossil-Free Sweden initiative which mobilises and supports key actors in their climate efforts by providing a platform for dialogue, cooperation and inspiration between themselves and the Government. It is furthermore an arena where difficulties and complications can be discussed and brought to the government's attention. (Fossilfritt Sverige 2017)

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

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

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

On a regular basis, the Swedish EPA conducts surveys that measure public awareness and attitudes towards climate change. The 2015 survey found that 8 out of 10 Swedes state that they can contribute to mitigation of greenhouse gas emissions. Swedes demonstrate a very high level of readiness to reduce their own greenhouse gas emissions, and a growing number have done something in their everyday lives to reduce their climate impact.

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.

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 2017 (Govt. Bill 2016/17:1), which has been approved by the Parliament, the Government proposed an expansion of contributions to energy research and development with funding of SEK 620 million for 2017–2020. This will result in a level of SEK 1.6 billion as of 2020, compared with the earlier level of SEK 1.3 billion.

The Swedish Energy's research and innovation program is based on Government Bill 2016/17:66 (Research and innovation in the energy sector for sustainable ecology, competition and security of supply). It takes its starting point in five different societal challenges:

- A 100% renewable energy system
- A flexible and robust energy system
- A resource-efficient society
- Innovation for jobs and climate
- Collaboration in the energy system

Following these five societal challenges, energy research and innovation is carried out under nine different thematic areas: the transport system, bioenergy, buildings in the energy system, power systems and electricity generation, industry, a sustainable society, general energy system studies, business development and commercialisation as well as international collaboration.

Alongside the Swedish energy research and innovation program, climate-related research is also being financed by other national research funding programs. In Government Bill 2016/17:50 (Knowledge in cooperation – for challenges in the society and strengthened competitiveness), climate is listed as one of several societal challenges that require special contributions. It has therefore been decided to establish a National ten-year Research Program for Climate and to increase funding by SEK 130 million by 2020.

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

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 has to increase its share from just under 44% (2007) to 49% in 2020. This is one percentage point lower than the national target for the same year. With policy instruments already decided upon and planned, and with latest projections, Sweden appears capable of fulfilling its commitment to the EU and meeting the national RES target. In fact, 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 54% in 2015.

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 remained relatively stable, as the expansion largely has been achieved by the increased use of biofuels, while the use of oil and coal has declined. The carbon dioxide tax is one of the main factors behind this trend, but the electricity certificate system is also 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.

Electricity certificate system

An electricity certificate system aiming to support electricity based on renewable energy was introduced in 2003. In October 2015, the Swedish Parliament approved a new target; as a result, Sweden will finance more renewable electricity production within the electricity certificate system – totalling 30 TWh by 2020 compared with the 2002 level. In addition, a new target has been set to increase the production with another 18 TWh by 2030. The electricity certificate system was also prolonged up until 2045.(Govt. Bill 2016/17:179) The increase of renewable electricity production through the electricity certificate system is a key element in the Swedish action plan to attain the country's renewables targets for 2020 and 2040.

As of 1 January 2012, Sweden and Norway have a common electricity certificate market. In order to implement Sweden's more ambitious goal, Sweden and Norway reached an agreement in modifying the common target from 26.4 TWh to 28.4 TWh by 2020 compared with the 2012 level. The new target for 2030 has also been agreed with Norway.(Govt. Bill 2016/17:187)

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 energy. (SFS 2011:1200).

Initiatives for wind power

The prospects for additional wind power generation have been improved by increased experience and technical development, which have resulted in lower wind energy costs. Furthermore, different 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 2017a).

Since 2004, certain land and water areas in Sweden have been designated as areas of national interest for wind power. There are 313 such areas in Sweden, of which 284 are located onshore and 29 offshore. The most recent update was carried out in 2013 and four areas were added in 2015. The total area of these national interests for wind power is roughly 7,900 km^2, representing about 1.5% of the country's land area, including Swedish waters. (Swedish Energy Agency 2017a)

In the budget proposal for 2018, the government proposes a new initiative for support to municipalities in order to facilitate wind farms.

Support for solar power

A subsidy for installations of photovoltaic cell technology was initiated in 2009.The budget for this support is set at SEK 1,395 million for the period 2016–2019. In the budget proposal for 2018, the Government has proposed an increased budget for this support, to SEK 3,34 billion for the period 2017–2020. All types of players can obtain financial support for installing grid-connected photovoltaic, solar electricity and solar hybrid systems. The investment aid contributes to the transformation of the energy sector and to business development of solar energy technology.

Tax relief for micro-production of renewable energy

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 amperes, but not more kWh than 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 4.4) show that emissions from the electricity and district heating sector (including back-pressure power) could have been 11–18 Mt CO_2 higher per year in the time period 2005–2015 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.

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 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. The total effect is thereby, for the period 1990–2030, a strong drive away from fossil fuels. (Profu 2017a)

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 CO_2-eq. per year) (Profu 2017a)

2005	2010	2015	2020	2025	2030
11	14	18	19	17	14

Residential and service sector

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 dioxide 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. This has made it considerably more expensive to use these fuels than if energy taxation was kept at its 1990 level (Profu 2017a). Oil prices and the available technologies for fossil-fuel substitutes have also had significant impact on trends in the sector.

Alongside carbon dioxide 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

Mandatory energy labelling of domestic appliances has been in force in the EU since 1995. Since 2005, energy labelling has been further developed through the Ecodesign Directive (revised 2009/125/EC) and the Energy Labelling Directive (2010/30/EU), which set combined energy efficiency requirements and other environmental aspects for products and energy label requirements. In principle the Directive applies to all energy-related products (except transport) and covers all energy sources.

In Sweden, the Ecodesign Act (SFS 2008:112) came into force in 2008. Under the Act, energy consumption and other environmental factors are important parts of product development when minimum requirements are established. Further, Sweden is particularly active in market surveillance activities, involving laboratory tests of products as well as supervision of distributors.

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.

Energy Performance Certificate Act

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. Building regulations for new production underwent a major change in 2006, including stricter requirements for electrically heated buildings effective 2009. The energy requirements for new buildings were revised and took effect in 2012, with a stepwise implementation period. These stricter requirements apply to energy use in buildings with heating systems other than electric heating (for which requirements were made stricter in 2009). Specific energy use (kWh/m^2 and year) and average thermal transmittance (W/m^{2}K) are now nearly 20 % stricter.

Support for renovation and energy efficiency of rental apartments*

In October 2016, a new support scheme was introduced to incentivise renovation and energy efficiency of rental apartments in areas with socioeconomic challenges (SFS 2016:837). The Government allocated SEK 800 million to

the scheme in 2016, and another SEK 1 billion will be set aside annually for the period 2017–2020. The support for energy efficiency is calculated based on the estimated level of energy efficiency after the renovation. Only cases in which the efficiency is improved by at least 20 % are eligible to receive support, and only projects including both renovation and energy-efficiency measures are approved.

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.(Swedish Energy Agency et.al. 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), public sector bodies that rent premises (HyLok) and food distribution (BeLivs).

Effects of policy instruments in the residential and service sector
Between the early 1990s and the present day, carbon dioxide 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, 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 2017a). This is shown in figure 4.4.

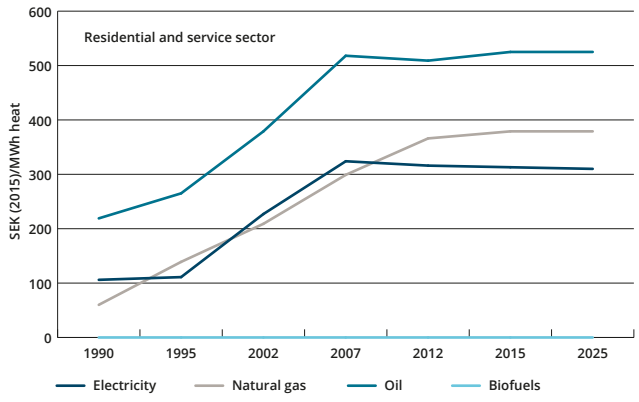


Figure 4.4 Policy instruments affecting light fuel oil, biofuels, natural gas and electricity in the residential and service sector: development between 1990 and 2015, and model assumptions for 2025 (constant 2015 prices) (Profu 2017a)

Analysis of model estimates based on TIMES-NORDIC shows that drivers for a switch to other heating options exist in both the scenario retaining 1990 policy instruments and the one based on current levels of instruments, but that the incentive to replace existing oil-fired heating is greater in the scenario in which taxes have been developed and raised to today's levels. By 2025, according to the model's scenarios, fossil based heating will be phased out altogether in the residential sector with current instruments, whereas there would still have been a certain proportion of fossil fuels left if instruments had remained at 1990 levels (Profu 2017a).

Table 4.2 Estimated aggregate effects of policy instruments introduced since 1990 on emissions from residential and service sector in Sweden, compared with a scenario based on 1990 instruments (Mt CO_2-eq. per year) (Profu 2017a)

2005	2010	2015	2020	2025	2030
1,4	1,3	1,4	0,4	0,4	0,4

4.2.4. Industrial emissions from combustion and processes (including emissions of fluorinated greenhouse gases)

Industrial emissions from combustion and processes
Total emissions from combustion in manufacturing industries are trending downward. The instruments primarily affecting combustion emissions from the industrial sector are the EU ETS, energy and carbon dioxide taxes, the electricity certificate system and the Environmental Code. Industrial process emissions have come almost entirely within the scope of the EU ETS since its expansion for the third trading period (2013–2020). These processes are also regulated by the Environmental Code's requirement to use the best available technology. Recently the initiative "Hydrogen Breakthrough Ironmaking Technology", was granted support to find solutions to the issue of CO_2 emissions in the steel industry.

HYBRIT – Hydrogen Breakthrough Ironmaking Technology *
The private enterprises SSAB, LKAB and Vattenfall have initiated a project with the aim to solve the issue of emissions of carbon dioxide from the steel industry. A feasibility study for the project was granted SEK 7.7 million and in February 2017 a resolution was passed to finance a 4-year long research project under The Swedish Energy research and innovation program (Govt. Bill 2016/17:66). The Swedish Energy Agency is administering the governmental grants. At the same time, the three companies behind the initiative, SSAB, LKAB, and Vattenfall, have decided to form a corporate joint venture to spur on this initiative.

The research project will investigate processes such as fossil fuel-free pellet manufacturing, hydrogen-based direct reduction, and the use of sponge iron in electric arc furnaces, along with providing an electrical power supply source for hydrogen manufacturing and storage. The research project has been allocated SEK 99 million, with The Swedish Energy Agency providing SEK 54 million of this amount and the three companies contributing the remaining SEK 45 million. (Swedish Energy Agency 2017b)

Industrial Leap*

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

Energy audit for large enterprises

The law on energy audit in large enterprises aims at promoting improved energy efficiency (SFS 2014:266)[13]. The law requires large enterprises to conduct energy audit, including information of total energy usage as well as proposals of cost efficient measures to improve the energy efficiency. The audit must be conducted at least every fourth year.

Grants for small and medium-sized enterprises for energy audit

To stimulate a more efficient use of energy, small and medium-sized enterprises[14] are since 2010 eligible to apply for financial support to conduct energy audit (SFS 2009:1577). The energy audit should include energy mapping, proposals of measures and an energy plan. Up until 2014 the maximum support per entity was 50 %, with a maximum of SEK 30,000. Since 2015 the grant ceiling was increased to SEK 50,000 with the percentage remaining at the same level.

Energy and climate coaches for small and medium-sized enterprises

Since 2016 municipalities are eligible to apply for the cost of one half-duty climate and energy coach (SFS 2016:385). The coach provides targeted advisory services to small and medium-sized enterprises[15]. One round of applications was completed during 2016 and the coaching activities will start in 2017. The support is available until 2019. The coaching activities aim to increase energy efficiency and reduce greenhouse gas emissions. By doing this, the enterprises will benefit from reduced costs, strengthened competitiveness and new opportunities for growth. (Swedish Energy Agency 2017c)

Energy efficiency networks for small and medium-sized enterprises

The Swedish Energy Agency initiated a network project for small and medium-sized enterprises in 2015. The goal is to operate 40 networks with a total of 400 companies, supporting them to introduce energy management principles with the help of regional coordinators and energy experts. Sharing experiences and learning from each other within and between the networks are also important success factors. The aim of the network activities is to reduce the energy use of the participating companies by 15 %. By doing this, the enterprises will benefit from reduced costs, strengthened competitiveness and new opportunities for growth. (Swedish Energy Agency 2017d)

Effects of policy instruments in the industrial sector

According to estimates made using the TIMES-NORDIC modelling tool, the effect of economic policy instruments on combustion-related emissions in this sector would have been somewhat greater if 1990 policy instruments had been retained. The difference in emissions between the 1990 scenario and current instruments scenarios is consistently small. This is mainly due to that Sweden already in 1990 applied energy tax in the sector. In 1991, the carbon dioxide tax was added to the tax system as part of a major tax reform, which included lowered levels of the energy tax and tax reductions for the industry. In 2005, most of the industries became part of the EU ETS in which the allowance prices have been kept at a relatively low level. (Profu 2017a)

Directive and regulation 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; it includes provisions for the use, reuse and destruction of f-gases and imposes conditions on the market introduction of specific products and equipment that contain, or whose function relies upon, 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. Within four years of adoption, the specified performance requirements are to be met. These could significantly reduce emissions from aluminium production.

Swedish Regulation 2016:1128 on fluorinated gases

Swedish Regulation 2016:1128 on fluorinated gases, which replaces Regulation 2007:846 (see Swedish second Biennial Report), complements the EU regulation. Provisions in Sweden for cooling and air conditioning and heat pump equipment include:

13 The law is part of fulfilling the EU Energy Efficiency Directive, EED (Directive 2012/27/EU)
14 Businesses using more than 300 MWh of energy annually, farms with at least 100 livestock units and economical organizations are eligible for the support.
15 Businesses using less than 300 MWh.

- Requirements on leak checks in conjunction with installation, conversion and other interventions.
- Requirements on leak checks and certification also apply to mobile equipment containing f-gases.
- 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 14 tonnes of CO_2-eq. refrigerants.
- It is prohibited to sell f-gases as refrigerants to recipients other than those stated in the regulation.
- Importers and those who transfer refrigerants are required to accept delivered refrigerants for disposal and provide containers for this purpose, at no charge to the buyer.
- Equipment manufactured, imported or brought into Sweden must have accompanying operating and maintenance instructions that are accurate and easy to understand.

4.2.5. Transport

Emissions from domestic transport, where road transport dominates, increased after 1990, reaching a peak in 2006–2007, thereafter declining but this declining has slowed down since 2013. The decrease in emissions since 2006 can be attributed to policy instruments introduced both nationally and at the EU level. The most significant ones include emission performance standards for new vehicles, vehicle taxes and vehicle fuel taxes. These have resulted in more energy-efficient vehicles and a greater use of renewable fuels. The Government notes that reducing transport-related emissions is essential to meet the climate targets set by the Swedish Parliament. Consequently the Government proposes several policies and measures aimed at the transport sector in the budget proposal for 2018. Lately the local climate investment program has granted support for infrastructure for the introduction of electrical vehicles. In the budget proposal for 2018, the Government proposes the introduction of a bonusmalus-system for the purchase of new light vehicles and an emission reduction obligation for petrol and diesel to further spur emission reductions in the sector. Moreover, the Government proposes that a tax on air travel will be introduced with the aim to reduce the climate impact of aviation.

Aviation

Tax on air travel

In the budget proposal for 2018, the Government proposes that a tax on air travel will be introduced with effect from 1 April 2018. A tax on air travel aims to reduce the climate impact of aviation. The proposed tax has been designed as a tax on commercial flights and will be paid for passengers travelling from a Swedish airport. The airline that carries out the flight shall be liable to tax. Various levels of tax (SEK 60, 250 and 400) will be levied based on the final destination. The Swedish Tax Agency will be the competent tax authority.

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.

Road transport

Emission reduction obligation (Fuel change)*

In the budget proposal for 2018, the Government proposes the implementation of an emission reduction obligation, planned to go into effect 1 July 2018, called the *Fuel Change*. The emission reduction obligation puts an obligation on petrol and diesel suppliers to reduce carbon dioxide emissions from petrol and diesel, through increased biofuel blending. The Fuel Change makes an important contribution to the phasing out of fossil fuels in transports. The indicative target to 2030 is to reduce emissions by at least 40 %, which equals a share of biofuels of about 50 %. The obligation will replace the current tax exemption for low-blended biofuels, i.e. biofuels covered by the scheme will be subject to the same tax rate per litre as fossil counterparts. At the same time, both the carbon dioxide and energy tax rates are reduced. High-blended biofuels are not covered by the scheme and will be completely exempt from both carbon dioxide and energy tax. (More information about the proposed adjustments of the tax rates are presented in chapter 4.2.2 above.)

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 became effective 1 January 2006. This requirement has resulted in an increased number of mainly E85 pumps. As of 1 January 2015, the legal requirements were loosened so that filling stations selling more than 1,500 m^3 of petrol or diesel must supply at least one kind of renewable fuel.

EC Fuel Quality Directive

In April 2009, Directive 2009/30/EC was adopted to revise the Fuel Quality Directive (98/70/EC). It amends a number of elements for petrol and diesel specifications and introduces requirements for fuel suppliers to reduce the greenhouse gas intensity of energy supplied for road transport (low carbon fuel standard). In addition, the Directive 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, 333/2014, 510/2011 and 253/2014) that set emission performance standards for new passenger cars and vans as part of the Community's integrated approach to reducing CO_2 emissions from light-duty vehicles. Under these regulations, new passenger cars should not emit an average of more than 130 g CO_2/km by 2015 and not more than 95 g CO_2/km by 2021. New vans should not emit an average of more than 175 g CO_2/km by 2017 and 147 g CO_2/km by 2020.

Differentiated vehicle tax

Since 2006, Sweden has differentiated the annual vehicle tax with respect to the vehicle's carbon dioxide emissions per kilometre. The CO_2-related vehicle tax is SEK 22 per g CO_2/km beyond 111 g CO_2/km in mixed driving. This CO_2 component is multiplied by a factor of 2.37 for diesel cars, since diesel fuel has a lower energy tax than petrol. Cars adapted for alternative fuels such as ethanol and gas, except LPG, are taxed at a lower rate of SEK 11 per g CO_2/km beyond the first 111 g CO_2/km. Light trucks, light buses and campers were also brought into the system of CO_2-differentiated vehicle taxation as of 2011. The taxation of older cars and heavy trucks is mainly based on weight. The main purpose of the differentiation is to make car buyers chose cars with a low climate impact.

Super-green car rebate

Buyers of passenger cars that meet EU exhaust requirements Euro 5 or Euro 6 and emit a maximum of 50 grams of carbon dioxide per kilometre are entitled to a super-green car rebate. The rebate is SEK 40,000 for private buyers of electric cars, and on 1 January 2016 was lowered to SEK 20,000 for buyers of hybrid cars. If the owner is a company or another organisation, the rebate is 35 or 17.5 % of the cost difference between the price of a super-green car and a non-super-green car of a similar type. The maximum rebate is SEK 40,000. This rebate mainly aims to contribute to technology development and deployment but also to create public awareness in order to lower barriers for a large-scale introduction of electric and hybrid electric cars in the future. In the budget proposal for 2018, the Government proposes that the super-green car rebate is abolished and replaced by a bonusmalus-system for new light vehicles.

Tax exemption for environmentally friendly vehicles

Sweden offers a tax exemption for environmentally friendly vehicles (EFVs) for new vehicles in their first five years according to a certain definition (SFS 2006:27). As of 1 January 2013, the definition of EFV is related to the car's curb weight and allows heavy vehicles to emit more CO_2 than lighter vehicles. According to the new definition, the highest approved emission level for an average-weight petrol or diesel car (average weight of 1,372 kilos) is 95 g CO_2/km. Flex-fuel vehicles (so called FFVs, powered by ethanol or CNG/CBG) are allowed to emit more CO_2 – an average of 150 g/km – and still be counted as EFVs. Electric cars and plug-in hybrids allowed maximum electricity consumption are restricted to 37 kWh/100 km. The new definition also applies to motor homes, vans and small buses, which were previously not included. In the budget proposal for 2018, the Government proposes that the tax exemption is removed when the bonusmalus-system for new light vehicles is approved.

Lower benefit value on cars with advanced environmental technology

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

The benefits of private use of a company car are subject to personal income taxes. The value of the benefit corresponds on average to the market value of the cost of owning the car.

Fuel provided by the employer is taxed separately. The value of the benefit corresponds to 1.2 times the market value of the cost of fuel. Hence, employees have an incentive to choose more fuel-efficient cars and to limit the private use of company cars.

To increase the incentive to purchase company cars that use environmental technologies, green cars receive relatively favourable tax treatment through the reduction of their benefit value. Typically, the benefit value is reduced to the (lower) level of a similar model without the environmental technology of the green car. This reduction is permanent.

In addition to this reduction, the benefit value of electric cars, plug-in hybrids and cars powered by natural gas (other than liquefied petroleum gas) were provided an extra reduction of 40 %, up to a maximum of SEK 16,000 annually until the end of 2016. This additional reduction has been lowered to SEK 10,000, starting in 2017 and applied until the end of 2020.

Electrical bus premium*

Regional public transport agencies are eligible to apply for an electrical bus premium as of 30 July 2016 (SFS 2016:836). The premium, which is administered by the Swedish Energy Agency, applies for electrical busses for public transportation use ordered after 31 December 2015. The size of the premium depends on the number of passengers and whether the bus runs on electricity only or is a hybrid. In total, SEK 350 million has been allocated for 2016–2019. The premium aims to contribute to the national environmental objectives 'Reduced climate impact', 'Clean air' and 'Good built environment' by promoting the market introduction of electrical busses.

Bonus-malus-system for new light vehicles*

In the budget proposal for 2018, the Government proposes the implementation of a bonusmalus-system for the purchase of new light vehicles, planned to go into effect 1 July 2018. Vehicles with low emissions of carbon dioxide will qualify for a bonus at purchase, while vehicles with high emissions of carbon dioxide will be taxed at a higher rate for the first three years. The system will replace the current tax exemption for environmentally friendly vehicles and super-green car rebate.

Local Climate Investment Program (Climate leap)*

In the budget proposal for 2018, the Government proposes a strengthening of the comprehensive investment support called the 'Climate Leap'. Municipalities, companies, organisations and others can apply for investment support for measures to reduce climate impact, to a large extent related to the transport sector. Such as investments in biogas plants or the installation of charging points for electric vehicles (more about the Climate leap in section 4.2.2 Cross-sectoral instruments).

Electric vehicle premium*

In the budget proposal for 2018, the Government proposes an 'electric vehicle premium'to improve the possibilities of commuting and transportation with electric bicycles or electric scooters. The Government is allocating SEK 350 million per year 2018–2020 for a premium that covers up to 25% of the purchase price. The electric vehicle premium makes it possible to commute longer distances by bike and will make large groups less car dependent.

Charge at home-grant*

In the budget proposal for 2018, the Government proposes a charge at home-grant. Private individuals receive a rebate equalling 50% of costs for buying and/or installing charging stations for electric vehicles in their homes. The maximum rebate is SEK 10 000. The rebate is to be administered by the Swedish EPA. The aim of the rebate is to make it easier and cheaper for households to switch to sustainable modes of transportation.

Urban environment agreements

Urban environment agreements are a scheme for investments in public transport and cycling infrastructure at the regional and local level in Sweden. The scheme commenced in 2015 and will continue until 2018. Municipalities are eligible to apply for grants to cover part of the investment costs for public transport infrastructure. The investment should be coupled with other actions aiming at increasing the long-term sustainability of urban areas and the transport system. These actions can include increased accessibility through public transport, urban planning for increased cycling and walking, lower vehicle speeds, parking policies and pricing. The scheme is administered by the Swedish Transport Administration with a total budget of SEK 2.75 billion. About half of that sum has been granted up to the end of 2016.

Research and demonstration

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

- FFI – Strategic vehicle research and innovation
- F3 – Collaboration program for renewable fuels and systems
- SFC – Research on biomass gasification
- Battery funding program
- Energy efficiency in the transport sector program
- Demonstration program for electric vehicles
- Vinnova – Innovations for a sustainable society

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 2016, the Riksdag decided on a new national infrastructure plan for 2018–2029, to be implemented by The Swedish Transport Administration with other actors. The Swedish Transport Administration is responsible for long-term planning of all modes of transport. Planning is undertaken in dialogue with local and regional planning bodies. Under the Planning and Building Act (SFS 2010:900), too, there is a clear requirement to take environmental and climate issues into account in planning.

Eco-bonus system for heavy transports*

In the budget proposal for 2018, the Government proposes the introduction of a temporary Eco-bonus system in order to stimulate the transfer of freight transport by road to shipping. The aim of the system is to reduce greenhouse gas emissions from heavy transports.The Government is allocating SEK 150 million for Eco-bonus over the period 2018–2020.

Effects of policy instruments in the transport sector

Carbon dioxide and energy taxes on fuels

Figure 4.5 shows actual emissions from road traffic between 1990 and 2015 and in 2020 scenario. The figure also shows projected emissions trends up until 2020 without the energy and CO_2 tax increases on fuels implemented since 1990. The estimate of fuel tax increases was made on the nominal tax rate that was in effect in 1990, since the decision to adjust inflationary fuel taxes was taken in 1994. The overall emissions impact of tax increases on diesel and petrol is estimated in 2010 to total about 2 million tonnes of CO_2/year and for both years 2015 and 2020 have an effect of approximately 2.3 million tonnes CO_2/year lower emissions compared to a scenario that retained the 1990 nominal tax level.

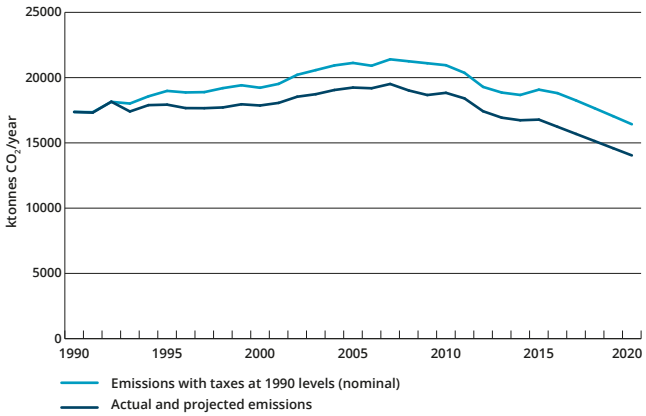


Figure 4.5 Greenhouse gas emissions from road traffic 1990–2015 and projection to year 2020 with fuel taxes decided (nominal prices), compared with estimated emissions if fuel taxes had been retained at 1990 levels.[16] (SPBI 2017) (Swedish Tax Agency 2017) (Swedish EPA 2017b).

16 Estimate with sliding elasticities from 0.3 to 0.7 for private transport and from 0.1 to 0.2 for commercial traffic. A simplified method was used that probably slightly overestimates the tax effect.

Tax exemption for biofuels

Incentives for biofuels have been crucial for their use, since they are more expensive to produce than fossil fuels. Biofuels that are verified as sustainable are not subject to the CO_2 tax. They also enjoy a lower energy tax, the amount of which varies depending on biofuel type (see section 4.2.1). Figure 4.6 shows actual emissions from road traffic 1990 to 2015 and from there a scenario to 2020, and the emissions figures without the use of biofuels. The effect of biofuel use in 2010 totalled about 1 million tonnes of CO_2/year, 2.5 million tonnes CO_2/year for 2015, and for 2020 is estimated to have an effect of about 4.2 million tonnes of CO_2/year[17] lower emissions than if no biofuels had been used.

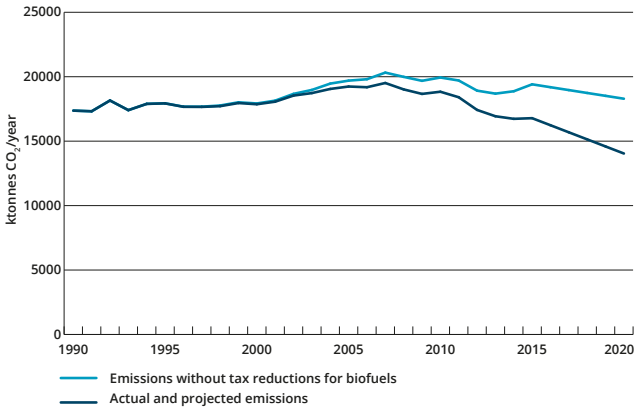


Figure 4.6 Actual emissions from road traffic 1990 to 2015 and from there a scenario to 2020, and the emissions figures without the use of biofuels.

National and EU instruments for energy efficiency

New cars are becoming more and more energy efficient, and emissions from the average car have steadily declined since the mid 1990's with an acceleration around 2005.

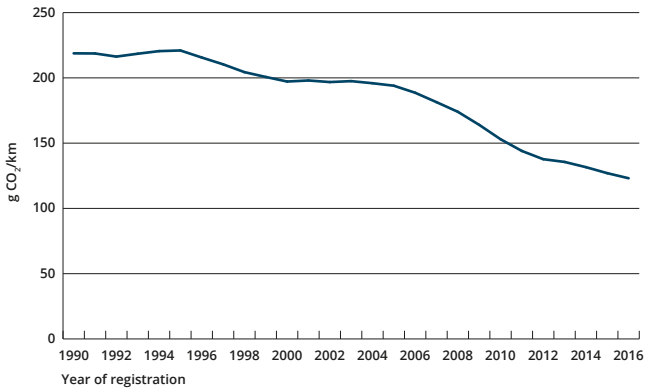


Figure 4.7 Average historic CO_2 emissions from new vehicles

There are several instruments that have interacted to promote the energy efficiency of new cars sold in Sweden. First, several national instruments[18] have been introduced since 2005. Second, the EU has introduced carbon dioxide requirements for new cars. The Swedish Transport Administration has estimated the effect on national emissions of the EU CO_2 requirements for new cars and the national instruments introduced since 2005 that affect car choices. Simplified assumptions have been used to estimate the effect of these instruments. The calculations were made using the HBEFA model, and three different scenarios[19] were analysed from 2005 up until 2035 for the development of the CO_2 emissions of passenger cars and light trucks. The results show that if neither EU requirements nor national instruments were in place and that the efficiency rate of new cars would thus have topped off at 0.5% per year, then 2015 emissions would have been 1.3 million tonnes of CO_2 higher per year. The effect increases over time since EU requirements up to 2021 will have a greater impact and an ever-increasing part of the fleet will be transformed. In 2030, the effect is estimated to have increased to 4.3 million tonnes CO_2/year. The analysis also shows that the short-term impact of emissions is largely due to national incentives, while the long-term impact largely depends on EU requirements.

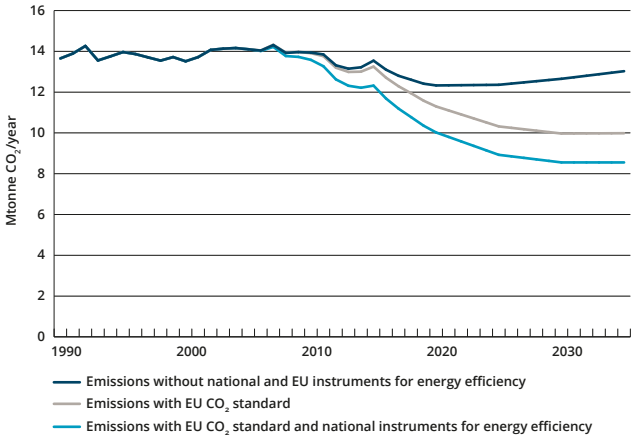


Figure 4.8 Historic and future CO_2 emissions from passenger cars and light trucks in with and without implemented policy instruments

4.2.6. Waste

Methane emissions from landfill sites have declined significantly since 1990 and are expected to continue falling sharply over the next ten years. The factors behind this decline are an expansion of methane recovery from landfills and reduced landfill disposal of organic material, combined with increases in recovery of materials and waste incineration with energy recovery. These measures are a consequence of a series of policy instruments at both national and EU levels. Demand for waste as a fuel for district heating has also strongly encouraged diversion from landfill to incineration.

Landfill Directive (1999/31/EC)

The Landfill Directive requires landfilling of biodegradable

17 With existing decided policy instruments.

18 CO_2-differentiated vehicle tax, green-car insurance premium, super-green car rebate, tax exemption for environmental friendly vehicles, lower benefit value on cars with advanced environmental technology

19 The first scenario assumes claims from the EU or additional national instruments after 2005 are introduced. The second scenario assumes that only EU requirements were introduced and no other national instruments were introduced after 2005. The third scenario looks at the evolution of EU requirements and national instruments (CO_2-differentiated vehicle tax, green-car insurance premium, super-green car rebate, vehicle tax exemption for green cars, car benefit taxation).

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 since January 2015 500 SEK per tonne landfilled waste.

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

The municipal waste planning requirement

Since 1991, 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 2012a) and the national prevention program (Swedish EPA 2015) act as guidance for the municipalities in developing their local plans and deciding on prioritised actions.

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 CO_2-eq. lower in 2015 than in a scenario based on 1990 instruments. By 2020, the difference was projected to be 1.9 Mt CO_2-eq.

4.2.7. Agriculture

Greenhouse gas emissions from Swedish agriculture have fallen compared to 1990. As yet, there are relatively few economic policy instruments directly targeting greenhouse gas emissions in this sector, other than the general economic instruments. 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. Apart from using CAP[21]-funding, investments in the agricultural sector have been granted from the Local Climate Investment Program (described in section 4.2.1).

Common Agricultural Policy

In 2013, the Council of EU Agriculture Ministers formally adopted the four Basic Regulations for a reformed Common Agricultural Policy (CAP) as well as Transition Rules for 2014. 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.

Rural Development Program 2014–2020

The Swedish Government decided on a new Rural Development Program in June 2014. The program for 2014–2020 includes investment grants for young entrepreneurs, capacity building, cooperation and innovation, support to areas with natural constraints, animal welfare subsidies, ecological farming, and environmental and climate actions. Measures specifically contributing to climate change mitigation include those aimed at: increasing energy efficiency; production and use of renewable energy (including biogas production and establishment of perennial energy crops); conversion from fossil to renewable energy sources; improved manure handling; more efficient use of nitrogen; climate and energy advice; measures to prevent the risk of nitrogen leakage; restoration and establishment of wetlands; 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 totals SEK 36 billion, of which 59 % is financed by Sweden and the remaining 41 % by the EU.

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

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

21 Common Agricultural Policy

together actors at the local, regional and central levels for exchanging information and experiences. The network is intended to reinforce implementation of these programs.

'Focus on Nutrients' advisory service

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

Support for biogas production

In January 2015, the Government introduced a support scheme for biogas production through anaerobic digestion of manure. The support aims to 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.(Swedish Board of Agriculture 2017) The increased digestion of manure offers several environmental benefits. It reduces both emissions of greenhouse gases and eutrophication of fresh and marine waters as well as produces biogas for energy. The biogas generated can be used to generate electricity or heat, or as vehicle fuel. The subsidy amounts to a maximum of 0.40 SEK/kWh of biogas produced. Between January 2015 and September 2016 a total amount of SEK 69 million was shared among 51 biogas plants. Support for investments in new biogas plants can be granted through the Rural Development Program or the local Climate Investment Program.

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

Forest Policy and the Forest Act

The Swedish Forestry Act (as of 1993) has two overarching, equal objectives: support production and protect the environment.

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

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

Environmental Code

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

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

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

The Swedish National Forest Program

The supply of sustainable biomass from Swedish forests has an important role to play in the continued transition to a fossil free society. In 2015 the Government initiated a comprehensive dialogue with stakeholders within the Swedish National Forest Program. The program contributes to Sweden's mitigation efforts by establishing goals and actions plans to increase the national supply of bio-based alternatives.

Government advice and training

As part of the 'Forest Kingdom' initiative, the Government allocated SEK 10 million each year during 2012–2015 to strengthen governmental advice and training for increased production and to promote environmental awareness in order to increase the uptake of carbon.

The Swedish Forest Agency provides information to forest owners on how climate change will affect their forests. It also offers guidance adapted to the owners' specific holdings on how to best manage their forests with the owners' specific goals in mind. The Swedish Forest Agency issued a report in 2016 on the effects of climate change on forests and the need for climate change adaptation in forest management. (Swedish Forest Agency 2017)

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 will not elect 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 CO_2-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 CO_2 per year in the second commitment period of the Protocol. For the years 2013-2015 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 CO_2 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.

4.2.9. Shipping and aviation, including international bunkers in Sweden

Tax on air travel*

In the budget proposal for 2018, the Government proposes that a tax on air travel will be introduced with effect from 1 April 2018. A tax on air travel aims to reduce the climate impact of aviation. The proposed tax has been designed as a tax on commercial flights and will be paid for passengers travelling from a Swedish airport. The airline that carries out the flight shall be liable to tax. Various levels of tax (SEK 60, 250 and 400) will be levied based on the final destination. The Swedish Tax Agency will be the competent tax authority.

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. In September 2016 ICAO decided to implement a global measure, the Carbon Offsetting and Reduction Scheme for International Aviation (CORSIA). Sweden is among the nations that have voluntarily participated in the scheme from its outset.

The EU ETS regulation was amended with an exemption in 2014 so that up until 31 December 2016 the scheme only covered intra-EU/EEA flights. Following the ICAO Assembly in 2016, the EU Commission is revisiting the EU ETS regulation due to the decision on the global market-based measure.

ICAO also adopted a carbon dioxide standard for aircraft in 2017. This new standard consists of a new Volume III in Annex 16 of the Chicago Convention. Implementation of the standard in European legislation is ongoing. The standard includes limits on carbon dioxide emissions from new aircraft (effective 2020) and aircraft in production (effective 2023, production cut-off 2028). Possible savings in the order of 650 million tonnes of CO_2 between 2020 and 2040 due to the new standard have been predicted, but factors like future fuel prices will affect the actual outcome.

In August 2016, Sweden submitted an updated version of its 2015 'State Action Plan on CO_2 Emissions Reduction Activities' to ICAO. The action plan includes a common section for the ECAC area, and a national section dedicated to Swedish initiatives. The action plan describes the measures and policy tools, currently available or planned, to reduce CO_2 emissions from international aviation, including estimated emissions reductions expected.

IMO

In the International Maritime Organization (IMO), Sweden has been one of the countries driving efforts to develop several technical and operational measures aimed at reducing greenhouse gas emissions. An Energy Efficiency Design Index (EEDI) – a standardised way to describe ships' energy efficiency – was made mandatory from 2013 for most (some 85%) newly built vessels. The EEDI attained by any ship can be compared with a reference level based on an average for existing vessels. Ships whose contracts are placed after 2013 must be at least as energy-efficient as this level. A mandatory Ship Energy Efficiency Management Plan (SEEMP) has also been introduced. This is to be used in ships' management systems to improve energy efficiency in both existing and new ships. In addition, a voluntary Energy Efficiency Operational Indicator (EEOI) has been introduced as a tool and benchmark. This can be used by existing ships.

In April 2015, an EU regulation was adopted on the monitoring, reporting and verification of carbon dioxide emissions from maritime transport. The regulation take effect 1 January 2018 and will apply to all ships above 5,000 gross tonnes in respect to their CO_2 emissions during their voyages to and from ports in the EU. Sweden is in the process of implementing this regulation. In the IMO, a similar mandatory data collection system for fuel consumption, as well as other additional specified data, was adopted in October 2016. This regulation is expected to enter into force on 1 March 2018 and applies to all ships in the world above 5,000 gross tonnes. These ships account for approximately 85% of CO_2 emissions from international shipping.

The mandatory data collection system is intended to be the IMO's first step in a three-step approach to decrease greenhouse gas emissions from shipping. The second step will be to analyse the data collected, which will provide the basis for the third step: further measures to enhance energy efficiency and address greenhouse gas emissions from international shipping.

In October 2016 the IMO also approved a roadmap (2017 through 2023) for developing a 'Comprehensive IMO strategy on reduction of GHG emissions from ships', which foresees an initial GHG strategy to be adopted in 2018. It contains a list of activities, including further IMO GHG studies with relevant timelines, and provides for alignment of those new activities with the ongoing work on the three-step approach to the ship energy-efficiency improvements mentioned above. This alignment provides a way forward to the adoption of a revised strategy in 2023 to include additional short-, mid-, and long-term measures as required, with implementation schedules. Under the roadmap, and to provide a long-term vision for the shipping sector, the IMO must address several important questions, such as what role the international shipping sector should play in supporting the goals of the Paris Agreement.

In the same October meeting the IMO also agreed to hold an intersessional working group meeting reducing GHG emissions from ships. The first intersessional meeting will be held in June 2017 and a second meeting is planned for autumn 2017. Sweden participates actively and is a member of the High Ambition Coalition for International Shipping.

Sweden also actively promotes the use of alternative fuels, such as LNG and methanol, as well as related infrastructure. Ships using LNG can potentially reduce greenhouse gas emissions up to 30% compared with conventional oil-based shipping fuel. Using LNG also means a low NOx level in the flue gases, and very low sulphur and particulates emissions. The drawback of LNG as a fuel is that it emits a certain amount of methane into the atmosphere. This issue needs to be addressed. In 2015 IMO adopted a regulatory framework for ship operations using gas or other alternative marine fuels with a low flash point, the so-called IGF Code. Sweden is now working to include methanol in this code as another possible marine fuel.

Furthermore, many Swedish ports have invested in infrastructure allowing ships to use shore-side electricity, considerably reducing their emissions. The Port of Stockholm has even introduced attractive incentives for ships using this infrastructure.

All these measures form a part of a national policy framework for development of alternative fuels and related infrastructure, implementing directive 2014/94/EU.

Global warming is driven not only by carbon dioxide, methane and other greenhouse gases. Another type of emissions influencing climate and also having considerable impact on the Arctic environment are emissions of black carbon. The impacts of 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 proposing to set this issue on the IMO agenda and now works actively to identify possible reduction measures.

4.2.10. 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 sixth 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.

4.3. Work on project-based 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. The program 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 collaboration.

All financial support from the program is results-based and corresponds to the emission reductions generated by each project. The projects and generated emission reductions are scrutinized and verified by the UNFCCC, ensuring the projects' additionality, cost effectiveness and promotion of sustainable development.

Sweden has committed SEK 2.4 billion to support climate initiatives. As of the end of 2016 the program has supported and been active in 11 multilateral carbon funds, 96 individual CDM projects and programs, and 2 JI projects, as well as numerous international collaborations. At the end of 2016, SEK 1.3 billion had been granted, corresponding to approximately 15 Mt CO_2-eq. The program contains legally binding agreements of further financial support totalling approximately SEK 1.1 billion, or approximately 25 Mt CO_2-eq. for the period up to 2022.

All the projects are being carried out in developing countries, and priority has been given to projects in least developed countries (LDCs), small island developing states (SIDS) and in 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[22] 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.

In 2016 the Swedish Parliament decided that international credits generated during the first commitment period of the Kyoto Protocol should be cancelled. The cancellation was conducted in 2017. The cancelled international credits cannot be utilized in any way, sold or used to fulfil commitments under the Kyoto Protocol and therefore the financial support related to cancelled international credits is reported as climate finance (see section 7.4.3).

4.4. Cost-effectiveness of policies and measures in Sweden's climate strategy

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

22 Partnership for Market Readiness, Transformative Carbon Asset Facility, Pilot Auction Facility for Methane and Climate Change Mitigation, Carbon Initiative for Development, Carbon Partnership Facility, Umbrella Carbon Facility Tranche 2, Prototype Carbon Fund, Future Carbon Fund, Asia Pacific Carbon Fund, Multilateral Carbon Credit Fund and Testing Ground Facility.

R&D investments, other obstacles to new technology and infrastructure, and various information failures. (Swedish EPA 2012b)

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.

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.

4.4.2. Costs of measures implemented as a consequence of Swedish climate policy instruments

This section includes analysis results that indicate the cost effectiveness of policy instruments in the energy- and transport sectors. As indicated by the estimations in section 4.2, the policy instruments in the sectors have a substantial effect on the emission reductions. Hence, technical measures in the sectors can to some extent be attributed to those policy instruments. Below estimates of the accounting costs of key technical measures implemented can therefore give a rough indication of the cost-effectiveness of the same policy instruments.

Costs and emission reductions in the energy sector

Historic costs and emission reductions for 17 key measures that reduce CO_2 in the electricity and heat sectors are presented here. The measures have contributed to the main part of the emission reduction in the sectors. Some measures judged to have a good potential for the future are also included. The cost and emission reduction of a measure is defined in relation to a reference measure. The reference measures used are the marginal energy carriers on the Northern European market for electricity, heat and district heating. Thereby, the reference measures are comparatively carbon intense and they are also those that would have been the most likely if Sweden had not introduced energy and climate policies in 1990 and thereafter.

Figure 4.9 shows the costs[23] for three time periods, between 2000 and 2015, for the CO_2 emission reduction measures in the electricity and heat sectors. Note that the first and the last measure in the diagram have values that fall outside the axis range[24]. Figure 4.10 shows the emission reductions that have taken place during the three time periods due to the different measures.[25] The reduction volume is determined by the sum of reductions over each time period.

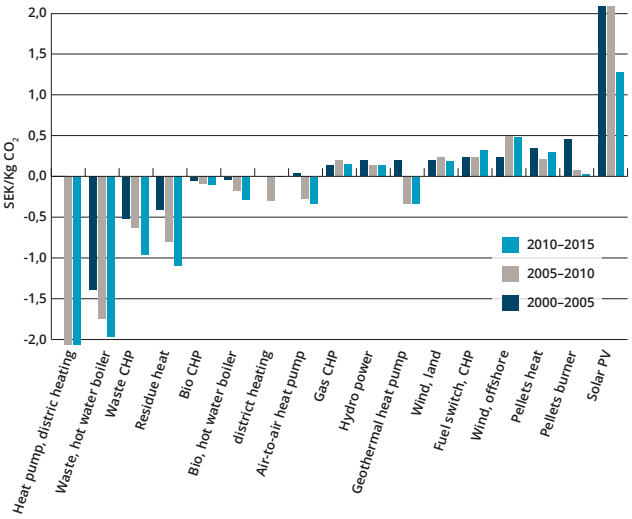


Figure 4.9. Cost per emission reduction unit for measures in the electricity and heat sectors compared to the reference alternative. (Profu 2017b)

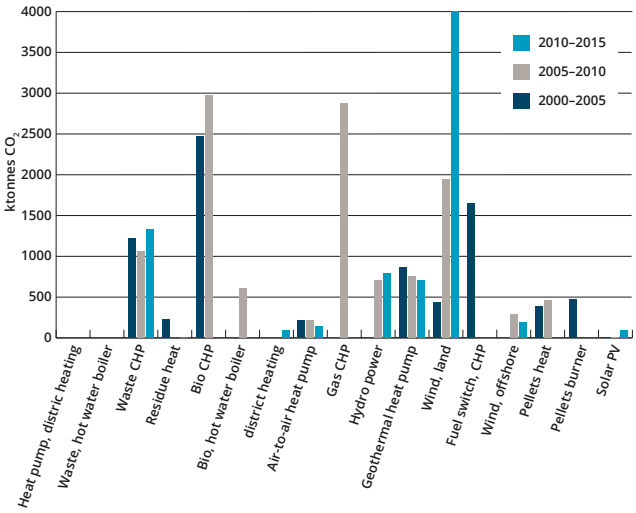


Figure 4.10. Emission reductions in the electricity and heat sectors compared to the reference alternative. (Profu 2017b)

A number of measures show negative costs, such as waste CHP, industrial residue heat and bio CHP. For waste CHP, this is due to the charge set by the receiving company for taking care of it. The capital cost is also relatively low for CHP plants. Despite a negative cost, the contribution to emission reductions may be low since it is only the measures that contribute positively to the production of heat and electricity, and hence replace fossil fuels, that show up in figure 2 as a reduction measure. Additionally, there can be other costs that are not included here, due to market failures, which can explain why a cheap measure is not utilized to the full potential.

Geothermal heat pumps in buildings have become more profitable over time. This is due to an improved efficiency of the pumps, but also due to increased prices for

23 The cost is calculated as the sum of the annualized capital cost, operation and maintenance cost and fuel costs. No taxes, charges or subsidies are included in the cost. Capital costs are calculated with a 4 % discount rate.

24 Heat pumps/district heating had a cost of -19 and -40 SEK2015/kg CO_2 in the second and third time period, respectively, and solar photovoltaic had a cost of 7 and 4 SEK2015/kg CO_2 in the same time periods.

25 Part of the emission reductions takes place outside Sweden.

electricity and oil for heating. The latter implies that the reference measure becomes more expensive over time. The contribution to emission reductions are positive, but have fallen over time since this source of heating is substituting for alternative low carbon heating and hence the contribution to emission reductions is low. Heat from burning pellets is on the other hand more expensive than the reference case, even if the reference measure would be 100 % heat from electricity, 100 % heat from oil or a mix of the two. The contribution to emission reductions of pellets has fallen to zero in the last time period since the substitution of fossil fuels is assumed to only have occurred early in the time period 2000–2015.

Solar PV is the measure that has dramatically been reduced in cost over all three time periods. It is the capital cost that has fallen due to efficiency improvements and the large application of this measure around the globe, which contributes to positive scale effects. However, the contribution to emission reductions in Sweden came late and is comparatively low.

Some measures have become more expensive over time, for example offshore wind power and fuel switch from coal to biomass in CHP plants. The reason for increased cost for offshore wind is the relatively high, and increasing, capital costs as well as high cost for operation and maintenance at sea. This development is also mirrored in the contribution to emission reductions. In terms of fuel switch from coal to biomass, the cost increase is in particular due to an increased cost difference between biomass and coal during the time period 2005–2015. The contribution of the fuel switch to emission reduction is assumed to have taken place only in the initial time period.

Land based wind power and natural gas CHP become more costly between the first and second time periods and become cheaper again in the third time period. For wind power it is the rapid technological development that accelerated around 2010 with longer running times that explains the cost development. Land based wind power is the measure that have reduced emissions the most over time. For gas CHP, it is in particular the increasing costs for alternative district heating that explains the development. A similar trend is shown for other CHP measures.

The reference case used in the analysis has a Nordic European system boundary. An alternative reference scenario, based on a Swedish system boundary, has also been analyzed. This reference alternative is much less carbon intense, which implies that the costs per unit emission reduction generally become higher than in the first reference alternative. Also, the emission reductions are less than in the Northern European reference case. (Profu 2017b)

Costs and emission reductions in passenger cars

CO_2 emissions from passenger cars are the largest contributor to transport emissions, which is more or less a third of Swedish CO_2 emissions, hence the importance of this sector for emission reductions. The reduction that have occurred in passenger cars since 2000 due to biofuels and efficiency improvements has lately been up weighted by an increase in the number of cars and more frequent use of them.

The costs[26] and emission reductions of measures in the passenger car sector are presented in Figure 4.11, over three time periods from 2000 to 2015. The six measures are the most common historic fuel and car type switches. Emissions are here limited to those related to fuel use i.e. tailpipe emissions. A CO_2 reduction measure for passenger cars is defined as a shift in the shares of different car types in the car park compared to a reference alternative. The reference alternative has the same number of cars as the time period studied, but the share of car types is as in the base year 2000. The reference car, which is replaced, is assumed to be a standard petrol car that has an emission efficiency improvement of 0.5 % per year.

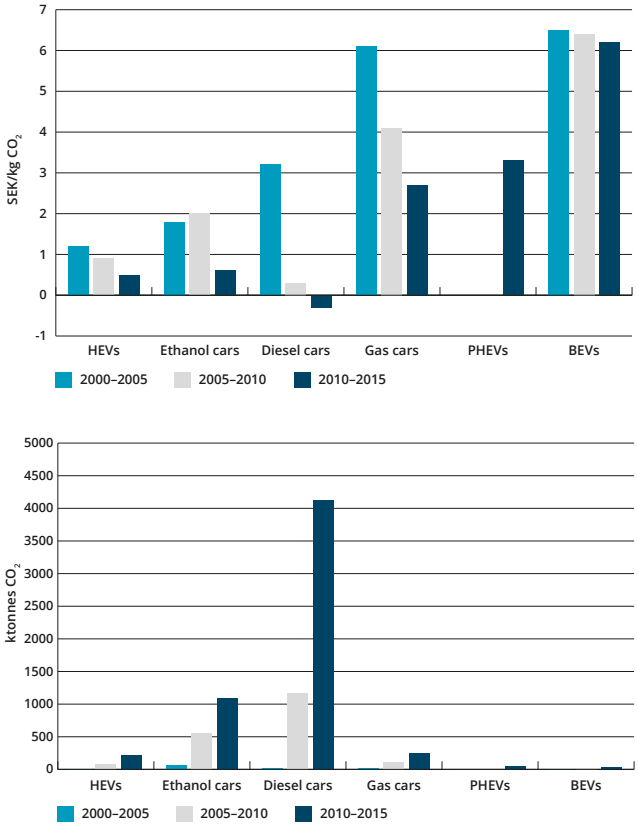


Figure 4.11. Costs and emission reductions in the passenger car sector in relation to the reference alternative (Krook Reikkola and Forsberg 2017)

26 The cost calculation is based on the sum of the annual investment cost, operation and maintenance cost as well as fuel costs. The discount rate used is 4 % and no VAT, taxes or subsidies are included in the cost.

For diesel cars both investment cost and the fuel price are higher than for the replaced petrol car. However, due to efficiency improvements, the total fuel cost is lower for diesel cars than petrol cars and hence the operation and maintenance cost has decreased over time. This results in a comparatively low cost of diesel cars for the consumer and also negative emission reduction costs in 2010-2015. This favorable situation has implied that many of the newly purchased cars have been a diesel car and thereby emissions of CO_2 have been reduced at an increasing rate.

Ethanol cars have had the same or similar investment cost as the reference car over the time period. The variation in the costs over time is mainly due to changes in the price of ethanol in relation to petrol. Ethanol cars show an increasing contribution to emission reductions over the three time periods in the analysis, which is mainly due to an increasing number of ethanol cars rather than efficiency improvement.

The cost of reducing emissions by running cars on compressed natural gas (CNG) and biogas is falling over the concerned time period. This is due to a relatively fast technological development of these cars compared to petrol cars. CNG cars show increasing emission reductions over the time periods. The increase is mainly due to the share of biogas mixed in the natural gas, which has increased from 42% to 75% between 2000 and 2015 (SPBI 2017).

Battery Electric Vehicles (BEVs) are costly in terms of emission reductions for all time periods. This indicates that the high investment costs in BEVs have not been compensated for by low operation and maintenance costs. BEVs show the largest reduction potential per car type, but are expensive and hence they do not contribute much to emission reductions as is seen in Figure 4.9.

Hybrid Electric Vehicles (HEVs) have a comparatively low cost of reducing emissions and it is falling over the concerned time period. The low fuel consumption is keeping the operational cost low, but the high investment cost is implying that the overall cost per unit emission reduction is still positive.

Plug-in hybrid electric vehicles (PHEVs) are relatively new on the market and data is only available in 2015. Hence they are currently difficult to analyze. (Krook Reikkola and Forsberg 2017)

Costs estimated by the European Commission

According to the European Commission's model based analysis, Sweden has had comparatively low costs related to investments in the energy system and other mitigation actions in comparison to other EU member states. The main reason is that Sweden has an energy system that historically has invested in renewable energies to a comparatively low cost due to the availability of natural resources. Additionally, Sweden is a technologically advanced country with a comparatively high GDP, which can explain that the cost given in relation to GDP is relatively low.

The cost estimates for future decades also looks good according to model based scenarios from the Commission. The macroeconomic model estimates that Sweden will have the second highest increase in Europe in GDP in 2030 when meeting the 2030 energy and climate policy goals, compared to the reference level. (European Commission 2016)

4.5. Summary of policies and measures

Table 4.3 Summary Policies and measures. Policy/measure marked with '*' are not included in the projections.

Name of policy/measure	Primary objective	Greenhouse gas(es) primarily affected	Type of instrument	Status of instrument	Implementing agency	Estimate of mitigation impact in Mt CO_2-eq. per year compared with 1990 instruments			
						2010	2015	2020	2030
Cross-sectoral									
Local climate investment program (Climate leap)	Enhance and speed reduction of greenhouse gas emissions	All	Economic	Ongoing (2015–2020)	Swedish Environmental Protection Agency	N.E.	N.E.	N.E.	N.E.
Environmental Code	Ecologically sustainable development	All	Legislation	Ongoing (1999–	Swedish Environmental Protection Agency	N.E.	N.E.	N.E.	N.E.
Planning and Building Act	Promote sustainable development of society	All	Legislation	Ongoing (2011–	Swedish National Board of Housing, Building and Planning	N.E.	N.E.	N.E .	N.E.
Fossil-Free Sweden initiative	Mobilize efforts from actors to reduce the use of fossil fuels.	CO_2	Information	Ongoing (2015–	Fossilfritt Sverige	N.E.	N.E.	N.E .	N.E.
Climate and energy advice	Greater awareness of possible measures	All	Information	Ongoing (1998–	Swedish Energy Agency	N.E.	N.E.	N.E.	N.E.
Research and development	Development of technology with very low climate impact	All	Economic	Ongoing (1990–	Swedish Energy Agency (mainly)	N.E.	N.E.	N.E.	N.E.
Production of electricity and district heating									
Energy tax	Fiscal, and to improve efficiency of energy use	Carbon dioxide	Economic	Ongoing (1957–	Swedish Tax Agency	14	18	19	14
Carbon dioxide tax	Reduce use of fossil fuels	Carbon dioxide	Economic	Ongoing (1991–	Swedish Tax Agency				
Electricity certificates system	Increase supply of electricity from renewable energy sources	Carbon dioxide	Economic	Ongoing (2003–	Swedish Energy Agency				
EU Emissions Trading System (EU ETS)	Reduce use of fossil fuels in trading sector	Carbon dioxide	Economic	Ongoing (2005–	Swedish Environmental Protection Agency and Swedish Energy Agency				
Initiatives for wind power	Increase supply of electricity from renewable energy sources	Carbon dioxide	Simplifying rules and Information	Ongoing	Swedish Energy Agency	N.E	N.E	N.E	N.E
Support for solar power	Increase supply of electricity from renewable energy sources	Carbon dioxide	Economic	Ongoing (2009–	Swedish Energy Agency	N.E	N.E	N.E	N.E
Income tax reduction for micro production of renewable energy	Increase micro production of renewable energy	Carbon dioxide	Economic	Ongoing (2015–	Swedish Tax Agency	N.E	N.E	N.E	N.E

Name of policy/measure	Primary objective	Greenhouse gas(es) primarily affected	Type of instrument	Status of instrument	Implementing agency	Estimate of mitigation impact in Mt CO_2-eq. per year compared with 1990 instruments			
						2010	2015	2020	2030
Residential and service sector									
Energy tax	Fiscal, and to improve efficiency of energy use	Carbon dioxide	Economic	Ongoing (1957–	Swedish Tax Agency	1.3	1.4	0.4	0.4
Carbon dioxide tax	Reduce use of fossil fuels	Carbon dioxide	Economic	Ongoing (1991–	Swedish Tax Agency				
Building regulations	More efficient energy use	Carbon dioxide	Legislation	Ongoing	Swedish National Board of Housing, Building and Planning				
Energy declarations	More efficient energy use	Carbon dioxide	Legislation and information	Ongoing (2006–	Swedish National Board of Housing, Building and Planning				
Ecodesign Directive	More efficient energy use	Carbon dioxide	Legislation	Ongoing (2010–	Swedish Energy Agency				
Mandatory energy labelling	More efficient energy use	Carbon dioxide	Information	Ongoing (1995–	Swedish Energy Agency				
Support for renovation and energy efficiency of rental apartments*	More efficient energy use	Carbon dioxide	Economic	Ongoing (2016–	Swedish Energy Agency	N.E	N.E	N.E	N.E
Training programs in building for low energy consumption*	More efficient energy use	Carbon dioxide	Information	Ongoing (2016–	Swedish Energy Agency	N.E	N.E	N.E	N.E
Technology procurement	More efficient energy use and increased use of renewable energy	Carbon dioxide	Economic	Ongoing	Swedish Energy Agency	N.E	N.E	N.E	N.E
Industrial emissions from combustion and processes									
Energy tax	Fiscal, and to improve efficiency of energy use	Carbon dioxide	Economic	Ongoing (1957–	Swedish Tax Agency	–0.8	–0.5	–0.4	–0.1
Carbon dioxide tax, incl. stepwise reduced carbon dioxide tax relief for industry outside EU ETS	Reduce use of fossil fuels	Carbon dioxide	Economic	Ongoing (1991–	Swedish Tax Agency				
Electricity certificate system	Increase supply of electricity from renewable energy sources	Carbon dioxide	Economic	Ongoing (2003–	Swedish Energy Agency				
EU Emissions Trading System (EU ETS)	Reduce use of fossil fuels in trading sector	Carbon dioxide	Economic	Ongoing (2005–	Swedish Environmental Protection Agency and Swedish Energy Agency				
HYBRIT*	Reduce emissions of carbon dioxide in steel industry	Carbon dioxide	Economic and research	Ongoing (2016–	Swedish Energy Agency	N.E	N.E	N.E	N.E
Energy audit for large enterprises	More efficient energy use	Carbon dioxide	Legislation and information	Ongoing (2014–	Swedish Energy Agency	N.E	N.E	N.E	N.E
Grants for energy audit to small and medium-sized enterprises	More efficient energy use	Carbon dioxide	Economic and information	Ongoing (2010–)	Swedish Energy Agency	N.E	N.E	N.E	N.E
Energy and climate coaches for small and medium-sized enterprises	More efficient energy use and reduction of greenhouse gases	Carbon dioxide	Information	Ongoing (2016–2019)	Swedish Energy Agency	N.E	N.E	N.E	N.E
Energy efficiency networks for small and medium-sized enterprises	More efficient energy use	Carbon dioxide	Information	Ongoing (2015–	Swedish Energy Agency	N.E	N.E	N.E	N.E
Environmental Code	Ecologically sustainable development	All	Legislation	Ongoing (1999-	Swedish Environmental Protection Agency	N.E	N.E	N.E	N.E

Name of policy/measure	Primary objective	Greenhouse gas(es) primarily affected	Type of instrument	Status of instrument	Implementing agency	Estimate of mitigation impact in Mt CO_2-eq. per year compared with 1990 instruments			
						2010	2015	2020	2030
Product use									
EU regulation on Fluorinated greenhouse gases and BREF	Reduce use of HFCs	HFCs	Legislation	Ongoing (new directive 2015)	Swedish Environmental Protection Agency	0.2	0.5	0.7	N.E
EU regulation on mobile air conditioning units in cars	Reduce use of HFCs	HFCs	Legislation	Ongoing (2006–	Swedish Environmental Protection Agency				
Swedish regulation on fluorinated gases and ozone depleting substances	Reduce use of HFCs and ozone depleting substances	HFCs	Legislation	Ongoing (new regulation 2016–)	Swedish Environmental Protection Agency				
Transport									
Energy tax, including stepwise increase of tax on diesel and petrol	Fiscal, and to improve efficiency of energy use	Carbon dioxide	Economic	Ongoing (1924–	Swedish Tax Agency	2	2	2.3	N.E
Carbon dioxide tax	Reduce use of fossil fuels	Carbon dioxide	Economic	Ongoing (1991–	Swedish Tax Agency				
Emission performance standards for new vehicles	Reduce carbon dioxide emissions from light-duty vehicles	Carbon dioxide	Legislation	Ongoing (2015, 2017 and 2020)	Swedish Transport Administration	0,4	1.3	2,6	4.3
Targeted instruments: Composition of the vehicle fleet: Differentiated vehicle tax, super-green car rebate, tax exemption for environmentally friendly vehicles, lower benefit value on cars with advanced environmental technology	Increase use of environmental friendly vehicles	Carbon dioxide	Economic	Ongoing	Swedish Tax Agency (mainly)				
Targeted instruments to promote introduction of renewable transport fuels: Energy and carbon dioxide tax reduction for biofuels, Requirements of renewable fuels at filling stations	Increase use of renewable transport fuels	Carbon dioxide	Economic	Ongoing	Swedish Tax Agency (mainly)	1	2.5	4.3	N.E
Local climate investment program (Climate leap)	Enhance and speed reduction of greenhouse gas emissions	All	Economic	Ongoing (2015–2020)	Swedish Environmental Protection Agency	N.E.	N.E.	N.E.	N.E.
Urban environment agreements	Reduce carbon dioxide emissions and incetivise building of public transport	Carbon dioxide	Economic	Ongoing (2015–2018)	Swedish Transport Administration	N.E	N.E	N.E	N.E
Electrical bus premium*	Reduce carbon dioxide emissions and other air polluntants	Carbon dioxide	Economic	Ongoing (2016–	Swedish Energy Agency	N.E	N.E	N.E	N.E
Support for research and demonstration	Develop technology for sustainable growth and reduced fossil fuel dependence	Carbon dioxide	Economic	Ongoing	Vinnova and Swedish Energy Agency (mainly)	N.E	N.E	N.E	N.E

Name of policy/measure	Primary objective	Greenhouse gas(es) primarily affected	Type of instrument	Status of instrument	Implementing agency	Estimate of mitigation impact in Mt CO_2-eq. per year compared with 1990 instruments			
						2010	2015	2020	2030
Waste									
Rules on municipal waste planning and on producer responsibility for certain products, landfill tax (2000), bans on landfill of combustible waste(2002) and of organic waste (2005)	Increase recycling and reduce total quantities of waste	Methane	Legislation and fiscal	Ongoing	Swedish Environmental Protection Agency, Swedish Tax Agency (landfill tax)	1,4	1,7	1,9	N.E
Agriculture									
Measures under the Rural Development Program	Reduced Climate Impact, a varied agricultural landscape and zero eutrophication	Nitrous oxide, methane and carbon dioxide	Economic	Ongoing (2014–2020)	Swedish Board of Agriculture	N.E.	N.E	N.E	N.E
Support for biogas production	Reducing emissions of greenhouse gases and production of biogas for energy purposes	Methane	Economic	Ongoing (2015–	Swedish Board of Agriculture	N.E.	N.E	N.E	N.E
The rural network	Reinforce implementation of the Rural Development Program	Nitrous oxide, methane and carbon dioxide	Information	Ongoing	Swedish Board of Agriculture	N.E.	N.E	N.E	N.E
Reduced carbon dioxide tax relief	Reduce use of fossil fuels	Carbon dioxide	Economic	Ongoing (2011, 2013, 2015, 2016, 2018)	Swedish Tax Agency	N.E.	N.E	N.E	N.E
Land use, land use change and forestry (LULUCF)									
Provisions of Forestry Act	Achieve environmental and production objectives for sustainable forest management	Carbon dioxide	Legislation	Ongoing	Swedish Forest Agency	N.E	N.E	N.E	N.E
Provisions of Envionmental Code including land drainage	Biodiversity	Carbon dioxide and methane	Legislation	Ongoing	County administrative boards	N.E	N.E	N.E	N.E
Provisions on nature reserves and habitat protection areas in Environmental Code, and nature conservation agreements	Biodiversity	Carbon dioxide	Legislation	Ongoing	Swedish Environmental Protection Agency and county administrative boards	N.E	N.E	N.E	N.E
Swedish National Forest Program	Increase the national supply of bio-based materials and energy	Carbon dioxide	Information	Ongoing	Swedish Forest Agency	N.E	N.E	N.E	N.E
Advice and training	Increase uptake of carbon	Carbon dioxide	Information	Ongoing	Swedish Forest Agency	N.E	N.E	N.E	N.E

Table 4.4 Policies and measures proposed by the Government in the budget proposal for 2018.

Name of policy instrument	Primary objective	Greenhouse gas(es) primarily affected	Type of instrument	Status of instrument
Cross-sectoral				
Increased budget for the Climate Leap	Reduce greenhouse gas emissions	All	Economic	Planned
Production of electricity and district heating				
Increased carbon dioxide tax for CHP plants within the EU ETS	Reduce greenhouse gas emissions	Carbon dioxide	Economic	Planned
Support to municipalities to facilitate wind farms	Reduce greenhouse gas emissions	Carbon dioxide	Economic	Planned
Increased support for solar power	Reduce greenhouse gas emissions	Carbon dioxide	Economic	Planned
Industrial emissions from combustion and processes				
Industrial Leap	Reduce greenhouse gas emissions	All	Research and market introduction	Planned
Transport				
Tax on air travel	Reduce greenhouse gas emissions	Carbon dioxide	Economic	Planned
Emission reduction obligation	Reduce greenhouse gas emissions	Carbon dioxide	Legislation	Planned
Bonus-Malus system	Reduce greenhouse gas emissions	Carbon dioxide	Economic	Planned
Electric vehicle premium	Reduce greenhouse gas emissions	Carbon dioxide	Economic	Planned
Charge at home grant	Reduce greenhouse gas emissions	Carbon dioxide	Economic	Planned
Eco-bonus system for heavy transport	Reduce greenhouse gas emissions	Carbon dioxide	Economic	Planned

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

The projections of emissions and removals of greenhouse gases described in this chapter have been developed for the present National Communication, the Third Biennial Report and for Sweden's reporting to the EU (Ministry of Environment, 2017) in accordance with the requirements of the EU decision on monitoring of greenhouse gases (EU Regulation 525/2013). The projections with existing measures are based on the policies and measures currently adopted by the EU and the Riksdag (the Swedish Parliament) up to June 2016.

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. 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 and for the road transportation 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 planned since the scenarios were produced, see chapter 4.

5.1. Aggregate projections

Total greenhouse gas emissions in Sweden in 2015 were 53.7 Mt CO_2-eq. (excluding The Land Use, Land Use Change and Forestry sector) (National Inventory Report, Submission 2017). Total emissions decreased by 25 %, between 1990 and 2015. The projection results point to a gradual decline in total emissions of greenhouse gases (excl. LULUCF) over the projection period. The projected emissions for 2020 are 30 % below 1990 levels, and by 2030 total emissions are projected to be 36 % below 1990 levels (see Table 5.1).

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

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Energy excl. transport	33.8	20.8	20.7	20.2	19.3	18.4	-39 %	-43 %
Transport	19.3	18.2	15.4	14.3	13.6	13.1	-20 %	-30 %
Industrial processes and product use	7.2	6.4	6.3	6.2	6.1	6.0	-12 %	-15 %
Agriculture	7.6	6.9	6.4	6.1	5.9	5.4	-17 %	-23 %
Waste	3.7	1.4	1.1	0.9	0.7	0.6	-72 %	-81 %
Total emissions	**71.6**	**53.7**	**49.9**	**47.7**	**45.6**	**43.6**	**-30 %**	**-36 %**
LULUCF	-36.7	-50.5	-43.3	-44.3	-42.2	-40.5	18 %	15 %

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

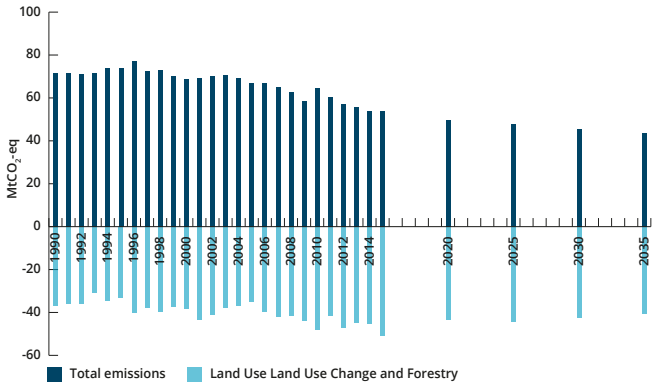

Figure 5.1 Historical and projected emissions and removals of greenhouse gases with existing measures (WEM).

5.2. Projections by gas

In 2015 carbon dioxide emissions accounted for 81 % of greenhouse gas emissions, while methane emissions accounted for just over 9 %, nitrous oxide for almost 9 % and fluorinated greenhouse gases for almost 2 %.

Until 2035, emissions of all gases are projected to decrease. The mix of greenhouse gases is expected to change over the projection period, with a slight increase in carbon dioxide's share of the total (see Table 5.2).

5.3. Projections by sector

The projected trend in emissions differs between sectors. Over the projection period, the emissions from transport, industrial processes and product use, agriculture and waste are expected to decrease until 2035. Emissions from the energy industries increase slightly according to the projection until 2020 and then stabilize and decrease until 2035.

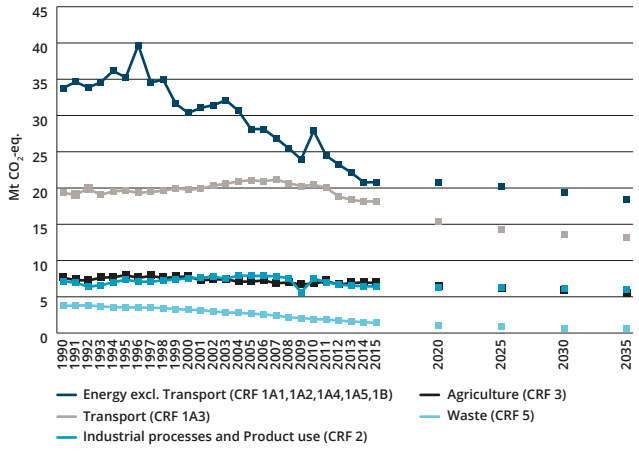

Figure 5.2 Historical and projected emissions of greenhouse gases by sector.

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

Emissions from the energy industries, i.e. production of electricity and district heating, refineries and the manufacture of solid fuels, are projected to increase slightly until 2020 and then stabilize and decrease until 2035. But the projections for the subsectors show differing trends.

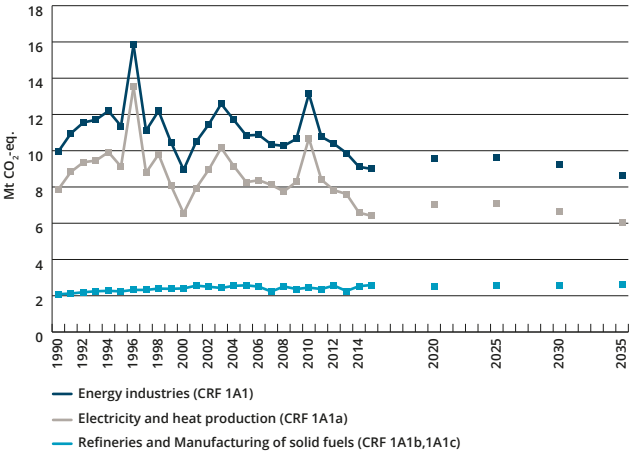

Figure 5.3 Historical and projected emissions of greenhouse gases from energy industries.

The 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. However, the emissions do not increase to the same extent as production, mainly due to biofuels. The emissions are projected to increase until 2020, then stabilise and decrease from 2030 onwards (see Table 5.3). An increased use of natural gas and waste contributes to the increase in emissions, but the increase is partly offset by increased use of biomass and wind power as well as decreased use of oil and coal. The use of biomass increases in combined heat and power plants especially, which is promoted by the electricity certificate system and the EU ETS. Production of electricity is assumed to grow more than consumption, resulting in a projected export of about 12 TWh by 2020 and 34 TWh by 2030.

Emissions from refineries and manufacturing of solid fuels are projected to continue increasing slightly during the projection period (see Table 5.4). The increase is due to increased production and to increased production emissions due to a shift to products that meet higher quality standards in refineries. The emissions from refineries are also reported in the sector of fugitive emissions.

5.3.2. Residential and commercial

The emissions from households and premises and from combustion in the agricultural, forestry and fishing sectors are projected to continue to decrease (see Table 5.5). 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. The shift to electric and district heating results in decreased emissions in this sector. On the other hand, emissions from the production of heat and electricity increase. However, since the increased production of electricity and heat is mainly based on biomass and waste and district heating is a more efficient way of heating, the emission increase is limited.

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

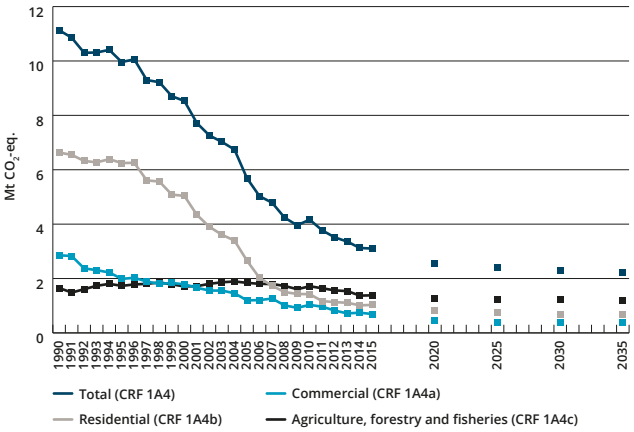

Figure 5.4 Historical and projected emissions of greenhouse gases from combustion in households, premises, agriculture, forestry and fisheries.

5.3.3. Industrial combustion

To cover all industry-related emissions, account needs to be taken 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.

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

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Carbon dioxide	57.5	43.3	40.7	39.1	37.5	36.2	-29 %	-35 %
Methane	7.6	4.9	4.3	3.9	3.6	3.2	-44 %	-53 %
Nitrous oxide	5.8	4.6	4.3	4.2	4.1	3.9	-26 %	-29 %
HFC	0.005	0.8	0.5	0.4	0.3	0.1	11522 %	5387 %
PFC	0.6	0.04	0.03	0.03	0.03	0.03	-94 %	-94 %
SF_6	0.1	0.05	0.05	0.05	0.05	0.06	-51 %	-51 %
Total emissions (excl. LULUCF)	**71.6**	**53.7**	**49.9**	**47.7**	**45.6**	**43.6**	**-30 %**	**-36 %**

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

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Carbon dioxide	7.7	6.1	6.8	6.8	6.4	5.8	-12 %	-17 %
Methane	0.02	0.04	0.04	0.04	0.04	0.04	174 %	155 %
Nitrous oxide	0.1	0.2	0.2	0.2	0.2	0.2	66 %	62 %
Total emissions	**7.9**	**6.4**	**7.0**	**7.1**	**6.7**	**6.0**	**-11 %**	**-15 %**

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

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Carbon dioxide	2.1	2.6	2.5	2.6	2.6	2.6	21 %	24 %
Methane	0.001	0.001	0.001	0.001	0.001	0.001	20 %	23 %
Nitrous oxide	0.006	0.003	0.003	0.003	0.003	0.003	-49 %	-48 %
Total emissions	**2.1**	**2.6**	**2.5**	**2.6**	**2.6**	**2.6**	**21 %**	**24 %**

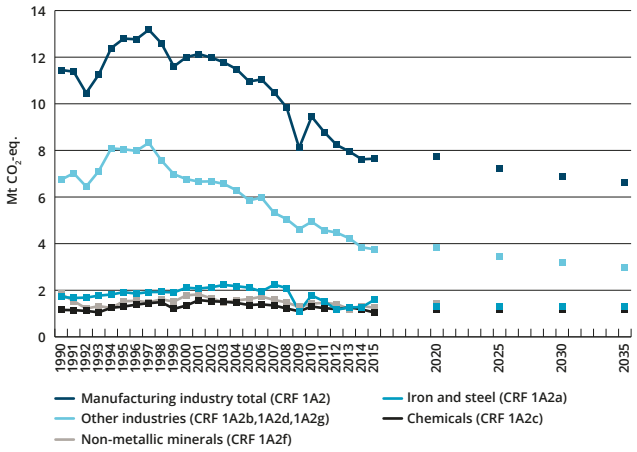

Figure 5.5 Historical and projected emissions of greenhouse gases from combustion in manufacturing industries.

Combustion emissions from manufacturing industries are projected to decrease until 2035, because the use of biofuel and electricity is expected to increase more than the use of fossil fuels (see Table 5.6). The decreasing emissions are mainly explained by the pulp and paper industry's shift from using fossil fuels to biofuels. Emissions from the food processing industry are also expected to decrease, while emissions from the chemical industry and the iron and steel industry remain fairly stable in the projection. Emissions from the mineral industry as well as emissions from working machinery in the industries are projected to increase until 2020 and then decrease. The increase is mainly due to a projected increase in constructing new residential buildings.

5.3.4. Fugitive emissions

The majority of fugitive emissions originate from refineries. The emissions are assumed to remain at the same level as in recent years until 2035 (see Table 5.7).

5.3.5. Industrial processes and product use

The industrial processes and product use sector contributes 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.

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

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2030
Carbon dioxide	10.7	2.7	2.2	2.0	1.9	1.9	-80 %	-82 %
Methane	0.3	0.3	0.3	0.3	0.3	0.3	-1 %	-12 %
Nitrous oxide	0.2	0.1	0.1	0.1	0.1	0.1	-44 %	-47 %
Total emissions	**11.1**	**3.1**	**2.6**	**2.4**	**2.3**	**2.2**	**-77 %**	**-79 %**

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

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2030
Carbon dioxide	11.2	7.4	7.5	7.0	6.7	6.4	-33 %	-40 %
Methane	0.05	0.05	0.06	0.06	0.06	0.06	3 %	3 %
Nitrous oxide	0.2	0.2	0.2	0.2	0.2	0.1	-23 %	-27 %
Total emissions	**11.5**	**7.6**	**7.7**	**7.2**	**6.9**	**6.6**	**-33 %**	**-40 %**

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

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2030
Carbon dioxide	0.3	0.8	0.7	0.7	0.7	0.7	133 %	133 %
Methane	0.09	0.1	0.1	0.1	0.1	0.1	-29 %	-29 %
Nitrous oxide	0.0004	0.0007	0.0006	0.0006	0.0006	0.0006	29 %	29 %
Total emissions	**0.4**	**0.9**	**0.8**	**0.8**	**0.8**	**0.8**	**95 %**	**95 %**

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

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2030
Carbon dioxide	5.5	5.3	5.4	5.5	5.5	5.6	-1 %	0 %
Methane	0.03	0.01	0.01	0.01	0.01	0.01	-65 %	-65 %
Nitrous oxide	1.0	0.2	0.2	0.2	0.2	0.2	-76 %	-76 %
Fluorinated greenhouse gases	0.7	0.9	0.6	0.5	0.3	0.2	-8 %	-50 %
Total emissions	**7.2**	**6.4**	**6.3**	**6.2**	**6.1**	**6.0**	**-12 %**	**-15 %**

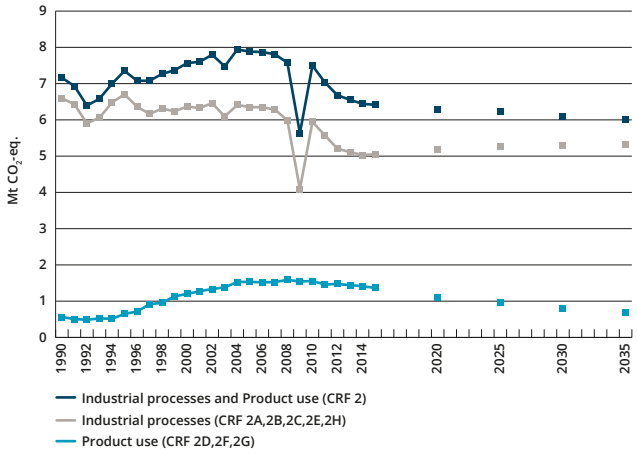

Figure 5.6 Historical and projected emissions of greenhouse gases from industrial processes and product use.

Greenhouse gas emissions from industrial processes and product use are projected to decrease slightly until 2035 (see Table 5.8). The decrease is caused by the decrease in emissions of fluorinated greenhouse gases.

Carbon dioxide emissions are expected to increase slightly until 2035. The increase is mainly due to increased production in the mineral industry. The emissions from the mineral industry are expected to increase due to a projected increase in constructing new buildings. Iron and steel production is expected to increase slightly, which leads to an increase in total greenhouse gas emissions compared with 2015. However, emissions are expected to be lower in 2030 compared with 1990 levels.

Emissions of fluorinated greenhouse gases are expected to decrease until 2035 due to a ban on their use that resulted from EU regulations.

5.3.6. Domestic transport

Emissions from domestic transport, especially from road transport, are projected to decrease until 2035 for several reasons (see Table 5.9 and 5.10). 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. In the projection the emission requirements are 95 and 147 grams of carbon

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

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2035
Road transportation	17.7	17.0	14.2	13.1	12.4	12.0	-20 %	-30 %
Civil aviation	0.7	0.5	0.5	0.5	0.5	0.5	-25 %	-29 %
Navigation	0.6	0.4	0.4	0.4	0.4	0.4	-34 %	-36 %
Railways	0.1	0.05	0.04	0.04	0.04	0.04	-57 %	-62 %
Other*	0.3	0.3	0.3	0.3	0.3	0.3	-2 %	-1 %

*includes mobile machinery not used in industry, agriculture, forestry or households

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

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2035
Carbon dioxide	19.0	18.0	15.2	14.1	13.3	12.9	-20 %	-30 %
Methane	0.2	0.04	0.03	0.03	0.03	0.03	-77 %	-79 %
Nitrous oxide	0.2	0.1	0.2	0.2	0.2	0.2	-9 %	-2 %
Total emissions	**19.3**	**18.2**	**15.4**	**14.3**	**13.6**	**13.1**	**-20 %**	**-30 %**

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

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2030
Carbon dioxide	0.8	0.2	0.2	0.2	0.2	0.2	-81 %	-81 %
Methane	0.001	0.0001	0.0001	0.0001	0.0001	0.0001	-95 %	-95 %
Nitrous oxide	0.02	0.003	0.002	0.002	0.002	0.002	-85 %	-85 %
Total emissions	**0.9**	**0.2**	**0.2**	**0.2**	**0.2**	**0.2**	**-81 %**	**-81 %**

Table 5.12 Historical and projected emissions of greenhouse gases from the waste sector (million tonnes CO_2-equivalents)

	1990	2015	2020	2025	2030	2035	1990-2020	1990-2030
Carbon dioxide	0.04	0.06	0.06	0.06	0.06	0.06	31 %	31 %
Methane	3.5	1.1	0.8	0.6	0.4	0.3	-78 %	-88 %
Nitrous oxide	0.2	0.2	0.2	0.2	0.2	0.2	6 %	7 %
Total	**3.7**	**1.4**	**1.1**	**0.9**	**0.7**	**0.6**	**-72 %**	**-81 %**

dioxide per kilometre, respectively, for passenger cars and light-duty vehicles in 2021. After 2021 the energy efficiency of new vehicles continues to increase, but at a slower rate. The energy efficiency is expected to be improved due to fewer petrol cars. Another reason for the decrease is a greater use of biofuels. In particular, the low-blend of biofuels in diesel, which is currently subject to tax exemptions and tax reductions, increases compared with the 2015 level in the projection.

Emissions from domestic aviation have fallen in recent years, mostly due to higher efficiency. In the projection, travel is assumed to be constant from today's level over the entire projection period as energy efficiency increases, resulting in decreasing emissions. Emissions from domestic navigation have varied between 0.3 and 0.7 Mt CO_2-eq.The emissions are assumed to be close to 0.4 million tonnes between 2020 and 2035. Emissions from railways are projected to decrease during the projection period.

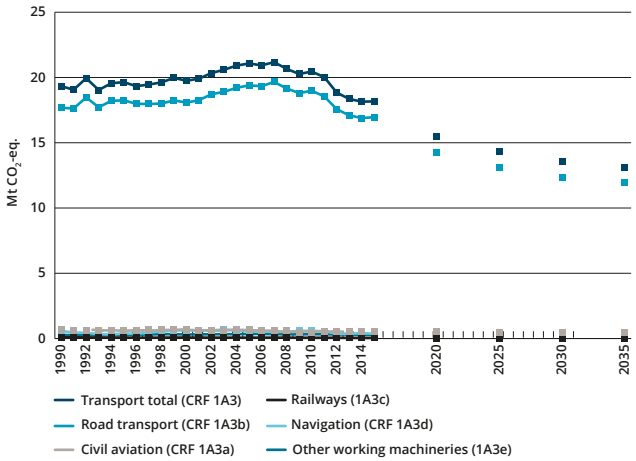

Figure 5.7 Historical and projected emissions of greenhouse gases from the domestic transport sector.

Emissions from the CRF sector 'Other' (mainly emissions from military transports) are expected to remain at around the same level as in recent years during the entire projection period (see Table 5.11).

5.3.7. Waste

Methane emissions from landfills are projected to decrease by 91 % until 2030 compared with 1990 (see Table 5.12). This decrease is mainly due to the 2002 ban on depositing combustible materials in landfills and the 2005 ban on depositing organic materials in landfills. Furthermore, a tax on depositing waste in landfills 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 wastes are expected to increase slightly during the period due to increased production of biogas.

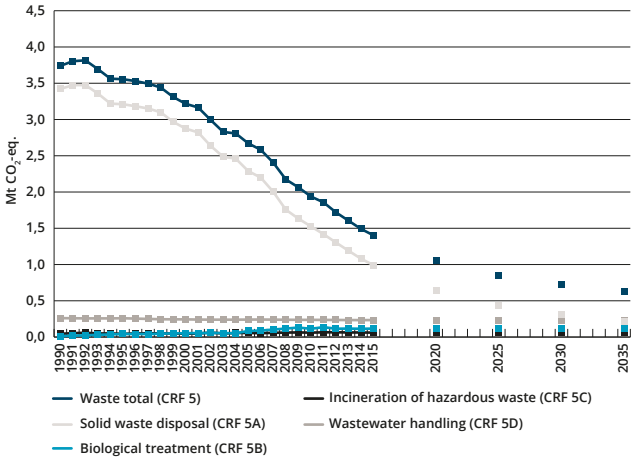

Figure 5.8 Historical and projected emissions of greenhouse gases from the waste sector.

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 are estimated to decrease as a result of a continuously declining cattle population. The reduced numbers of dairy cows for 2020 and 2030 are primarily a result of increased productivity, product pricing mechanisms and continuous adaptation to EU agricultural policy regulations. Emissions from agricultural land are also projected to decrease until 2030 (see table 5.13 and 5.14).

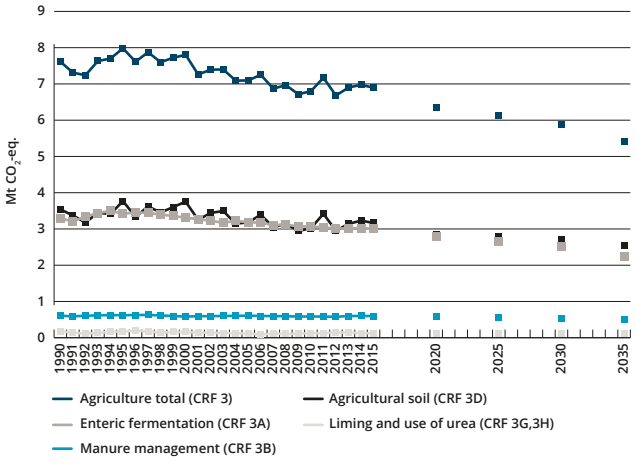

Figure 5.9 Historical and projected emissions of greenhouse gases from agriculture.

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 1990–2015. The net

removals for LULUCF are expected to decrease until 2035 (see Table 5.15). The decrease is mainly due to a decrease in removals from forest land. The projected decrease in removals of carbon dioxide from forest land is based on the assumption that the harvest level will continue to gradually increase at about the same pace as in recent years. Continuously increasing harvests have been added to the projections mainly after 2025, since it is foreseen that the demand for biomass will increase over time.

Net emissions from cropland have varied during the period 1990–2015 and these yearly variations are expected to continue. The emissions are projected to be at about the same level as the average for the last 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

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

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Methane	3.5	3.3	3.0	2.9	2.7	2.4	-14 %	-22 %
Nitrous oxide	3.9	3.5	3.2	3.1	3.0	2.8	-18 %	-23 %
Carbon dioxide	0.2	0.1	0.1	0.1	0.1	0.1	-30 %	-30 %
Total emissions	**7.6**	**6.9**	**6.4**	**6.1**	**5.9**	**5.4**	**-17 %**	**-23 %**

Table 5.14 Historical and projected emissions of greenhouse gases from agriculture (million tonnes CO_2-equivalents)

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Enteric fermentation	3.3	3.0	2.8	2.7	2.5	2.2	-15 %	-24 %
Manure management	0.6	0.6	0.6	0.6	0.5	0.5	-5 %	-11 %
Agricultural land	3.5	3.2	2.9	2.8	2.7	2.6	-19 %	-24 %
Liming/Use of urea	0.2	0.1	0.1	0.1	0.1	0.1	-30 %	-30 %
Total emissions	**7.6**	**6.9**	**6.4**	**6.1**	**5.9**	**5.4**	**-17 %**	**-23 %**

Table 5.15 Historical and projected emissions (+) end removals (-) of greenhouse gases from LULUCF (million tonnes CO_2-equivalents)

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Forest land	-38.7	-46.6	-46.3	-46.7	-43.8	-40.9	20 %	13 %
Cropland	3.5	-0.2	2.8	2.8	2.8	2.8	-20 %	-20 %
Grassland	0.4	0.1	0.4	0.4	0.3	0.3	-10 %	-15 %
Wetlands	0.1	0.2	0.2	0.2	0.2	0.2	122 %	122 %
Settlements	3.0	2.8	4.0	4.0	4.0	4.0	34 %	34 %
HWP	-5.0	-6.7	-4.4	-5.0	-5.8	-7.0	-12 %	16 %
Total net removals	**-36.7**	**-50.5**	**-43.3**	**-44.3**	**-42.2**	**-40.5**	**18 %**	**15 %**

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

	1990	2015	2020	2025	2030	2035	1990–2020	1990–2030
Navigation	2.3	6.2	6.5	6.6	6.6	6.6	189 %	190 %
Aviation	1.4	2.2	2.4	2.5	2.7	2.9	76 %	100 %
Total emissions	**3.6**	**8.4**	**8.9**	**9.1**	**9.3**	**9.5**	**147 %**	**157 %**

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	2015	2020	2025	2030	2035	1990–2020	1990–2030
Projections WEM	71.6	53.7	49.9	47.7	45.6	43.6	-30 %	-36 %
Energy sector including transport								
Projection "Higher fossil fuel prices"			48.9	46.5	44.4	42.5	-32 %	-38 %
Projection "Higher GDP"			50.1	47.9	45.8	43.9	-30 %	-36 %
Transport sector								
Projections "Higher mileage"			50.2	48.5	46.8	45.2	-30 %	-35 %

grassland and wetlands were small during the period 1990–2015 and are projected to stay low during the projection period.

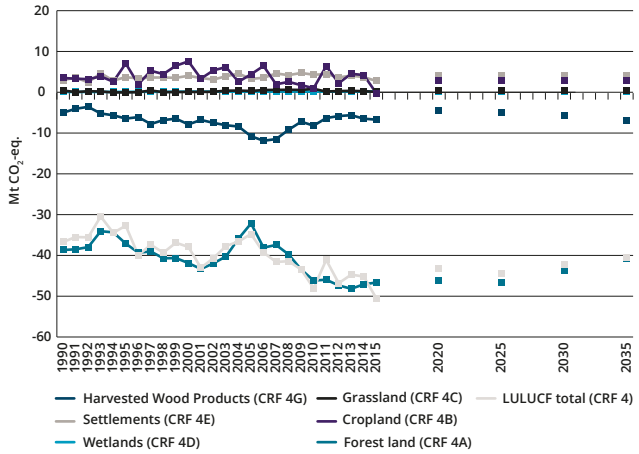

Figure 5.10 Emissions (+) and removals (-) from the LULUCF sector and its subcategories in Mt CO_2-equivalents per year.

5.3.10. International transport

Emissions from bunkers for international transport are projected to increase until 2035, mainly due to increased emissions from international aviation (see Table 5.16). This increase is explained by an expected increase in private consumption during the projection period, resulting in increased travel.

The increased use of fuel for international navigation is due to changes in passenger traffic, growth in the 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 the international ships and airplanes choose to refuel.

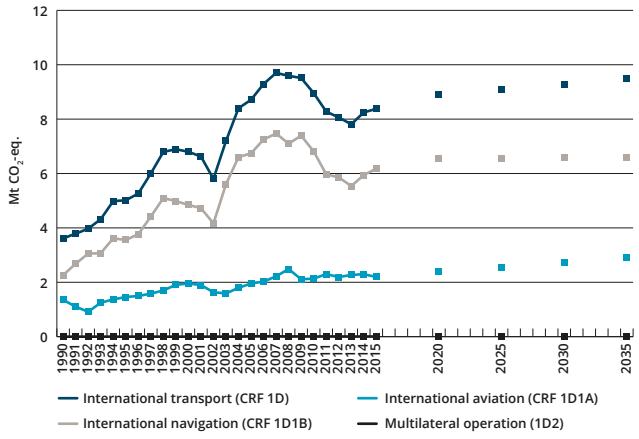

Figure 5.11 Historical and projected emissions of greenhouse gases from international bunkers.

5.4. Sensitivity analysis

Sensitivity calculations were produced by varying some parameters in the energy sector (incl. transport) and one in the transport sector. Aggregated for all sectors, the sensitivity calculations show that the emission level in 2030 may be 35 to 38 % 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.

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

The calculations of the sensitivity projections show that the projection with higher fossil fuel prices results in lower emissions than in the reference projection until 2035, as expected. The emissions are approximately 1.2 Mt CO_2-eq. lower than in the reference projection in 2030. A higher fossil fuel price boosts the incentive to replace fossil fuels and increase energy efficiency in industry and reduces the need for transportation, giving lower emissions in the transport sector.

The projection with higher economic growth than in the reference projection results in higher emissions in the energy and transport sectors than in the reference projection. In this case the emissions are close to 0.2 Mt CO_2-eq. higher in 2020 and 2030 than in the reference projection. The main reason for the increased emissions is a higher energy demand due to higher production in the industrial sector. Greater economic growth leads to a higher demand for the transportation of both goods and people.

For the road transportation sector, one additional sensitivity projections were performed separately, one with higher mileage. In the projection, the mileage is assumed to be 10 % higher in 2035 than in the reference projection. The calculations show that the projections with higher mileage result in emissions that are approximately 1.2 Mt CO_2-eq. higher in 2030.

5.5. Comparison with the Sixth National Communication and Second Biennial Report

The projections presented in 2014 in Sweden's Sixth National Communication were based on the inventory submission of 2013. The projections presented here are based on the inventory submission of 2017, which is based on IPCC 2006 guidelines. As the inventory data is not comparable between these years, the projection results are also not comparable as sectors and GWP have changed. The projection results are therefore compared with Sweden's Second Biennial Report, while assumptions used in projections are compared with both the Sixth National Communication and the Second Biennial Report (see Table 5.18).

The projections presented in 2016 in Sweden's Second Biennial Report (BR2) showed reductions in total greenhouse gas emissions of 23 % between 1990 and 2020

and of 28 % between 1990 and 2030. The projection set out here, in the Seventh National Communication (NC7), uses partly different assumptions and assessments based on trends over the last few years. The new projections show a decrease in total greenhouse gas emissions of 30 % between 1990 and 2020 and of 36 % between 1990 and 2030. A comparison of percentage changes in emissions overall and by sector is shown in Figure 5.12.

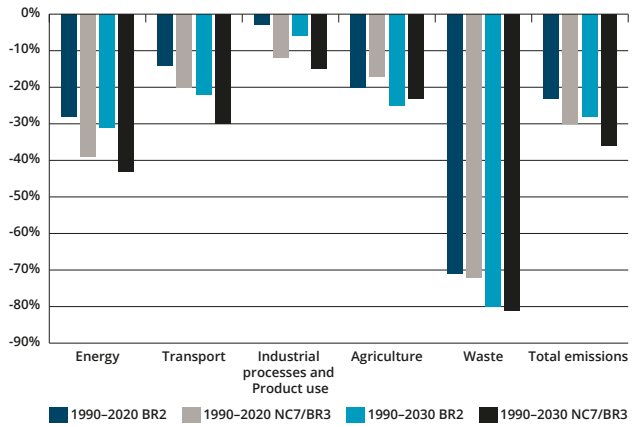

Figure 5.12 Percentage changes in emissions between 1990 and 2020 and 2030 respectively as projected in BR2 and NC7/BR3, overall and by sector.

The projections presented here indicate a larger reduction of emissions by 2020 and 2030 for almost all sectors compared with those in BR2. The difference is mainly due to differing assumptions, for instance regarding emissions trading prices, and assumptions based on the trend over the last few years.

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

Sector	2015	2020
Electricity and district heating	18	19
Residential and service sector	1.4	0.4
Industry	0	0.3
Transport	6	9
Waste	1.7	1.9
Total	**26.8**	**29.9**

Figure 5.13 shows an estimated emissions trajectory without measures, together with a graph of historic and projected emissions in Sweden up to 2020. The figure illustrates the effects of policies and measures implemented since 1990. In addition to the effects of the policies and measures presented in Chapter 4, the 'without measures' estimate takes account of the effects of the cross-sectoral instruments LIP (local investment programs for ecologically sustainable development) and KLIMP (local climate investment programs), which have been discontinued. The 'with measures' projection encompasses policies and measures adopted up to 2016. Further, the graph 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.

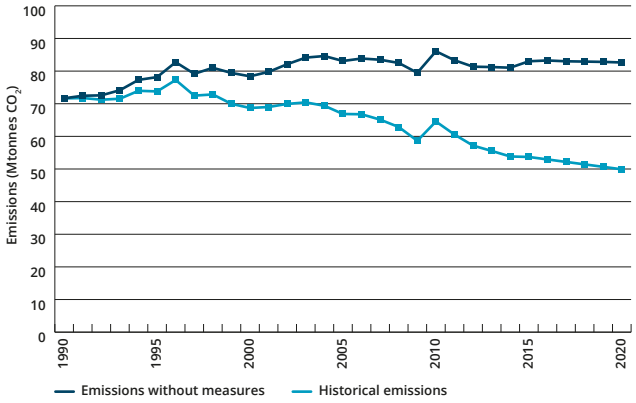

Figure 5.13 Estimated emissions without measures compared with historic and projected emissions with existing measures.

Table 5.18 Key assumptions in the Sixth and Seventh National Communication and the Second Biennial Report

	NC6		BR2		NC7/BR3	
	2010–2020	**2020–2030**	**2011–2035**		**2013–2035**	
GDP (annual change %)	2.4	1.9	2.0		2.28	
	2020 (2007 prices)	**2030** (2007 prices)	**2020** (2011 prices)	**2030** (2011 prices)	**2020** (2013 prices)	**2035** (2013 prices)
Price of crude oil (USD/barrel)	112	128	118	133	109	117
Price of coal (USD/tonne)	104	110	110	116	82	110
Price of natural gas (USD/MBtu)	10	12	12.1	13.1	12	12
Emissions trading (Euro/tonne CO_2)	16.5	36	8	20	15	42
Electricity certificates (new renewable electricity compared with 2012)	25 TWh by 2020		26.4 TWh by 2020		28.4 TWh by 2020	

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 third 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[27].

Furthermore, Sweden can use credits from international project activities to meet the target. The annual use is restricted to 3 % of 2005 emissions[28], 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.

For the year 2013 and 2014 Sweden's ESD emissions were lower than the ESD target. The surplus amount of AEAs was over 6 million per year compared to the Swedish ESD target. The surplus for 2013 was deleted in December 2016 and the surplus for 2014 will be deleted when the Compliance Account for 2014 is closed. Sweden has already taken a decision to delete the ESD surplus for 2015 and the Government has proposed to the Parliament that also the surplus for 2016 shall be deleted.

The target for Sweden is set to 36.1 Mt CO_2-eq. in 2020 (EU Decision C(2013)1708). The projections indicate an overachievement until 2020 in relation to the ESD target. The ESD emissions are projected to decrease to 29.7 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. However, investments in international projects have already been made if such credits would be required to meet the ESD target. The projections also indicate that Sweden will have a yearly surplus of allowances during 2016–2020. Note that these figures are uncertain and preliminary (see Table 5.20).

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)

	2005	2013	2014	2015	2020	2030
Total emissions	66.9	55.5	53.8	53.7	49.9	45.6
ETS emissions	23.6	20.1	19.3	19.2	19.7	19.2
Domestic aviation	0.7	0.5	0.5	0.5	0.5	0.5
ESD emissions[29] [30]	42.6	34.9	34.0	34.0	29.7	26.0
ESD target[31]		41.7	41.0	40.4	36.1	
Overachievement in relation to ESD target		6.8	7.1	6.5	6.4	

27 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.

28 According to National Inventory Report submission 2012

29 Historical ESD emissions are presented according to National Inventory report submission 2017. The compliance for 2013 and 2014 was based on National Inventory Report Sweden, submission 2016. The emissions in 2013 according to submission 2016 were 35.3 Mt CO_2-eq. which means that a surplus of 6.4 million AEAs was cancelled. Emissions in 2014 according to submission 2016 were 34.5 Mt CO_2-eq. which means a surplus of 6.5 million AEAs.

30 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 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.z

31 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.

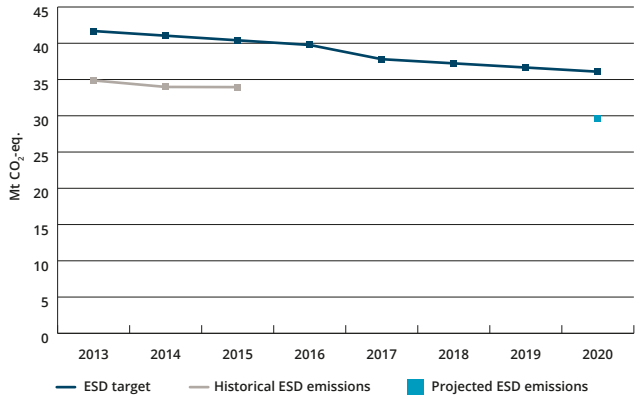

Figure 5.14 The ESD target (scope 13–20), emissions in 2013–2015 and the projected Swedish ESD emissions (scope 13–20).

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 which are not included in the EU ETS is to be reduced by 40 %, or around 20 million tonnes, between 1990 and 2020[32]. One-third of this figure can be reduced through emission reductions in other countries. However, the present government aims to fulfil the emission target with national measures. In 2020, the national target will preliminary be 28.8 million tonnes. The projections indicate that there will be a gap to target of approximately 0.9 Mt CO_2-eq. in 2020. In addition the uncertainty has to be taken into account. Note that numbers are preliminary until 2022–2023, when a definitive calculation can be done based on reviewed inventory data. If a gap to target still remains, it can be closed by emission reductions in other countries.

Table 5.21 Target fulfilment in relation to the domestic target for ESD emissions (scope 2013–2020, excluding aviation) in 2020.

	2020
Domestic target for ESD emissions	28.8 Mt
Projections ESD-emissions	29.7 Mt
Gap to target	0.9 Mt

In June 2017 the Riksdag adopted a climate policy framework including targets until 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 these targets, no more than 8 and 2 percentage points, respectively, of the emissions reductions may be realized through supplementary measures. A reduction of 63 % means that the target is preliminary set to 17.3 Mt CO_2-eq. in 2030. The emissions outside EU ETS are projected to decrease to 26 Mt CO_2-eq. in 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 with 2010. The emissions from domestic transport are projected to decrease by 35 % between 2010 and 2030.

32 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.

5.9. References for Chapter 5

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

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

National Inventory Report Sweden, Submission 2017.

6. Vulnerability assessment, climate change impacts and adaptation measures

In Sweden, plenty of research is carried out on climate change and its effects. The information from Swedish authorities is freely available to all, but not always easy to use or understand for the uninitiated user. But efforts are being made to ensure that stakeholders receive relevant and useable information.

As a result of climate change, temperatures in Sweden will increase by 2–7 degrees by the end of the century, depending on the scenario used. The greatest increase is expected in the north, and the increase will be greater in the winter than in the summer. This will mean milder winters with decreasing snow cover. Precipitation patterns will also change, and are expected to increase by 0–40 % by 2100. The greatest increase will be during the winter. During the summer, precipitation for southern Sweden is expected to decrease, and increased transpiration may lead to a shortage of drinking water in some areas.

Many aspects of Swedish society will be affected by climate change. Heavy rainfall is already causing significant economic damage, and the occurrence of these types of events is expected to increase. That climate change affects human health is well known, however the magnitude is hard to predict with precision, and varies with local preconditions and vulnerability. In addition, there are important impacts on infrastructure, agriculture, cultural heritage and other areas.

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

Adaptation to climate change spans many different fields, and it is therefore important to consider areas with multiple benefits as well as conflicting targets.

6.1. Expected impacts of climate change

6.1.1. Climate research and climate services

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 increasing 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 www.smhi.se/klimat presents climate information in the form of maps, diagrams and downloadable data, free of charge. 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. The information is based on the latest generation of global climate models (CMIP5). In 2014, a project was carried out at the Rossby Centre to downscale the global scenarios RCP2.6, RCP4.5 and RCP 8.5 from IPCC AR5 to regional level.

In 2015, the regional results were published in the form of a series of regional reports, available through www.smhi.se. The purpose of these reports was to provide relevant and useful information for decision makers at the regional and local levels. In total, 21 reports were produced, one for each administrative region. In order to ensure that all regions would have comparable information, the reports were developed with a common information base (temperature, precipitation, runoff and soil moisture). Region-specific information was then added in dialogue with regional stakeholders, to ensure that the provided information was relevant and presented in a suitable way. For the northern regions, the added analysis included information on snow as well as more detailed information on runoff. For the southern parts of the country, information was added on low water availability, the need for cooling and heating, and more detailed information about precipitation. The reports provide information about current and historic climate as well as scenarios for future climate.

Once the reports were completed, they were delivered to users through a nation-wide tour, where SMHI experts visited each region to explain the results and discuss how they could be used as a basis for work on adaptation. The work was funded by the National Knowledge Centre for Adaptation at SMHI.

Two degrees globally – effects on Sweden

According to the Paris Agreement, the increase in global average temperatures should be kept to below 2°C, and preferably to 1.5°C, compared with pre-industrial (1881–1910) levels. At the Rossby Centre, researchers have investigated what the effects of a global 2-degree increase would be in Sweden. The results show that if scenario RCP8.5 is followed, average temperatures in Sweden will have increased by 2 degrees compared with pre-industrial levels by as early as 2040 (Figure 6.1).

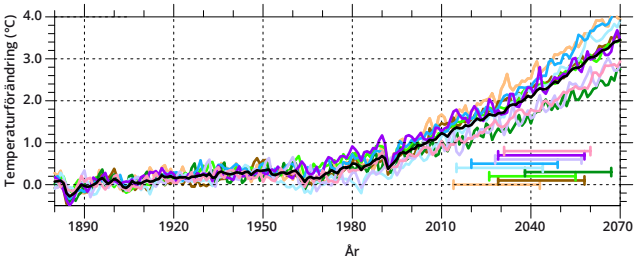

Figure 6.1 Global temperature increase compared to 1881–1910 according to nine different climate models according to scenario RCP8.5 (coloured lines) and the average of the model ensemble (black line). The thirty-year period representing two degrees warming are shown as horizontal lines with the same colours as the respective models.

The results also show that the warming will be greater in the north of Sweden. At the time when the global average temperature increase reaches 2°C according to scenario RCP8.5, temperatures in the north of Sweden will have increased by up to 4°C (Figure 6.2).

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.

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 slightly greater warming than the global is expected in Sweden during the same period.

The regional climate scenarios developed for Sweden, based on global climate scenarios RCP4,5 and RCP8,5, show that Sweden's annual mean temperature will increase by 2 to 7 degrees Celsius by the period 2071–2100 compared with the reference period 1961–1990. The greatest temperature increase is expected to be during the winter, between 2 and 9 degrees by the end of the century. Changes in the summer are estimated to be less than in the winter, between 1 and 6 degrees warmer.

The changes have significant regional differences, with the biggest effect in the north of Sweden. This is mainly due

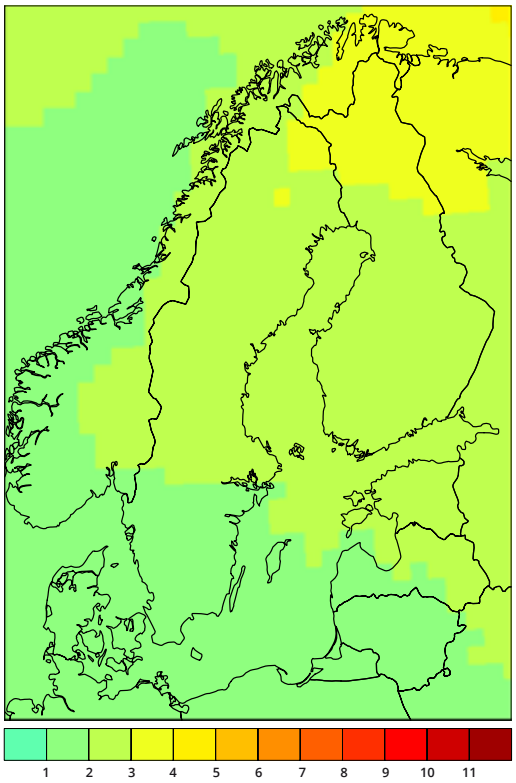

Figure 6.2 Calculated change of average annual temperature (°C) compared to the period 1971–2000 at the time of a global temperature increase of 2°C according to scenario RCP8.5.

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

The precipitation in Sweden is expected to increase by 0–40 % over the next century. Variations in precipitation between different years and different decades are greater than for temperature. The greatest precipitation increase is during the winter.

During the summer, precipitation for southern Sweden is expected to decrease, while changes for the northern part of the country appear to be small (possibly a small increase). This means runoff will increase by 5–25 % for Sweden in total, but with large regional differences.

Snow conditions are not only affected by winter precipitation but also by temperature. Consequently, the snow season will become shorter and the maximum snow cover less thick, despite increased 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. Most scenarios show some increase in wind speed across the parts of the Baltic that will become ice-free in a warmer climate. This includes the Gulf of Finland, the Gulf of Bothnia and the Bothnian Sea.

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.

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 can increase regardless of changes in the wind climate. The extent of the damage also depends on other factors that are more related to human behaviour and our vulnerability to disruptions in the infrastructure, not least regarding our 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 a farmer sows crops earlier in response to warmer spring temperatures. Impacts on socioeconomic systems are presented with the risks and vulnerabilities in section 6.2.1.

6.1.4. Physical systems

Wildfire and drought

Compared to many other countries, Sweden is spared from major disasters caused by extreme drought. During dry years, however, water shortages pose serious challenges in the country both locally and regionally. Mainly the eastern parts of southern and central Sweden are affected.

Every year, 3,000–4,000 wildfires occur in Sweden on average. The magnitude of the fires varies from year to year, but often more than 2,000 hectares of land is affected. The financial impacts are large in terms of emergency response and damage to forests and buildings.

Climate scenarios indicate a decrease in water availability in large parts of southern Sweden. This is mainly due to the plants' increased consumption 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 the lakes of Vänern and Vättern, with over 60 more days of drought every year by the end of the century. These conditions may also increase the risk of wildfires.

Drought can cause water scarcity and hamper vegetation growth. In southern Sweden the water demand is often greatest when resources are at their lowest. The consequences are even worse in combination with high temperatures as evaporation will increase. Drought causes low water flow to waterways and low water levels in lakes, leading to water shortages and competition between different types of water use such as water supply, irrigation or sewage.

It is not just drought and wind conditions 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 rises. 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 too dry or wet. Humidity also significantly affects the formation of ice, for instance on roads, aircrafts, wind turbines and masts.

Relative humidity is the amount of water vapour in the air relative to the maximum amount at same temperature. When the relative humidity is high and the 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 (number of days when the average daily temperature for a single period is over 5 degrees) is expected to increase by one to two months throughout Sweden, except in the far south where the increase is estimated to be up to three months. A higher mean temperature of 3°C means that Sundsvall in the north of Sweden will have the same average temperature in the future as Stockholm today.

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

An increase in temperature will cause temperature zones to move north. Each degree increase in average temperature

corresponds to a north-south distance of about 150 kilometres in Sweden. A warming of 3–4°C also results in an upward shift of the tree line by approximately 500 vertical metres.

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 our population is adapted 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 parks, waterways and air-conditioned indoor environments are all important factors for the effects of heatwaves.

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

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 increased evaporation.

The water table fluctuates between seasons and is lower during the summer. The time period for the reduced water table during summertime may be extended because of earlier snow melt, higher temperatures and longer summers. This can cause problems for domestic water supplies.

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

Heavy precipitation

Events of heavy precipitation have a major impact on our society. Flooded streets and roads, collapsing roofs and 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. Heavy loads of snow can overload roofs.

Extreme rainfall can lead to high water flows in rivers and lakes. A large part of the flooding that affects Sweden arises when several rain events have already passed, one after the other, although each individually would not have given any extreme amounts. 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.

Climate scenarios indicate that torrential rain (more than 40mm rain per day) in Sweden is becoming more common in a warmer climate. We can expect more frequent cloudbursts and an increase in intensity. As always, there are large regional and local differences.

During summertime 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 down to 6–10 years during the summer and 2–4 years for the winter in Sweden. This is based on comparisons between the periods 1961–1990 and 2071–2100.

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. The 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, the snow cover duration is expected to decrease, and in the southern parts of the country there is likely to be no long-lasting snow cover at all. This may reduce the extent of spring floods, but increase water flows during the winter.

The ice season and geographical extent will also be shortened. 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 the variations from year to year will continue to be large. This means that severe winter conditions can occur in the future, although they might be less frequent. The same patterns can be seen for lakes. The 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 temperature 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 south of Sweden, around Lake Vänern and along the coast. Zero crossings can cause damage to roads, buildings, bridges and other stone constructions.

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.

Flooding

An area covered in water, which is normally not under water, is described as 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, the local differences are large. For large parts of the country, the spring floods are expected to be lower and the winter floods will increase. Extreme floods are expected to occur less often in northern Sweden and for the western part of the central areas. In the rest of the country, extreme floods are expected to be more common.

Rising sea levels will increase the incidents of flooding along the southern coast of Sweden over a very long period in the future. Flooding of industrial areas may dislodge pollutants which may move into waterways or into the groundwater.

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 on changes in temperature that affect snow melt and evaporation.

The annual average stream flow is expected to decrease in the eastern parts of Götaland and Svealand, while an increase can be seen in large parts of Norrland. 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 increased evaporation.

Higher rates of flow can also lead to the inundation of old and new industrial areas, sewage treatment plants, etc. This results in pollution shocks that may have an impact on human, plant and animal life.

Sea level and water levels in lakes

Many processes affect the water levels along our coasts and in our lakes. For the sea this includes water temperature, wind, air pressure and postglacial rebound. The lakes are affected mostly by rainfall, snowmelt and water regulations.

During the last century, the sea level has risen at a rate that has nearly doubled in the last 20 years. According to IPCC AR5, global sea levels may increase by 52–98 cm in scenario RCP8.5. It is also emphasized that the ocean will likely continue to rise long after the year 2100.

Postglacial rebound in Sweden will mean that local sea level rise will be lower than global levels in the central and northern parts of Sweden. In the south, land rise is very small and will not have this effect. This is demonstrated in Figure 6.3, which shows the net effect of sea level rise minus land uplift along the coast of Sweden, subject to a global sea level rise of 1 metre in 100 years. The calculation of uplift is based on the Swedish National Land Survey uplift model NKG2005LU.

Currently, however, large parts of Sweden are still experiencing decreasing sea levels. This is illustrated by the Stockholm sea level series, Figure 6.4, which is one of the longest sea level records in the world. In the series, the ongoing sea level rise is inferred. The figure shows the annual mean for sea level in Stockholm since 1774. The sea level's rise since the late 1800s emerges as the deviation from the regression line that reflects land uplift.

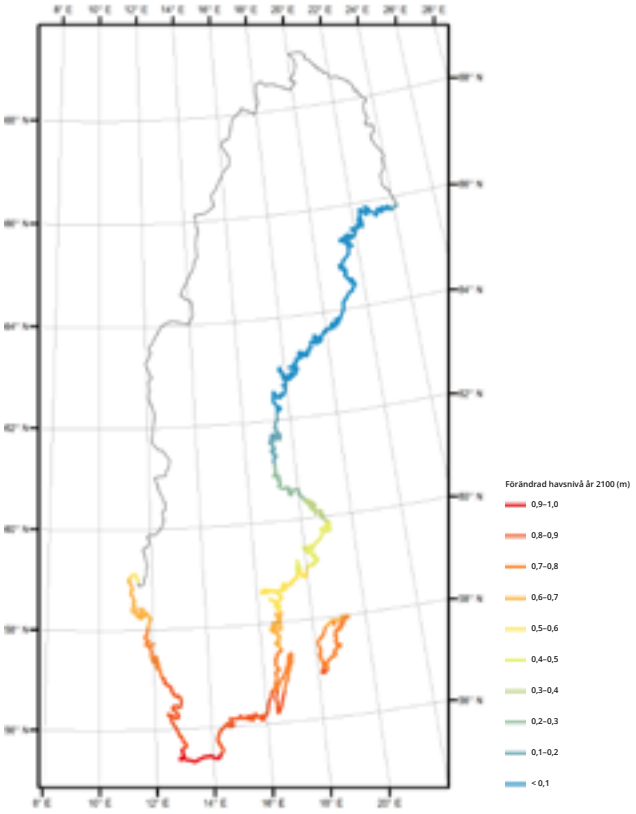

Figure 6.3 Net effect of sea level rise minus land uplift.

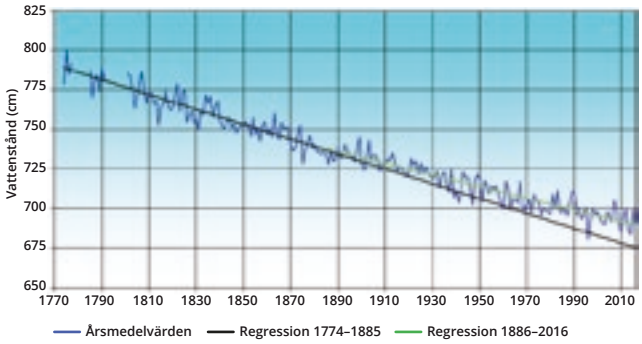

Figure 6.4 The Stockholm sea level series.

The water level in the 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 waters are regulated, and especially in the case of the largest power producing rivers, this has a big effect on water levels. It is not possible to give a general answer on how water levels in lakes will change in 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. Even low water levels may have implications for water supply and irrigation, among other things. For lakes Mälaren and Vänern, the low water levels can affect the intense shipping traffic.

Erosion and landslides

Erosion is the effect caused by the wearing down of the landscape by running water, waves, wind and ice. In Sweden, it is mainly water erosion that is of significance to built-up areas. Coastal erosion is affected chiefly by geological conditions, sea level, wave climate, wind conditions and currents.

Increased precipitation and runoff can cause high flows and erosion along river banks and watercourses. The most affected areas are in the western parts of the country and areas in central and northern Sweden. This affects the countryside as well as built-up areas. Decreased soil stability due to increased precipitation and erosion can also cause landslides.

As an effect of higher sea levels, coastal erosion will increase along the country's coast, primarily in southern Sweden. It is primarily along sandy coasts that erosion will increase. Frequent sand erosion takes place, for example, along the coast of Skåne, where the coastline has moved over 150 m inland over the last 30 years in some places.

The country's western and southern parts, as well as areas along the east coast, are the main areas that face an increased risk of landslides in the event of climate change. The risk of ravines developing might increase in parts of south-western and central Sweden, as well as parts of the northern areas. An increased risk of moraine landslides and mudslides is also expected in central areas.

6.1.5. Biological systems

When the climate becomes warmer, the climate zones and vegetation zones move northwards. This brings significant ecosystem changes. Which in turn affects the reproduction of plants and animals, the distribution and size of their populations and the incidence of pathogens. Endangered species may disappear, while new species may become established. Mountainous areas are particularly sensitive to climate change. The size of Sweden's alpine areas is expected to decrease sharply when the tree line rises, reducing the living space for species such as the arctic fox.

Changes to the conditions in the Baltic Sea will result in major changes to its biodiversity. The temperature in the Baltic Sea is increasing and the extent of the sea ice is decreasing drastically. An increase in the global sea level will entail a rise in the level of the Baltic Sea. It is also expected that the salinity of the Baltic Sea might change as a result of changes to wind conditions and the flow of fresh water from increased precipitation and drainage from watercourses. This will affect marine life.

Warm and calm weather are prime conditions for cyanobacteria, and in a relatively short time they can spread over huge areas. When the cyanobacteria decompose, large areas of hypoxia – a lack of oxygen near the sea floor – are formed in the Baltic Sea, causing damage to ecosystems and fish populations. In a changed climate with rising temperatures, conditions will become more favourable for cyanobacteria.

6.2. Assessment of risk and vulnerability to climate change

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 and 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 investigation into the legislative framework for adaptation, detailing any required amendments and clarifying roles and responsibilities was reported in May 2017.

The access to national risk and vulnerability analysis is relatively good but the need for local and regional analysis is still significant. In addition, there is a need for vulnerability assessments that include cross-border aspects (e.g. linked to the Baltic Sea Strategy), as well as assessments that include the indirect effects of climate change outside Sweden.

6.2.1. Assessment of impact, risk and vulnerability for socio-economic sectors

All the information in this section originates from www.klimatanpassning.se, and has been provided by the national authorities responsible for each area.

Energy security

Increased precipitation and heavier rainfall will lead to an increased risk of landslides and floods. Other weather-related threats such as extreme heatwaves, storms, thunderstorms, sleet and icing may also increase. Events like these already pose threats to the Swedish energy system, mainly at the regional and local level.

Energy security can also be affected by changes in the annual pattern of energy use, runoff patterns for water power, higher cooling water temperatures and changes in biofuel management. None of these changes manifest any greater vulnerability of the energy security, but in combination they may weaken the Swedish energy supply chain.

Many different types of weather threats, and also in combination with other external factors, can cause adverse events in the energy system. The consequences include limited access to energy, high energy prices and interruptions in delivery.

Because energy security concerns so many, efforts at national, regional and municipal levels will be needed. The Swedish Energy Agency has proposed measures for trade associations, private individuals, companies, funding agencies, municipalities, authorities and government.

Dam safety

Sweden has many hydropower dams, especially in the northern parts of the country. Changes in high water flows are the dominant influence on climate change and dam safety. If the inflow exceeds the dam plant's releasing capacity, the water level will rise in the reservoir. If the reservoir rises above the dam's limit, exceeding its dimensions, it could lead to dam failure. Adaptation measures for hydroelectric dams include reconstruction measures as well as operating and water conservation measures.

Other climate indicators such as wind, torrential rain, temperature changes, ground frost and snow affect dam safety, to a certain extent, but not as much as extreme flows.

Spatial planning

Spatial planning provides opportunities for long-term and preventive climate adaptation work for future buildings and infrastructure.

Waterfront buildings and areas that are already often exposed to floods are especially vulnerable to the effects of climate change. This applies both along lakes and rivers and in coastal areas. Problems related to flooding or landslides may increase as precipitation is expected to become more intense and frequent in the future and as a result of rising sea levels.

Housing areas are also affected more directly, for example, by changed snow and wind loads. A warmer and damper climate increases the risk of problems with humidity and mould. The heating demand decreases, while the need for cooling increases.

Historical locales represent irreplaceable values. Many environments and old cities of great cultural value are located in coastal areas, where they are vulnerable to rising sea levels and extreme weather.

Financial markets and insurance

The role of financial markets is to calculate risks, achieve profit and avoid loss. Balancing different types of risk can be very difficult, and climate change has long been absent in different types of risk analyses.

New rules and regulations, the revaluation of fossil energy reserves and extreme weather events are examples of factors that affect the financial markets. Climate change is therefore an issue of financial stability. To see sustainability as a condition for good investments, not a threat, paves the way for a more long-term balance of risks and investments.

In 2014, flooding, storms and forest fires brought high costs for society and for the insurance business. In particular, costs for flooding increased to over one billion SEK for the insurance companies.

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 repeat flooding of a basement, for example. No insurance mechanisms currently support preventive action. Swedish home insurance typically includes cover for flooding, but this practice may become difficult to maintain with repeated incidents and increasing costs. Cloudbursts in major cities can knock out important societal functions and the cost of damages can escalate.

The individual home owner is responsible for damages to his or her property. Preventive action decreases the risk of flooding. The owner can, for example, separate wastewater from stormwater and avoid paved surfaces. To support home owners, scientists and insurance companies have developed a web-based tool called Vis adapt (www.visadapt.info). It provides information about the effects of a changing climate and advice on how to avoid damage to buildings.

Electronic communication

Society is dependent on well-functioning and safe electronic communication. This is, in turn, dependent on a continuous supply of electricity. Even short power cuts can result in large consequences for the users.

Increased risks for storm damage to forests affects power lines in the air, as well as the masts. Work is ongoing to move more lines underground, and to move to radio communications, but air lines, and the risks connected to them, will remain for several years.

During a flood, entire areas are likely to lose power. This means that electronic communication may become compromised. Many large fibre cables are incorporated into bridges and will be damaged if the bridge is flushed away. Work is ongoing to protect electronic communication, for example to increase the robustness of systems and their resilience to precipitation, wind, thunder, dampness, extreme temperatures, floods, landslides and fire.

Aviation

Aviation is not affected by climate change to a great degree. Changes in ground frost and groundwater could

affect the buoyancy of the airfield, and increased precipitation could put an increased strain on airports' stormwater systems. Heat may affect the surfacing of the 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 perhaps a thicker layer of concrete to counteract the loss of buoyancy.

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 may need to be adjusted to higher water levels.

Increased water flows could bring difficulties through an increased risk for erosion and landslides in narrow passages, such as canals. The risk of landslides is high along the Göta älv, which is an important shipping route in the west of Sweden, and shipping 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.

Roads and railways

Transport on roads and railways is likely to increase in the future, which places demands on a robust infrastructure. At the same time, changes in the climate increase the risk for cloudburst, flooding and landslides, affecting roads and railways. This may lead to an increase in accidents. Falling trees can also cause traffic obstructions. Identifying areas of risk and putting measures in place can address these problems. Changes in groundwater levels may affect drainage and buoyancy. Low bridges may need to be rebuilt higher.

Warmer winters will decrease the need for salting the roads, and probably for clearing them of snow. There may be more zero crossings in the north and central parts of the country, leading to increased risks for difficult driving conditions and damage to roads and other infrastructure. Long periods of warm weather affect the railroads negatively. The railway lines and various other components can expand in the heat and cause disruptions in traffic.

The Swedish Transport Administration works to increase the robustness of the transport system by decreasing the risk for damage caused by landslide, erosion and flooding. Trees growing close to the railway track are removed, and risk inventories are carried out across the country.

Cultural heritage

Adapting the cultural heritage to climate change involves measures to prevent or mitigate damage caused by climate change. The degradation processes for most materials are affected by temperature and humidity. Higher temperature speeds up chemical reactions and changes, and variations in humidity affect the degradation of most materials.

Climate change risks can be both immediate and clearly visible, such as floods, but also slow and difficult to identify, such as mould, pests and overgrowth. The 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 posed by a changing climate on cultural heritage can already be seen today, but could become more common or have greater consequences in the future. Moreover, they interact with each other. Prevention measures such as risk analysis, surveillance and maintenance are essential to prevent and mitigate damage to cultural heritage.

Animal husbandry

Climate change increases the risk for outbreaks of infectious animal diseases, mainly due to ecosystem changes and increased presence of 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 factors.

Therefore, it is important that Sweden is well prepared for surveillance and handling of new or emerging animal diseases, and that there is good collaboration between the agencies concerned.

Farm animals housed indoors may suffer from increased temperature and humidity, increasing risks of mortality and disease. Stables in Sweden are in general built to protect the animals from wind and low temperatures, not from heat.

Agriculture

The Swedish Board of Agriculture has mapped how the climate may affect Swedish agriculture within a 25-year period. It is expected that the positive and negative effects from climate change are expected to basically offset one another for the agricultural sector. The higher carbon dioxide levels are expected to increase yields by about 5%. The potential to grow more winter crops and crops like corn are expected to get better. Meanwhile, crop conditions can deteriorate and the risk of drought can increase. The risk of flooding is expected to increase.

The changing climate will lead to more rainfall and more droughts. This puts greater demands on water infrastructure in agriculture such as ditches, covered ditches, embankments and irrigation dams.

Reindeer husbandry

Sudden weather changes, shifting of the seasons, changes in vegetation and increased unpredictability are some of the effects of climate change. These effects pose major challenges for reindeer herding, both now and in the future. The risks are most apparent in the winter and are not solely linked to a slow warming but also to extreme weather events.

Climate change means that reindeer herders need to have greater flexibility and access to several different types of

pastures. The times for moving the herd and for slaughter may also need to change.

In order to meet the climate challenge, enhanced possibilities for action in other areas are required, such as influence over competing land use and issues regarding predatory animals. The indirect adaption and improved opportunities for collaboration with other stakeholders will be a key issue for the reindeer industry.

Forestry

As the growing season is extended, forest growth will increase. With milder winters, deer species have an increased survival rate, leading to increased grazing of pine and leaf vegetation. Many vermin and some pathogenic fungi will gain better conditions and be able to spread. One way to address these problems would be to increase the diversity of tree species that are planted. Also, changed future climate conditions are being addressed in Swedish plant breeding programs.

The spread of root rot is more likely when harvesting occurs during the growth season. We might see more storm damages in the future as water levels are higher during winter and ground frost is absent. The risk of forest fires and spring frosts increases and more forest roads that function during mild winters are needed.

Better construction and maintenance of the forest roads will be central, as well as more respect for the environment, especially in humid environments and along creeks when driving on non-frozen woodland.

Tourism

It is expected that both national and international tourism will increase in Sweden. The coastal areas are important both for tourists and for the recreation of the local population. The most important resources are the beaches and the water. In the north of the country, winter tourism is also very important, as are opportunities for hunting and fishing.

The tourism industry could benefit from a changing climate with warmer summers. Winters with less snow cover are already affecting the ski resorts, which are becoming more dependent on making artificial snow to aid the winter tourist season.

Tourism around the Mediterranean may decrease due to warmer summers. The strong warming expected in the Alps may also lead to decreased tourism in that area. This could bring more tourism to Scandinavia.

Increased tourism requires resilient infrastructure. It also means more pressure on the environment in popular areas, and access to good-quality water resources will become a key issue.

Stormwater and wastewater

Water drainage systems will be affected by increased intensity of rainfall as well as increased levels in seas, waterways and lakes.

In recent years, several incidents with extreme rains and flooding in cities have focused attention on urban water management. It is expected that climate change will bring with it more rain and more intense rainfall. This adds extra stress to the systems. To adapt, green and blue infrastructure is necessary. Green infrastructure includes parks, gardens and green roofs. Blue infrastructure includes waterways, wetlands and sustainable drainage systems.

Stormwater management requires collaboration across several sectors, since there is not one stakeholder responsible for the entire issue.

Drinking water

Climate change is already having an impact on the conditions for a secure supply of drinking water, with increased average temperatures, greater volumes of precipitation, altered drainage patterns, evaporation and groundwater formation all creating new challenges.

Extreme weather events such as heatwaves, droughts, torrential rain, storms, high rivers and floods can, as with sea level rises, lead to quantitative and qualitative changes to raw water resources. Other effects that may arise in some places are a lack of water and salt water ingress in water sources used for drinking water.

The availability and quality of both groundwater and surface water might be affected. Surface water resources are more exposed than groundwater resources to a range of risk factors and are therefore more vulnerable to increases in temperature, intensity of precipitation and pollution.

Even with the current climate, parts of the country sometimes experience low water flow rates and water shortages. In the future, it is expected that low flow rates will occur more often in southern Sweden, primarily in the east. This may lead to drinking water shortages.

Health effects

Climate change impacts human health. A reduction in the number of extremely cold winter days will have a positive effect in terms of reduced mortality and fewer illnesses caused by cardiovascular diseases.

On the other hand, more frequent heatwaves will increase the number of deaths in summer time. The high-risk groups include people suffering from cardiovascular and respiratory diseases. Young children and the elderly are also at risk, especially those who spend a lot of time indoors where temperatures may be significantly higher, particularly if the building and ventilation is not adapted to a warmer climate.

Air pollution further exacerbates the health risks posed by high temperatures. Information for high-risk groups is important, as is adapting indoor temperatures in homes for the elderly, hospitals and other care facilities. Besides reducing the warming effect, green spaces in the urban environment often bring about other positive health effects.

The risk of water borne infections increases during warm summers, when more people are outdoors swimming more frequently. Wound infections caused by vibrio bacteria in water represent a new problem that emerged in the area around the Baltic Sea in the 2000s. These bacteria increase

in number in higher water temperatures. Higher water temperatures also increase the risk of toxic algal blooms and the growth of gastro-intestinal bacteria.

The length and climate of the seasons will change dramatically. This affects both pollen-producing species and the risk of vector-borne diseases, where the infectious agent is transmitted by for example mosquitoes and ticks. The high-risk season for Lyme disease and TBE may increase by up to four months by the end of the century. A changed climate may contribute to the survival of new disease-carrying insects and pathogens. There may also be an increase in the spread of zoonotic diseases.

Impact of global changes

The effects of climate change can have consequences far beyond the affected region. This is mainly due to the interaction between different processes in society and ecosystems and to the global nature of the issue, in part as a result of international trade.

It is important 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. It is therefore important for a country like Sweden, which is extensively internationalised, to be attentive to how changes in the rest of the world can have an impact at home. The impact of climate change on the flows of trade, infectious diseases, economic development and migration present some relevant areas for further study.

6.3. Adaptation measures

6.3.1. Domestic adaptation policies and strategies

In 2009 the Swedish Parliament adopted a coherent policy for climate and energy (Govt. Bill 2008/09:162. 2008. *An Integrated Climate and Energy Policy*), which includes the initial steps for Swedish society to adapt to a changing climate. It lays the foundation for a medium-term process to progressively identify the effects of climate change, assess the risks, and develop and implement adaptation measures. The strategy commits to concrete steps in the further development and implementation of adaptation measures. It follows an integrated approach that takes account of the interactions between sector and regional activities and strives to incorporate consideration of the possible impacts of climate change in all relevant policies.

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

Many Swedish authorities play an important role in adaptation work through their respective sectoral responsibilities and are working on preventive measures, building knowledge and improving resilience.

The regional government offices (County Administrative Boards, or CABs) are responsible for coordinating the regional adaptation work and supporting local actors in their adaptation work. The CABs report annually to the Government about 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 2017, the Centre has a budget of approximately SEK 35 million.

6.3.2. Adaptation action plans

To underpin the national strategy with specific actions, the regional government offices have adopted 21 regional action plans covering the entire country of Sweden with nearly 800 proposed actions. The main actions proposed in the plans concern flood protection, protection of drinking water, shoreline protection, infrastructure (roads, railways), adaptation of agriculture and forestry, resilience for heatwaves and health care. An overview of these regional adaptation action plans is available as a summary.

Several national authorities have developed or are developing action plans for the sectors that fall under their responsibility. Prioritised sectors have been food production, human health, national environmental objectives and planning/construction. So far, sectors that have received funds for developing such plans include forestry, human health, construction/land use and reindeer herding/sami culture. Using the same funds, 12 tools to assist with adaptation work have been developed. These include tools to handle uncertainties in adaptation work, nature-based methods to prevent flooding and designs to prevent beach erosion. Some local authorities have also developed adaptation action plans for their municipality. Significant progress and increased awareness of the importance of adaptation have been achieved in the last few years, at all levels of society.

6.3.3. Implementation

Following the climate and energy bill in 2009, the Government has financed measures of some SEK 100 million per year to improve knowledge about the impacts of climate change and to address these impacts, for example by implementing prevention measures against landslides and flooding. In the budget proposal for 2018, the government proposes that the allocation "Adaptation to climate change" to be raised to SEK 214 million. It will then also include funding for actions preventing landslides in a particularly vulnerable area of Sweden.

The Swedish climate change adaptation work is primarily organised by sector. During 2016 the previous network of authorities behind the National Portal for Climate Change Adaptation became the National Network for Adaptation, with a wider remit and the aim to increase the resilience of society to climate change. 18 national authorities with responsibilities for adaptation participate in the network, as well as the regional CABs. The secretariat for the network is provided by SMHI.

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

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

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

Several coordination forums currently exist in Sweden where sector agencies and other stakeholders can share experiences and plan key actions. These stakeholders 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
- Network for adaptation

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 adaptations have been started, above all, in municipalities hit by extreme weather events. In particular, this has involved measures in the areas of physical planning and building. Some municipalities have also raised the minimum level for construction, built levees and invested in pump systems to protect against flooding. Some have begun to modify water and sewerage systems to avoid the harmful effects of heavy downpours.

In built-up areas where the risk of natural disasters is particularly high, municipalities can apply for state funding for preventive actions. There is about SEK75 million available annually for the years 2017–2020. 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 threatened objects' value. Natural disaster in this context refers mainly to landslides or flooding.

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 a 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. A report for the consideration of the Ministry of the Environment and Energy was presented in December 2016.

During 2017, the adaptation work in Sweden is evaluated under the European Commission Adaptation Strategy using the Scoreboard tool. A similar exercise was carried out in 2015; those results showed that Sweden scores well in terms of availability of information and in awareness, but lacks some clarity around the division of responsibilities and has not completed sufficient work on monitoring and evaluation.

6.3.5. Progress and outcomes of adaptation action

Sweden is facing climate risks such as flooding, landslides, erosion, storm damage, drinking water contamination, heatwaves, drought, spread of diseases and challenges for reindeer herding. Climate adaptation initiatives in Sweden have advanced significantly in recent years to address future threats. There is a positive trend regarding municipal climate adaptation work. However, the progress of the municipalities varies widely. Large municipalities have generally made more progress compared to small and medium-sized municipalities, and coastal municipalities have gradually established their climate adaptation work compared with inland municipalities.

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 sickness. The measure affects around half a million people, and is partly financed through green bonds.

Case studies on adaptation actions and their outcomes

The Swedish National Knowledge Centre for Climate Change Adaptation gathers case studies of adaptation work in Sweden. The purpose is to provide inspiration and to share experiences of different types of adaptation work.

The city of Malmö is vulnerable to flooding, and has taken different measures to adapt. An open surface runoff system was introduced in the neighbourhood of Augustenborg at the end of the 1990s due to regular flooding of cellars. Instead of underground pipes, the urban environment transitioned to canals, ponds and green roofs. The surface water system can delay and store rain water so that it can then slowly run off into a nearby watercourse. The green roofs provide environmental benefits besides reducing the pressure on the city's surface water system. In addition, the roofs work as a natural purifier for both water and air, and also produce a cooling effect. There have been no floods in the neighbourhood since the runoff system was built, despite heavy rain.

Not only Malmö has found a solution with a synergy effect. Stockholm has been using a system for tree planting for many years. Using trees in urban environments reduces

several negative effects of climate change. As well as improving the air quality by capturing dust from traffic, the trees have a temperature-equalising effect and offer shade and coolness in the cities during hot summer days. As for precipitation, trees can reduce the impact of heavy rainfall by taking up large amounts of water. Trees in urban environments also benefit biodiversity and provide a habitat for birds and for different plants and insects.

One of the country's first water and landscape protection projects took place in southern Sweden in order to counteract eutrophication, promote biodiversity and recreation, and decrease the risk of flooding. Three municipalities worked together on a mutual solution along the Höje River, a watercourse that they share. Throughout the entire project, over 80 wetlands were created with a combined area of almost 110 ha. A holistic view combined with cost sharing made surveillance of water quality easier and enabled the municipalities to initiate tangible measures and invest in major projects. The goal of the project was to reduce the transport of nitrogen to the sea by 80 tonnes per year and transport of phosphorus by a substantial amount. According to a survey conducted at the end of the project, emissions in the whole catchment decreased by a total of 62 tonnes of nitrogen and 2.5 tonnes of phosphorus on an annual basis.

A different type of case study can be found in northern Sweden. Reindeer herding in Sweden has a history of adapting to different weather conditions, but climate change involves greater and more long-term challenges. In early winter, repeated freezing and thawing means that a layer of ice forms on the ground, locking in the reindeers' winter feed. Also, many areas of grazing land used in warm winters are today not available to the herders due to the expansion of extensive infrastructure, forestry, wind power and tourism. These changes have caused problems for reindeer herding in recent years. Fencing and emergency feeding of the animals is often necessary, however this causes stress and health problems for the animals.

The Vilhemina Northern Herding Cooperative has developed tools to track and gather information about the movements of their reindeer in different weather conditions. Working together with the Swedish Forest Agency and researchers, the Cooperative has developed a reindeer husbandry plan to be used when consulting and communicating with other industries in the area.

6.4. References for Chapter 6

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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 that took office in September 2014. 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.

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.

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.

In order to increase transparency Sweden has in its National Communication chosen to report its climate finance in the Common Tabular Format used in the Biennial Report – see Annex 6. This includes all the information, and even additional information, required by the guidelines of the National Communication, at the same time as it increases coherence between reports and reduced the burden of reporting.

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 new 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 are important 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.

7.2.3. New and additional resources

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. One common definition, supported by many countries, is that climate financing should be additional to the international development aid goal of 0.7 % of gross national income (GNI).

Sweden is one of few OECD DAC members to have met, and even far exceeded, the UN target of 0.7 %. There is broad Parliamentary support, to continue delivering 1 % of Sweden's GNI to Official Development Assistance (ODA). Figures for total Swedish ODA 2013-2016 are shown in Table 7.1, together with the share of climate finance compared to total ODA.

Table 7.1 Total Swedish official development assistance, 2013–2016

	2013	2014	2015[33]	2016
SEK million	37 954	42 756	59 780	41 701
USD million	5 827	6 233	7 092	4 870
% of GNI	1.02	1.09	1.40	0.94
Climate finance as share of total ODA	7 %	6 %	5 %	9 %

All exchange rates used in this report are based on the annual average dollar exchange rates for OECD Development Assistance Committee (DAC) members[34]. For Sweden, this means USD 1 = SEK 6.514 (2013), SEK 6.861 (2014), SEK 8.435 (2015) and SEK 8.562 (2016).

In addition to the climate finance within ODA, Sweden has also contributed to international climate finance through Other Official Flows e.g. within the Swedish Program for International Climate Initiatives through the Kyoto Protocol's flexible mechanism. Sweden has chosen to voluntarily cancel purchased international credits and report them as climate finance. The cancelled credits cannot be utilised in any way, sold or used to fulfil Sweden's mitigation commitments (see section 7.4.3).

Against this background, all climate finance provided by Sweden during 2013–2016 should be viewed as new and additional.

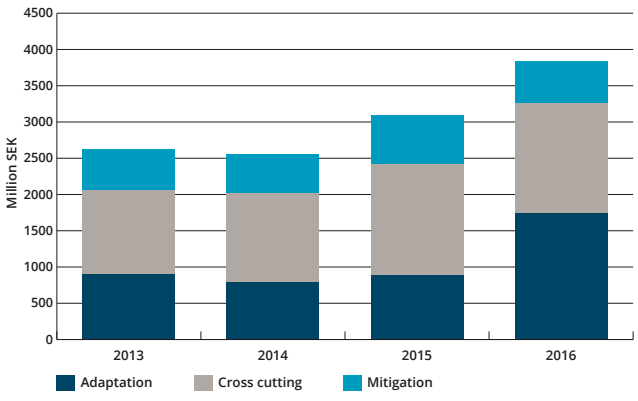


Figure 7.1 Total Swedish climate finance, 2013–2016, excluding core funding to MDBs and UN organisations.

7.3. Multilateral financial support

Sweden is 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). In calendar years 2013–2016, 55–70 % of GEF's recorded commitments of funding were climate-related (using the Rio Markers methodology)[35], which has been the basis to calculate Sweden's imputed share of climate finance (see Table 7.2 below).

Table 7.2 GEF climate-related commitments, 2013–2016

Year	2013	2014	2015	2016
% of total	55 %	56 %	70 %	60 %

In addition, Sweden provided substantial climate finance through a number of other multilateral climate change funds, such as the Adaptation Fund and the Least Developed Countries Fund. In 2016 Sweden was also one of the first donors to provide support to the Capacity Building Initiative for Transparency, established at COP21 in Paris. All of the contributions to multilateral climate funds are accounted as 100 % climate finance.

Multilateral climate finance (presented in Annex 6, CTF Table 7 and 7a) 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 7a (please note that it does not provide an exhaustive list of all of Sweden's multilateral contributions). Final data regarding the climate specific share of core contributions was not available for all years and for all of these multilateral development banks and UN organisations. Some data were however available from MDBs for 2015–2016, summarised in table 7.3. Thus it can be concluded that Sweden's contribution to international climate finance exceeds the total figures presented in the CTF-tables, Annex 6.

The Ministry of Environment and Energy administered support to a number of strategic initiatives linked to the UNFCCC negotiations, such as the UNFCCC Trust Fund, the African Group of Negotiators working with the Africa Renewable Energy Initiative, the New Climate Economy, the Clean Energy Solution Centre and the International Institute for Sustainable Development's work with Fossil Fuel Subsidy Reform. 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 SIDS DOCK[36].

33 In 2015 the levels of Swedish ODA were exceptionally high due to factors such as the following: actual costs for asylum seekers (20.2 bn SEK) exceeded budgeted costs (8.9 bn SEK); the full amount of the promissory note to the GCF 2015–2023 was registered in accordance with the OECD DAC rules; and Sweden made advance payments (for 2016 commitments) of a total of 2.5 bn SEK to CERF, UNHCR, UNWRA, UNDP and EDF.

34 https://data.oecd.org/conversion/exchange-rates.htm

35 According to figures bilaterally communicated from the GEF Secretariat to Sweden. Further information is available from the GEF Secretariat.

36 Small Island Developing States(SIDS) DOCKing station, is an initiative among member countries of the Alliance of Small Island States (AOSIS) to provide the Small Island Developing States (SIDS) with a collective institutional mechanism to assist them transform their national energy sectors into a catalyst for sustainable economic development and help generate financial resources to address adaptation to climate change.

An overview of Sweden's multilateral support is presented in Table 7.4 and Figure 7.2 below. More detailed information for each year can be found in Annex 6, CTF Table 7a.

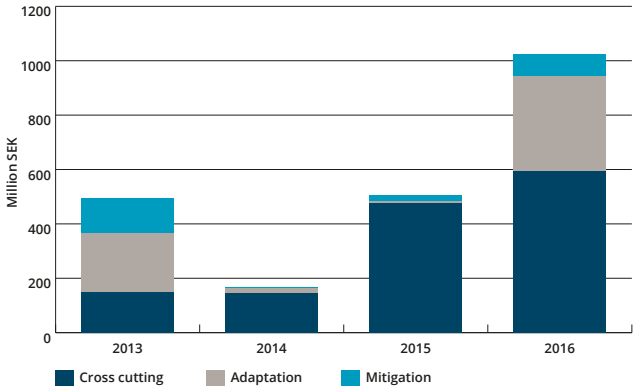


Figure 7.2. Multilateral climate finance provided by Sweden through the Ministry for Foreign Affairs and the Ministry of Environment during 2013–2016, by type of climate action.

As shown in Figure 7.2, Sweden increased its multilateral climate finance substantially from 2013 to 2016. More specifically, the overall increase was 106 %, i.e. more than double. The financial support to adaptation increased by 64 %, to cross-cutting increased by 295 %, while support to mitigation decreased by 42 % during the same time period.

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. Integration of gender issues is improving, 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

7.4.1. 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 Annex 6, CTF Table 7: summary financial information, 7b: details at component level, 8: examples of technology development support, and 9: 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. Sida is currently making efforts to enable climate finance reporting through IATI, and aims to present such a pilot in 2018.

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 7.5). In Annex 6, CTF Table 7 and 7b, 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

Table 7.3. MDB climate finance as percentage of total MDB operations.

MDB:	ADB	AfDB	ERDB	EIB	IDBG	WBG
2015[36]	15.3 %	15.6 %	25.5 %	26.2 %	16.1 %	17.9 %
2016[37]	22 %	9 %	28 %	21 %	22 %	18 %

Table 7.4 Multilateral climate finance 2013–2016 through the Ministry for Foreign Affairs and Ministry of Environment and Energy.

Year	Mitigation MSEK (% of total*)	Adaptation MSEK (% of total*)	Cross-Cutting MSEK (% of total*)	Total MSEK
2013	130 (26 %)	215 (43 %)	150 (30 %)	495
2014	6 (4 %)	15 (9 %)	147 (87 %)	168
2015	22 (4 %)	6 (1 %)	477 (95 %)	504
2016	77 (8 %)	352 (34 %)	592 (58 %)	1 022
	Mitigation MUSD (% of total*)	**Adaptation MUSD (% of total*)**	**Cross-Cutting MUSD (% of total*)**	**Total MUSD**
2013	20 (26 %)	33 (43 %)	23 (30 %)	76
2014	1 (4 %)	2 (9 %)	21 (88 %)	25
2015	3 (4 %)	1 (1 %)	57 (95 %)	60
2016	9 (8 %)	41 (34 %)	69 (58 %)	119

*Total contributions through multilateral channels.

37 2015, Joint Report on Multilateral Development Banks' Climate Finance.
38 2016 Joint Report on Multilateral Development Banks' Climate Finance.

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 Table 7.5.

Table 7.5 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

Sweden reports on the climate finance it provided in 2015–2016 in the form of a National Communication and a Biennual Report (BR) to the UNFCCC, as well as the annual Monitoring Mechanism Regulation (MMR) report to the EU. To be transparent, the same gross list of contributions that is presented in the CTF Table 7b is used for all three reports. For the National Communication, support to some Annex I Parties to UNFCCC (that are also eligible for ODA) is included in the summarized amounts, while the BR and MMR focus exclusively on support to non-Annex I Parties, in line with the reporting guidelines. Sida's support to Kosovo is included in the gross list for transparency reasons, but is excluded from the summarized amount since Kosovo is not yet a Party to UNFCCC. Support to Palestine is included for 2016, since it became a Party to the UNFCCC that year, but excluded in earlier years. Some contributions are included in the CTF-table more than once. That is a presentation of different components of a contribution separately that is done because climate change relevance is tracked at the component level (one contribution can have several components). To get a full picture of the climate finance to a contribution, the climate finance to the different components can be added up. There are some differences between the data for 2013–2015 presented in this NC/BR and data reported earlier. This is primarily because the climate relevance of some contributions has been adjusted as a result of actual changes in policy or quality assurance of the tracking. In this report, the figures are based on the most recent and best available data at the time of reporting.

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. Gender integration for Sweden's bilateral support is presented in Figures 7.3 and 7.4.

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".

7.4.2. Bilateral financial support through Sida

The majority of Swedish climate finance to low- and middle-income countries is channelled as bilateral ODA through Sida. It includes support provided to local and national institutions, bilateral support to multilateral organisations[39] and other global and regional organisations. In the area of climate change, Sida provides significant climate change support at several levels. It 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 actors in low- and middle-income countries, including government institutions, multilateral organisations, research institutions, non-governmental organisations, the private sector and Swedish authorities and municipalities. ODA channelled through Sida is disbursed at national, regional and global levels.

Table 7.6 Climate finance provided by Sida during 2013–2016.

Year	Adaptation MSEK (% of total)	Mitigation MSEK (% of total)	Cross-Cutting MSEK (% of total)	Total MSEK
2013	688 (33 %)	391 (19 %)	1 001 (48 %)	2 080
2014	772 (33 %)	456 (20 %)	1 092 (47 %)	2 320
2015	880 (35 %)	583 (23 %)	1 052 (42 %)	2 514
2016	1 388 (50 %)	487 (17 %)	921 (33 %)	2 796
	Adaptation MUSD (% of total)	**Mitigation MUSD (% of total)**	**Cross-Cutting MUSD (% of total)**	**Total MUSD**
2013	106 (33 %)	60 (19 %)	154 (48 %)	319
2014	112 (33 %)	66 (20 %)	159 (47 %)	338
2015	104 (35 %)	69 (23 %)	125 (42 %)	298
2016	162 (50 %)	57 (17 %)	108 (33 %)	327

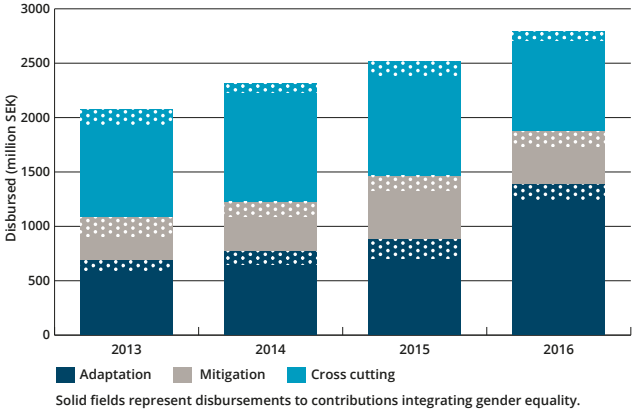


Figure 7.3 Climate finance provided by Sweden through Sida during 2013–2016, by type of climate action, and levels of gender equality integration.[40]

39 "Multi-bi" according to OECD DAC definitions

40 The figures represent disbursements to non-Annex II Parties to UNFCCC plus regional and global contributions for 2013–2016.

As shown in Figure 7.3 Sweden increased its bilateral climate finance substantially from 2013 to 2016. More specifically, the overall increase was 34 %. The financial support to adaptation increased by 102 % and to mitigation by 25 %, while support to cross-cutting initiatives decreased by 8 % during the same time period. 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 (see multilateral section above, and Annex 6, CTF Table 7a). Globally, the majority of international climate finance is directed to climate change mitigation (77 % in 2013–2014), and only a relatively small proportion to climate change adaptation (16 % in 2013–2014)[41]. While adaptation is underfunded, the needs continue to grow, as do demands for support from adaptation finance.

Sida's work is conducted within the framework of bilateral, regional and global development cooperation strategies decided by the Swedish Government. 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 a fundamental entry point in all of Sida's operations. The countries that have received most bilateral climate finance from Sweden during 2013–2016 are presented in Table 7.7. African countries are among the main recipients of Swedish bilateral climate finance in general, and Mozambique and Kenya have been among the top five recipients all four years. In other regions, Bolivia and Bangladesh are among the top recipients. It can also be highlighted that one fragile state, Somalia, has been among the top recipients despite the conflict/post-conflict context that makes implementation highly challenging in the country. For all countries, payments may vary significantly between years. This depends greatly on context and a range of reasons, including administrative and political reasons.

BOX 7.1

Sida supports Tanzania's Productive Social Safety Net (PSSN), which targets one million households that are extremely poor. PSSN provides cash transfers and also has a public works component. People in poverty are hit hard by climate change impacts because they are more exposed and more vulnerable and have less support than others. Social safety nets help them to better cope with climate change impacts such as extreme weather events and unpredictable agricultural seasons. Sida's total contribution to PSSN in 2016 was 300 MSEK. Climate change adaptation is not identified as the primary objective of the program but a significant objective and therefore only 40 % of the total disbursement is considered climate specific, that is 120 MSEK (see Section 7.4.1. above for more information about the methodology).

BOX 7.2

Sida supports Tanzania's Rural Energy Agency (REA) during 2015–2019 to scale up modern rural energy access as part of Tanzania's contribution to the SE4All ambition to reach universal energy access by 2030. The objective is poverty alleviation in rural mainland Tanzania through access to modern energy services based on renewable resources. It is achieved through extensive on-grid electrification investments, complemented by private sector led off-grid and mini-grid renewable energy investments.

BOX 7.3

The Landscape and Forest Management Multi Donor Trust Fund in Mozambique addresses the alarming levels of deforestation and forest degradation in the country that directly affect the rural population's resilience and cause severe economic, social and environmental consequences. The intervention is implemented at two levels: the national level, with the aim to strengthen the overall national forest management (including institutional capacity building, law enforcement and review of policy framework) and at the local level, focusing on climate-smart agriculture, sustainable use of wood fuels and sustainable forestry. The initiative is considered to have climate change adaptation and mitigation as the primary objectives. Hence, Sida's total disbursement in 2016 of 40 MSEK is identified as climate finance.

BOX 7.4

The Local Government Initiative on Climate Change initiative aims to support the local implementation of Bangladesh's national Climate Change Strategy and Action Plan. Climate adaptation action that is designed and implemented with local ownership can efficiently increase the resilience of vulnerable groups to climate change. The initiative strengthens the capacity of local government agencies to integrate climate adaptation in local development plans, improve national mechanisms for local climate finance and to implement climate adaptation actions identified jointly by local government and local communities. The initiative has climate change adaptation as its primary objective, and Sida's total disbursement in 2016 of 35 MSEK is identified as climate finance.

41 OECD and CPI, 2015, *Climate Finance in 2013–2014 and the USD 100 Billion Goal.*

Table 7.7 A summary of the top five countries receiving Sida climate finance during 2013–2016. All the countries are among Sweden's major bilateral development cooperation partners.

2013	Country	Disbursed (MSEK)	Disbursed (MUSD)
1.	Mozambique	190	29
2.	Kenya	77	12
3.	Bolivia	75	12
4.	Burkina Faso	74	11
5.	Tanzania	66	10
2014	**Country**	**Disbursed**	**Disbursed**
1.	Mozambique	197	29
2.	Kenya	124	18
3.	Zambia	70	10
4.	Burkina Faso	59	9
5.	Somalia	58	8
2015	**Country**	**Disbursed**	**Disbursed**
1.	Mozambique	212	25
2.	Tanzania	150	18
3.	Kenya	148	18
4.	Zambia	91	11
5.	Bolivia	70	8
2016	**Country**	**Disbursed**	**Disbursed**
1.	Tanzania	196	23
2.	Mozambique	107	12
3.	Kenya	105	12
4.	Mali	82	10
5.	Ethiopia	71	8

Since 2014, Sweden has a feminist foreign policy. 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 2013-2016 is presented in Figure 7.4. The overall level of gender integration is around 80%. There is a slightly increasing trend, but a further stepping up of efforts can be sought, in particular in the mitigation portfolio. Within adaptation, the level has in general been higher, but there is scope for improvement here as well. The decrease in proportion of gender integration in adaptation finance in 2015 was partly due to new agreements with a few multi-donor trust funds that were not integrating gender equality sufficiently. 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. Overall integration of gender issues is improving, thus also contributing to the efficiency and long-term sustainability of the projects and programs funded by multilateral climate funds.

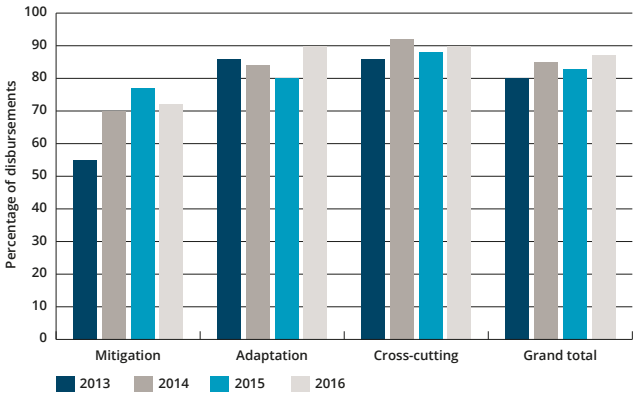


Figure 7.4 Level of gender equality integration in by Sida's climate finance during 2013–2016.[42]

The climate finance Sida provided in 2013–2016 was distributed among sectors[43] as shown in Figure 7.5. The largest climate finance disbursements were made to initiatives within the sector groups 'environmental policy and administration', 'agriculture/forestry/fisheries', 'urban development, rural development and multisector', and 'water and sanitation'. Disbursements to the energy sector have varied significantly between the years, as expected due to the relatively few but large-scale investments in that sector. Positive trends are the increased level of climate integration within human rights, democracy and related sectors, as well as within humanitarian support and disaster risk reduction support. Climate change can be better integrated within sectors such as social protection, health and education.

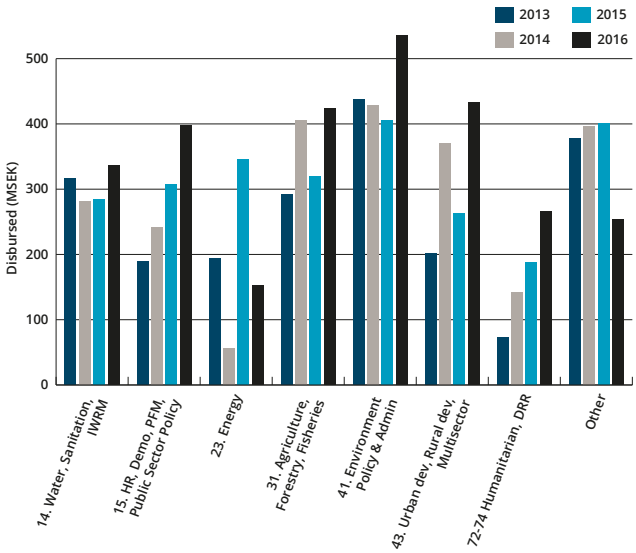
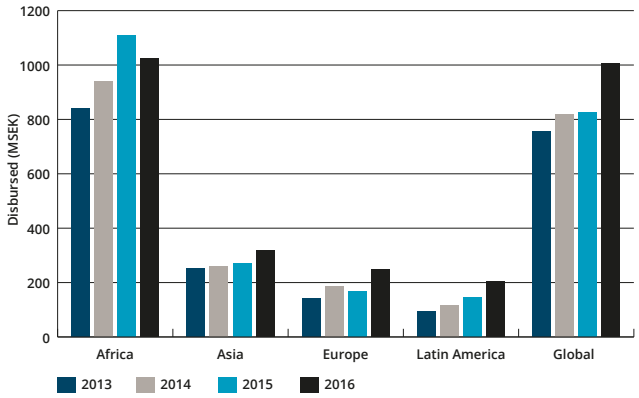


Figure 7.5 Sida's climate finance by groups of sectors during 2013–2016[44]. The category "Other" includes budget support, SME/Agroindustries, Trade, Social protection, Education, and Health. Sectors are defined according to OECD DAC. Multiple sectors beginning with the same two first figures of the OECD DAC sector codes are grouped.

42 The figures represent disbursements to non-Annex II Parties to UNFCCC plus regional and global contributions for 2013–2016
43 OECD DAC purpose codes for sector classification are used http://www.oecd.org/dac/stats/purposecodessectorclassification.htm
44 The figures represent disbursements to non-Annex II Parties to UNFCCC plus regional and global contributions for 2013–2016.

The climate finance Sida disbursed in 2013–2016 was distributed among geographic regions and global organisations as shown in Figure 7.6. The largest proportion of the financing was provided to local, national and regional actors in Africa. The smaller portfolios in Asia, Europe and Latin America increased during the time period, as did the large portfolio of climate change initiatives at the global level.



The figures represent disbursements to non-Annex II Parties to UNFCCC plus regional and global contributions for 2013–2016.

Figure 7.6 Sida's climate finance by geographic region and global organisations during 2013–2016.[45]

7.4.3. Bilateral financial support through the project-based flexible mechanisms under the Kyoto Protocol

The Swedish Program for International Climate Initiatives through the Kyoto Protocol's flexible mechanism spans for almost 20 years. The objectives of the program have evolved over time in response to the development of the international climate negotiations and the international carbon markets. However, the core mission of the program has remained to support the development of international climate cooperation, to achieve cost-effective greenhouse gas reductions and to contribute to sustainable development in developing countries. Through the program, Sweden supports over 90 bilateral projects through the Clean Development Mechanism (CDM) and Joint Implementation (JI) as well as participation in ten multilateral carbon funds[46] with a total commitment of 2,4 billion SEK Priority project types include renewable energy, energy efficiency and waste management. Priority has been given to bilateral projects in Sub-Saharan Africa (37 % of portfolio emission reduction volume) and South East Asia (16 % of portfolio emission reduction volume). Underrepresented developing countries have been of particular interest for the program, Small Island Developing States (SIDS) 2 % of portfolio emission reduction volume, and Least Developed Countries (LDC) 18 % of portfolio emission reduction volume.[47]

All international credits delivered to the Swedish holding account generated during the first commitment period of the Kyoto Protocol have been cancelled.[48] Thereby ensuring that the international credits cannot be utilized in any way, sold or used to fulfill Sweden's commitment under the Kyoto protocol.

The financial support is committed through an Emission Reduction Purchase Agreement between the Swedish Energy Agency and the project owner. The commitment is made at an early stage of the CDM- or JI-project in order to enable the development of projects. Through the Emission Reduction Purchase Agreement the Swedish Energy Agency commits to purchase the international credits upon issuance. The actual financial flow is provided once the international credits have been, generated, verified and certified by the UNFCCC and forwarded to Sweden's holding account. The cancelled international credits are reported as climate finance the year of the financial flow from the Swedish government to the project owner.

Through the Program for International Climate Initiatives, Sweden has provided result-based climate finance of approximately 211 M SEK over the years 2013–2016.

Table 7.8 Bilateral financial support through the Program for International Climate Initiatives during 2013–2016

	MSEK
2013	55
2014	70
2015	72
2016	14
Total	**211**

Since the main objective of the projects and carbon funds is climate change mitigation, the support provided is regarded as 100 % climate finance according to the Rio markers (climate change mitigation is principal objective). The Figures are also included in Annex 6, CTF table 7 and 7b.

7.5. Financial flows leveraged 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

45 The figures represent disbursements to non-Annex II Parties to UNFCCC plus regional and global contributions for 2013–2016

46 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) and Testing Ground Facility (TGF).

47 Can be compared to the CDM-market as a whole where Sub-Saharan Africa represents 3 %, Small Island Developing States (SIDS) represents 0,3 % and Least Developed Countries (LDC) represents less than 1 % (http://www.cdmpipeline.org/ (CDM pipeline overview (20160216))).

48 Reference M2017/00821/KI

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 2016, Sida had guarantees to climate-relevant initiatives with a total guarantee volume of 3.1 billion SEK, mobilising about 6.9 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.

7.5.2. Mobilisation of private capital through Swedfund

Swedfund is Sweden's development finance institution. It is owned by the Swedish state through the Ministry of Enterprise and Innovation and the Ministry of Foreign Affairs. Swedfund's mission is to contribute to the goals set out in Sweden´s Policy for Global Development and can be summarized in Swedfund's mission statement: "Contribute to poverty alleviation through sustainable investments". 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 2016 Swedfund had 63 investments in companies and funds in 27 countries, of which more than half were located in Africa.

Environmental and social aspects are of paramount importance in all our investments, as demonstrated in Swedfund's comprehensive Policy for Sustainable Development. In order to measure our performance, Swedfund has adopted four strategic sustainability goals. Indicators have been developed which are carefully measured and followed up during the value-creation phase of each investment.

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. Swedfund views its additionality as an investor 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

As an example of Swedfund's climate efforts, in 2016 it strengthened its work to develop a method to measure the carbon dioxide emissions of portfolio companies. In addition, Swedfund increased its investments in renewable energy significantly.

Swedfund has also been part of developing the Interact Climate Change Facility (ICCF), a structure which mobilises significant amounts of long-term debt funding

Table 7.9 Guarantees provided by Sida in 2016 for climate-relevant investments, in millions SEK.

	Guarantee volume (MSEK)	Mobilised capital (MSEK)	Main source of mobilised capital	Guarantee volume (MUSD)	Mobilised capital (MUSD)
Guarantee BiH Sberbank (formerly Volksbank) in cooperation with USAID	25	42	Private	3	5
Pakistan – Guar Windpower	480	1 071	Public	56	125
Agri Guarantee USAID Multi Party	37	51	Private	4	6
Agri Guarantee USAID Zanaco	26	46	Private	3	5
Loan Portfolio Guarantee for Sustainable Energy Moldova	9	15	Private	1	2
Conflict-Affected and Fragile Economies Facility (CAFEF/MIGA) – Guarantee	200	684	Private	23	80
Portfolio Guarantee – Asian Development Bank	2 000	4 500	Public	234	526
NEFCO Portfolio guarantee	175	228	Public	20	27
Global Guarantee Facility Household Technologies	117	210	Mixed	14	25
Zambia, bioenergy Madison Finance LPG guarantee	26	33	Private	3	4
Total	**3 093**	**6 880**		**361**	**804**

Table 7.10 Swedfund's investments and contributions

Projects	MUSD	Specifics
IFC Women Entrepreneurs Debt fund*	20	Fund focusing on women entrepreneurs in sub-Sahara Africa
XacBank	10	Bank in Mongolia with focus on minimising climate change. Under the umbrella clean air are companies offered financing to ensure energy efficient systems and production lines.
ICCF	5	Climate facility with focus on renewable energy
DBL Industries	15	Swedfund invests together with Ethiopian Development Bank and company from Bangladesh, DBS, to build textile factory in Ethiopia. Strong focus on sustainability, environment and women.

* Swedfund's share of total amount mobilised amounted to less than 7 % according to a standardized average percentage.

for climate change projects in a cost-efficient and innovative manner. The projects to date are primarily focused on electricity generation using renewable resources (e.g. wind, solar, hydro). Swedfund has together with other development finance institutions made several commitments to ICCF over the past few years, with an additional million USD7.7 committed by Swedfund in 2016, bringing Swedfund's total commitment to ICCF to million USD 24.

In addition to financial commitments, Swedfund continued to contribute to renewable energy in developing countries by, for example, cooperating with the wider European development community within the realm of Electri FI, a facility set up to develop early-stage electrification projects using renewable resources.

In 2016, Swedfund made the investments and helped mobilise the amounts of capital listed below (see Table 7.8), all with the aim to contribute to long-term, concrete results to fight poverty and for financially, environmentally, climatically and socially sustainable development. Swedfund's share for each sector is estimated to an average percentage of the total investments divided over many years, since our non-disclosure provisions give Swedfund a right to publicly disclose only certain key data. Due to the lack of an internationally agreed method for reporting on guarantees and mobilized finance, Sida does not yet include the figures from table 7.9 and 7.10 in the summarized amounts of Sida's and Sweden's climate finance.

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.

Examples of Sweden's support to building climate change capacity are provided in Annex 6 – CTF table 9 and 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 wider research capacity and scientific knowledge, and contributions where climate change is integrated in operations building capacity in areas such as energy, DRR or water resources governance. It often includes support directly to low-income country government institutions. Examples include support to the two government universities in Bolivia and support via multilateral institutions as in the case of the Landscape and Forests Management Multi Donor Trust Fund with the World Bank in Mozambique. It includes support to regionally owned institutions, such as the International Centre for Integrated Mountain Development (ICIMOD) and Western Indian Ocean Marine Science Association (WIOMSA), to civil society based organisations, such as the Huairou Commission, which works with grassroots organisations in the countries, and support through Swedish Authorities, such as the International Training Program on Climate Change held by the Swedish Meteorological and Hydrological Institute.

While there is a high level of knowledge about effective capacity building support, there is today no internationally agreed approach to track capacity building in ODA quantitatively.

BOX 7.5

Sida contributes to the Energy Sector Management Assistance Program (ESMAP). ESMAP is a partnership between the World Bank Group and 17 partners to help low- and middle-income countries reduce poverty and boost growth through environmentally sustainable energy solutions. It focuses on SDG 7 and the SE4All goals and has activities in over 130 countries. Situated within the World Bank, ESMAP influences billions in loans for development projects, leverages public and private financing, and shapes global policy.

BOX 7.6

The Huairou Commission is a global membership and partner coalition working with women leaders at the grass roots level. It aims to make concrete improvements on a local level and to strengthen women's collective power on a global level. One of the Commission's key areas is to increase the capacity of its partner organisations within climate change, resilience and disaster risk reduction. Sida supports the Huairou Commission to implement its strategic plan for 2015–2020.

BOX 7.7

In 2016 Sweden was one of the first donors to support to the Capacity Building Initiative for Transparency (CBIT), established at COP21 in Paris. The goal of the CBIT is to strengthen the institutional and technical capacities of developing countries to meet the enhanced transparency requirements of the Paris Agreement.

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 (EPA) has a fund totalling 15 MSEK allocated to support countries that have strategic importance to the global environment and climate. Four Swedish government agencies are involved to carry out this bilateral cooperation: the Swedish Agency for Marine and Water Management, the Swedish Chemicals Agency, the Swedish EPA and the Swedish Meteorological and Hydrological Institute (SMHI).

BOX 7.8

SMHI has collaborated with the city Curitiba in Brazil with local and regional environmental authorities and universities. In this project, participants are developing a method to determine the emissions of particles and their impact on the city's air quality. The first phase of the project was initiated in 2016 and includes an inventory of the existing sources and emissions from air pollutants. As a result of this project, the city's department of urban planning and mobility has taken an interest in the environment impact of air pollutants and how to reduce the pollutants through urban planning.

BOX 7.9

In accordance with the Paris Agreement and Montreal Protocol to phase out hydrofluorocarbons (HFCs) the Swedish EPA organised a workshop in Stockholm to initiate cooperation with China aimed at promoting an elimination of HFCs and energy efficiency through district cooling systems. This is an area that Sweden prioritises also by strengthen the Swedish export opportunities. This collaboration is between the Swedish EPA and the Foreign Economic Cooperation Office (FECO), an office under the Chinese Ministry of Environmental Protection. The project has resulted in a roadmap for future work and collaboration.

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 development of climate-friendly technology development or technology transfer. Transfer of technology is often combined in an integrated way with capacity building to ensure long-term sustainability. Examples are presented in the Annex 6 – CTF table 8 and boxes below. The examples represent different types 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

The Consultative Group for International Agricultural Research (CGIAR) is a global research partnership for improved food security. A tangible example of technology development in their work is the story of scuba rice – a rice variety that survives better in flooded areas than other rice varieties and at the same time has a high nutritional value. Scuba rice was developed by CGIAR's rice research institute from a traditional Indian rice variety. It is today grown by millions of people in Asia, improving food security.

BOX 7.11

To increase access to clean electricity, Sida supports the rehabilitation of two old hydro-electric power stations with a total capacity of about 100 MW along Rio Revué in the central part of Mozambique using modern technology. This rehabilitation contributes to the country's development by securing energy access with continued low greenhouse gas emissions. The repair works have been financed by a development loan supplied as a grant portion and a commercial loan.

7.7.2. Technology development through other official flows (OOF)

BOX 7.12

Within the framework of the Swedish-Indian cooperation in the field of energy, the Swedish Energy Agency (SEA) has been active since 2009. Its overall objective is to build long-term relationships based on trade, research cooperation and knowledge development from the Swedish side. This will contribute to the agency's mission of developing the energy system and achieving climate commitments. In line with this objective the Energy Agency has, since 2013, developed the program *India-Sweden Innovations Accelerator (ISIA)*. This program supports business-oriented innovation development and dissemination by promoting networking, knowledge sharing and development of relations between Swedish and Indian actors active in innovative energy technologies.

BOX 7.13

The Swedish-Indian cooperation has also included a number of research-oriented activities supported by the SEA. At the Andaman & Nicobar Islands three consortiums of Swedish Small and Medium Enterprises (SMEs) together with academia and research institutes have analysed the pre-conditions and developed project design for pilot projects based on hybrid solutions based on local renewable resources and circular economy.

BOX 7.14

In Indonesia, the Swedish Energy Agency has a cooperation with the Indonesian Secretariat of the National Energy Council (NEC) since 2013, called the Indonesian Swedish Initiative on Sustainable Energy Solutions (INSISTs). It encompasses bilateral work that focuses on renewable energy and energy efficiency promotion. It also encompasses joint R&D efforts, e.g. in the form of a bioenergy roadmap for Indonesia. SEA also works closely with Business Sweden to assist SME:s to enter the Indonesian market, with a focus on innovative companies in the renewables and energy efficiency sector. Another long-term area for cooperation with Indonesia is the waste management and waste-to-energy sector, where SEA together with Business Sweden and NEC in 2016 conducted field visits to two cities in Indonesia, Payakumbuh in West Sumatra, and Balikpapan in East Kalimantan. Starting in 2017, SEA aims to facilitate consortia building in the field of waste management and waste-to-energy solutions for Indonesia.

8. Research and systematic observation

Key developments in research initiatives since NC6

The Swedish government supports strategic research areas (SRAs) at higher education institutions with the aim to strengthen international collaboration and innovation within research. The support was introduced in 2008[49]. It was evaluated in 2015[50], and subsequently continued. The SRAs constitute a rather large addition of resources to the Swedish research system. SRAs are mainly organised in centre-like constellations and may involve more than one university. Most of them have a well-developed stakeholder involvement. Two of the SRAs focus on climate processes and models, others on research on the effects of climate change, as well as energy.

8.1. Policy and funding in research, development and systematic observation

8.1.1. Climate research policy

The Government's latest research bill, *Collaborating for knowledge – for society's challenges and strengthened competitiveness*[51], adopted by Parliament on 4 April 2017 (addresses the period 2017–2020), strongly emphasises climate research. The bill proposed six national research programs with ten-year duration. These are now being initiated by the Research Councils. Most of these programs are relevant to the UN Sustainable Development Goals, and one specifically to the climate change challenge and realisation of the Paris Agreement: "Ett nationellt forskningsprogram för klimatet" (*A national research program for the climate*). Also inherently relevant for the climate change challenge is the new national research program on building a sustainable society: "Ett nationellt forskningsprogram för att bygga ett hållbart samhälle" (*A national research program on building a sustainable society*).

The Government points to the need for policy-oriented research on how emissions can be reduced and how society can adapt to a changing climate. As climate change affects all parts of society, this calls for interdisciplinary and transdisciplinary research efforts. More research is needed on resource-efficient processes and material flows and on the substitution of raw materials. Therefore, research on the circular bio-based economy also has gained increased funding. A new analytical function, hosted by the Research Council Formas, will carry out systematic reviews within the environmental field, investigating the evidence base for measures, and practice. This, along with producing compilations of current scientific knowledge, aims at providing better support for more robust decision making. The latest research bill also includes spending on space research and space operations, as research based on satellite data on the state of the earth, the seas and the atmosphere is critical to understanding and managing the global climate and environmental challenge.

To strengthen innovation, five innovation partnership programs have been launched, involving enterprises and research actors. The programs enable new ways to meet societal challenges, address travel and transport, smart cities, a circular bio-based economy, life sciences, and the industrial internet of things, and new materials.

8.2. International collaboration

8.2.1. Nordic collaboration

Sweden collaborates within the framework of the Nordic Council of Ministers (NCM), an intergovernmental body between Sweden, Denmark, Finland, Norway and Iceland. The common Nordic research body, Nordforsk, has supported the Nordic Centres of Excellence, which have been an arena for collaboration between Nordic researchers during the reporting period on issues like changes in the Arctic, tundra and adaptation. Through The Swedish Energy Agency, Sweden also takes part in Nordic Energy Research (NEF), which funds and coordinates research and provides administrative expertise, networking and counselling in areas of energy research that are of common interest to Nordic stakeholders.

8.2.2. European cooperation

Sweden participates in several collaborative projects and programs, such as EC-Earth, the collaboration between

49 Government Bill 2008/09:50
50 Evaluation of the Strategic Research Area Initiative 2010-2014, Swedish Research Council 2015
51 http://www.government.se/government-of-sweden/ministry-of-education-and-research/helene-hellmark-knutsson/

some 30 different institutes and universities in Europe. Within EC-Earth, SMHI and its Rossby Centre are co-leading efforts to develop the new earth system model that will be part of the global climate modelling project CMIP6 (Coupled Model Intercomparison Project phase 6), which is expected to provide a wealth of information for the next IPCC assessment (AR6).

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. Furthermore, 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 research and long-term development. Within the context of climate research, Sweden also participates in the Joint Programming Initiative JPI Climate, where Swedish funding agencies and researchers actively contribute to a common strategic research agenda. The Swedish research council 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.

Sweden participates in Horizon 2020, the EU's framework program for research and innovation for 2014–2020, which has a budget of nearly 80 billion euros. The program is divided into three strategic objectives: excellent science, industrial leadership and societal challenges. The work program 2018–2020 for the Societal Challenge on *Climate action, environment, resource efficiency and raw materials*[52] aims to strengthen pan-European research and innovation within these areas to support the implementation of the Paris Agreement. Support is also given to further cooperation between Member State funding bodies, through ERA-NET Cofund actions and JPI-specific calls. The Societal Challenge on *Safe, clean and efficient energy* aims to support the implementation and development of energy policy within the EU. Sweden, via The Swedish Energy Agency, is active in many collaborative research projects regarding combined heat and power, bioenergy, solar energy, ocean energy, wind energy, transportation, smart grids, and smart cities and communities.

Chalmers University of Technology and Lund University together participate with two Swedish cities and four to five businesses in Europe's largest public-private partnership, the Climate Knowledge and Innovation Community (Climate-KIC), where over 200 universities, business and cities collaborate on innovations for climate solutions.

Examples of a few other EU projects that Sweden participates in include:

- Clean Sky, an aerospace industry project aiming to reduce the climate impact of aircraft. Funded by The Swedish Innovation Agency (Vinnova).
- Road Owners Adapting to Climate Change (ROADAPT[53]), which intended to provide road authorities with robust climate adaptation technologies, methods and tools for selecting adaptation methods for road networks. Carried out by the Swedish Geotechnical Institute (SGI).
- Citizen and Multi-Actor Consultation (CIMULACT[54]), which uses citizen participation to help solve major social issues such as sustainable construction and climate adaptation. Participation through SGI.

8.2.3. Global collaboration

Sweden and Swedish researchers are participants or partners in many global research activities and organisations. Most important for climate research is the participation in the Intergovernmental Panel on Climate Change (IPCC). SMHI acts as the Swedish Focal Point. Sweden also participates in other important organisations engaged in climate change issues, among them the World Climate Research Program (WCRP), International Council for Science (ICSU), 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 (in bilateral collaboration with the Swedish Polar Secretariat on the NSF's research icebreaker Oden), and Future Earth. The Swedish Secretariat for Environmental Earth System Sciences (SSEESS) has served as a Focal Point to Future Earth, which has a hub in Sweden, and five of the Core Projects have secretariats in Sweden. As Knowledge-Action Networks become increasingly important, Sweden will continue to support these collaborations mainly through the Research Council Formas, since the SSEESS secretariat will be closed down in 2017. Through Formas, Sweden is a member of the Global Research Alliance on Agricultural Greenhouse Gases since 2008 and is now also partner to Belmont Forum. 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. Sweden has placed special focus this past reporting period on resilience and social-ecological issues.

SMHI hosts the international project office for the Coordinated Regional Climate Downscaling Experiment (CORDEX), on behalf of WCRP. The Rossby Centre at SMHI is one of the leading centres for producing and publishing regional climate change projections. They have 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

52 https://ec.europa.eu/programs/horizon2020/en/h2020-section/climate-action-environment-resource-efficiency-and-raw-materials
53 http://www.swedgeo.se/sv/kunskapscentrum/aktuell-forskning/Eu-projekt/avslutade/
54 http://www.swedgeo.se/sv/kunskapscentrum/aktuell-forskning/Eu-projekt/

in Sweden and Europe but also on other continents including developing countries.

Another significant climate-related effort is the Intergovernmental Platform on Biodiversity and Ecosystem Services (IPBES) concerning nature and people. Sweden supported this initiative in 2011, and the Swedish EPA serves as the Focal Point.

8.3. Organisation

8.3.1. Government research funding

The government and other parts of the public sector are the largest funders of academic research. 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. With the inclusion of the private sector as well, the business sector is the largest funder of R&D.

The Swedish Research Council Formas funds basic and needs-driven research within the areas of environment, agricultural sciences and spatial planning. The main part of the climate research is funded through open, bottom-up calls. Formas also funds climate research through targeted calls. In 2017, Formas was tasked by the Government to initiate three 10-year national research programs, on climate, on sustainable spatial planning, social housing and the built environment, and on food. .Vinnova, Sweden's Innovation Agency, funds broad cross- and interdisciplinary research of a technical nature. They are the Focal Point for EU research collaboration on climate issues. The Swedish Research Council has no special mission for climate research funding, but its open calls attract applications that address climate-related research questions. The National Space Board (SNSB) distributes government grants for space research, technology development and remote sensing activities. Of the Swedish research foundations, especially the Mistra Foundation funds climate-related research. Mistra was formed in 1994 through the use of government assets, but acts independently of the Government. It funds research of strategic importance for the environment and operates in close dialogue with businesses and other users of research results. Their annual funding for climate change research is roughly SEK 12 million.

	Reserach	Research infrastructure
Formas	100 MSEK/year	20 MSEK/year
VR	87 MSEK/year*	33 MSEK/year**

*175 projects (over the four years)

** 56.1 MSEK to 16 different national research infrastructures and 77.8 MSEK to 6 different international research infrastructures over the four years.

Table 8.1 Main public climate research funding via research councils (2013–2016)

8.3.2. Government sector funding

A few government agencies fund research to 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 by far the biggest funder, allocating SEK 1.3 billion per year during the reporting period to efforts in research, development, demonstration, commercialisation and innovation in the energy sector. In focus is combining ecological sustainability, competitiveness and security of energy supply, which indirectly also contributes to research related to the effects of climate change. Several of the funded projects are interdisciplinary, and look into 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 and pledges (INDCs, NDCs).

The Swedish EPA funds research in support of the Swedish Environmental Objectives [55] with roughly 80 MSEK per year. Even if this does not directly focus on climate, many of the funded projects do address climate change issues. For example, projects concerning sustainable consumption had a budget of roughly SEK 40 million for the period. Swedish participation in the international New Climate Economy initiative is also financed through the EPA's research funds.

The Swedish Civil Contingencies Agency (MSB) is a government agency under the Department of Justice. It has a research budget of about SEK 120 million per year[56]. A smaller part, about SEK 5 million/year, is earmarked for robust decision-making around climate risks. The bulk of the funding is for disaster and resilience research to prevent and handle accidents and emergencies including climate impacts and adaptation. Through external collaboration, the agency builds a national innovation mechanism to contribute to new services, solutions, methods and products.

The Swedish Geological Survey (SGU) has a small research budget. For the period 2015–2020, funding for research on the landscape and climate trends as the basis for a variety of applications in hydrogeology, engineering geology and geothermal energy totals SEK 5.8 million per year. SGU provides for research that aims at new methods to better understand and predict coastal processes in general, and geological risks such as flooding, erosion and landslides in a changing climate.

8.3.3. Performers

Almost two thirds of publicly funded research in Sweden is conducted at universities and university colleges. These have own research resources, in the form of a basic grant from the Government, complemented by competitive research funding from national, Nordic, European and international mechanisms. Other public research performers include industrial research institutes and some sector agencies.

55 http://www.swedishepa.se/Environmental-objectives-and-cooperation/Swedish-environmental-work/Research/
56 https://www.msb.se/en/Sok/?query=research+climate+change+adaptation&pn=1

In addition, the government agency SMHI and its Rossby Centre play a most central role for climate research on areas such as climate models and scenarios. The Stockholm Environment Institute (SEI) is an international research institute that builds bridges between research and policies within the following areas: Reducing Climate Risk, Managing Environmental Systems, Transforming Vulnerable Communities and Rethinking Development.

An industry-driven public-private institute, the Swedish Environmental Research Institute (IVL) conducts broad research within the environment and sustainability using public and private funding[57]. There are others, such as the Swedish Geotechnical Institute (SGI) conducts research and development that meets societal challenges for a sustainable and resilient society with regard to natural events and climate change. This research underpins long-term climate adaptation work throughout society.

8.4. Systematic observation

Systematic climate observation includes various measurements in meteorology, hydrology and oceanography. The Swedish Meteorological and Hydrological Institute (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.

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), Global Biodiversity Information Facility (GBIF), European Consortium for Ocean Research Drilling (ECORD), International Continental Scientific Drilling Program (ICDP) and Life Watch (WRAM, RINFI, etc.). Through the Research Council, Sweden also participates in coordinating observations in the Arctic and Antarctic through the organisations IASC and SCAR. In 2016, Sweden joined the infrastructure on aerosols and clouds, ACTRIS, under the European Research Infrastructure ESFRI.

The national research infrastructure ICOS Sweden was up and running in 2016. A carbon portal based at Lund University is responsible for verifying data sampled throughout Europe with the ICOS standard. The Swedish Infrastructure for Ecosystem Science (SITES) is a national coordinated infrastructure for terrestrial and limnological field research that performs systematic observations on land and land use related to climate. The National Inventory of Landscapes in Sweden (NILS) is a remote sensing program covering more than 600 permanent plots within the Swedish EPA's Environmental Monitoring. Its primary purpose is to monitor the conditions for biodiversity in the Swedish landscape, and it also provides data following events such as the displacement of tree and forest borders in the mountains.

The Swedish National Data Service (SND) at the University of Gothenburg became responsible for the Environment Climate Data Sweden (ECDS) data portal in June 2016; the infrastructure was previously run by SMHI. ECDS was established with the support of the Swedish Research Council (VR) in 2009 as an infrastructure project to improve Swedish researchers' access to environmental and climate data.

8.5. Programs and funding of climate research, including international cooperation

Sweden maintains strong climate research efforts on climate models, effects of climate change on ecosystems and society and measures for reducing emissions and adapting to climate change, including technology. Research on climate change is also gaining more transdisciplinarity and integration with the society. Energy research and research on societal actors, institutions and processes is likewise highly relevant for understanding mitigation and adaptation to climate change, but it might not always be categorised as climate research.

8.5.1. Climate processes

As during the previous reporting period, the long-term Strategic Research Area (SRA) funding to the Bolin Centre at Stockholm University enables studies of climate processes and Earth system modelling is to stimulate the comparative use of climate models [58]. Working with others, the aim is also to build a stronger Nordic climate-modelling capacity. Similarly, the SRA Modelling the Regional and Global Earth System (MERGE[59]) is a collaboration among several universities, and focuses on modelling the interaction between the atmosphere, vegetation and terrestrial ecosystems.

8.6. Modelling and prediction, including global and regional models

The Rossby Centre at SMHI is the main Swedish performer of climate model development and climate projections. It contributes internationally both to global and regional climate modelling. The Centre co-leads the work of developing a new global Earth system model EC-Earth that describes several additional processes, such as dynamic vegetation as well as components for interactive atmospheric chemistry and ocean biogeochemistry. The above-mentioned university research (Bolin Centre, MERGE) contributes to this development. Inclusion of these different parts of the climate system are necessary for the long-term study of climate effects, as climate change-induced changes in the natural carbon cycle can be quite significant, with consequences for the overall warming and cumulative emissions. A previous version of the EC-Earth was used to produce climate projections for CMIP5 (the fifth Climate Model Intercomparison Project)

57 http://www.ivl.se/english/startpage/pages/current-research.html
58 http://www.bolin.su.se/index.php/research
59 http://www.merge.lu.se/

by SMHI and Stockholm University. The new model version will be used in the context of CMIP6 to produce climate change projections. In Sweden, SMHI, Stockholm University and Lund University are the main contributors to this work.

SMHI is a world-leading producer of regional climate scenarios. Its Rossby Centre has produced and made available a very large number of CORDEX simulations (Coordinated Regional Downscaling Climate Experiment) via the Swedish ESGF node (ESGF, the Earth System Grid Federation, is the international standard for sharing climate model data and is also used in the CMIP). The data is used for regional studies of climate change impacts, and SMHI has created much of its work on national climate change information and climate adaptation support based on this material. The Rossby Centre also drives the development of next-generation high-resolution regional models intended to be used for calculations at a horizontal resolution of a few kilometres. High-resolution models provide better opportunities to study weather phenomena such as high-intensity rainfall and wind conditions in complex terrain.

8.6.1. Research on the effects of climate change

Climate impact studies are included in many of the cross-cutting research initiatives. One such program, Future Forests, has ended during the period. It lead the interdisciplinary scientific development of forest governance and management science in Sweden. It built on the principle that integrated knowledge from a broad range of disciplines will be needed to seek effective solutions for a complex issue that has no optimal solution.

Two SRAs belong to this category. *Ecosystem dynamics in the Baltic Sea in a changing climate* (EcoChange[60]) investigates the impact of climate change on the Baltic Sea food web. *Biodiversity and ecosystem services in a changing climate* (BECC[61]) aims to better understand how land use and climate change affect ecosystems and biodiversity. It focuses on the Swedish ecosystems' forests, agriculture, aquatic systems and subarctic areas.

Swedish EPA supports research for the international Convention on Long-Range Transboundary Air Pollution (CLRTAP) and for national measures for reducing air pollution and their impact on human health, ecosystems and climate. Better knowledge of particle transport across continents will serve as a basis for modelling cost-effectiveness measures and connection to climate change.

Citizen research is gaining ground as a new approach to research. One example is a project undertaken by the Swedish University of Agricultural Sciences (SLU)[62] in the autumn of 2016, which focused on oak tree diversity and their changes in colour at different times of the year. This initiative engages nearly 12,000 students from all around the country. The project goal is to study how changes affect the insects that live on the trees and the long-term impact on biodiversity and ecosystem services.

8.6.2. Socio-economic analysis, including effects and response measures

The indirect effects of climate change on the functioning of the economy and people's safety in society has gained much interest in recent years.

One such area is circular economy with focus on product design, smart materials, recycling, etc. including analyses of sustainable production and consumption. Swedish EPA funds the national research program *Policy instruments and consumption*[63] in addition to the program *Environment impacts of Swedish consumption,* inside and outside Sweden's borders, using the latest modelling and statistical techniques. Ongoing projects as well as forthcoming ones by Mistra for the bio-economy provide additional funding in this area. Also the Swedish Energy Agency funds related research (see further below).

There are also several research projects addressing geopolitical issues. Sweden has a keen interest on the Arctic, because of its importance both in the region and to the global climate system. One outcome is the *Arctic Resilience Report*[64]. The Mistra-funded Arctic Sustainable Development project [65] contributes new insights through its focii on *Environmental Governance in the Anthropocene* and *the Need for Social Learning as a Feature of Governance in Times of Rapid Change.* Two more recent Mistra initiatives, *Transformative changes in society to achieve challenging climate goals and 'Geopolitics and Sustainable Development'*, consider inter alia climate change adaptation, and provide new knowledge of geopolitics (www.mistra.org).

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. During 2014–2018, projects address International climate policy after Paris: Strategies to deal with carbon dioxide and other greenhouse gases, carbon footprints as a tool for climate policy, evaluation of climate-affecting black carbon emissions with a focus on biofuels and the Artic, premises for bioenergy with carbon capture and storage in the global response to climate change, promoting multifunctional land-use systems – for creating synergies between UNFCCC and the Sustainable Development Goals, private-sector finance for NDC implementation in Sub-Saharan Africa and robust Emissions Trading in a Complex Policy Environment.

The Centre for Climate Science and Policy Research (CSPR) is one example of local collaboration on socio-economic analyses between a university, Linköping University, and the SMHI. Its research focuses on climate change linked to other policies such as development, trade,

60 http://www.umf.umu.se/english/ecochange
61 http://www.cec.lu.se/research/becc
62 https://youtu.be/WocHflssr7w
63 http://www.swedishepa.se/Guidance/Research/For-applicants-and-reviewers/Closed-Calls1/Policy-instruments-and-consumption1/
64 http://arctic-council.org/arr/
65 http://www.mistraarctic.se/about/

air transport, land use and biodiversity, knowledge production and transformation into data for local, national and international decision-making. CSPR is presently conducting a long-term, ongoing study of the UN process at COP meetings and interviews member states.

8.6.3. Research and development of measures for reducing emissions and adapting to climate change, including technology

This area gains the largest amount of funding.

There are three SRAs funded within the energy sector. STandUP for energy[66] on energy supply from sustainable and renewable sources, Chalmers Initiative for energy[67] on future technologies and Bio4Energy[68], an example of biorefinery research using all parts of a tree.

The technical focus of energy research is increasingly being strengthened with perspectives of the user, behavioural and marketing aspects, and also by business models related to the sector (one example of a smaller project is on *Women and men in boards of directors* aiming to find out whether more women on boards would help businesses increase their efforts to reduce climate emissions). Through its research funding, the Swedish Energy Agency underlines the importance of interconnecting the infrastructure and systems of different sectors and of testing and developing comprehensive solutions for a sustainable society.

The main funder on this area is the Swedish Energy Agency. It funds research that can contribute to the transition to a sustainable energy system (see chapter 4). The Swedish Energy 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.

8.6.4. Support for climate-related research in developing countries

The major part of Swedish support to research in developing countries goes through the Swedish International Development Cooperation Agency Sida. The total support to research cooperation was worth SEK 765 million in 2016. Of this, more than half is earmarked for natural sciences. Support for environmental and climate change research, include policy and individual capacity building. All research contributions supported by Sida must include environment and climate change aspects. Synergies between agendas that jointly pursue solutions for environmental sustainability will be added in the future. Geographically there is a strong focus on Sub-Saharan Africa. However, research support is given to partner countries in all regions of the global South (Africa, Latin America, Middle East and North Africa, and South-East Asia).

Sida's research portfolio currently supports 72 research organisations, including 13 universities in Bolivia, Ethiopia, Mozambique, Tanzania, Ethiopia and Uganda. Sida's research funding for the environment and climate change covers the following areas of support: direct research on the subject, multidisciplinary research relevant to environmental sustainability, and development and implementation of environmental plans at partner country universities. In addition, the agency always reflects on the potential environmental risks of its contributions. Rapidly changing global realities require social and innovative 'development through knowledge' solutions. Research cooperation has been initiated also with new partners, with strategic focus on supporting long-term research capacity within global environmental change, social transformation and science for sustainability as a basis for decision-making.

A few organisations receive support in the nexus of environment, climate and health. These organisations do not explicitly work with the themes of environment and climate, but their research topics may be highly connected to them. Examples include research on malaria, TBC, tropical diseases, urban environments and health systems. Nine organisations work on environmental and climate change in the intersection between the science community, civil society and policy makers.

8.6.5. Social and economic dimensions of environmental and climate change

This area represents SEK 25 million. Research at the Beijer Institute, the Environmental Economics Unit (EEU) at Gothenburg University explicitly focuses on transdisciplinary and interdisciplinary global environmental change research concerning social transformation to sustainability.

8.6.6. Research support for global sustainability

Transdisciplinary research on global sustainability is a growing area. It is solution-oriented and includes environment, climate, natural resources, energy and other relevant areas from the perspective of both the natural sciences and social sciences. Support for capacity building and research funding ensures a critical mass of researchers in global sustainability science in low-income countries, who can both produce new research and participate in international activities. Sida supports actors such as:

- The agricultural research consortium CGIAR (SEK 115 million annually), which addresses the challenges of food production. Achieving sustainable food security in a world with a growing population, with focus on vulnerable rural communities, changing diets and a changing climate presents a major challenge. The Swedish University for Agricultural Sciences (SLU) is collaborating in certain areas without Sida support.
- Sida, together with the Research Council Formas provides support in 2013–2018 to young researchers in CGIAR on food security. This support aims to finance the research of young researchers and encourage research cooperation between Sweden and low-income countries. It also aims to find solutions to problems that

66 www.standupforenergy.se
67 www.Chalmers.se
68 www.bio4energy.se

affect people and the environment in low-income countries.

- The International Social Science Council (ISSC) launched a new program called *Transformations to Sustainability*. It intends to support international Transformative Knowledge Networks that undertake integrated, solutions-oriented research for sustainability on concrete challenges and in specific socio-ecological settings.
- The Biosciences Eastern and Central Africa (BecA) Hub promotes an innovative, multifaceted approach to climate change through the introduction of forage grass that is well adapted to survive droughts and on poor soil, providing forage year round in areas where this is otherwise unfeasible. This results both to lowering the greenhouse gas emissions, and provided better conditions for smallholder livestock farmers.
- The new 5-year program of the International Council for Science (ICSU) launched open calls for research grants and capacity building in global sustainability research, including 'Sustainable energy', 'Human health and well-being in urban environment', 'Global environmental change' and 'Disaster risk reduction and resilience'. Sida enables researchers from low-income countries to participate and take the lead in these international projects. Sida's support to ICSU aims to catalyse the generation and use of new, integrated and policy-relevant scientific knowledge in Africa, Latin America and the Caribbean. through building scientific capacity to undertake trans-disciplinary research, administering collaborative research grants, and supporting community building, networking and science integration into policy making.

8.6.7. Research support for regional cooperation

Sida provides direct research support to regional universities and networks, and through Swedish universities and institutes.

- Regional research cooperation in Asia has a strong focus on environmental economics, with two research networks, one covering South Asia (SANDEE) and one Southeast Asia (EEPSEA). Research on the economics of climate change focuses on evaluation of the impacts of climate change; economic analysis of adaptation measures; evaluation of the mitigation strategies, particularly those that offer local co-benefits; and examination of institutions and policies for low carbon growth and long-term adjustment to climate change.
- The Stockholm Environment Institute coordinates a regional research network in Southeast Asia (Sumernet) on sustainability research. The majority of the projects have a climate focus, including REDD+, climate change vulnerability and climate-resilient development.
- The African marine research organisation WIOMSA supports researchers in modelling the effects of climate change on the distribution of shared fishery species in the subtropical Western Indian Ocean. Studies are also made on the feasibility of mangrove REDD+ projects in the Western Indian Ocean, linking mangrove conservation and climate change adaptation to the global carbon markets.

8.6.8. Other collaboration and cooperation efforts

The Swedish Research Council (VR) has specific grant for strengthening relevant, quality-assured research in developing countries. The latest joint call, in May 2016, 'Sustainability and Resilience – Tackling climate and environmental changes', was coordinated by the Research Council Formas and Sida.

SMHI has engaged in several workshops in which African scientists are conducting their own scientific studies based on CORDEX material.

SEI organises the Swedish International Agricultural Network Initiative (SIANI) around themes of collaboration with selected organisations aimed at developing a working relationship between Swedish researchers and communities of practitioners as well as policy makers in sustainable agriculture, food and nutrition security, development and poverty alleviation. SIANI acts as a knowledge broker to facilitate cross-sector communication among these organisations.

8.7. Programs and funding for systematic monitoring, including international cooperation

Sweden has an extensive environmental monitoring system, and the lengths of Swedish measurement series are often unique in the world. These are of great importance in documenting changes as well as the long-term effects of climate change and responses of measures. Climate and climate-related observations comprise the systematic collection of meteorological, hydrological and oceanic data. These are complemented by the monitoring of sources and sinks of greenhouse gas emissions and climate-related impacts on ecosystems, such as vegetation and soil changes. Changes in vegetation and soil conditions are monitored and then collected in a joint archive[69] of satellite data created by the authorities. Each year, multispectral optical satellite data at resolutions of 10–30 meters are added to the archive; these data collected during the vegetation period cover all of Sweden.

8.7.1. Responsible monitoring organisations

The Swedish Meteorological and Hydrological Institute (SMHI) is tasked with meteorological, hydrological and oceanographic systematic monitoring and data provision, as well as reporting for the long-term national and international databases. SMHI represents Sweden in the World Meteorological Organization (WMO), Intergovernmental Oceanographic Commission (IOC), Group on Earth Observations (GEO), European Centre for Medium Range Weather Forecasts (ECMWF) and in the European Common satellite programs of the

69 www.saccess.lantmateriet.se

European Organization for the Exploitation of Meteorological Satellites (EUMETSAT), where climate monitoring has become increasingly important. The cooperation between the weather services in Europe, EUMETNET, is a group of 31 European National Meteorological Services that provides a framework to organise co-operative programs between its members in the various fields of basic meteorological activities. These activities include observation systems, data processing, basic forecasting products, research and development, and training.

SMHI is also the Swedish representative in the user forum of the European Commission-established Copernicus (formerly GMES, the Global Monitoring for Environment and Security), where fifteen agencies using Earth observation data define the end user requirements concerning climate, atmosphere, oceans, land, disasters, and security.

The Swedish EPA is responsible for coordinating environmental monitoring and reporting to the EU and UNFCCC. More than SEK 30 million goes to SMHI and SLU for providing data to the National Inventory of Forests[70]. These data cover forest and soil conditions, including carbon sequestration. Government funding to the Swedish EPA for general environmental monitoring is divided into different program areas: air, forest, farmland, mountains, landscapes, wetlands, toxic substances and health-related environmental monitoring. The Swedish EPA represents Sweden in the EEA (which coordinates European monitoring) and the UN Environment Program.

The Swedish Agency for Marine and Water Management is responsible for monitoring coasts and seas, and freshwater. It participates in most of the international conventions and organisations that deal with marine and water issues, such as HELCOM and OSPAR.

The Swedish National Space Board represents Sweden in the European Space Agency (ESA) and the Copernicus Committee. The Swedish National Space Board also works on bilateral and multilateral satellite projects, where the satellite ODIN, stratospheric ozone monitoring, is still in operation.

8.7.2. Monitoring of changes in carbon balance, biomass and land use

Changes in carbon balance in forested and farmed land are monitored by the Swedish National Inventory of Forests, which comprises the National Forest Inventory (NFI) and the Forest Soil Inventory. NFI is part of the official statistics, with data since 1923. The inventory includes more than 30,000 samples. 10,000 sample plots that are inventoried each year during the snow season.

8.7.3. Participation in international cooperation for systematic climate monitoring, including GCOS

Sweden contributes in several ways to the Global Climate Observing System (GCOS). The principles of systematic monitoring established in GCOS have had impact on the performance of the Swedish systematic observations. Uninterrupted series of high-quality observations are achieved by careful managing of automation as stations have been converted from manned to automatic stations.

An important aspect of the ongoing development of observation systems in Sweden is to create synergies between meteorology, hydrology, oceanography, and climate and environmental systems. The importance of legacy data for a deeper understanding of the climate and its variations has increased as a result of improved methods to perform the analysis of different variables. Continuous efforts to digitise legacy data are ongoing, but will take many years to complete because of the high data volumes.

Sweden contributes to GCOS through SMHI with long-term observations and measurements of temperature, precipitation, wave height, icing, variations in glaciers, etc. called 'essential climate variables' (ECVs). Observations with global, regional and national coverage also require measurements from satellite-based systems. Sweden contributes to several international programs, such as the ESA Climate Change Initiative (CCI), to achieve the goals in the 'Implementation Plan for the Global Observing System for Climate in Support of the UNFCCC'. In addition, the Copernicus Climate Change Service provides the long-term design and development of several ECVs.

8.7.4. Atmospheric monitoring

SMHI contributes with atmospheric data to WMO's World Weather Watch (WWW), which are reported further to GCOS. Through the European Meteorological Network EUMETNET, Sweden also contributes data on wind and temperature obtained at various levels by civil aviation and with integrated humidity in the atmosphere from GPS measurements, for example, from the National Land Survey of Sweden SWEPOS networks. Weather radar data on wind and precipitation are also included.

8.7.5. Monitoring of the sea

On a European scale, SMHI takes part in EuroGOOS that works for increasing data access and to improve measurements for organisations like the European Marine Observation and Data Network (EMODnet). Similar activities are taking place in the Baltic Sea, where the Baltic Operational Oceanographic System (BOOS) is responsible for coordination and buoys that have been installed by Sweden. In -situ coordination and production takes place within the Copernicus Marine Monitoring Service, including for the Baltic Sea.

8.7.6. Monitoring of land

SMHI reports river discharge data to the Global Terrestrial Observing System (GTOS) and the Global Runoff Data Centre (GRDC).

8.7.7. Sweden's contribution to satellite data for climate monitoring

Since 2008, Sweden has been participating in the ESA program for Global Monitoring of Essential Climate Variables (ESA CCI). It aims to safeguard existing legacy

70 https://www.slu.se/en/Collaborative-Centres-and-Projects/the-swedish-national-forest-inventory/

data from research satellites that can be used to improve the reliability of climate models through re-analysis.

Sweden contributes to developing new infrastructure for global observation systems. It is a participating state in Europe's Copernicus Sentinel satellite program, including Sentinel-1A and Sentinel-1B that radar satellites for monitoring ice and snow, Sentinel-2A, which is an optical satellite for soil mapping and the recently launched Sentinel-3A for monitoring both land and sea, and remote sensing-based services. Copernicus is also the EU's contribution to GEO/GEOSS.

8.8. Website references for Chapter 8

Centre for Climate Science and Policy Research: https://liu.se/en/research/centre-for-climate-science-and-policy-research-cspr

Clear Sky: http://www.cleansky.eu/

Environment Climate Data Sweden: https://ecds.se/

EUMETNET: http://eumetnet.eu/

Formas: http://www.formas.se/en/

Lund University: http://www.cec.lu.se/

Mistra Foundation: http://www.mistra.org/en/mistra.html

National Space Board: http://www.rymdstyrelsen.se/en/Home/Home/

Nordforsk: https://www.nordforsk.org/

Rossby Centre: http://www.smhi.se/en/research/research-departments/climate-research-rossby-centre2-552

Stockholm Environment Institute: https://www.sei-international.org/

Swedish Energy Agency: http://www.energimyndigheten.se/en/innovations-r--d/

Swedish Environmental Research Institute: http://www.ivl.se/english/startpage.html

Swedish Geotechnical Institute: http://www.swedgeo.se/en/

Swedish International Agricultural Network Initiative: http://www.siani.se/sv/theme-groups

Swedish International Development Cooperation Agency: http://www.sida.se/English/

Swedish Meteorological and Hydrological Institute: http://www.smhi.se/en

Swedish Research Council: https://www.vr.se/inenglish.4.12fff4451215cbd83e4800015152.html

Vinnova: http://www2.vinnova.se/en/

9. Policy for education, training and public awareness

In Sweden, communicating climate change knowledge is one key factor to succeding in achieving emission reducing and adaptation activities. Communication, public awareness, public participation and education on climate change providing clear, easily accessible information are encouraged. Current positions as reflected in the The Climate Act 2017 for a climate policy framework, reflects that there is a broad national support for climate action.

In Sweden preschools, schools and adult education have a clear remit to understand the requirements for sustainable development, both ecologically, economically as well as socially. This remit is formulated in national governance documents such as the Education Act, curricula and syllabuses.

9.1. Public awareness, mass media and climate change communication

The public awareness on climate change is generally high in Sweden. The Swedish Environmental Protection Agency regularly conducts surveys of Swedes' attitudes on climate change solutions. 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 2015 survey shows that Swedes remain highly prepared to reduce their own climate impacting emissions, requesting more information on how to contribute. The vast majority, almost 8 out of 10, believe it is possible to reduce Sweden's climate impact and over 7 out of 10 think they can contribute themselves. Moreover, there is a high awareness on recycling and an increasing awareness on meat consumption. Furthermore, the general acceptance on taxation instruments for the climate is high in Sweden. Almost 8 out of 10 are positive to taxes on goods and services that cause major climate impacts such as petrol, oil and flights. This is an increase from 2009, when more than 6 out of 10 were positive to taxes and expenses on emissions.

The SOM Institute, based at Gothenburg University, has conducted surveys to collect research data and presented annual trend analyses on public opinion and media habits in Sweden since 1986. The SOM Institute general survey presented in April 2007 proves that climate change is at top of all issues that the Swedish society in general are concerned about, with 49 % stating climate change as very worrying about the future.

News reporting on climate change in the Swedish media varies over time.

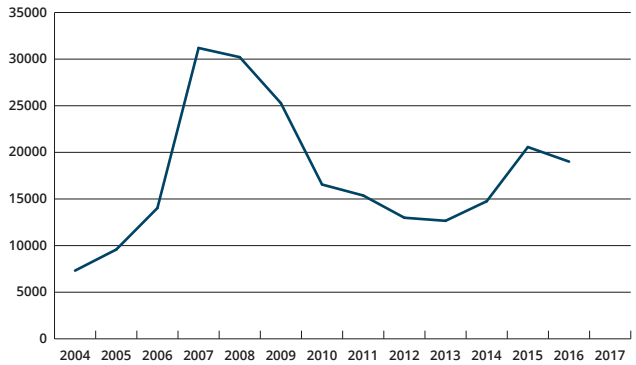


Figure 9.1: Media coverage climate change in Sweden 2004–2017. Source: Newsmachine, on-line media analysis

As Fig. 9.1 shows, 2007 was a record year in Sweden in terms of the number of articles published in on-line media. Climate change related articles featured in the media at a rising level right up to the Copenhagen climate negotiations in 2009, and then the interest slowly declined. However, the Swedish media interest on climate change increased, up until the Paris Agreement in 2015.

According to a Stockholm Environment Institute (SEI) brief report; *"Building bridges and changing minds: Insights from climate communication research and practice (2016)",* effective climate communication is crucial to building the momentum and on-the-ground engagement from the Paris Agreement. This brief report on climate communication was presented by SEI to the European Parliament in May 2016, and the aim is to synthesize the "state of the art" on climate communication, particularly as relevant for European policy actors, and to highlight important questions and challenges that warrant further exploration.

The Paris Agreement is widely seen as a turning point for climate policy and the European Union has positioned itself to be a leader in this transformation.

Yet translating the vision into action will require strong political momentum, combined with strong public engagement and support. The Stockholm Environment Institute brief report is written for European policy audiences, and examines what science and practical experience are teaching us about effective communication, focusing on three key objectives: 1) building support for and reducing opposition to climate policies; 2) driving personal behaviour change to reduce our emissions and prepare for climate change; and 3) mobilizing citizens to push for more ambitious climate action by governments or businesses.

For several years, there has been a shift in public interest from asking about the causes of climate change to asking about solutions, which also reflects in the media coverage. A media analysis produced for the Swedish Environmental Agency (2015), shows that climate change is described by Swedish media as an ongoing reality, not a distant threat, and news from research and policy is driving the coverage. The debate focuses on advantages and disadvantages of proposed solutions. Notable, the reporting is based on a "top-down" logic; where the solutions primarily come from the UN, EU or Parliament / Government. However, also initiatives and local solutions are portrayed in the media based on bottom-up logic, where cities, companies and consumers develop or absorb products, services and behavior to reduce emissions. A media analysis produced for the nongovernmental organisation Agroforestry network/Vi-Skogen (2016) highlights a rural-city conflict in the climate change media narrative. According to that analysis, articles that were shared and commented most during 2016 were on how urban citizens are moralizing about, for example, meat consumption. A widely spread debate came from a Swedish farmer, stating: *"There's nothing wrong with my cows – but rather your flights to Thailand"*. This may serve as an example on the current Swedish media debate on different climate change solutions.

9.2. Resources and information centres

Swedish governmental authorities communicate on climate issues in their respective areas of responsibility. Swedish governmental authorities have long experience of using knowledge and communication as policy instruments.

Governmental authorities refer, engage and involve relevant stakeholders in activities on climate change education, training and public awareness. Non-governmental organisations, climate networks and knowledge centres help building awareness and promote dialogue on climate change solutions.

Swedish Environmental Protection Agency (Swedish EPA)

The Swedish Environmental Protection Agency is a national government agency with a key role in Sweden's environmental endeavor to achieve the environmental objectives of Sweden, the EU, and internationally. As a focal point for the implementation of environmental policy, the Swedish Environmental Protection Agency is a driving force and provides support.

Tackling climate change is key to achieving many of Sweden's environmental quality objectives, as well as several other policy objectives. Therefore, the Swedish EPA strategic communication on climate change is action oriented and focusses on cross-sectoral synergies. Currently, there is a focus on sustainable transport planning and its contributions to climate goals.

The website www.naturvardsverket.se (mainly in Swedish) is a hub for statistics and facts on emissions and knowledge on effective mitigation activities, widely used by policymakers, media, business, organisations and researchers. In addition to national territorial statistics, the Swedish Environmental Protection Agency also estimates and communicates how Swedish consumption affects emissions in other countries on an annual basis. Active media work and webbased information on both territorial and consumption-based emissions, have resulted in substantial impact on the Swedish debate.

The Swedish Environmental Protection Agency arranges annually the climate change conference 'Climate Forum', bringing together agencies, organisations, municipalities, businesses and politicians.

The Swedish Energy Agency

As the central government authority for energy issues, the Swedish Energy Agency is responsible for giving both citizens and businesses information and advice on more efficient energy use. The Agency website www.energimyndigheten.se contains extensive information (mainly in Swedish) about households' energy use and what can be done to reduce it. Along with energysaving tips for the public, there is a special website for schools, www.energikunskap.se addressing teachers and pupils. The Energy Agency's Testlab tests the energy consumption and functioning of various products, and publishes the results on the website. The Energy Agency arranges, funds and takes part in a range of activities at local or regional level. The Agency takes part in The National European Regional Development Fund program 2014–2020. By different subsidies, the agency supports the shift towards a low-carbon economy focused on small and medium-sized enterprises and organisations; SMEs. The aim is to help enterprises to improve the energy efficiency of their activities and become more market competitive. After two years of organizing workshops and seminars, educating coaches and highlighting best practice, around 800 SME are taking part in the program.

In 2016–17, The Swedish Energy Agency has lead a national project for a national strategy for a fossile free transport sector. Six governmental agencies cooperated to present a common proposal on a national strategy to the Swedish government. Public participation and several workshops and seminars involving stakeholders, non-governmental organizations and enterprises within the fuel sector contributed to the work.

The Swedish Meteorological and Hydrological Institute

The Swedish Meteorological and Hydrological Institute (SMHI) develops and distributes information about the weather, water and climate change adaptation for the purpose of providing knowledge and high-quality decision support for the public and business sectors and for citizens. The website www.smhi.se contains abundant material (including maps) on various climate scenarios for users to download. Information on climate change, in Swedish, has been compiled on the https://www.smhi.se/klimat and in English: https://www.smhi.se/en/climate

The SMHI is the Swedish IPCC Focal Point, providing information about the IPCC and the results from the assessment cycles on their website https://www.smhi.se/klimat/ipcc/ipcc

The Rossby Centre at the SMHI pursues research on climate processes and the behaviour of the climate system, including participation in international activities. SMHI is leading the Knowledge Dissemination task, targeting not only policy and decision makers, but also the international climate research community, climate impacts and regional downscaling communities, adaptation and mitigation researchers, and the general public.

The National Knowledge Centre for Climate Change Adaptation at SMHI is a resource for everybody with a responsibility for, or interest in, Sweden's adaptation to the impacts of climate change. The Centre provides tools and information to help society cope with a changing climate, now and in the future. It links science, policy and practice, bringing together the decision makers, businesses, research providers and organizations that make climate change adaptation happen. The Centre collects, develops and shares research, information from authorities and learning examples to facilitate sound decision making. The Centre was established in 2012 and runs the National Network for Climate Change Adaptation, a gathering of government agencies. The Centre also manages the Portal for climate change adaptation (www.klimatanpassning.se), in collaboration with 17 other government agencies. The portal offers comprehensive information and support on different aspects of adaptation, to assist society and citizens preparing for the consequences of climate change.

The Fossil Free Sweden initiative

The Swedish Government has launched the Fossil Free Sweden initiative with the aim to make Sweden one of the world's first fossil free wellfare states. To achieve this, all parts of society must work actively to reduce emissions. In Sweden, there are many enterprises, municipalities, associations and other types of actors willing and able to help reduce greenhouse gas emissions. Fossil Free Sweden mobilises and supports these actors in their climate efforts by providing a platform for dialogue, cooperation and inspiration between themselves and the government. It is an arena where difficulties and complications can be discussed and brought to the government´s attention.

Fossil Free Sweden is working to highlight and promote the actors who, in their activities, help solve the climate issue and achieve the goal of a fossil free society. The initiative showcases their efforts under a common umbrella, both in Sweden and internationally. The vision of a fossil free society is vital for increasing the pace of the climate work and Fossil Free Sweden continuously work to make this vision wide spread to motivate the whole society to embrace the transformation to a fossil free life. Fossil Free Sweden has launched challenges about concrete actions that enterprises and municipalities can engage in to speed up the transition. The challenges deal with e.g. fossil free transports, solar cells on the roof or fossil free investments and actors who adopt one or several of the challenges are made public to create driving forces for additional actors to join. www.fossilfritt-sverige.se

The Swedish Transport Administration

The Swedish Transport Administration is a central government agency tasked with ensuring that the systems for road and rail transport, shipping and aviation are of a high standard, economically efficient and universally available.

The Administration is in charge of environmental issues associated with the state road and rail networks. It works to reduce emissions that affect climate, by promoting attractive, accessible towns and cities characterised by reduced car dependence, energy-efficient goods transport chains, more energy-efficient road vehicles and railway rolling stock on a sustainable energy basis, and by reducing the emissions of greenhouse gases from infrastructure building and maintenance in a lifecycle perspective. The website www.trafikverket.se contains general information about the environmental impact of road and rail transport, and about how individuals can reduce emissions by, for example, choosing low-emission modes of transport, driving economically and selecting fuelsaving vehicles.

The Swedish Consumer Agency

The Swedish Consumer Agency, the country's central administrative authority for consumer affairs, bears primary responsibility for implementing government consumer policy. The Agency's remit includes integrated responsibility for consumer-related environmental and sustainability issues, and also special responsibility for progress towards environmental objectives within its own sphere of activities. The Agency's website, www.hallakonsument.se ("Hello Consumer") serves as a portal for its own and other authorities' consumer information. It includes information about climate and environmental labels, such as the Nordic Ecolabel, Good Environmental Choice and the EU Ecolabel. It provides a link to the web-based tool, the 'Climate Account' and it has a web-based tool called the 'Ecolabel Guide' (Märkningsguiden) to allow consumers to find information on various ecolabels. The Consumer Agency also provides Bilsvar.se – an online service offering an overview of vehicles' fuel consumption, CO_2 emissions, economy and safety. In 2017, the Consumer Agency received two new government commissions, (1) to establish and provide a forum for environmentally friendly consumption and (2) to encourage environmentally friendly consumption patterns.

The Swedish Museum of Natural History
The Museum of Natural History in Stockholm is a knowledge centre and meeting place for the public and experts with an interest in nature and the environment. The museum hosts the exibition *Mission: Climate Earth*, an exhibition designed to impart basic knowledge of climate issues and of what can be done to curb climate change. The exhibition combines facts and sensory experiences, combined with study material and a teacher's guide linked to the exhibition, catering for school pupils of all ages. The content of the exhibition was devised in cooperation with Stockholm University, the Swedish Environmental Protection Agency, the World Wide Fund for Nature (WWF) and SMHI.

The Swedish Forest Agency
The Swedish Forest Agency focus on e-services and digital information to inform forest owners and forest officers. Two films, *How climate change increases risks for forest damage* and *How to adjust for reduced forest damage* have been produced. Also a special e-service; *Forests climate counseling service*, giving forest owners conceptual advice on property level. The book *Forest and climate* has been published and even some leaflets in various climate topics. The Agency's website, www.skogsstyrelsen.se , and the magazine Skogseko ('Forest Echo') are important channels reaching key audiences. Climate change adaptation is recurrent in many different contexts linked to forest managements.

The Swedish Board of Agriculture
The Swedish Board of Agriculture works with producing reports and fact sheets on measures how to reduce the climate impact of agriculture as well as on climate adaptation. Together with the Federation of Swedish Farmers and the County Administrative Boards of Sweden, Swedish Board of Agriculture runs the information project *"Focus on Nutrients"* which focuses on advising for individual farmers on, for example, how to mitigate emissions at the farm-level.

The Swedish Civil Contingencies Agency
The Swedish Civil Contingencies Agency (MSB) is responsible for issues concerning civil protection, public safety, emergency management and civil defence as long as no other authority has responsibility. MSB work to ensure the development of society's ability to prevent and mitigate the effects of natural accidents, as well as supporing the work on security in social planning and to adapt the work of social protection and preparedness to a changing climate.

The Swedish Defence Research Agency
The Swedish Defence Research Agency (FOI) is a research institute in the area of defence and security. Within the area of crises preparedness and societal security, FOI has developed and practiced methods for constructing scenarios of extreme weather events, for example severe heat waves and heavy precipitation. FOI has also developed methods for using these scenarios in risk and vulnerability analyses on local, regional and national level to identify the impact of climate change on societal vital functions and to suggest measures to enhance the societal resilience. The Agency furthermore conducts research with the aim of understanding how adaptation is conducted in the Swedish context as a pre-requisite to develop decision support methods. Such methods have been developed in an earlier research program, Climatools, www.climatools.se, and in an ongoing research program *Robust decisions,* www.kth.se. The latter program is focused on robust decision making strategies under deep uncertainty. The methods are tested in close cooperation with stakeholders in Swedish organisations to ensure their usefulness.

9.3. Additional resources and information centres

Swedish non-governmental organisations, think-tanks and networks play an active part in public debate on climate change, by creating arenas and meeting places for discussion, debate and action. A couple relevant examples, each with a distinctive emphasis, are:

- Swedish Society for Nature Conservation (SSNC), www.naturskyddsforeningen.se
- Keep Sweden Tidy Foundation, www.hsr.se
- Swedish Association of Green Motorists www.gronabilister.se
- WWF, www.wwf.se
- Greenpeace, www.greenpeace.se
- Friends of the Earth Sweden, www.mjv.se
- PUSH Sweden (in Swedish), www.pushsverige.se
- Nature & Youth Sweden (Fältbiologerna), www.faltbiologerna.se
- Stormwarning, a network of musicians, artists, researchers, experts and communicators. www.stormvarning.org
- *FORES* Forum for Reforms, Entrepreneurship and Sustainability; a green and liberal think tank
- *The Haga Initiative* is a business network that works to reduce emissions from the business sector and proves that ambitious climate policy strengthens the competitiveness of Sweden and the member companies. The initiative includes AkzoNobel, Axfood, Coca-Cola European Partner Sverige, Folksam, Fortum Värme, Green Cargo, JM, Lantmännen, Löfbergs, McDonald's, HKScan Sweden, Preem, Siemens, Stena Recycling and Sveaskog. In February 2017 the member companies set a new target; to become fossil free within their own operations by 2030.
- *The Climate-Neutral Freight Transportation network (KNEG)* is a cooperative project with the mission to reduce the climate impact of goods transport on Swedish roads. The goal is to halve emissions from a typical Swedish long-haul transport operation by 2020 compared with 2005. A large number of companies, researchers, organizations and the Swedish Transport Administration have joined forces to test and demonstrate new solutions and to share good examples with the industry and society. The network is hosted by the Centre for Environment and Sustainability at Chalmers University of Technology and the University of Gothenburg.

- *The Food and Environment network* is a network for food producers there is run by the Swedish Institute for Food and Biotechnology (SIK). The purpose of this network is to expand knowledge and understanding of the climate impact of food products, and to strengthen the producers' positions on the market. Participants meet regularly and benefit from one another's experience.

9.4. Education and training activities

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 at 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 climaterelated subjects like energy and forestry. There are various networks and centres of competence; for example, at Karlstad University, there is a Centre for Climate and Safety that aspires to accumulate knowledge and experience of risks associated with climate change and the Centre for Climate and Environmental Research at Lund University; www.cec.lu.se

Several governmental agencies and knowledge centres offer climate communication addressing pupils of various ages. Here are a couple examples:

A climate smart meal; a teaching manual adapted for the compulsory school (ages 13–16) and can be linked to the core content of physics, geography, home and consumer studies and chemistry and as an interdisciplinary task. The educational setup is provided by the *Environmental Objectives Portal*, a gateway to information about Sweden's environmental goals and progress towards achieving them, edited by *the Swedish Environmental Protecion Agency*. Teaching linked to the environmental goals is a way to get the environmental component of teaching on sustainable development, and the portal provides educational setups on the environmental goals.

The Green Flag award – Eco Schools, provided by *the Keep Sweden Tidy Foundation*, assists a growing number of Swedish schools and preschools with a plan and a structure for their environmental work. The issues of climate change, energy efficiency and resource conservation are dealt with under the overarching objective of sustainable development.

The Forest in Schools project, by *the Swedish Forest Agency and forest stakeholders, connects theory and practice* with the purpose of enhancing knowledge of and interest in forests and all the values they represent, including their bearing on the climate.

The knowledge link, is an arena for sustainable learning, a national project aiming to give children and young people the opportunity to acquire the knowledge, skills, values and attitudes needed to contribute to sustainable development through cross-sectoral cooperation (2008–2016). http://www.kunskapslänken.nu/

Earth Hour teaching handbooks, by *The World Wide Fund for Nature in Sweden (WWF)* deepens the knowledge about energy and climate. WWF has for many years developed support for formal, non-formal and informal education by national and international education initiatives. WWF in Sweden has in recent years mainly focused on climate-related initiatives. These include Earth Hour, a worldwide movement for the Planet encouraging individuals and communities, households and businesses to turn off their non-essential lights for one hour, from 8:30 to 9:30 pm towards the end of March, as a symbol for their commitment to the planet.

Our City 2030, is a teaching manual provided by *WWF* in Sweden as is part of WWF's efforts to endorse sustainable cities, support learning and participation and reduce the ecological footprint we are leaving on our planet. The project focuses on climate and energy work in the local municipality. The approach challenges and motivates students to become involved in community development.

Food on Sustainable Way, developed by *WWF,* is focusing on the food's large impact on the climate and how we can, through knowledge, choose a more sustainable way forward.

Energifallet, a thematic webpage provided by *Swedish Society for Nature Conservation*, facilitates its direct cooperation with schools including webbased educational material and study visits. Energifallet maintains a wide variety of short information films, factsheets and other teaching material on climate, climate-friendly consumption, energy and transport. http://www.naturskyddsforeningen.se/skola/energifallet

Greenspeakers are volunteers from Greenpeace, giving talks in schools at request. Interest in these talks has increased, and considerable scope has been given to climate change, which is a key issue for Greenpeace.

The Swedish Portal for Climate Change Adaptation, with its facts and guidance on adaptation to a warmer climate, is managed by *the National Knowledge Centre for Climate Change Adaptation*, set up at SMHI.

The Portal is a resource for those engaged in adapting society to climate change, and also forother stakeholders. Training courses on how environmental and climate requirements can be imposed in procurement are held by a range of providers at national, regional and local level. SMHI offers lectures and customised courses on climate change to companies, municipalities and agencies, explaining the science behind climate change, its causes and effects, focusing on the audience's activities.

Furthermore, environment and climate training is one of the steps taken by companies to achieve environmental certification to international standards (ISO and EMAS).

9.5. Public awareness, participation and access to information activities

There is extensive scope in Sweden to ask questions and express views on an area of knowledge or a policy proposal, through consultation procedures and open meetings, hearings and seminars. Special initiatives are taken to increase public participation in climate work. Activities range from answering questions online to engaging in open consultations. Non-profit organisations often establish web-based forums or appeals where the public are urged to express their opinions. Energy and climate advisers in Sweden's municipalities reply free of charge to questions about heating, energy costs and efficiency, transport, climate, government grants relating to energy and a great deal else. This advisory service caters for the general public, SMEs and organisations. Agencies and organisations at national level regularly communicates with the public.

In Sweden, there is a rising awareness on products and services affecting the climate. Sustainability is discussed to a larger extent and consumption is increasingly associated to climate change. As a result, several agencies and organisations provides online information empowering consumers on climate change. A growing volume of activities offer advice and guidance empowering the public on climate action. Find below a couple examples:

Municipal energy and climate advisers, provides advice and support for households and businesses, from changing a heating system to insulation and other ways of improving energy efficiency. In Sweden, a majority of municipalities have energy and climate adivisers, supported financially by *the Swedish Energy Agency*.

The Earth Hour campaign. As part of the campaign, WWF has invited towns and cities in selected countries to present inspiring and credible plans for radically increasing the share of renewable energy used over the next few decades.

Smergy (Smart energy) campaign 2014–2016, by *the Swedish Society for Nature Conservation's* was a project supported by EU (IEE, Intelligent Energy – Europe), targeting youth between 18 and 29 with messages promoting smart energy consumption and encouraging fact-finding by competitions and activities. http://smergy.se

Climate Calculator by SEI and WWF. Just in time for the environmental manifestation Earth Hour on March 25, 2017, the Stockholm Environment Institute, together with WWF, launched the mobile-friendly climate calculator; "Klimatkalkylatorn". There is great interest – in a few weeks, more than 28 000 unique users in Sweden tested the calculator to check their greenhouse gas emissions. https://www.klimatkalkylatorn.se/

The 'Climate Account', provided by *IVL Swedish Environmental Research Institute,* is a web-based tool for individuals to measure their carbon footprint. The Climate Account empowers the public to reduce climate impact from consumption, providing information and estimation on greenhouse gas emissions, underpinned by basic information on policy instruments on society's emissions.

The podcast "Talk on Climate" (Prat om klimat) was launched by Swedish Environmental Protection Agency in 2017.

Emission checks carried out by the Swedish vehicle inspection company Bilprovningen are its most important contribution to reducing the environmental impact of traffic on Swedish roads. The company disseminates environmental advice to vehicle owners. Roughly a third of emissions in Sweden come from road transport, and most of these come from passenger cars. Inspections carried out by the company include several important environmental checks that reveal environment-related defects in nearly 5 % of all cars.

The Swedish Association of Green Motorists promotes development of environmentally sound road transport by, for example, surveying the local presence of green cars. The organisation provides advice and support to purchasers of green cars, publishes an annual list of the greenest vehicles and, in various ways, highlights climate initiatives in the road transport sector.

The Global Lightening Challenge, a campaign that Sweden is a partner, represented by the Swedish Energy Agency. Inviting businesses, municipalities, NGO:s and governmental agencies to review the lightening, the aim is to cut the energy use. The actors set up individual goals, publicly on the web. Until now more than 60 actors take part, among them IKEA.

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. The EU-system for energy labelling started 20 years ago and the celebration was covered by Swedish media. The Swedish Energy Agency has produced a film (Swedish and English) to focus on the history and results of this labelling system https://www.youtube.com/watch?v=gSDEo9v2pY$_0$ Consumers can download an app, the "Lamp guide" to more easily find an expedient light – bulb.

Information about food with a relatively low climate impact and simple ways of saving electricity in the kitchen is disseminated by a range of stakeholders. Joint efforts are being made by the central government and various sectoral bodies to develop climate labelling for food.

"Good Environmental Choice" (Bra Miljöval) is an environmental labeling system managed by the Swedish Society for Nature Conservation. The labeling system provides labeling of electricity services from renewable sources according to strict requirements.

The Swedish Environmental Management Council offers a method of listing the greenhouse gas emissions from products according to the international Environmental Product Declaration (EPD) system www.environdec.com

The EPD represents a comprehensive approach to the climate impact of products and can be used by manufacturers, but also by purchasers and consumers wishing to make climate-friendly buying decisions.

9.6. Conferences and events

In Sweden, a large amount of conferences and events are held annually on climate change, engaging a wide range of stakeholders and policy makers. These events play a strong part in creating action for climate empowerment in Sweden, engaging public agencies and private companies. The increasing engagement is reflected by a rising amount of jointly held business networks on climate and environment promoting business development. Climate and energy experts from agencies and organisations are often among the speakers. A couple examples are:

The Climate Forum, arranged by the Swedish Environmental Protection Agency jointly with different partners (2014–17 conferences jointly with Bonnier Business Sustainability), **the Energy Outlook**, arranged by the Swedish Energy Agency, **Climate Adaption Sweden** (Klimatanpassning Sverige), arranged by Bonnier Business Sustainability jointly with various public agencies, **Ecotransport**, arranged by think tank Fores jointly with Bonnier Business Sustainability, S**ustainable Transports** and **State of the Environment** arranged by IVL Swedish Enviromental Research Institute. These conferences attracts thousands of stakeholders annually and are meeting places for agencies, organisations, businesses and politicians. Moreover, In Sweden, during the **Almedalen Week**, an event where 40 000 policymakers, organisations and business interacts with the public and the media annually, around 1500 seminars were held on the topic climate change between 2014–2016.

9.7. Participation in international activities

Both governmental and non-governmental Swedish resources and information centres are active in a numerous international activities on climate change education and public awareness. Most resources and information centres listed above participate in related international activities. Find below two examples.

Within the Swedish governmental initiative "Team Sweden", the Swedish Energy Agency promote SME in cleantech innovation, to find new international markets. The aim is to boost jobs and growth in Sweden and a globally sustainable energy transition. In cooperation with Business Sweden the Swedish Energy Agency open three hubs in San Francisco, Shanghai and London. Interested SME joins a competition where innovation, financial strength and business plans are screened. The initiative has aroused great interest.

Swedish Environmental Institute, SEI, is an independent, international research institute, rated as the world's most influential think tank on environmental policy issues in the University of Pennsylvania's 2016 Global Go To Think Tanks Index, billed as the "premier database and measure of world think tanks". SEI has been engaged in environment and development issues at local, national, regional and global policy levels for more than a quarter of a century. SEI supports decision making for sustainable development by bridging science and policy and have succesfully reached global media coverage on its research. www.sei-international.org

9.8. References for Chapter 9

Stockholm Environment Institute (SEI) Discussion brief report; Building bridges and changing minds: Insights from climate communication research and practice, (2016) Author(s): Vulturius, G., M. Davis and S. Bharwani.

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	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
F	Construction (Swedish Standard Industrial Classification SNI 2007)
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
Govt. Bill	Government Bill
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
NC_6	Sixth 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

Summary report for CO_2 equivalent emissions

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)	**19192,64**	**8101,91**	**6963,77**	**4,60**	**568,78**	**101,73**	**NA**	**NA**	**34933,43**
1. Energy	**51821,23**	**616,35**	**684,52**						**53122,10**
A. Fuel combustion (sectoral approach)	51524,37	523,88	684,09						52732,33
1. Energy industries	9814,87	16,63	123,77						9955,27
2. Manufacturing industries and construction	11190,35	54,09	205,13						11449,57
3. Transport	18996,77	155,96	180,18						19332,91
4. Other sectors	10676,28	296,16	159,30						11131,74
5. Other	846,10	1,04	15,70						862,84
B. Fugitive emissions from fuels	296,87	92,47	0,43						389,77
1. Solid fuels	5,32	0,00	0,00						5,32
2. Oil and natural gas	291,55	92,47	0,43						384,45
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5505,48**	**26,21**	**953,36**	**4,60**	**568,78**	**101,73**	**NA**	**NA**	**7160,16**
A. Mineral industry	1684,25								1684,25
B. Chemical industry	126,04	0,70	802,96	NA	NA	NA	NA	NA	929,70
C. Metal industry	3283,78	19,42	NA	NO	568,78	22,80			3894,78
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				4,60	NO				4,60
G. Other product manufacture and use	NE,NA	NA	86,73		NO	78,93			165,66
H. Other	18,43	6,08	63,67						88,19
3. Agriculture	**177,75**	**3533,19**	**3903,89**						**7614,83**
A. Enteric fermentation		3288,11							3288,11
B. Manure management		245,08	362,20						607,29
C. Rice cultivation		NO							NO
D. Agricultural soils			3541,68						3541,68
E. Prescribed burning of savannas									
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)	**-38355,68**	**462,19**	**1190,32**						**-36703,17**
A. Forest land	-39994,66	232,89	1087,42						-38674,35
B. Cropland	3281,82	216,53	2,80						3501,15
C. Grassland	358,02	7,44	35,98						401,44
D. Wetlands	70,47	5,33	0,93						76,73
E. Settlements	2924,01	IE	55,47						2979,47
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-4995,34								-4995,34
H. Other	NO	NO	NO						NO
5. Waste	**43,85**	**3463,98**	**231,69**						**3739,53**
A. Solid waste disposal	NO,NA	3421,70							3421,70
B. Biological treatment of solid waste		7,10	5,07						12,17
C. Incineration and open burning of waste	43,85	0,01	0,99						44,85
D. Waste water treatment and discharge		35,18	225,63						260,81
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	3562,81	0,81	53,75						3617,37
Aviation	1334,94	0,44	18,59						1353,98
Navigation	2227,87	0,37	35,16						2263,40
Multilateral operations	0,05	0,00	0,00						0,05
CO_2 emissions from biomass	12390,46								12390,46
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**4,91**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									71636,61
Total CO_2 equivalent emissions with land use, land-use change and forestry									34933,43
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**20616,38**	**8103,82**	**6847,69**	**9,36**	**573,84**	**102,69**	**NA**	**NA**	**36253,79**
1. Energy	**52337,13**	**647,48**	**710,85**						**53695,46**
A. Fuel combustion (sectoral approach)	52088,39	543,29	710,48						53342,15
1. Energy industries	10784,70	18,99	150,19						10953,87
2. Manufacturing industries and construction	11120,50	53,08	205,14						11378,72
3. Transport	18723,76	163,06	176,45						19063,27
4. Other sectors	10391,25	307,01	159,55						10857,80
5. Other	1068,18	1,15	19,16						1088,49
B. Fugitive emissions from fuels	248,74	104,20	0,37						353,31
1. Solid fuels	5,18	0,00	0,00						5,19
2. Oil and natural gas	243,56	104,19	0,37						348,13
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5220,98**	**28,33**	**997,91**	**9,36**	**573,84**	**102,69**	**NA**	**NA**	**6933,10**
A. Mineral industry	1544,59								1544,59
B. Chemical industry	127,07	0,69	844,24	NA	NA	NA	NA	NA	972,00
C. Metal industry	3200,02	21,16	NA	NO	572,88	22,80			3816,86
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				9,12	NO				9,12
G. Other product manufacture and use	NE,NA	NA	85,61		NO	79,12			164,73
H. Other	18,08	6,48	68,06						92,62
3. Agriculture	**140,48**	**3447,10**	**3724,86**						**7312,44**
A. Enteric fermentation		3209,50							3209,50
B. Manure management		237,60	352,39						589,99
C. Rice cultivation		NO							NO
D. Agricultural soils			3372,47						3372,47
E. Prescribed burning of savannas									
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)	**-37134,40**	**461,60**	**1181,22**						**-35491,58**
A. Forest land	-39801,26	232,99	1070,05						-38498,22
B. Cropland	3103,86	215,96	3,34						3323,17
C. Grassland	19,57	7,72	35,44						62,73
D. Wetlands	67,97	4,93	0,86						73,76
E. Settlements	3530,40	IE	67,07						3597,47
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-4054,95								-4054,95
H. Other	NO	NO	NO						NO
5. Waste	**52,20**	**3519,31**	**232,85**						**3804,36**
A. Solid waste disposal	NO,NA	3473,82							3473,82
B. Biological treatment of solid waste		10,60	7,58						18,17
C. Incineration and open burning of waste	52,20	0,01	1,15						53,36
D. Waste water treatment and discharge		34,89	224,12						259,01
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	3727,65	0,79	57,34						3785,78
Aviation	1087,92	0,35	16,11						1104,38
Navigation	2639,73	0,45	41,22						2681,40
Multilateral operations	0,05	0,00	0,00						0,05
CO_2 emissions from biomass	13178,66								13178,66
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			2,86						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									71745,37
Total CO_2 equivalent emissions with land use, land-use change and forestry									36253,79
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**20265,11**	**8248,16**	**6656,21**	**11,82**	**389,48**	**102,58**	**NA**	**NA**	**35673,36**
1. Energy	**52427,41**	**648,31**	**722,37**						**53798,08**
A. Fuel combustion (sectoral approach)	52142,50	543,30	721,94						53407,75
1. Energy industries	11385,47	15,39	155,92						11556,78
2. Manufacturing industries and construction	10196,80	61,44	204,58						10462,81
3. Transport	19599,25	153,28	190,93						19943,46
4. Other sectors	9840,73	312,13	150,70						10303,56
5. Other	1120,26	1,06	19,81						1141,13
B. Fugitive emissions from fuels	284,90	105,00	0,42						390,33
1. Solid fuels	4,57	0,00	0,00						4,58
2. Oil and natural gas	280,33	105,00	0,42						385,75
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**4878,18**	**27,26**	**984,17**	**11,82**	**389,48**	**102,58**	**NA**	**NA**	**6393,50**
A. Mineral industry	1460,26								1460,26
B. Chemical industry	120,58	0,73	812,99	NA	NA	NA	NA	NA	934,29
C. Metal industry	2984,14	20,08	NA	NO	388,51	22,80			3415,53
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				11,58	NO				11,58
G. Other product manufacture and use	NE,NA	NA	103,41		NO	79,01			182,41
H. Other	18,26	6,45	67,78						92,49
3. Agriculture	**112,86**	**3587,37**	**3538,79**						**7239,02**
A. Enteric fermentation		3343,20							3343,20
B. Manure management		244,17	361,94						606,11
C. Rice cultivation		NO							NO
D. Agricultural soils			3176,85						3176,85
E. Prescribed burning of savannas									
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)	**-37211,67**	**461,69**	**1177,05**						**-35572,94**
A. Forest land	-39262,78	232,94	1061,30						-37968,54
B. Cropland	2999,53	215,76	3,78						3219,07
C. Grassland	201,34	7,65	35,08						244,07
D. Wetlands	76,09	5,33	0,93						82,34
E. Settlements	2353,77	IE	72,75						2426,52
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-3579,61								-3579,61
H. Other	NO	NO	NO						NO
5. Waste	**58,33**	**3523,54**	**233,84**						**3815,70**
A. Solid waste disposal	NO,NA	3474,86							3474,86
B. Biological treatment of solid waste		14,10	10,08						24,18
C. Incineration and open burning of waste	58,33	0,01	1,15						59,48
D. Waste water treatment and discharge		34,57	222,61						257,18
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	3908,69	0,78	62,13						3971,60
Aviation	899,49	0,28	15,03						914,79
Navigation	3009,20	0,51	47,10						3056,81
Multilateral operations	0,05	0,00	0,00						0,05
CO_2 emissions from biomass	14103,60								14103,60
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			2,01						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									71246,30
Total CO_2 equivalent emissions with land use, land-use change and forestry									35673,36
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**25318,32**	**8231,43**	**6944,15**	**38,43**	**453,21**	**99,35**	**NA**	**NA**	**41084,88**
1. Energy	**52233,48**	**641,35**	**746,77**						**53621,60**
A. Fuel combustion (sectoral approach)	51922,95	535,52	746,31						53204,78
1. Energy industries	11523,64	18,58	164,62						11706,84
2. Manufacturing industries and construction	10976,35	61,28	213,11						11250,74
3. Transport	18702,97	135,65	201,93						19040,55
4. Other sectors	9842,01	319,26	152,75						10314,01
5. Other	877,99	0,75	13,91						892,65
B. Fugitive emissions from fuels	310,53	105,82	0,46						416,82
1. Solid fuels	4,72	0,00	0,00						4,73
2. Oil and natural gas	305,81	105,82	0,46						412,09
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5001,61**	**27,47**	**963,16**	**38,43**	**453,21**	**99,35**	**NA**	**NA**	**6583,22**
A. Mineral industry	1482,66								1482,66
B. Chemical industry	124,45	0,68	790,36	NA	NA	NA	NA	NA	915,48
C. Metal industry	3072,97	20,15	NA	NO	449,96	22,80			3565,89
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				38,14	NO				38,14
G. Other product manufacture and use	NE,NA	NA	103,11		NO	75,78			178,89
H. Other	14,28	6,64	69,69						90,60
3. Agriculture	**134,44**	**3691,23**	**3807,37**						**7633,05**
A. Enteric fermentation		3436,79							3436,79
B. Manure management		254,44	363,16						617,60
C. Rice cultivation		NO							NO
D. Agricultural soils			3444,22						3444,22
E. Prescribed burning of savannas									
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)	**-32099,23**	**461,65**	**1190,31**						**-30447,27**
A. Forest land	-35366,21	233,87	1064,81						-34067,54
B. Cropland	3647,36	214,95	4,23						3866,55
C. Grassland	152,24	7,66	34,81						194,71
D. Wetlands	77,01	5,17	0,90						83,08
E. Settlements	4587,52	IE	82,68						4670,19
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-5197,14								-5197,14
H. Other	NO	NO	NO						NO
5. Waste	**48,02**	**3409,73**	**236,54**						**3694,29**
A. Solid waste disposal	NO,NA	3357,87							3357,87
B. Biological treatment of solid waste		17,60	12,59						30,18
C. Incineration and open burning of waste	48,02	0,01	1,03						49,05
D. Waste water treatment and discharge		34,26	222,92						257,18
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	4252,15	0,87	65,27						4318,30
Aviation	1229,76	0,36	18,04						1248,17
Navigation	3022,39	0,51	47,23						3070,13
Multilateral operations	0,32	0,00	0,00						0,32
CO_2 emissions from biomass	15299,86								15299,86
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,78**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									71532,15
Total CO_2 equivalent emissions with land use, land-use change and forestry									41084,88
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**23734,86**	**8166,28**	**6917,45**	**87,02**	**485,08**	**106,37**	**NA**	**NA**	**39497,07**
1. Energy	**54288,93**	**646,58**	**768,92**						**55704,43**
A. Fuel combustion (sectoral approach)	54029,21	539,04	768,54						55336,79
1. Energy industries	12005,55	21,11	165,30						12191,96
2. Manufacturing industries and construction	12081,01	68,53	241,12						12390,67
3. Transport	19216,72	140,20	200,87						19557,78
4. Other sectors	9951,31	308,52	149,76						10409,59
5. Other	774,63	0,68	11,48						786,79
B. Fugitive emissions from fuels	259,71	107,54	0,39						367,64
1. Solid fuels	5,56	0,00	0,00						5,57
2. Oil and natural gas	254,15	107,54	0,38						362,07
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5363,38**	**27,69**	**925,85**	**87,02**	**485,08**	**106,37**	**NA**	**NA**	**6995,40**
A. Mineral industry	1570,19								1570,19
B. Chemical industry	121,41	0,79	764,70	NA	NA	NA	NA	NA	886,89
C. Metal industry	3400,43	20,33	NA	NO	480,50	25,08			3926,33
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				86,56	NO				86,56
G. Other product manufacture and use	NE,NA	NA	92,08		NO	79,76			171,84
H. Other	14,33	6,58	69,07						89,98
3. Agriculture	**161,20**	**3754,60**	**3783,49**						**7699,29**
A. Enteric fermentation		3498,40							3498,40
B. Manure management		256,19	369,39						625,58
C. Rice cultivation		NO							NO
D. Agricultural soils			3414,10						3414,10
E. Prescribed burning of savannas									
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)	**-36127,73**	**463,32**	**1199,75**						**-34464,66**
A. Forest land	-35642,25	235,13	1069,05						-34338,07
B. Cropland	2371,83	214,97	5,08						2591,88
C. Grassland	-82,07	7,57	33,82						-40,69
D. Wetlands	86,62	5,65	0,98						93,25
E. Settlements	2777,75	IE	88,29						2866,04
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-5639,60								-5639,60
H. Other	NO	NO	NO						NO
5. Waste	**49,08**	**3274,10**	**239,43**						**3562,60**
A. Solid waste disposal	NO,NA	3219,00							3219,00
B. Biological treatment of solid waste		21,10	15,09						36,19
C. Incineration and open burning of waste	49,08	0,01	1,11						50,19
D. Waste water treatment and discharge		33,99	223,23						257,22
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	4910,27	0,99	74,78						4986,04
Aviation	1350,46	0,38	19,30						1370,14
Navigation	3559,82	0,60	55,47						3615,90
Multilateral operations	0,32	0,00	0,00						0,32
CO_2 emissions from biomass	16803,48								16803,48
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,57**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									73961,72
Total CO_2 equivalent emissions with land use, land-use change and forestry									39497,07
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**24894,43**	**8074,88**	**7268,53**	**149,18**	**532,24**	**135,19**	**NA**	**NA**	**41054,45**
1. Energy	**53450,50**	**646,31**	**789,59**						**54886,40**
A. Fuel combustion (sectoral approach)	53149,44	541,11	789,14						54479,69
1. Energy industries	11168,30	21,71	172,92						11362,94
2. Manufacturing industries and construction	12490,27	66,66	240,61						12797,53
3. Transport	19296,53	129,29	217,72						19643,55
4. Other sectors	9490,93	322,77	147,44						9961,14
5. Other	703,40	0,68	10,45						714,53
B. Fugitive emissions from fuels	301,07	105,20	0,45						406,71
1. Solid fuels	6,06	0,00	0,00						6,06
2. Oil and natural gas	295,01	105,19	0,44						400,64
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5626,62**	**18,35**	**890,29**	**149,18**	**532,24**	**135,19**	**NA**	**NA**	**7351,87**
A. Mineral industry	1702,11								1702,11
B. Chemical industry	114,52	0,83	701,88	NA	NA	NA	NA	NA	817,23
C. Metal industry	3522,65	10,89	NA	NO	521,15	25,08			4079,77
D. Non-energy products from fuels and solvent use	272,77	NA	NA						272,77
E. Electronic Industry				0,46	10,83	2,37			13,66
F. Product uses as ODS substitutes				148,73	0,26				148,99
G. Other product manufacture and use	NE,NA	NA	118,90		NO	107,74			226,64
H. Other	14,57	6,63	69,51						90,71
3. Agriculture	**172,89**	**3677,05**	**4132,57**						**7982,51**
A. Enteric fermentation		3420,88							3420,88
B. Manure management		256,18	363,60						619,78
C. Rice cultivation		NO							NO
D. Agricultural soils			3768,97						3768,97
E. Prescribed burning of savannas									
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)	**-34398,32**	**464,24**	**1211,86**						**-32722,22**
A. Forest land	-38405,52	235,64	1073,73						-37096,15
B. Cropland	6833,22	214,89	6,08						7054,19
C. Grassland	-82,65	7,49	33,38						-41,78
D. Wetlands	97,15	6,22	1,08						104,45
E. Settlements	3605,97	IE	94,41						3700,39
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-6446,50								-6446,50
H. Other	NO	NO	NO						NO
5. Waste	**42,74**	**3268,94**	**244,22**						**3555,90**
A. Solid waste disposal	NO,NA	3210,60							3210,60
B. Biological treatment of solid waste		24,80	17,59						42,39
C. Incineration and open burning of waste	42,74	0,01	1,08						43,82
D. Waste water treatment and discharge		33,53	225,55						259,08
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	4937,26	1,18	74,90						5013,35
Aviation	1436,78	0,59	20,51						1457,87
Navigation	3500,49	0,60	54,39						3555,47
Multilateral operations	0,32	0,00	0,00						0,32
CO_2 emissions from biomass	17669,06								17669,06
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			1,82						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									73776,68
Total CO_2 equivalent emissions with land use, land-use change and forestry									41054,45
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**21597,97**	**8091,77**	**6823,89**	**235,27**	**469,07**	**116,88**	**NA**	**NA**	**37334,84**
1. Energy	**57598,19**	**664,83**	**792,27**						**59055,30**
A. Fuel combustion (sectoral approach)	57310,69	551,07	791,81						58653,57
1. Energy industries	15625,21	28,94	185,12						15839,26
2. Manufacturing industries and construction	12467,28	64,64	234,56						12766,48
3. Transport	18992,35	125,57	214,01						19331,93
4. Other sectors	9580,17	331,36	148,36						10059,89
5. Other	645,68	0,55	9,77						656,01
B. Fugitive emissions from fuels	287,50	113,76	0,46						401,73
1. Solid fuels	5,89	0,00	0,00						5,89
2. Oil and natural gas	281,62	113,76	0,46						395,83
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5373,52**	**8,37**	**875,12**	**235,27**	**469,07**	**116,88**	**NA**	**NA**	**7078,23**
A. Mineral industry	1630,63								1630,63
B. Chemical industry	123,31	0,85	674,66	NA	NA	NA	NA	NA	798,81
C. Metal industry	3343,34	0,99	NA	NO	452,36	29,64			3826,32
D. Non-energy products from fuels and solvent use	261,62	NA	NA						261,62
E. Electronic Industry				0,72	15,65	2,37			18,74
F. Product uses as ODS substitutes				234,55	1,06				235,61
G. Other product manufacture and use	NE,NA	NA	132,01		NO	84,87			216,88
H. Other	14,63	6,53	68,45						89,60
3. Agriculture	**197,33**	**3713,79**	**3701,71**						**7612,83**
A. Enteric fermentation		3454,57							3454,57
B. Manure management		259,23	367,69						626,92
C. Rice cultivation		NO							NO
D. Agricultural soils			3334,02						3334,02
E. Prescribed burning of savannas									
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)	**-41620,19**	**463,92**	**1215,29**						**-39940,98**
A. Forest land	-40631,43	236,30	1075,10						-39320,03
B. Cropland	1744,77	214,69	6,08						1965,55
C. Grassland	-19,84	7,43	33,15						20,75
D. Wetlands	91,29	5,49	0,96						97,74
E. Settlements	3297,55	IE	97,35						3394,90
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-6102,54								-6102,54
H. Other	NO	NO	NO						NO
5. Waste	**49,12**	**3240,86**	**239,49**						**3529,46**
A. Solid waste disposal	NO,NA	3183,05							3183,05
B. Biological treatment of solid waste		24,80	17,16						41,97
C. Incineration and open burning of waste	49,12	0,00	0,81						49,93
D. Waste water treatment and discharge		33,01	221,51						254,52
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	5183,43	1,09	79,36						5263,88
Aviation	1475,28	0,46	21,47						1497,21
Navigation	3708,15	0,63	57,89						3766,67
Multilateral operations	0,32	0,00	0,00						0,32
CO_2 emissions from biomass	19231,98								19231,98
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,65**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									77275,82
Total CO_2 equivalent emissions with land use, land-use change and forestry									37334,84
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**19032,32**	**8025,43**	**7079,43**	**352,79**	**432,25**	**159,59**	**NA**	**NA**	**35081,81**
1. Energy	**52661,82**	**629,05**	**757,06**						**54047,94**
A. Fuel combustion (sectoral approach)	52376,71	516,35	756,63						53649,69
1. Energy industries	10937,47	24,12	148,46						11110,06
2. Manufacturing industries and construction	12876,05	62,79	237,19						13176,03
3. Transport	19123,49	113,40	224,18						19461,07
4. Other sectors	8854,24	315,49	138,04						9307,77
5. Other	585,46	0,54	8,76						594,76
B. Fugitive emissions from fuels	285,11	112,71	0,44						398,25
1. Solid fuels	5,70	0,00	0,00						5,71
2. Oil and natural gas	279,41	112,70	0,43						392,55
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5250,45**	**8,85**	**876,26**	**352,79**	**432,25**	**159,59**	**NA**	**NA**	**7080,19**
A. Mineral industry	1531,98								1531,98
B. Chemical industry	115,56	0,84	666,83	NA	NA	NA	NA	NA	783,23
C. Metal industry	3281,73	1,02	NA	NO	413,87	38,76			3735,38
D. Non-energy products from fuels and solvent use	309,40	NA	NA						309,40
E. Electronic Industry				0,55	16,89	3,17			20,60
F. Product uses as ODS substitutes				352,24	1,49				353,74
G. Other product manufacture and use	NE,NA	NA	136,19		NO	117,66			253,85
H. Other	11,77	6,98	73,25						92,00
3. Agriculture	**178,37**	**3704,89**	**3990,26**						**7873,51**
A. Enteric fermentation		3446,72							3446,72
B. Manure management		258,16	369,51						627,67
C. Rice cultivation		NO							NO
D. Agricultural soils			3620,75						3620,75
E. Prescribed burning of savannas									
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)	**-39108,92**	**473,39**	**1220,62**						**-37414,92**
A. Forest land	-40353,42	244,78	1073,69						-39034,94
B. Cropland	5043,65	214,55	6,31						5264,51
C. Grassland	381,19	7,52	35,39						424,10
D. Wetlands	108,37	6,54	1,14						116,05
E. Settlements	3504,23	IE	101,85						3606,08
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-7792,96								-7792,96
H. Other	NO	NO	NO						NO
5. Waste	**50,60**	**3209,26**	**235,22**						**3495,08**
A. Solid waste disposal	NO,NA	3151,89							3151,89
B. Biological treatment of solid waste		24,90	16,81						41,71
C. Incineration and open burning of waste	50,60	0,01	0,94						51,55
D. Waste water treatment and discharge		32,46	217,48						249,94
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	5908,50	1,18	90,74						6000,42
Aviation	1560,09	0,45	22,83						1583,37
Navigation	4348,41	0,74	67,91						4417,05
Multilateral operations	0,32	0,00	0,00						0,32
CO_2 emissions from biomass	18061,66								18061,66
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,30**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									72496,73
Total CO_2 equivalent emissions with land use, land-use change and forestry									35081,81
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**17696,18**	**7886,58**	**6978,44**	**435,27**	**418,75**	**111,22**	**NA**	**NA**	**33526,45**
1. Energy	**53201,32**	**604,55**	**733,84**						**54539,70**
A. Fuel combustion (sectoral approach)	52900,06	488,03	733,40						54121,48
1. Energy industries	12010,65	25,64	159,19						12195,47
2. Manufacturing industries and construction	12306,12	62,65	230,47						12599,25
3. Transport	19308,59	107,04	207,50						19623,13
4. Other sectors	8802,63	292,27	129,27						9224,17
5. Other	472,07	0,42	6,97						479,45
B. Fugitive emissions from fuels	301,26	116,52	0,44						418,22
1. Solid fuels	5,54	0,00	0,00						5,54
2. Oil and natural gas	295,72	116,51	0,44						412,68
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5333,57**	**8,66**	**958,67**	**435,27**	**418,75**	**111,22**	**NA**	**NA**	**7266,14**
A. Mineral industry	1659,69								1659,69
B. Chemical industry	113,48	0,86	748,23	NA	NA	NA	NA	NA	862,57
C. Metal industry	3246,11	0,95	NA	NO	401,51	36,48			3685,05
D. Non-energy products from fuels and solvent use	306,31	NA	NA						306,31
E. Electronic Industry				0,58	15,96	1,60			18,14
F. Product uses as ODS substitutes				434,69	1,28				435,97
G. Other product manufacture and use	NE,NA	NA	138,57		NO	73,14			211,71
H. Other	7,98	6,86	71,86						86,70
3. Agriculture	**133,78**	**3649,12**	**3819,03**						**7601,93**
A. Enteric fermentation		3396,89							3396,89
B. Manure management		252,24	362,86						615,09
C. Rice cultivation		NO							NO
D. Agricultural soils			3456,17						3456,17
E. Prescribed burning of savannas									
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)	**-41021,65**	**464,06**	**1233,92**						**-39323,67**
A. Forest land	-42033,65	236,84	1082,21						-40714,60
B. Cropland	4238,68	214,38	6,77						4459,83
C. Grassland	-14,28	7,42	35,06						28,20
D. Wetlands	95,85	5,41	0,94						102,20
E. Settlements	3512,96	IE	106,74						3619,70
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-6821,20								-6821,20
H. Other	NO	NO	NO						NO
5. Waste	**49,16**	**3160,19**	**232,99**						**3442,35**
A. Solid waste disposal	NO,NA	3100,52							3100,52
B. Biological treatment of solid waste		27,75	18,42						46,17
C. Incineration and open burning of waste	49,16	0,01	0,95						50,12
D. Waste water treatment and discharge		31,92	213,62						245,54
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	6690,20	1,36	102,94						6794,50
Aviation	1672,90	0,51	24,59						1698,01
Navigation	5017,30	0,85	78,35						5096,49
Multilateral operations	0,32	0,00	0,00						0,32
CO_2 emissions from biomass	18317,45								18317,45
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,32**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									72850,12
Total CO_2 equivalent emissions with land use, land-use change and forestry									33526,45
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**17245,46**	**7691,01**	**7009,34**	**549,65**	**451,74**	**121,21**	**NA**	**NA**	**33068,42**
1. Energy	**50267,62**	**579,21**	**712,30**						**51559,13**
A. Fuel combustion (sectoral approach)	49959,99	465,97	711,84						51137,80
1. Energy industries	10274,07	25,38	150,09						10449,54
2. Manufacturing industries and construction	11327,28	59,31	214,39						11600,97
3. Transport	19652,60	99,60	215,75						19967,95
4. Other sectors	8296,15	281,33	125,65						8703,13
5. Other	409,89	0,35	5,97						416,21
B. Fugitive emissions from fuels	307,62	113,24	0,46						421,33
1. Solid fuels	5,61	0,00	0,00						5,62
2. Oil and natural gas	302,01	113,24	0,46						415,71
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5373,83**	**8,46**	**865,98**	**549,65**	**451,74**	**121,21**	**NA**	**NA**	**7370,88**
A. Mineral industry	1643,81								1643,81
B. Chemical industry	111,43	0,52	663,79	NA	NA	NA	NA	NA	775,73
C. Metal industry	3239,37	0,99	NA	NO	441,03	36,48			3717,87
D. Non-energy products from fuels and solvent use	370,81	NA	NA						370,81
E. Electronic Industry				0,22	9,30	1,57			11,10
F. Product uses as ODS substitutes				549,43	1,40				550,83
G. Other product manufacture and use	NE,NA	NA	129,33		NO	83,16			212,50
H. Other	8,41	6,95	72,86						88,23
3. Agriculture	**160,29**	**3604,72**	**3953,78**						**7718,79**
A. Enteric fermentation		3358,03							3358,03
B. Manure management		246,69	352,24						598,93
C. Rice cultivation		NO							NO
D. Agricultural soils			3601,54						3601,54
E. Prescribed burning of savannas									
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)	**-38604,48**	**468,88**	**1243,62**						**-36891,98**
A. Forest land	-41976,15	239,67	1086,11						-40650,36
B. Cropland	6277,50	213,98	6,77						6498,25
C. Grassland	4,06	7,39	34,67						46,13
D. Wetlands	131,16	7,83	1,36						140,36
E. Settlements	3425,22	IE	111,71						3536,93
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-6466,27								-6466,27
H. Other	NO	NO	NO						NO
5. Waste	**48,20**	**3029,75**	**233,66**						**3311,60**
A. Solid waste disposal	NO,NA	2967,77							2967,77
B. Biological treatment of solid waste		30,60	20,03						50,63
C. Incineration and open burning of waste	48,20	0,01	0,95						49,16
D. Waste water treatment and discharge		31,37	212,68						244,05
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	6788,09	1,37	103,05						6892,51
Aviation	1879,19	0,52	27,27						1906,98
Navigation	4908,90	0,85	75,78						4985,52
Multilateral operations	0,32	0,00	0,00						0,32
CO_2 emissions from biomass	18386,39								18386,39
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,71**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									69960,40
Total CO_2 equivalent emissions with land use, land-use change and forestry									33068,42
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**15077,78**	**7521,16**	**7053,21**	**631,37**	**372,93**	**118,78**	**NA**	**NA**	**30775,23**
1. Energy	**48919,92**	**558,88**	**631,94**						**50110,74**
A. Fuel combustion (sectoral approach)	48563,52	447,41	631,46						49642,39
1. Energy industries	8781,49	24,25	146,60						8952,33
2. Manufacturing industries and construction	11754,19	49,75	200,10						12004,04
3. Transport	19509,95	90,50	154,03						19754,48
4. Other sectors	8123,71	282,67	124,85						8531,24
5. Other	394,18	0,24	5,88						400,30
B. Fugitive emissions from fuels	356,40	111,47	0,48						468,35
1. Solid fuels	5,52	0,00	0,00						5,53
2. Oil and natural gas	350,89	111,47	0,47						462,83
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5603,12**	**9,41**	**830,25**	**631,37**	**372,93**	**118,78**	**NA**	**NA**	**7565,86**
A. Mineral industry	1768,89								1768,89
B. Chemical industry	122,48	0,75	631,72	NA	NA	NA	NA	NA	754,95
C. Metal industry	3315,45	0,90	NA	NO	363,16	50,16			3729,67
D. Non-energy products from fuels and solvent use	383,04	NA	NA						383,04
E. Electronic Industry				0,22	8,21	1,57			10,01
F. Product uses as ODS substitutes				631,15	1,56				632,70
G. Other product manufacture and use	NE,NA	NA	117,41		NO	67,05			184,46
H. Other	13,26	7,75	81,12						102,14
3. Agriculture	**159,68**	**3545,77**	**4099,30**						**7804,74**
A. Enteric fermentation		3308,01							3308,01
B. Manure management		237,76	345,21						582,97
C. Rice cultivation		NO							NO
D. Agricultural soils			3754,09						3754,09
E. Prescribed burning of savannas									
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)	**-39649,38**	**469,69**	**1257,24**						**-37922,44**
A. Forest land	-43208,45	240,10	1086,47						-41881,87
B. Cropland	7356,23	213,80	7,55						7577,58
C. Grassland	33,95	7,39	37,51						78,85
D. Wetlands	141,21	8,40	1,46						151,07
E. Settlements	3908,50	IE	121,23						4029,73
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-7880,82								-7880,82
H. Other	NO	NO	NO						NO
5. Waste	**44,44**	**2937,42**	**234,48**						**3216,33**
A. Solid waste disposal	NO,NA	2874,35							2874,35
B. Biological treatment of solid waste		32,20	20,74						52,95
C. Incineration and open burning of waste	44,44	0,01	0,92						45,36
D. Waste water treatment and discharge		30,86	212,82						243,67
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	6696,74	1,28	101,13						6799,15
Aviation	1926,23	0,45	27,99						1954,67
Navigation	4770,51	0,83	73,14						4844,48
Multilateral operations	0,32	0,00	0,00						0,32
CO_2 emissions from biomass	17018,10								17018,10
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,68**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									68697,67
Total CO_2 equivalent emissions with land use, land-use change and forestry									30775,23
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**10918,74**	**7452,71**	**6420,23**	**683,19**	**365,69**	**122,78**	**NA**	**NA**	**25963,33**
1. Energy	**49748,29**	**563,41**	**657,15**						**50968,86**
A. Fuel combustion (sectoral approach)	49423,09	446,61	656,70						50526,40
1. Energy industries	10294,62	29,40	170,33						10494,35
2. Manufacturing industries and construction	11844,43	64,26	226,20						12134,89
3. Transport	19682,63	83,36	141,05						19907,04
4. Other sectors	7330,62	269,44	115,13						7715,19
5. Other	270,80	0,15	3,99						274,94
B. Fugitive emissions from fuels	325,20	116,80	0,45						442,46
1. Solid fuels	5,91	0,00	0,00						5,92
2. Oil and natural gas	319,29	116,80	0,45						436,54
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5750,74**	**9,64**	**670,99**	**683,19**	**365,69**	**122,78**	**NA**	**NA**	**7603,02**
A. Mineral industry	1816,97								1816,97
B. Chemical industry	121,26	0,99	477,06	NA	NA	NA	NA	NA	599,31
C. Metal industry	3389,87	1,00	NA	NO	355,16	52,94			3798,96
D. Non-energy products from fuels and solvent use	409,71	NA	NA						409,71
E. Electronic Industry				0,39	9,19	2,71			12,29
F. Product uses as ODS substitutes				682,80	1,34				684,14
G. Other product manufacture and use	NE,NA	NA	113,84		NO	67,12			180,96
H. Other	12,93	7,66	80,09						100,68
3. Agriculture	**139,96**	**3523,51**	**3596,83**						**7260,30**
A. Enteric fermentation		3273,54							3273,54
B. Manure management		249,97	344,53						594,50
C. Rice cultivation		NO							NO
D. Agricultural soils			3252,30						3252,30
E. Prescribed burning of savannas									
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)	**-44767,73**	**470,26**	**1262,23**						**-43035,24**
A. Forest land	-44651,73	240,75	1086,39						-43324,59
B. Cropland	3124,04	213,72	8,00						3345,76
C. Grassland	38,56	7,32	36,57						82,44
D. Wetlands	146,41	8,48	1,48						156,37
E. Settlements	3364,03	IE	127,46						3491,48
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-6789,03								-6789,03
H. Other	NO	NO	NO						NO
5. Waste	**47,47**	**2885,88**	**233,02**						**3166,38**
A. Solid waste disposal	NO,NA	2822,15							2822,15
B. Biological treatment of solid waste		33,38	21,15						54,53
C. Incineration and open burning of waste	47,47	0,01	1,02						48,50
D. Waste water treatment and discharge		30,35	210,85						241,19
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	6525,44	1,21	98,19						6624,84
Aviation	1870,75	0,39	27,15						1898,30
Navigation	4654,69	0,82	71,04						4726,55
Multilateral operations	0,79	0,00	0,01						0,80
CO_2 emissions from biomass	20111,08								20111,08
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			1,43						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									68998,56
Total CO_2 equivalent emissions with land use, land-use change and forestry									25963,33
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**14232,76**	**7207,61**	**6567,46**	**743,11**	**403,93**	**119,60**	**NA**	**NA**	**29274,46**
1. Energy	**50566,23**	**553,98**	**643,42**						**51763,63**
A. Fuel combustion (sectoral approach)	50261,40	443,75	643,00						51348,15
1. Energy industries	11232,15	32,67	182,26						11447,08
2. Manufacturing industries and construction	11711,38	56,25	210,00						11977,64
3. Transport	20129,44	77,30	131,99						20338,73
4. Other sectors	6869,08	277,36	114,09						7260,53
5. Other	319,35	0,16	4,66						324,17
B. Fugitive emissions from fuels	304,84	110,23	0,42						415,48
1. Solid fuels	6,11	0,00	0,00						6,12
2. Oil and natural gas	298,72	110,23	0,41						409,36
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5878,98**	**9,59**	**641,05**	**743,11**	**403,93**	**119,60**	**NA**	**NA**	**7796,25**
A. Mineral industry	1832,48								1832,48
B. Chemical industry	118,16	0,98	439,68	NA	NA	NA	NA	NA	558,81
C. Metal industry	3504,20	1,01	NA	NO	387,30	62,84			3955,35
D. Non-energy products from fuels and solvent use	413,61	NA	NA						413,61
E. Electronic Industry				0,46	14,73	1,81			16,99
F. Product uses as ODS substitutes				742,65	1,90				744,55
G. Other product manufacture and use	NE,NA	NA	122,22		NO	54,96			177,17
H. Other	10,54	7,59	79,16						97,29
3. Agriculture	**133,31**	**3471,57**	**3788,38**						**7393,26**
A. Enteric fermentation		3223,40							3223,40
B. Manure management		248,17	346,73						594,91
C. Rice cultivation		NO							NO
D. Agricultural soils			3441,65						3441,65
E. Prescribed burning of savannas									
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)	**-42406,49**	**472,33**	**1262,20**						**-40671,95**
A. Forest land	-43278,86	243,11	1085,18						-41950,57
B. Cropland	5145,61	213,30	8,21						5367,12
C. Grassland	84,35	7,69	31,37						123,42
D. Wetlands	148,80	8,24	1,43						158,47
E. Settlements	2990,68	IE	134,22						3124,90
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-7497,07								-7497,07
H. Other	NO	NO	NO						NO
5. Waste	**60,73**	**2700,14**	**232,41**						**2993,27**
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		29,84	209,77						239,61
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	5715,02	1,02	86,60						5802,65
Aviation	1611,07	0,31	23,73						1635,12
Navigation	4103,95	0,71	62,87						4167,53
Multilateral operations	1,12	0,00	0,01						1,13
CO_2 emissions from biomass	19757,87								19757,87
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**0,98**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									69946,42
Total CO_2 equivalent emissions with land use, land-use change and forestry									29274,46
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**17752,35**	**7011,27**	**6657,72**	**790,72**	**401,03**	**85,13**	**NA**	**NA**	**32698,22**
1. Energy	**51501,99**	**551,93**	**646,93**						**52700,85**
A. Fuel combustion (sectoral approach)	51180,58	455,47	646,47						52282,52
1. Energy industries	12354,38	35,55	194,20						12584,13
2. Manufacturing industries and construction	11526,26	52,19	199,40						11777,85
3. Transport	20394,93	71,64	126,84						20593,41
4. Other sectors	6605,05	295,95	121,74						7022,74
5. Other	299,96	0,14	4,30						304,40
B. Fugitive emissions from fuels	321,41	96,46	0,46						418,33
1. Solid fuels	5,00	0,00	0,00						5,00
2. Oil and natural gas	316,41	96,46	0,46						413,33
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5544,79**	**9,89**	**643,59**	**790,72**	**401,03**	**85,13**	**NA**	**NA**	**7475,14**
A. Mineral industry	1743,32								1743,32
B. Chemical industry	127,01	0,98	428,48	NA	NA	NA	NA	NA	556,47
C. Metal industry	3257,35	0,83	NA	NO	388,77	33,45			3680,40
D. Non-energy products from fuels and solvent use	407,32	NA	NA						407,32
E. Electronic Industry				0,20	9,92	2,02			12,13
F. Product uses as ODS substitutes				790,53	2,34				792,87
G. Other product manufacture and use	NE,NA	NA	131,10		NO	49,66			180,76
H. Other	9,80	8,07	84,01						101,88
3. Agriculture	**129,93**	**3428,24**	**3841,58**						**7399,75**
A. Enteric fermentation		3173,16							3173,16
B. Manure management		255,09	345,51						600,59
C. Rice cultivation		NO							NO
D. Agricultural soils			3496,07						3496,07
E. Prescribed burning of savannas									
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)	**-39469,10**	**472,63**	**1290,70**						**-37705,77**
A. Forest land	-41575,79	244,40	1087,00						-40244,40
B. Cropland	5946,44	212,83	8,21						6167,48
C. Grassland	332,37	7,80	51,98						392,16
D. Wetlands	144,94	7,59	1,32						153,85
E. Settlements	3776,61	IE	140,05						3916,66
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-8093,66								-8093,66
H. Other	NO	NO	NO						NO
5. Waste	**44,75**	**2548,58**	**234,91**						**2828,24**
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	44,75	0,02	3,53						48,30
D. Waste water treatment and discharge		29,33	210,41						239,74
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	7086,67	1,26	107,17						7195,09
Aviation	1566,27	0,29	23,01						1589,57
Navigation	5520,40	0,97	84,16						5605,53
Multilateral operations	1,03	0,00	0,01						1,04
CO_2 emissions from biomass	20800,60								20800,60
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,17**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									70403,99
Total CO_2 equivalent emissions with land use, land-use change and forestry									32698,22
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**18046,76**	**7042,40**	**6350,13**	**856,75**	**397,43**	**94,69**	**NA**	**NA**	**32788,17**
1. Energy	**50327,92**	**562,34**	**655,54**						**51545,80**
A. Fuel combustion (sectoral approach)	50016,86	453,42	655,08						51125,35
1. Energy industries	11449,51	35,34	219,68						11704,54
2. Manufacturing industries and construction	11241,43	52,06	192,86						11486,36
3. Transport	20722,32	67,16	120,68						20910,16
4. Other sectors	6324,81	298,72	117,99						6741,51
5. Other	278,79	0,13	3,87						282,79
B. Fugitive emissions from fuels	311,06	108,93	0,46						420,45
1. Solid fuels	7,30	0,00	0,00						7,31
2. Oil and natural gas	303,75	108,92	0,46						413,13
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5931,22**	**9,85**	**650,08**	**856,75**	**397,43**	**94,69**	**NA**	**NA**	**7940,03**
A. Mineral industry	1822,21								1822,21
B. Chemical industry	124,72	1,01	427,10	NA	NA	NA	NA	NA	552,83
C. Metal industry	3500,97	0,91	NA	NO	390,97	38,58			3931,42
D. Non-energy products from fuels and solvent use	473,29	NA	NA						473,29
E. Electronic Industry				0,07	3,92	1,04			5,03
F. Product uses as ODS substitutes				856,68	2,54				859,23
G. Other product manufacture and use	NE,NA	NA	140,52		NO	55,07			195,59
H. Other	10,04	7,93	82,46						100,42
3. Agriculture	**123,23**	**3475,28**	**3492,65**						**7091,16**
A. Enteric fermentation		3219,98							3219,98
B. Manure management		255,31	347,09						602,40
C. Rice cultivation		NO							NO
D. Agricultural soils			3145,55						3145,55
E. Prescribed burning of savannas									
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)	**-38387,52**	**473,13**	**1317,54**						**-36596,84**
A. Forest land	-37241,94	246,77	1103,95						-35891,22
B. Cropland	2351,17	212,52	8,63						2572,32
C. Grassland	354,77	7,39	52,46						414,62
D. Wetlands	133,50	6,46	1,12						141,08
E. Settlements	4411,76	IE	148,97						4560,73
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-8396,78								-8396,78
H. Other	NO	NO	NO						NO
5. Waste	**51,91**	**2521,79**	**234,32**						**2808,02**
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	51,91	0,03	3,94						55,87
D. Waste water treatment and discharge		28,81	210,79						239,60
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	8274,01	1,48	123,82						8399,32
Aviation	1771,00	0,33	25,48						1796,81
Navigation	6503,01	1,15	98,34						6602,50
Multilateral operations	1,54	0,00	0,02						1,56
CO_2 emissions from biomass	21065,07								21065,07
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			1,46						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									
Total CO_2 equivalent emissions with land use, land-use change and forestry									32788,17
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**17380,78**	**6870,62**	**6409,12**	**880,32**	**403,09**	**151,59**	**NA**	**NA**	**32095,52**
1. Energy	**47989,72**	**565,12**	**648,21**						**49203,04**
A. Fuel combustion (sectoral approach)	47674,02	465,30	647,78						48787,09
1. Energy industries	10575,06	38,87	225,97						10839,89
2. Manufacturing industries and construction	10724,83	51,04	185,93						10961,80
3. Transport	20889,60	64,05	119,51						21073,17
4. Other sectors	5261,17	311,23	113,36						5685,76
5. Other	223,36	0,11	3,01						226,48
B. Fugitive emissions from fuels	315,70	99,82	0,43						415,95
1. Solid fuels	5,39	0,00	0,00						5,40
2. Oil and natural gas	310,31	99,82	0,43						410,55
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5795,80**	**9,36**	**644,82**	**880,32**	**403,09**	**151,59**	**NA**	**NA**	**7884,98**
A. Mineral industry	1946,03								1946,03
B. Chemical industry	133,79	0,84	431,40	NA	NA	NA	NA	NA	566,04
C. Metal industry	3241,92	0,61	NA	NO	400,86	95,26			3738,64
D. Non-energy products from fuels and solvent use	462,97	NA	NA						462,97
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				880,32	2,23				882,55
G. Other product manufacture and use	NE,NA	NA	131,18		NO	56,33			187,51
H. Other	11,09	7,91	82,24						101,24
3. Agriculture	**116,50**	**3451,59**	**3528,48**						**7096,57**
A. Enteric fermentation		3186,95							3186,95
B. Manure management		264,65	344,61						609,26
C. Rice cultivation		NO							NO
D. Agricultural soils			3183,87						3183,87
E. Prescribed burning of savannas									
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)	**-36573,43**	**476,27**	**1337,19**						**-34759,97**
A. Forest land	-33540,28	247,93	1120,08						-32172,26
B. Cropland	4184,23	212,54	9,07						4405,84
C. Grassland	266,78	7,48	49,72						323,99
D. Wetlands	161,49	8,32	1,45						171,25
E. Settlements	3133,81	IE	153,28						3287,09
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-10779,46								-10779,46
H. Other	NO	NO	NO						NO
5. Waste	**52,20**	**2368,27**	**250,43**						**2670,90**
A. Solid waste disposal	NO,NA	2288,83							2288,83
B. Biological treatment of solid waste		51,14	32,89						84,03
C. Incineration and open burning of waste	52,20	0,02	4,91						57,13
D. Waste water treatment and discharge		28,27	212,63						240,90
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	8566,17	1,53	129,18						8696,88
Aviation	1926,52	0,35	27,67						1954,54
Navigation	6639,65	1,18	101,51						6742,34
Multilateral operations	14,16	0,00	0,20						14,36
CO_2 emissions from biomass	22715,95								22715,95
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**2,17**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									66855,49
Total CO_2 equivalent emissions with land use, land-use change and forestry									32095,52
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**12634,08**	**6760,61**	**6667,84**	**913,25**	**389,19**	**112,64**	**NA**	**NA**	**27477,61**
1. Energy	**47861,02**	**549,03**	**658,51**						**49068,56**
A. Fuel combustion (sectoral approach)	47009,20	452,87	657,26						48119,33
1. Energy industries	10601,67	42,21	231,14						10875,03
2. Manufacturing industries and construction	10781,07	57,79	202,98						11041,84
3. Transport	20753,22	60,30	116,01						20929,54
4. Other sectors	4631,61	292,45	103,68						5027,75
5. Other	241,62	0,11	3,44						245,17
B. Fugitive emissions from fuels	851,83	96,16	1,25						949,24
1. Solid fuels	5,14	0,00	0,00						5,15
2. Oil and natural gas	846,68	96,16	1,25						944,09
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5788,24**	**9,40**	**657,22**	**913,25**	**389,19**	**112,64**	**NA**	**NA**	**7869,93**
A. Mineral industry	2024,15								2024,15
B. Chemical industry	137,69	1,02	448,04	NA	NA	NA	NA	NA	586,75
C. Metal industry	3180,22	0,40	NA	NO	382,05	73,40			3636,07
D. Non-energy products from fuels and solvent use	434,29	NA	NA						434,29
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				913,25	2,28				915,53
G. Other product manufacture and use	NE,NA	NA	126,20		4,86	39,24			170,30
H. Other	11,89	7,97	82,97						102,84
3. Agriculture	**89,61**	**3431,30**	**3731,18**						**7252,10**
A. Enteric fermentation		3171,34							3171,34
B. Manure management		259,95	339,19						599,14
C. Rice cultivation		NO							NO
D. Agricultural soils			3392,00						3392,00
E. Prescribed burning of savannas									
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)	**-41153,70**	**488,13**	**1370,55**						**-39295,02**
A. Forest land	-39505,20	263,29	1151,25						-38090,66
B. Cropland	6232,58	211,99	9,79						6454,36
C. Grassland	491,58	7,84	47,60						547,02
D. Wetlands	124,28	5,01	0,87						130,16
E. Settlements	3389,29	IE	157,06						3546,35
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-11886,24								-11886,24
H. Other	NO	NO	NO						NO
5. Waste	**48,90**	**2282,76**	**250,37**						**2582,04**
A. Solid waste disposal	NO,NA	2198,45							2198,45
B. Biological treatment of solid waste		56,59	32,35						88,94
C. Incineration and open burning of waste	48,90	0,02	4,03						52,96
D. Waste water treatment and discharge		27,70	213,99						241,69
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	9135,94	1,69	137,64						9275,27
Aviation	1996,37	0,42	28,74						2025,53
Navigation	7139,58	1,27	108,90						7249,75
Multilateral operations	15,83	0,00	0,24						16,07
CO_2 emissions from biomass	24086,77								24086,77
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**2,32**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									66772,63
Total CO_2 equivalent emissions with land use, land-use change and forestry									27477,61
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**9411,39**	**6503,81**	**6136,55**	**937,99**	**397,54**	**137,38**	**NA**	**NA**	**23524,66**
1. Energy	**46845,01**	**547,16**	**649,57**						**48041,73**
A. Fuel combustion (sectoral approach)	45957,09	450,37	648,34						47055,80
1. Energy industries	10063,73	41,91	239,01						10344,64
2. Manufacturing industries and construction	10255,54	55,25	186,30						10497,09
3. Transport	21006,43	54,75	112,37						21173,55
4. Other sectors	4382,92	298,37	107,42						4788,71
5. Other	248,48	0,09	3,24						251,81
B. Fugitive emissions from fuels	887,92	96,79	1,23						985,93
1. Solid fuels	4,59	0,00	0,00						4,59
2. Oil and natural gas	883,33	96,78	1,22						981,33
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5893,80**	**9,34**	**435,87**	**937,99**	**397,54**	**137,38**	**NA**	**NA**	**7811,92**
A. Mineral industry	1972,47								1972,47
B. Chemical industry	136,10	1,00	242,46	NA	NA	NA	NA	NA	379,56
C. Metal industry	3336,09	0,37	NA	NO	385,55	107,96			3829,98
D. Non-energy products from fuels and solvent use	437,46	NA	NA						437,46
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				937,99	2,27				940,26
G. Other product manufacture and use	NE,NA	NA	110,48		9,71	29,42			149,61
H. Other	11,68	7,97	82,93						102,58
3. Agriculture	**115,58**	**3366,49**	**3387,08**						**6869,15**
A. Enteric fermentation		3108,70							3108,70
B. Manure management		257,79	340,84						598,63
C. Rice cultivation		NO							NO
D. Agricultural soils			3046,24						3046,24
E. Prescribed burning of savannas									
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)	**-43497,20**	**483,77**	**1411,28**						**-41602,16**
A. Forest land	-38866,28	256,06	1184,65						-37425,56
B. Cropland	1715,04	211,69	10,27						1937,00
C. Grassland	526,35	7,69	45,81						579,85
D. Wetlands	169,75	8,32	1,45						179,52
E. Settlements	4440,69	IE	163,87						4604,56
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-11482,76								-11482,76
H. Other	NO	NO	NO						NO
5. Waste	**54,21**	**2097,06**	**252,75**						**2404,01**
A. Solid waste disposal	NO,NA	2001,90							2001,90
B. Biological treatment of solid waste		66,66	36,85						103,52
C. Incineration and open burning of waste	54,21	0,03	4,09						58,32
D. Waste water treatment and discharge		28,47	211,80						240,27
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	9544,70	1,71	142,22						9688,63
Aviation	2187,09	0,40	30,25						2217,74
Navigation	7357,62	1,31	111,96						7470,89
Multilateral operations	11,70	0,00	0,16						11,86
CO_2 emissions from biomass	24631,00								24631,00
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**3,26**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									65126,81
Total CO_2 equivalent emissions with land use, land-use change and forestry									23524,66
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**7472,18**	**6283,78**	**6292,47**	**968,04**	**347,85**	**72,85**	**NA**	**NA**	**21437,18**
1. Energy	**44948,90**	**540,64**	**654,89**						**46144,43**
A. Fuel combustion (sectoral approach)	44056,10	454,30	653,52						45163,92
1. Energy industries	9974,01	44,86	247,13						10265,99
2. Manufacturing industries and construction	9604,46	55,39	183,82						9843,67
3. Transport	20494,00	52,01	115,03						20661,04
4. Other sectors	3831,37	301,98	105,55						4238,90
5. Other	152,27	0,06	1,99						154,32
B. Fugitive emissions from fuels	892,80	86,33	1,38						980,51
1. Solid fuels	4,45	0,00	0,00						4,45
2. Oil and natural gas	888,35	86,33	1,37						976,05
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5713,90**	**8,83**	**463,87**	**968,04**	**347,85**	**72,85**	**NA**	**NA**	**7575,34**
A. Mineral industry	1995,47								1995,47
B. Chemical industry	141,77	0,88	265,24	NA	NA	NA	NA	NA	407,89
C. Metal industry	3101,96	0,22	NA	NO	335,83	45,63			3483,63
D. Non-energy products from fuels and solvent use	461,91	NA	NA						461,91
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				968,04	2,31				970,35
G. Other product manufacture and use	NE,NA	NA	118,27		9,71	27,22			155,21
H. Other	12,80	7,73	80,36						100,88
3. Agriculture	**104,59**	**3374,51**	**3489,26**						**6968,36**
A. Enteric fermentation		3120,90							3120,90
B. Manure management		253,62	339,09						592,71
C. Rice cultivation		NO							NO
D. Agricultural soils			3150,17						3150,17
E. Prescribed burning of savannas									
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)	**-43351,73**	**499,37**	**1427,95**						**-41424,41**
A. Forest land	-41250,25	273,11	1215,24						-39761,90
B. Cropland	2323,97	211,18	10,30						2545,46
C. Grassland	561,39	7,68	38,50						607,57
D. Wetlands	161,81	7,40	1,29						170,50
E. Settlements	4041,57	IE	155,96						4197,53
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-9190,23								-9190,23
H. Other	NO	NO	NO						NO
5. Waste	**56,53**	**1860,43**	**256,50**						**2173,46**
A. Solid waste disposal	NO,NA	1756,10							1756,10
B. Biological treatment of solid waste		76,14	40,67						116,81
C. Incineration and open burning of waste	56,53	0,03	5,32						61,87
D. Waste water treatment and discharge		28,17	210,51						238,67
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	9443,94	1,86	139,16						9584,96
Aviation	2452,92	0,61	33,08						2486,60
Navigation	6991,02	1,25	106,08						7098,35
Multilateral operations	7,51	0,00	0,10						7,61
CO_2 emissions from biomass	26329,87								26329,87
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**4,19**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									62861,59
Total CO_2 equivalent emissions with land use, land-use change and forestry									21437,18
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**1867,23**	**6112,69**	**6110,98**	**973,20**	**46,66**	**70,01**	**NA**	**NA**	**15180,76**
1. Energy	**43018,29**	**547,44**	**665,02**						**44230,75**
A. Fuel combustion (sectoral approach)	42105,75	466,19	663,74						43235,68
1. Energy industries	10346,21	49,93	260,56						10656,70
2. Manufacturing industries and construction	7876,06	54,88	175,93						8106,87
3. Transport	20105,33	49,61	116,20						20271,13
4. Other sectors	3537,34	311,69	107,72						3956,75
5. Other	240,82	0,08	3,33						244,23
B. Fugitive emissions from fuels	912,54	81,24	1,28						995,07
1. Solid fuels	14,54	0,01	0,01						14,56
2. Oil and natural gas	898,00	81,24	1,27						980,51
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**4052,62**	**8,43**	**481,88**	**973,20**	**46,66**	**70,01**	**NA**	**NA**	**5632,80**
A. Mineral industry	1699,26								1699,26
B. Chemical industry	124,38	0,84	299,96	NA	NA	NA	NA	NA	425,18
C. Metal industry	1802,36	0,13	NA	NO	39,45	27,87			1869,81
D. Non-energy products from fuels and solvent use	417,02	NA	NA						417,02
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				973,20	2,35				975,55
G. Other product manufacture and use	NE,NA	NA	104,30		4,86	42,14			151,30
H. Other	9,60	7,46	77,63						94,69
3. Agriculture	**114,54**	**3320,97**	**3280,27**						**6715,78**
A. Enteric fermentation		3070,70							3070,70
B. Manure management		250,27	333,88						584,15
C. Rice cultivation		NO							NO
D. Agricultural soils			2946,39						2946,39
E. Prescribed burning of savannas									
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)	**-45376,66**	**489,77**	**1423,48**						**-43463,40**
A. Forest land	-44954,83	264,68	1237,79						-43452,37
B. Cropland	1520,37	210,03	10,49						1740,89
C. Grassland	553,64	8,20	13,07						574,90
D. Wetlands	158,10	6,88	1,20						166,17
E. Settlements	4578,46	IE	154,74						4733,20
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-7232,39								-7232,39
H. Other	NO	NO	NO						NO
5. Waste	**58,44**	**1746,09**	**260,32**						**2064,84**
A. Solid waste disposal	NO,NA	1633,43							1633,43
B. Biological treatment of solid waste		85,83	45,09						130,92
C. Incineration and open burning of waste	58,44	0,02	4,95						63,41
D. Waste water treatment and discharge		26,81	210,28						237,09
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	9363,50	1,84	138,57						9503,90
Aviation	2082,50	0,52	28,36						2111,39
Navigation	7280,99	1,32	110,21						7392,51
Multilateral operations	8,71	0,00	0,12						8,83
CO_2 emissions from biomass	27757,90								27757,90
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**3,90**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									58644,16
Total CO_2 equivalent emissions with land use, land-use change and forestry									15180,76
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**3031,31**	**5998,31**	**6283,83**	**950,24**	**186,81**	**62,91**	**NA**	**NA**	**16513,40**
1. Energy	**47060,28**	**550,38**	**707,28**						**48317,94**
A. Fuel combustion (sectoral approach)	46189,51	474,34	705,86						47369,71
1. Energy industries	12789,74	55,92	285,40						13131,06
2. Manufacturing industries and construction	9201,51	58,57	188,30						9448,38
3. Transport	20275,98	49,57	122,94						20448,49
4. Other sectors	3748,51	310,21	106,90						4165,63
5. Other	173,76	0,06	2,33						176,15
B. Fugitive emissions from fuels	870,78	76,04	1,42						948,23
1. Solid fuels	5,01	0,00	0,00						5,01
2. Oil and natural gas	865,77	76,03	1,41						943,22
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5783,83**	**8,68**	**506,48**	**950,24**	**186,81**	**62,91**	**NA**	**NA**	**7498,95**
A. Mineral industry	1902,32								1902,32
B. Chemical industry	147,58	0,84	306,61	NA	NA	NA	NA	NA	455,02
C. Metal industry	3269,84	0,21	NA	NO	184,38	32,69			3487,12
D. Non-energy products from fuels and solvent use	451,71	NA	NA						451,71
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				950,24	2,43				952,67
G. Other product manufacture and use	NE,NA	NA	120,41		NO	30,22			150,63
H. Other	12,39	7,63	79,47						99,49
3. Agriculture	**123,80**	**3322,55**	**3353,63**						**6799,98**
A. Enteric fermentation		3072,31							3072,31
B. Manure management		250,24	335,54						585,78
C. Rice cultivation		NO							NO
D. Agricultural soils			3018,09						3018,09
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	123,06								123,06
H. Urea application	0,73								0,73
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry(1)	**-49992,87**	**490,59**	**1460,88**						**-48041,40**
A. Forest land	-47706,44	267,73	1276,09						-46162,62
B. Cropland	788,11	208,74	10,74						1007,59
C. Grassland	801,18	7,99	16,25						825,42
D. Wetlands	151,71	6,13	1,07						158,91
E. Settlements	4148,59	IE	147,85						4296,44
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-8176,02								-8176,02
H. Other	NO	NO	NO						NO
5. Waste	**56,27**	**1626,11**	**255,56**						**1937,93**
A. Solid waste disposal	NO,NA	1526,34							1526,34
B. Biological treatment of solid waste		73,16	40,50						113,66
C. Incineration and open burning of waste	56,27	0,02	4,50						60,79
D. Waste water treatment and discharge		26,58	210,56						237,14
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	8815,57	1,70	131,98						8949,24
Aviation	2105,18	0,51	29,02						2134,71
Navigation	6710,38	1,19	102,96						6814,53
Multilateral operations	8,53	0,00	0,12						8,65
CO_2 emissions from biomass	30071,41								30071,41
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**5,62**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									64554,80
Total CO_2 equivalent emissions with land use, land-use change and forestry									16513,40
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**6053,49**	**5874,10**	**6346,85**	**915,23**	**215,25**	**54,77**	**NA**	**NA**	**19459,69**
1. Energy	**43295,77**	**542,38**	**657,06**						**44495,21**
A. Fuel combustion (sectoral approach)	42426,16	469,11	656,15						43551,42
1. Energy industries	10472,64	46,61	250,43						10769,68
2. Manufacturing industries and construction	8560,78	55,71	172,27						8788,76
3. Transport	19863,02	47,52	123,97						20034,51
4. Other sectors	3345,97	319,20	106,99						3772,17
5. Other	183,75	0,06	2,49						186,30
B. Fugitive emissions from fuels	869,61	73,27	0,91						943,79
1. Solid fuels	5,85	0,00	0,00						5,86
2. Oil and natural gas	863,76	73,27	0,91						937,94
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5617,81**	**8,50**	**218,81**	**915,23**	**215,25**	**54,77**	**NA**	**NA**	**7030,37**
A. Mineral industry	1937,89								1937,89
B. Chemical industry	151,03	0,83	46,77	NA	NA	NA	NA	NA	198,63
C. Metal industry	3100,92	0,21	NA	NO	212,76	25,05			3338,95
D. Non-energy products from fuels and solvent use	417,49	NA	NA						417,49
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				915,23	2,49				917,72
G. Other product manufacture and use	NE,NA	NA	94,49		NO	29,71			124,20
H. Other	10,48	7,45	77,56						95,49
3. Agriculture	**123,86**	**3294,81**	**3752,71**						**7171,39**
A. Enteric fermentation		3043,33							3043,33
B. Manure management		251,48	332,92						584,40
C. Rice cultivation		NO							NO
D. Agricultural soils			3419,79						3419,79
E. Prescribed burning of savannas									
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)	**-43043,64**	**494,28**	**1454,05**						**-41095,30**
A. Forest land	-47501,69	272,22	1271,78						-45957,69
B. Cropland	6179,37	207,09	10,26						6396,71
C. Grassland	152,55	8,21	15,99						176,75
D. Wetlands	163,81	6,76	1,18						171,74
E. Settlements	4289,01	IE	148,73						4437,74
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-6326,68								-6326,68
H. Other	NO	NO	NO						NO
5. Waste	**59,68**	**1534,13**	**264,21**						**1858,02**
A. Solid waste disposal	NO,NA	1419,76							1419,76
B. Biological treatment of solid waste		87,05	49,36						136,41
C. Incineration and open burning of waste	59,68	0,02	5,50						65,20
D. Waste water treatment and discharge		27,30	209,35						236,65
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	8146,97	1,61	122,07						8270,65
Aviation	2268,53	0,58	31,25						2300,36
Navigation	5878,44	1,03	90,82						5970,29
Multilateral operations	8,67	0,00	0,12						8,80
CO_2 emissions from biomass	28077,76								28077,76
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**3,71**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									60554,99
Total CO_2 equivalent emissions with land use, land-use change and forestry									19459,69
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**-2243,32**	**5702,61**	**5890,28**	**869,97**	**79,11**	**52,34**	**NA**	**NA**	**10350,98**
1. Energy	**40895,65**	**535,15**	**653,01**						**42083,81**
A. Fuel combustion (sectoral approach)	40030,59	454,29	652,50						41137,38
1. Energy industries	10091,11	47,94	243,25						10382,30
2. Manufacturing industries and construction	8005,93	55,52	170,71						8232,16
3. Transport	18669,07	42,95	131,19						18843,21
4. Other sectors	3100,70	307,83	105,08						3513,61
5. Other	163,78	0,05	2,26						166,09
B. Fugitive emissions from fuels	865,07	80,85	0,52						946,44
1. Solid fuels	8,65	0,00	0,01						8,66
2. Oil and natural gas	856,41	80,85	0,51						937,78
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5424,89**	**9,11**	**244,40**	**869,97**	**79,11**	**52,34**	**NA**	**NA**	**6679,81**
A. Mineral industry	2004,56								2004,56
B. Chemical industry	153,67	0,84	71,11	NA	NA	NA	NA	NA	225,62
C. Metal industry	2772,52	0,48	NA	0,27	76,93	24,44			2874,64
D. Non-energy products from fuels and solvent use	482,88	NA	NA						482,88
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				869,70	2,19				871,88
G. Other product manufacture and use	NE,NA	NA	92,31		NO	27,89			120,20
H. Other	11,26	7,78	80,99						100,03
3. Agriculture	**142,12**	**3259,16**	**3278,47**						**6679,75**
A. Enteric fermentation		3012,03							3012,03
B. Manure management		247,13	329,17						576,31
C. Rice cultivation		NO							NO
D. Agricultural soils			2949,29						2949,29
E. Prescribed burning of savannas									
F. Field burning of agricultural residues		NO	NO						NO
G. Liming	141,65								141,65
H. Urea application	0,46								0,46
I. Other carbon-containing fertilizers	NO								NO
J. Other									
4. Land use, land-use change and forestry(1)	**-48765,99**	**493,66**	**1460,59**						**-46811,74**
A. Forest land	-48911,27	272,81	1275,83						-47362,63
B. Cropland	2036,68	205,89	9,34						2251,91
C. Grassland	268,15	7,94	15,76						291,85
D. Wetlands	169,13	7,02	1,22						177,38
E. Settlements	3503,40	IE	153,33						3656,73
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-5832,08								-5832,08
H. Other	NO	NO	NO						NO
5. Waste	**60,01**	**1405,53**	**253,81**						**1719,35**
A. Solid waste disposal	NO,NA	1303,30							1303,30
B. Biological treatment of solid waste		75,02	39,97						114,99
C. Incineration and open burning of waste	60,01	0,03	5,34						65,38
D. Waste water treatment and discharge		27,18	208,50						235,68
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	7932,04	1,56	119,75						8053,35
Aviation	2162,56	0,56	30,10						2193,22
Navigation	5769,47	1,00	89,66						5860,13
Multilateral operations	6,24	0,00	0,08						6,33
CO_2 emissions from biomass	28788,19								28788,19
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**3,20**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									57162,72
Total CO_2 equivalent emissions with land use, land-use change and forestry									10350,98
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**-1782,68**	**5607,77**	**6072,99**	**838,55**	**51,54**	**41,21**	**NA**	**NA**	**10829,38**
1. Energy	**39277,65**	**528,40**	**673,12**						**40479,17**
A. Fuel combustion (sectoral approach)	38561,12	458,01	672,66						39691,79
1. Energy industries	9563,45	48,42	259,85						9871,73
2. Manufacturing industries and construction	7728,05	56,75	170,28						7955,08
3. Transport	18174,96	43,74	136,22						18354,93
4. Other sectors	2945,72	309,04	104,22						3358,98
5. Other	148,94	0,04	2,08						151,07
B. Fugitive emissions from fuels	716,53	70,39	0,46						787,39
1. Solid fuels	3,30	0,00	0,00						3,30
2. Oil and natural gas	713,24	70,39	0,46						784,09
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5400,88**	**8,76**	**212,08**	**838,55**	**51,54**	**41,21**	**NA**	**NA**	**6553,02**
A. Mineral industry	1911,17								1911,17
B. Chemical industry	158,52	0,79	54,50	NA	NA	NA	NA	NA	213,81
C. Metal industry	2824,79	0,21	NA	0,18	49,83	11,19			2886,20
D. Non-energy products from fuels and solvent use	495,56	NA	NA						495,56
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				838,37	1,71				840,08
G. Other product manufacture and use	NE,NA	NA	76,95		NO	30,02			106,97
H. Other	10,85	7,76	80,63						99,23
3. Agriculture	**142,56**	**3276,65**	**3481,11**						**6900,33**
A. Enteric fermentation		3018,43							3018,43
B. Manure management		258,22	340,97						599,19
C. Rice cultivation		NO							NO
D. Agricultural soils			3140,15						3140,15
E. Prescribed burning of savannas									
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)	**-46662,04**	**497,04**	**1456,98**						**-44708,02**
A. Forest land	-49737,09	277,86	1275,59						-48183,64
B. Cropland	4310,43	204,48	9,15						4524,05
C. Grassland	312,06	8,11	17,44						337,61
D. Wetlands	168,42	6,59	1,15						176,15
E. Settlements	3904,37	IE	150,85						4055,22
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-5620,22								-5620,22
H. Other	NO	NO	NO						NO
5. Waste	**58,26**	**1296,92**	**249,69**						**1604,87**
A. Solid waste disposal	NO,NA	1190,79							1190,79
B. Biological treatment of solid waste		78,85	37,80						116,65
C. Incineration and open burning of waste	58,26	0,03	5,05						63,33
D. Waste water treatment and discharge		27,26	206,85						234,11
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	7690,39	1,52	115,95						7807,85
Aviation	2237,32	0,57	30,97						2268,87
Navigation	5453,07	0,94	84,98						5538,98
Multilateral operations	5,28	0,00	0,08						5,36
CO_2 emissions from biomass	29767,48								29767,48
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,68**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									55537,40
Total CO_2 equivalent emissions with land use, land-use change and forestry									10829,38
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**-3933,25**	**5505,51**	**6149,55**	**810,59**	**82,57**	**44,99**	**NA**	**NA**	**8659,96**
1. Energy	**37807,31**	**498,61**	**620,31**						**38926,22**
A. Fuel combustion (sectoral approach)	37115,63	433,31	619,75						38168,69
1. Energy industries	8836,77	42,57	231,82						9111,17
2. Manufacturing industries and construction	7408,85	52,89	157,02						7618,76
3. Transport	17963,98	42,24	142,78						18149,00
4. Other sectors	2742,03	295,56	85,83						3123,42
5. Other	164,00	0,05	2,30						166,34
B. Fugitive emissions from fuels	691,68	65,30	0,56						757,54
1. Solid fuels	7,11	0,00	0,00						7,11
2. Oil and natural gas	684,58	65,30	0,55						750,42
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5266,52**	**8,90**	**229,76**	**810,59**	**82,57**	**44,99**	**NA**	**NA**	**6443,32**
A. Mineral industry	1847,87								1847,87
B. Chemical industry	155,01	0,83	62,36	NA	NA	NA	NA	NA	218,20
C. Metal industry	2767,47	0,19	NA	NO	80,89	15,75			2864,30
D. Non-energy products from fuels and solvent use	485,90	NA	NA						485,90
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				810,59	1,68				812,27
G. Other product manufacture and use	NE,NA	NA	85,47		NO	29,24			114,71
H. Other	10,27	7,88	81,93						100,07
3. Agriculture	**123,33**	**3281,08**	**3571,41**						**6975,81**
A. Enteric fermentation		3023,24							3023,24
B. Manure management		257,84	342,16						600,00
C. Rice cultivation		NO							NO
D. Agricultural soils			3229,25						3229,25
E. Prescribed burning of savannas									
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)	**-47187,91**	**528,49**	**1483,14**						**-45176,28**
A. Forest land	-48685,04	308,98	1296,89						-47079,17
B. Cropland	4003,49	203,03	9,35						4215,87
C. Grassland	232,00	8,73	18,08						258,82
D. Wetlands	186,77	7,74	1,35						195,85
E. Settlements	3550,42	IE	154,83						3705,25
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-6475,55								-6475,55
H. Other	NO	NO	NO						NO
5. Waste	**57,51**	**1188,44**	**244,93**						**1490,88**
A. Solid waste disposal	NA,NO	1080,13							1080,13
B. Biological treatment of solid waste		80,56	33,47						114,03
C. Incineration and open burning of waste	57,51	0,02	5,37						62,90
D. Waste water treatment and discharge		27,73	206,09						233,82
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	8116,25	1,57	123,30						8241,12
Aviation	2265,91	0,57	31,37						2297,85
Navigation	5850,34	1,00	91,93						5943,27
Multilateral operations	5,82	0,00	0,09						5,91
CO_2 emissions from biomass	27690,36								27690,36
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**1,59**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									53836,24
Total CO_2 equivalent emissions with land use, land-use change and forestry									8659,96
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 emissions positive (+).

(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 report for CO_2 equivalent emissions

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)	**-9165,58**	**5374,18**	**6105,51**	**773,11**	**35,84**	**54,28**	**NA**	**NA**	**3177,33**
1. Energy	**37830,33**	**497,52**	**649,11**						**38976,96**
A. Fuel combustion (sectoral approach)	37018,30	434,98	648,41						38101,69
1. Energy industries	8710,74	42,88	243,52						8997,14
2. Manufacturing industries and construction	7435,12	53,98	155,27						7644,37
3. Transport	17975,49	43,33	149,21						18168,04
4. Other sectors	2708,75	294,74	97,70						3101,20
5. Other	188,20	0,05	2,71						190,95
B. Fugitive emissions from fuels	812,03	62,54	0,70						875,27
1. Solid fuels	23,72	0,01	0,02						23,75
2. Oil and natural gas	788,31	62,53	0,69						851,53
C. CO_2 transport and storage	NO								NO
2. Industrial processes and product use	**5335,68**	**8,88**	**208,60**	**773,11**	**35,84**	**54,28**	**NA**	**NA**	**6416,38**
A. Mineral industry	1986,02								1986,02
B. Chemical industry	159,35		40,98	NA	NA	NA	NA	NA	200,33
C. Metal industry	2712,34	0,18	NA	NO	34,20	19,65			2766,38
D. Non-energy products from fuels and solvent use	469,60	NA	NA						469,60
E. Electronic Industry				NO	NO	NO			NO
F. Product uses as ODS substitutes				773,11	1,64				774,74
G. Other product manufacture and use	NE,NA	NA	85,47		NO	34,63			120,10
H. Other	8,37	C	82,15						
3. Agriculture	**124,48**	**3260,81**	**3509,38**						**6894,67**
A. Enteric fermentation		3005,12							3005,12
B. Manure management		255,68	342,88						598,56
C. Rice cultivation		NO							NO
D. Agricultural soils			3166,50						3166,50
E. Prescribed burning of savannas									
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)	**-52511,86**	**501,82**	**1497,02**						**-50513,03**
A. Forest land	-48245,89	283,68	1315,49						-46646,72
B. Cropland	-437,79	201,76	7,91						-228,13
C. Grassland	60,73	8,20	17,81						86,74
D. Wetlands	195,10	8,18	1,42						204,70
E. Settlements	2632,62	IE	150,62						2783,24
F. Other land	NO,NA	NA	NA						NO,NA
G. Harvested wood products	-6716,63								-6716,63
H. Other	NO	NO	NO						NO
5. Waste	**55,80**	**1105,15**	**241,40**						**1402,34**
A. Solid waste disposal	NO,NA	990,95							990,95
B. Biological treatment of solid waste		86,28	29,92						116,20
C. Incineration and open burning of waste	55,80	0,01	5,20						61,01
D. Waste water treatment and discharge		27,91	206,28						234,19
E. Other									
6. Other *(as specified in summary 1.A)*									

Memo items:(2)									
International bunkers	8239,26	1,37	132,18						8372,82
Aviation	2164,40	0,45	30,59						2195,45
Navigation	6074,86	0,92	101,59						6177,37
Multilateral operations	6,63	0,00	0,10						6,74
CO_2 emissions from biomass	29311,40								29311,40
CO_2 captured	NO								NO
Long-term storage of C in waste disposal sites	NE								NE
Indirect N_2O			**2,34**						
Indirect CO_2(3)	**NO**								
Total CO_2 equivalent emissions without land use, land-use change and forestry									53690,36
Total CO_2 equivalent emissions with land use, land-use change and forestry									3177,33
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 emissions positive (+).

(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 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 (see section 1.3). 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.

The national system for 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.

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. Supplemental to the Ordinance on Climate Reporting, formal agreements between the Swedish EPA and the concerned agencies have been signed, detailing the requirements regarding content and timetable from each agency.

Sweden also has legislation which indirectly supports 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 to submit annual data. In addition, government agencies in Sweden must comply by the Information and Secrecy Act[71] (SFS 2009:400).

Institutional arrangements

Preparing the annual inventory and other reports is done in collaboration between the Ministry of the Environment and Energy, the Swedish EPA and other government agencies and consultants. Depending on the role of these agencies in the climate-reporting process, this responsibility may range from supplying data and producing emission factors/calorific values to performing calculations for estimating emissions or conducting a national peer review. Figure A3.1 illustrates the institutional arrangements for the yearly inventory report, as well as for other reporting, to the European Commission and the UNFCCC.

The Ministry of the Environment and Energy 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 coordinating the national system for climate reporting, for maintaining the necessary reporting system and for producing data and drafts for the required reporting and submitting the material to the Government.

Under contract to the Swedish EPA, the consortium SMED[72] processes data and documentation received from the various government agencies, as well as their own data,

71 Read more at http://www.regeringen.se/informationsmaterial/2009/09/public-access-to-information-and-secrecy-act/

72 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)

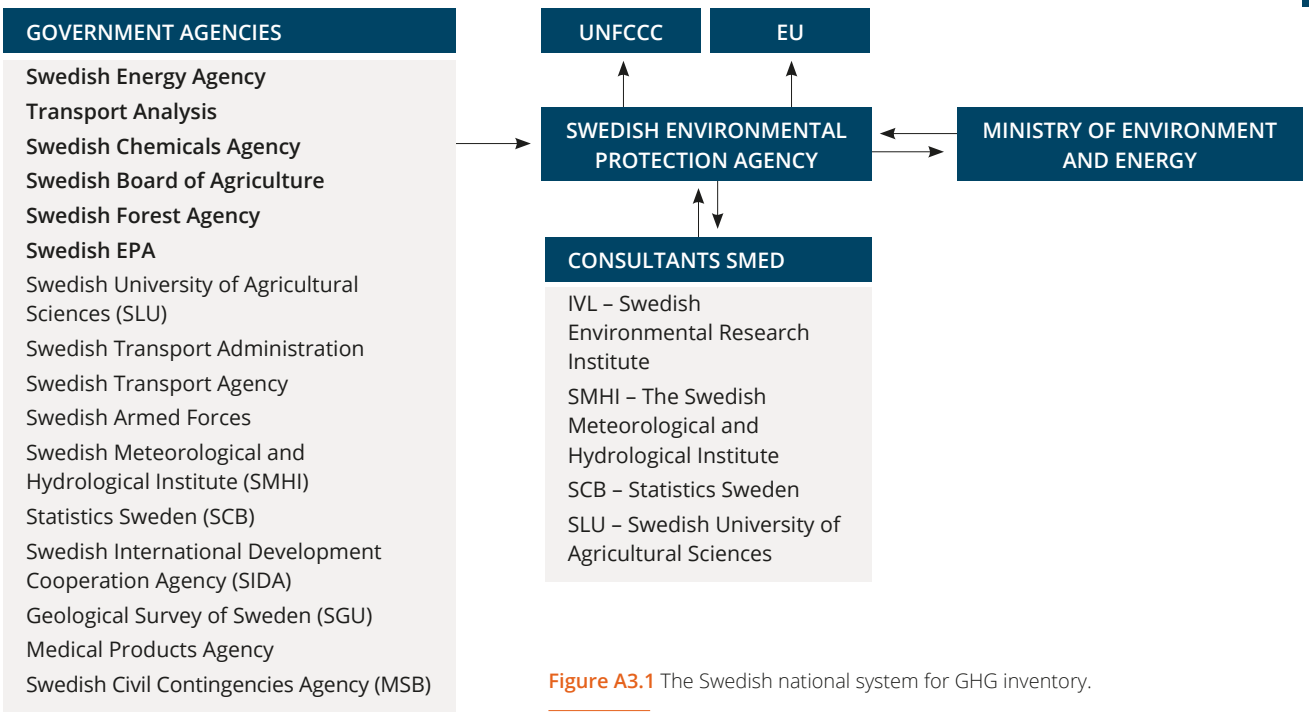


Figure A3.1 The Swedish national system for GHG inventory.

to calculate Swedish greenhouse gas emissions and removals.

Contact details of organisation responsible

The Swedish Ministry of the Environment and Energy is the national entity with overall responsibility for the inventory.

Ministry of Environment and Energy
Address: SE 103 33 Stockholm, Sweden
Telephone: +46 8 405 10 00
Contact: Ms. Nilla Thomson
m.climate@regeringskansliet.se

Inventory planning, preparation and management

The Swedish greenhouse gas inventory is compiled in accordance with the various reporting guidelines drawn up by the Intergovernmental Panel on Climate Change (IPCC) 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.

Planning and development

In any given year, priorities are set on the basis of recommendations received from international and national reviews, the results of key category analysis, uncertainty analysis, ideas for improvements from the Swedish EPA and the SMED consultants, and new requirements arising from international decisions, for example.

Based on these criteria, the Swedish EPA decides on development projects, which are undertaken by the SMED consultants. On completion of these projects, the results are implemented in the inventory.

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.

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

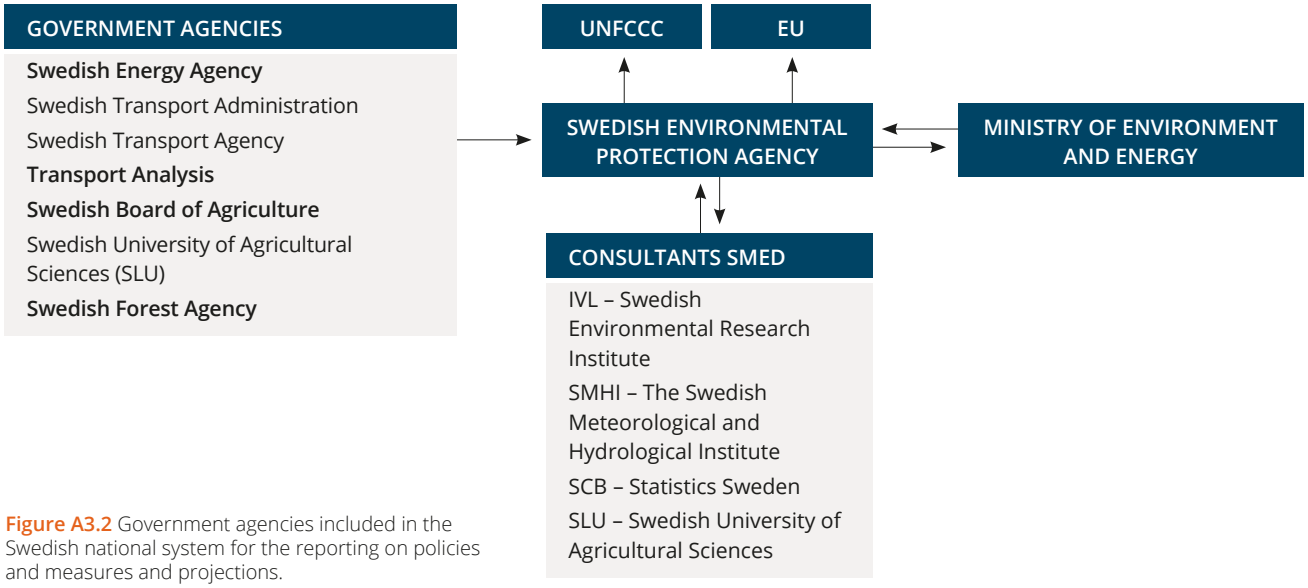


Figure A3.2 Government agencies included in the Swedish national system for the reporting on policies and measures and projections.

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.

Finalisation, publication and submission

The preliminary results are published nationally in late November or early December each year. The Swedish EPA supplies a draft report to the Ministry of the Environment in the beginning of January. The EPA submits the inventory to the EU on 15 January and to the UNFCCC on 15 April.

Follow-up and improvements

Each year, suggestions for improvements from the national and international reviews, and from SMED and the Swedish EPA, are compiled into a list. Based on this list, priorities are set and development work is carried out in preparation for the next year's reporting. Any suggestions not implemented one year remain on the list for consideration in subsequent years.

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.

The national system for policies and measures and projections

According to Article 12 of Regulation (EU) No 525/2013 of the European Parliament and the Council on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information at national and Union level relevant to climate change every member state needs to have this national system. The Swedish national system for policies and measures and projections was established in 2015. Its aim is to ensure that policies and measures and projections to the Secretariat of the Convention (UNFCCC), the Kyoto Protocol (19/CMP.1) and the European Commission are reported in compliance with specified requirements.

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[73] (SFS 2014:1434). See more information of the Ordinance under section 1.2.1.1. The Ordinance includes all reporting according to (EU/No 525/2013) on a mechanism for monitoring and reporting greenhouse gas emissions and for reporting other information and Union level relevant to climate change (EU/No/525/2013)).

Accompanying the Ordinance on Climate Reporting (SFS 2014:3414), formal agreements between the Swedish EPA and the concerned agencies have been established, specifying in detail the content and timetable for each agency for providing information on policies and measures and projections.

Institutional arrangements

To prepare the reporting on policies and measures and projections, cooperation takes place between the Ministry of the Environment and Energy, the Swedish EPA and other government agencies (see Fig. A3.2)

The Ministry of the Environment and Energy 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

73 http://www.lagboken.se/Views/Pages/GetFile.ashx?portalId=56&cat=24593&docId=2232659&propId=5

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 to consultants (SMED[74]) as for the GHG inventory is used in the institutional process of policies and measures and projections.

Contact details of organisation responsible

The contact details are the same as for Sweden's national system for the GHG inventory (see above).

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.

Planning and development

The report on policies and measures and projections are planned in due time before reporting. The report is compiled and includes quality control activities.

Work on the report on projections starts one year before submission and includes planning and defining assumptions and sensitive alternatives. 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 compiled by the Swedish EPA. Government agencies, in accordance with the Ordinance, then perform quality assurance activities.

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.

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 decision and submission of the report.

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.

Finalisation and submission

After quality assurance activities and, if needed, adjustments of the report, the Swedish EPA submits the reports to the EU on 15 March biennially, in years when the Biennial Report is not produced.

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 analyses are performed by applying a range of lower and higher estimates to the key assumptions.

Information on changes in the national system

Since the latest National communication (NC_6) has Sweden set up a national system also for polices and measures and projections in accordance with EU legislation, Monitoring Mechanism Regulation[75].

References

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

SFS 2014:1434, Svensk Författnings Samling; Klimatrapporteringsförordning, 2014:1434

SFS 2009:400, Svenska Författnings Samling Offentlighets- och sekretesslag, SFS 2009:400.

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

74 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).

75 EU 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

Annex 4
The national registry

The national registry

Registry administrator	
Name: Titti Norlin	Country: Sweden
Address: Box 310	Phone: +46 (0)16 544 22 73
Postcode: SE-631 04	Fax: +46 (0)16 544 2099
City: Eskilstuna	Email: titti.norlin@energimyndigheten.se

Under the EU Emissions Trading Directive, every member state is required to establish and operate a national registry. 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 national registries within the EU are thus identical in terms of maintenance and basic security standards.

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.

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.

The Swedish registry publishes the information specified in Annex XIV of the EU Registry Regulation at www.utslappshandel.se. The Swedish registry is available at https://ets-registry.webgate.ec.europa.eu/euregistry/SE/index.xhtml.

Annex 5
Projections methodology and calculation assumptions

Methodology

Different projection methods are used for different sectors. The methods which have been used to draw up the projections in this report are described in this section.

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 the 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 A5.1. Expert assessments are an important element in all stages of the process.

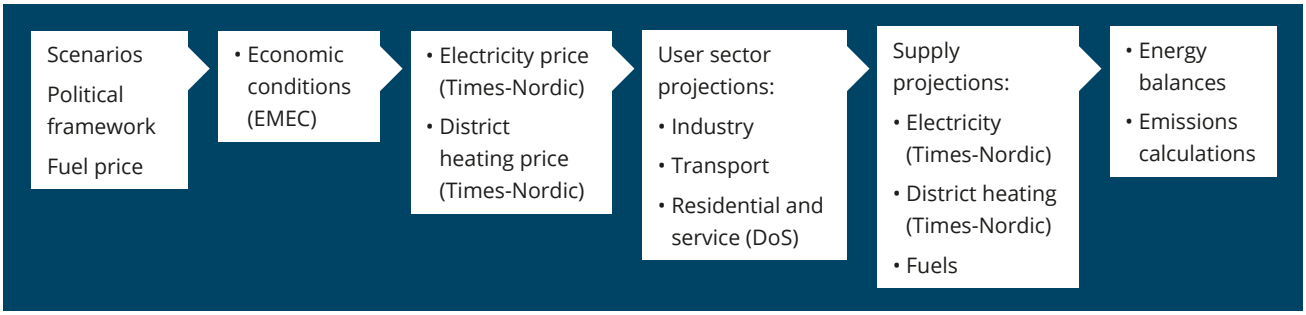
A starting point in the projection work on the development of the energy system in the short and long term is assumptions on economic trends, both in Sweden and internationally. The economic variables included in the work on energy projections mainly consists of estimates of the trend in gross domestic product, private and public consumption, disposable income and trends in value-added for industry and commerce. Estimates of economic development at the level of individual branches of industries are included for industry.

The projections on economic development are drawn up using a general equilibrium model, EMEC, by the National Institute of Economic Research. Input data for the projections on economic development are harmonized with the 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 labour 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 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.

The projections on using 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

Figure A5.1 Projection process for emissions from the energy sector (Model used in brackets)



use in the user sectors. Times-Nordic represents all Nordic countries (excluding Iceland) and permits electricity trade between neighbouring countries. Not just the Swedish energy system but the Nordic energy system is therefore optimised.

The projections of energy use in the other sectors are drawn up by combining the model results from Times-Nordic and assessments by industry 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.

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 the 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.

The projections on carbon dioxide emissions from the **transport sector** are calculated on the basis of projections on 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 is 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.

The carbon dioxide emissions of **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 better detailed knowledge on the industries and emissions concerned.

Emissions from landfills in the **waste sector** are calculated using a model developed by the IPCC which has been partially modified so that it fits Swedish circumstances better. The results of the model calculations are also compared with results of field measurements. The method is based on figures on quantities of landfilled waste from 1952, the organic content of the waste, the gas potentials of different types of waste and emissions factors.

The projections of activity data for the **agricultural sector** are based on the result from an economic equilibrium model; the Swedish Agricultural Sector model (SASM)[76], 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 being done for current emissions within the climate reporting process. Activity data includes figures related to numbers of livestock, manure production, stable period, method of mature management and annual balances of nitrogen flows to and from agricultural land.

The projections for net removals in the *Forest land* in **the Land Use, Land-Use Change and Forestry sector** are mainly estimated using the Heureka Regwise modelling tool (Wikström et.al. 2011). The model simulates the future development of the forests on the basis of 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 are distributed to the different product groups equally as today, i.e. as an average of the five latest years in the latest submission.

76 Jonasson. 2016. Modellberäkningar i SASM. PM 2016-08-04.

Assumptions underlying the calculations

Calculation assumptions for the energy sector[77]

General assumptions on which estimates for the energy sector are based:

- Within the EU emissions trading scheme, a price of 15 euros is assumed per tonne of carbon dioxide 2020 and 42 euros per tonne 2035 (in 2013 price).
- Based on the decision in force regarding the Swedish-Norwegian electricity certificate system, it is 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 2035.
- In general, current taxes and other instruments (in place first of July 2016) are assumed to remain unchanged until 2035.
- National Institute of Economic Research estimates of economic development (%/year):

	Reference
	2013–2035
GDP	2.28
Private consumption	2.59
Export	3.25
Import	3.61

- The trends in fossil fuel prices are given by the European Commission (2013 prices)

	Base year	Reference
	2013	2035
Crude oil (USD/barrel)	109	117
Coal (USD/tonnes)	82	110
Natural gas (USD/Mbtu)	12	12

- The Swedish Energy Agency's evaluation of price trends for biofuels (SEK/MWh (2013 prices)):

	2013	2035
Wood chips	195	245

- The projection is based on normal production circumstances. Changes as a consequence of future climate effects have not been taken into consideration.

Assumptions on which estimates for energy industries are based:

- 4 of Sweden's 10 nuclear reactors are assumed to be closed until 2020. This leads to a decrease of the nuclear capacity in Sweden. All other nuclear power plants are assumed to have an economic working life of 60 years,
- Projections of the Swedish sector price for electricity for the years 2020 and 2035. (Annual average, 2013 price level in SEK/kWh)

	2013	2035
Electricity price	0.33	0.53

- Electricity production from hydropower (incl. small-scale hydropower) and nuclear power production are assumed to be, in TWh:

	2013	2035
Hydropower	61	69
Nuclear power production	64	48

- For the refinery sector, the emissions are assumed to increase during the projection period, in accordance with the expansion plans of this sector. For the period 2013–2035, the projected emissions indicate an increase in level with the economic growth for the petrochemical industry, which according to the National Institute of Economic Research, is 2.0 % per year.

Assumptions on which estimates for households, premises and combustion in the 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.
- Assumptions on the development of the area of houses and premises between 2013 and 2035:

	Annual increase
Number of new apartments in single-dwelling houses	9,000
Number of new apartments in multi-dwelling houses	29,000
Area of commercial and service premises	1 %
Area of new single-dwelling houses	149 m²
Area of new apartments	65 m²

- Of the new buildings, one fourth is projected to be single dwelling houses while three forth multi-dwelling buildings. Single dwelling houses are assumed principally to install electric heating, including heat pumps, while multi-dwelling houses are assumed primarily to install district heating.
- Future climate effects have not been taken into consideration for assumptions on future heating demands

77 Energimyndigheten.ER 2017:06. Scenarier över Sveriges energisystem 2016

- The projections for households and premises are normal-year corrected while the historical emissions are not. Of this follows that the emissions in the projections are high compared to the historical time series, since the latest years have been warmer than a normal year.

Calculation assumptions for industry

Assumptions on which estimates for manufacturing industries 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 2013 and 2035 (National Institute of Economic Research):

Industry	Annual growth (%) 2013–2035
Pulp and paper industry	1.24
Chemical industry	2.46
Iron and steel industry	0.79
Manufacture of non-metallic mineral products	1.86
Non-ferrous metalworks	1.45
Engineering industry	3.13
Mining	1.09

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.

Calculation for transport sector

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.
- The prices assumed for ethanol (E85 and ED95) and CNG (Compressed Natural Gas) are assumed to be profitable in relation to petrol/diesel during the whole period. Only fuels that are on the market as of today are included.
- Fuel prices, SEK/litre, excluding tax and VAT, (2013 year fixed prices)

	2013	2035
Petrol, with low-blend ethanol	6.3	6.8
Diesel, with low blend biodiesel	5.9	7.1
E85	5.3	6.3

- For low blend of fuels the same tax levels as of today are assumed during the whole period. This is the case even though the allowance for state support is ended on 31st December 2015, because there is no information about further policies. This implies that low blend of up to 5 % of ethanol into petrol and up to 7 % of FAME in to diesel respectively is exempt from tax. In the projection these two levels set the upper limit for what is profitable and that the tax exemption is a strong incitement for low blending up to that limit. HVO is fully exempted from tax of blend into diesel. The low blending in diesel is assumed to increase to 25 %.

Calculation for waste sector

Assumptions on which estimates for 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 future biogas production data.

Calculation for agriculture sector

Assumptions on which estimates for the agricultural sector are based:

- The projections are based on assumptions on prices, productivity and available areas and buildings.
- The prices are based on the 2015 prices in the EU and price projections from OECD/FAO[78] with an extrapolation to 2035.
- Assumed growth in productivity per year:

	Change per year
Harvest	+0.5 %
Milk yield	+0.75 %
Swine per sow	+1 %
Supplies	-0.5 %
Labour	-1.5 %

- Assumed availability of buildings: 20 % of current buildings are assumed to be in use in 2030 with only maintenance needed, 20 % are disposed and 60 % can be used if renovations are made.
- The current agricultural policy (CAP) in 2015 is assumed to continue until 2035.

78 OECD/FAO. 2016. OECD-FAO Agricultural outlook 2016–2025. OECD Publishing.

Calculation for LULUCF- sector

Assumptions on which estimates for the LULUCF-sector are based:

Forest land,

- The projections are based on the business as usual scenario in an analysis of the forest development (SKA-15) in terms of management, climate effect, nature conservation and so forth.[79]
- Harvest is assumed to continue to increase in the future and further increase after 2025 since it is foreseen that the demand for biomass will increase.
- The reported projection is based on a scenario in which felling is assumed to be below the level of what is regarded 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 scenario present forest management practices are assumed, including environmental measures in forestry and environmental policy aimed at preserving biological diversity. This means that a total of 822 000 ha is set aside for nature conservation through legal protection and 2 954 000 ha is set aside through nature conservation measures in forest management and through voluntary measures by forest owners.
- In the scenario 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,

- The projections for each carbon pool are based on the mean net annual carbon stock change for the period 2006–2015 as reported in the National Inventory Report, submission 2017.
- The mean annual carbon stock change per area is multiplied with the projected area of cropland estimated by areas provided by the Swedish Board of Agriculture.

Wetlands, Settlements,

- The projected emissions/removals for each reported carbon pool are assumed to be constant and estimated as a mean for the period 2006–2015 as reported in the National Inventory Report, submission 2017.

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, i.e. as an average of the five latest years reported in submission 2017.

Assumptions on which estimates for the sensitive alternatives for the energy sector are based:

- Import prices on fossil fuels and exchange rates, (2013 prices)

	Base year	Reference and Higher GDP	Higher fossil fuel prices
	2013	2035	2035
Crude oil (USD/barrel)	109	117	153
Coal (USD/tonnes)	82	110	142
Natural gas (USD/Mbtu)	12	12	15

- National Institute of Economic Research estimates of economic development (%/year):

	Reference	Higher GDP
	2013–2035	2013–2035
GDP	2.28	2.69
Private consumption	2.59	2.95
Export	3.25	3.72
Import	3.61	3.93

- Swedish sector price for electricity in projections for 2030. (Annual average, 2013 price level)

SEK/kWh	2013	2035
Reference	0.33	0.53
Higher GDP	0.33	0.53
Higher fossil fuel prices	0.33	0.55

79 Cleasson, S., Duvemo, K., Lundström, A., & Wikberg, P.E. 2015. Skogliga konsekvensanalyser 2015 – SKA 15. Skogsstyrelsen. Rapport 10/2015.

Annex 6
Financial, technological and capacity-building support

See the Additional tables to Sweden's Seventh National Communication (NC) on Climate Change and third Biennial Report (BR) under UNFCCC – Annex 6 (NC) and Annex 1 (BR); Provision of financial, technological and capacity-building support.

Annex 7

Information in accordance with Article 7.2 of the Kyoto Protocol

Reported information	NC7 section
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
Programs, 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	
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

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