Report for Sweden on projections of greenhouse gas emissions and removals

In accordance with article 18 under Regulation (EU) No 2018/1999 of the European parliament and of the Council Decision on the Governance of the Energy Union and Climate Action

2025

Contents

1 Introduction

This is a report for Sweden on projections of greenhouse gas emissions and removals in accordance with article 18 under Regulation (EU) No 2018/1999 of the European parliament and of the Council Decision on the Governance of the Energy Union and Climate Action.

Chapter 2 provides information on projections of greenhouse gas emissions and removals with existing measures. The projections are presented at an aggregate level and per sector.

Chapter 3 provides a description of the status of the low carbon development strategy. For this submission, there are no updates relating to Sweden's low carbon development strategy, which was reported in 2020.

Chapter 4 provides a description of the national system for the reporting of policies and measures and projections. For this submission, there are no updates.

As part of this report datasheets are also provided, as follows:

- data projections per sector and gas (uploaded on Reportnet as an excel file) based on existing measures.
- summary table with projection parameters (uploaded on Reportnet as an excel file)
- model fact sheets for models used to produce projections (uploaded on Reportnet as an excel file)
- information on existing policies and measures and quantified effects when available uploaded on Reportnet via a web form.

2 Swedish projections of greenhouse gas emissions and removals

Projections of greenhouse gas emissions in Sweden have been produced until 2055[1]. The projections with existing measures (WEM) are based on the policies and measures adopted by the Swedish parliament up to December 2024. The base-year for the projections is 2023 in the National inventory report submission 2025 and the historical emissions are presented for 1990-2023.[2] All emissions and removals of greenhouse gases use global warming potentials from IPCC Fifth Assessment Report (AR5).

When producing the projections, model-based calculations and to some extent expert evaluations have been used. The projections are based on a number of assumptions, all of which are characterised by uncertainty. The results should be interpreted with this aspect in mind. The projections can mainly be regarded as a consequential analysis of the assumptions that have been made. The method for estimating the projections is mainly developed for a medium-term or a long-term projection, which means that the projections generally do not take into consideration variations on a short-term basis.

In addition to the projections, sensitivity projections have been calculated for the LULUCF sector. In the sensitivity projection one parameter has been modified to assess the effect of that parameter.

Policies and measures are continuously developed, and new measures are planned. However, for this report, there were no planned measures in time for producing a projection with additional measures.

2.1 Aggregate projections

Total greenhouse gas emissions in Sweden totalled 44.4 million tonnes of carbon dioxide equivalents (Mt CO_2-eq.) in 2023 (excluding The Land Use, Land Use Change and Forestry sector). Total emissions decreased by 26.8 Mt CO_2-eq, or 38%, between 1990 and 2023. The projections, with existing measures, show that the total emissions of greenhouse gases, (excluding LULUCF) are estimated to be around 34 Mt CO_2-eq. in 2030 or 52% below the 1990 level. After 2030, emissions

[1] Methods presented in this report are used until 2050 and projections for 2055 are assumed to be the same as for 2050

[2] National Inventory Report Sweden, submission 2025

are projected to continue to decrease, and in 2050 the total emissions of greenhouse gases are estimated to be 73% below the 1990 level.

The Land Use, Land Use Change and Forestry sector (LULUCF) contributed to an annual net removal of carbon dioxide in Sweden during the period 1990-2023, with a decreasing trend in latest years. The net removals are projected to decrease by around 50% until 2030 in comparison with 1990 and further decrease to 2050.

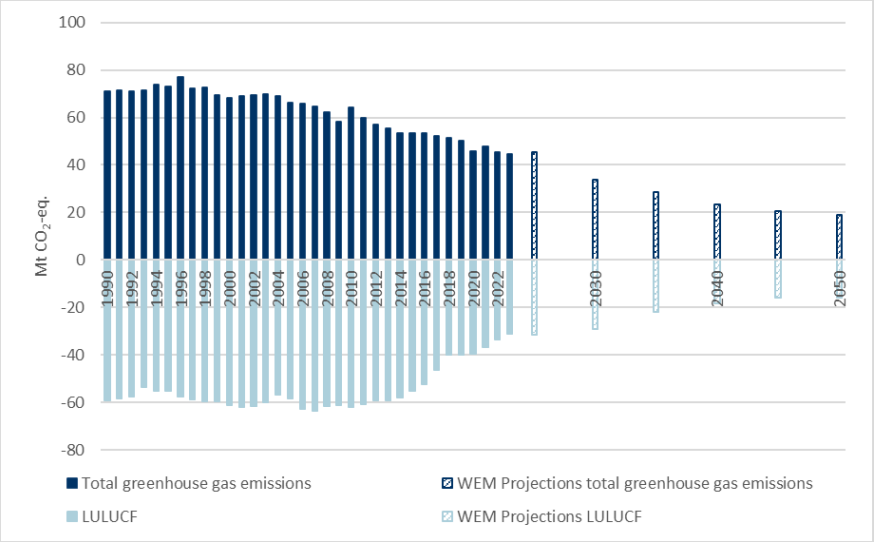

Figure 1 Historical emissions and removals of greenhouse gases and projections with existing measures (WEM).

Table 1. Historical emissions/removals of greenhouse gases per sector and projections with existing measures (WEM). The projections of net removals are based on several assumptions which are characterised by large uncertainties, especially in the long term after 2035. (Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Energy excl. transport	32.0	16.2	10.7	9.3	8.2	7.9	7.7	7.7
Transport	20.4	14.2	12.4	8.6	5.6	3.4	2.1	2.1
Industrial processes and product use	7.2	6.6	3.8	3.8	2.7	2.7	2.6	2.6
Agriculture	7.3	6.3	6.1	6.0	6.0	6.0	5.9	5.9
Waste	4.3	1.1	0.9	0.8	0.8	0.7	0.7	0.7
Total emissions without LULUCF	**71.2**	**44.4**	**33.9**	**28.6**	**23.3**	**20.5**	**19.1**	**19.1**
LULUCF	-59.3	-31.2	-29.3	-22.1	*-18.1*	*-15.9*	*-15.8*	*-15.8*
Total emissions with LULUCF	11.9	13.2	4.7	6.5	*5.2*	*4.6*	*3.3*	*3.3*

2.2 Projections per gas

For the year 2023 carbon dioxide emissions account for 80% of the greenhouse gas emissions, while methane emissions account for around 10%, nitrous oxide for around 8% and fluorinated greenhouse gases for around 2%.
During the projection period, the emissions of all gases decrease, but the share of carbon dioxide emissions is estimated to decrease to about 62% in the year 2050. The other greenhouse gases are estimated to reduce their contribution to total emissions. See Table 2 for the development of the emissions of different greenhouse gases.

Table 2. Historical emissions of greenhouse gases per gas and projections with existing measures (WEM). (Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	57.4	35.5	25.9	20.8	15.9	13.2	11.9	11.9
Methane	8.5	4.6	4.4	4.3	4.1	4.0	4.0	4.0
Nitrous oxide	4.7	3.4	3.2	3.2	3.1	3.1	3.1	3.1
Fluorinated greenhouse gases	0.6	0.8	0.4	0.3	0.2	0.1	0.1	0.1
Total emissions (excl. LULUCF)	**71.2**	**44.4**	**33.9**	**28.6**	**23.3**	**20.5**	**19.1**	**19.1**

2.3 Projections by sector

In the projections, the emissions from all sectors are decreasing until 2050. The largest reduction is projected for the energy and transport sectors.

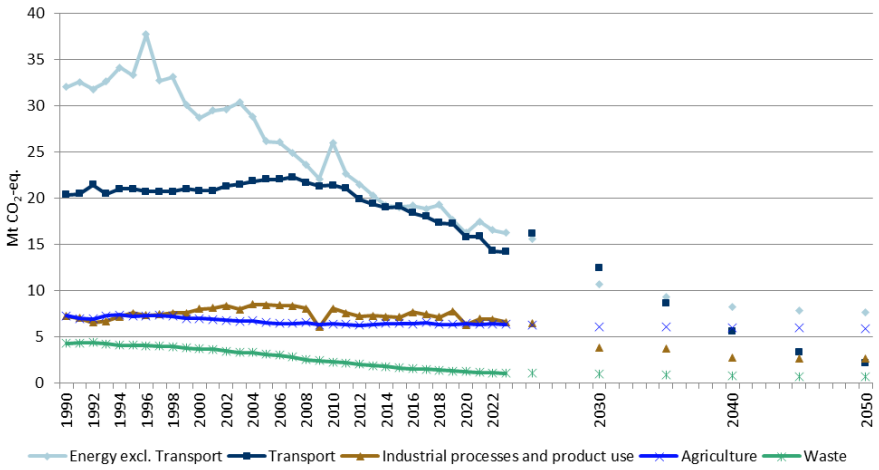

Figure 2. Historical and projected emissions of greenhouse gases by sector.

2.3.1 Energy sector excluding transport

Emissions from the energy sector excluding transport include emissions from electricity and heat production, refineries, manufacture of solid fuels, manufacturing industries, other sectors (including commercial/institutional, residential, agriculture, forestry and fisheries) and fugitive emissions.

Emissions of greenhouse gases by the energy sector excluding transport were 16.2 Mt CO_2-eq. in 2023. Emissions from the energy sector have varied since 1990 depending on temperature and precipitation conditions and the state of the economy, but the trend is decreasing. The total emissions from the energy sector are estimated to decrease by 67% until 2030, and by 76% until 2050, in comparison with 1990.

Table 3. Historical and projected emissions of greenhouse gases from the energy sector excluding transport (CRT 1 excl. 1A3. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	31.5	15.7	10.2	8.8	7.7	7.4	7.2	7.2
Methane	0.3	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Nitrous oxide	0.3	0.3	0.3	0.3	0.3	0.3	0.3	0.3
Total emissions	**32.0**	**16.2**	**10.7**	**9.3**	**8.2**	**7.9**	**7.7**	**7.7**

The general assumptions on which the projections for the energy sector are based are summarized below. In addition to these, a number of specific assumptions are made for the particular sub-sector concerned.

GENERAL ASSUMPTIONS ON WHICH ESTIMATES FOR THE ENERGY SECTOR ARE BASED:

- In general, current taxes and other instruments (in place December 2024) are assumed to remain unchanged until 2050.
- Estimates of economic development, (%/year)
  (National Institute of Economic Research)

	2024-2030	2031-2040	2041-2050
GDP	2.2	1.7	1.6
Private consumption	3.1	2.0	1.8
Export	2.9	2.5	2.1
Import	3.7	2.2	1.8

- The trends in fossil fuel prices are given by the European Commission
  (2023 prices)

	2023	2030	2040	2050
Crude oil (Euro/GJ)	12.5	13.9	15.8	19.7
Coal (Euro/GJ)	4.4	4.0	3.8	4.0
Natural gas (Euro/GJ)	10.9	9.0	10.1	9.6

- The trends in carbon prices in ETSI are given by the European Commission (2023 prices)

	2023	2030	2040	2050
Carbon price ETSI (Euro/tCO_2)	85	95	100	190

- The trends in carbon prices in ETSII are given by the European Commission (2023 prices)

	2027	2028	2029	2030
Carbon price ETSII (Euro/tCO_2)	30	50	55	60

- In the projections a climate effect is included, based on the RCP 4.5 scenario (IPCC 2013).

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

The emissions from energy industries include emissions from electricity- and heat production, refineries and manufacturing of solid fuels.
The emissions of greenhouse gases from *electricity and heat production* have varied since 1990, mainly due to temperature variations and precipitation. The emissions were 5.4 Mt CO_2-eq. in 2023 and are projected to decrease by 69% until 2050 compared to 1990 level. In the projections, there is a decrease in production from natural gas, oil and coal while use of waste and biomass increases. Furthermore, a shift to fossil-free technology is assumed for the iron and steel industry which leads to a decrease in emissions after 2030 due to a decrease in use of residual gases.

Emissions from *refineries* have increased since 1990 due to increased production. The emissions are projected to decrease until 2050, due to the assumed effect of measures performed resulting in higher efficiency and due to producing more biofuels. The emissions are projected to be 18% higher emissions in 2030 and 9% in 2050, compared to the 1990 level. Emissions from refineries are also accounted for in the sector of fugitive emissions.

The emissions from *manufacturing of solid fuels* were 24% higher in 2023 compared to 1990. The emissions are estimated to remain at the same level until 2030 and then decrease due to an assumed shift to fossil free technology.

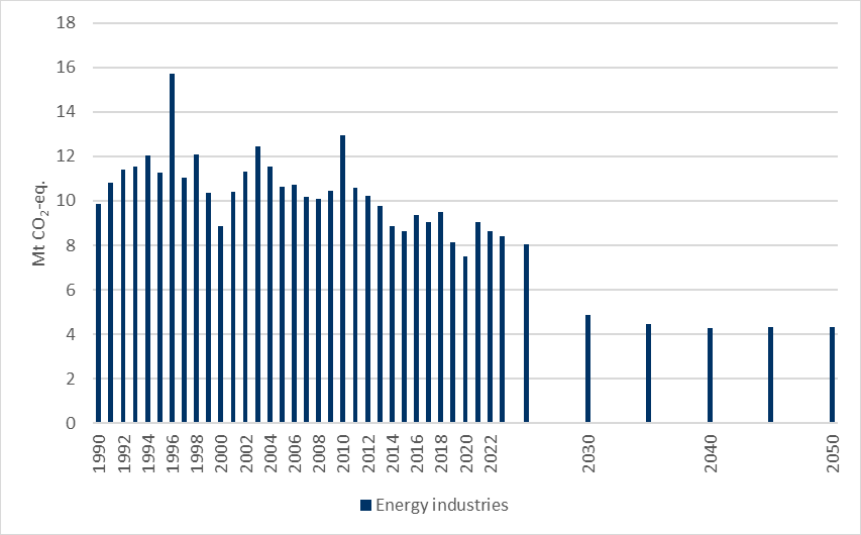

Figure 3. Historical and projected emissions of greenhouse gases from energy industries including emissions from electricity and heat production, refineries and manufacturing of solid fuels.

Table 4. Historical and projected emissions of greenhouse gases from energy industries (CRT 1A1. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	9.7	8.2	4.6	4.2	4.1	4.1	4.1	4.1
Methane	0.01	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Nitrous oxide	0.1	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total emissions	**9.9**	**8.4**	**4.9**	**4.5**	**4.3**	**4.3**	**4.3**	**4.3**

ASSUMPTIONS ON WHICH ESTIMATES FOR ENERGY INDUSTRIES ARE BASED:

- 2 of Sweden's 8 reactors were shut down before 2020. This leads to a decrease of the nuclear capacity in Sweden. The remaining nuclear power plants are assumed to have an economic working life of 60 years, which means until 2045. Then the lifetime is lengthened by 20 years.
- The electricity certificate system started in 2003 in Sweden and from 2012 it is a joint market with Norway. The target of 46.4 TWh new renewable electric power production in 2030 was reached in 2021.
- A shift to fossil-free technology is assumed for the iron and steel industry which leads to a decrease in emissions after 2030 from manufacturing of solid fuels and electricity and heat production, due to a decrease in use of residual gases.
- For the refinery sector, the emissions are assumed to decrease slightly during the projection period, in accordance with higher efficiency and the increasing production of renewable fuels.
- For part of emissions from waste in electricity and heat production and part of emissions from refineries carbon capture and storage of CO_2 is assumed after 2035 and 2030 respectively.

2.3.3 Combustion in manufacturing industries

The emissions of greenhouse gases from combustion in manufacturing industries were 5.8 Mt CO_2-eq. in 2023. It should be noted that, to cover all industry related emissions, emissions from industrial processes should be added to the emissions from combustion (see section 2.3.7).

In 2023, the emissions from combustion in manufacturing industries were 46% lower than the 1990 level and are projected to be 61% lower in 2030 and 78% lower in 2050 compared to the 1990 level. It should be noted that the emission trends have varied between years, which is likely connected to the economic development. Emissions are expected to decrease until 2050 because the use of biofuel and electricity is expected to continue to increase while use of fossil fuels are decreasing. The decreasing emissions are mainly explained by a decrease in emissions from the pulp and paper industry due to a shift from using fossil fuels to biofuels. The decrease after 2030 can also be explained by an assumed shift in technology for the iron and steel industry.

Emissions from working machinery in the industry were 1.1 Mt CO_2-eq. in 2023, which is an increase by 20% compared to 1990 level. The emissions are projected to decrease by 23% until 2050 compared to 1990 level, mainly due to assumed electrification.

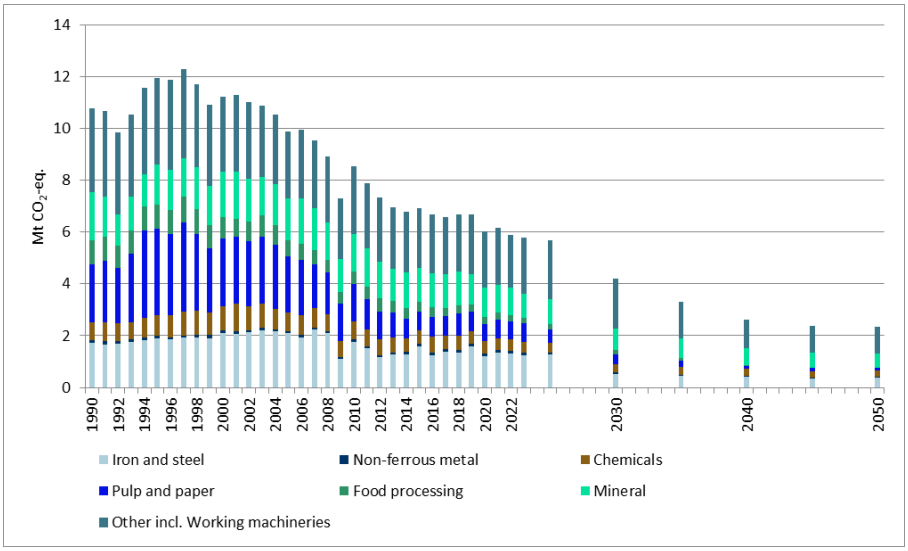

Figure 4. Historical and projected emissions of greenhouse gases from combustion in manufacturing industries.

Table 5. Historical and projected emissions of greenhouse gases from combustion in manufacturing industries (CRT 1A2. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	10.6	5.7	4.1	3.2	2.5	2.4	2.3	2.3
Methane	0.03	0.02	0.02	0.02	0.03	0.03	0.03	0.03
Nitrous oxide	0.1	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total emissions	**10.8**	**5.8**	**4.2**	**3.3**	**2.6**	**2.5**	**2.4**	**2.4**

ASSUMPTIONS ON WHICH ESTIMATES FOR MANUFACTURING INDUSTRIES ARE BASED:

- The projection for manufacturing industries is based on assumptions on the economic development, the extent of energy efficiency efforts, assessments of investments for change in technologies and assumptions on future fuel and energy prices.
- A shift to fossil-free technology is assumed for the iron and steel industry which leads to a decrease in emissions in 2025-2030.
- For working machineries, the emission reduction obligation establishes an obligation on petrol and diesel suppliers to reduce life-cycle carbon dioxide emissions, by blending with sustainable biofuels. Until 2022, there was a gradual increase in the reduction obligation, and in 2023 the reduction level was maintained at the 2022 level, 30% for diesel and 7.8% for gasoline. In 2024, the reduction obligation decreased to 6 percent and then increase to 10%, starting 1 July 2025. The level of 10 % of blending of biofuels in diesel and petrol, including also fossil-free electricity sold from public charging stations, is assumed to be unchanged until 2050.

2.3.4 Households, premises and combustion in agricultural, forestry and fishing sectors

The emissions from households and premises and from combustion in the agricultural, forestry and fishing sector decreased between 1990 and 2023 from 10.9 to 2.0 Mt CO_2-eq. and are expected to continue to decrease. The emissions in 2023 are 82% lower than in 1990 and are expected to decrease further to 85% and 91% below the 1990 level in 2030 and 2050 respectively. The decrease is mainly due to 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 leads to decreased emissions in this sector. On the other hand, emissions are generated during production in energy industries. Since the increased production of electricity and heat mainly is based on biomass and waste and district heating is a more efficient way of heating, the emissions still decrease until 2050.

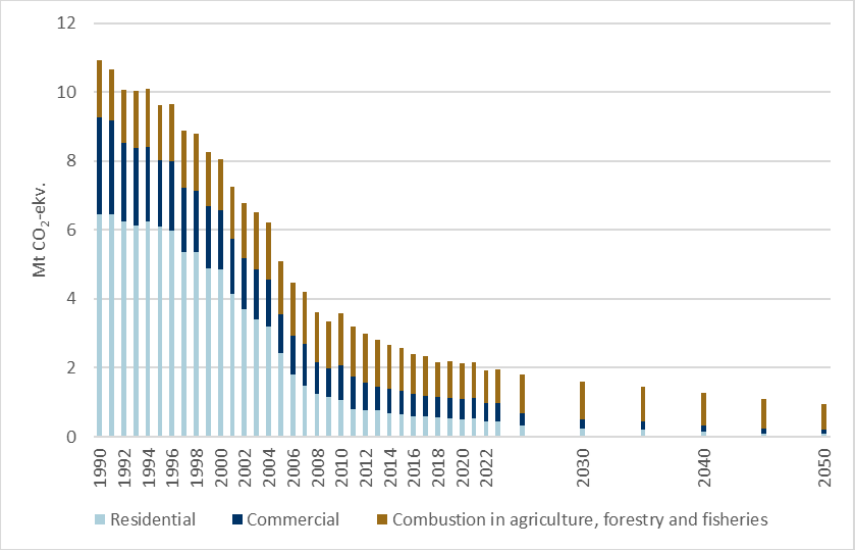

Figure 5. Historical and projected emissions of greenhouse gases from combustion in households, premises, agriculture, forestry and fisheries sectors.

The emissions from combustion in the agricultural, forestry and fishing sectors are expected to decrease during the projection period. The emissions from energy use in the agricultural sector are expected to decrease until 2050, as a consequence of a reduction in the use of diesel fuel for working machines and a reduction in the oil consumption for buildings. The emissions from working machinery in the agriculture and forestry sector are expected to decrease during the projection period due to an increased use of electricity. Emissions from fisheries are assumed to stay unchanged during the projection period.

Table 6. Historical and projected emissions of greenhouse gases from households, premises, agriculture, forestry and fisheries sectors. (CRT 1A4. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	10.7	1.8	1.5	1.4	1.2	1.0	0.9	0.9
Methane	0.1	0.06	0.05	0.04	0.04	0.03	0.03	0.03
Nitrous oxide	0.1	0.06	0.06	0.05	0.05	0.04	0.04	0.04
Total	**10.9**	**2.0**	**1.6**	**1.5**	**1.3**	**1.1**	**1.0**	**1.0**

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.

- Future temperature conditions are based on IPCC scenario RCP 4.5.[3]
- Population growth (Statistics Sweden)

	2022	2030	2040	2050
Population	10 521 556	10 719 455	11 007 742	11 353 867

- The number of new apartments in single-dwelling houses and multi-dwelling houses in the projection is assumed to increase by 361 000 from 2022 to 2030 and by 430 000 from 2030 to 2050 (Statistics Sweden and Swedish Energy Agency).
- Heated area of new single dwelling houses and new apartment buildings is assumed to be 164 m^2 and 61 m^2 respectively.
- The projections for energy use from working machinery in agricultural sector are based on the projections in the agriculture sector. For working machinery in forestry the projections are based on projections of different processes in forest management. The energy use for fisheries is assumed to increase until 2025 and then it is assumed to stay the same level until 2050.
- For working machineries, the emission reduction obligation establishes an obligation on petrol and diesel suppliers to reduce life-cycle carbon dioxide emissions, by blending with sustainable biofuels. Until 2022, there was a gradual increase in the reduction obligation, and in 2023 the reduction level was maintained at the 2022 level, 30% for diesel and 7.8% for gasoline. In 2024, the reduction obligation decreased to 6 percent and then increase to 10%, starting 1 July 2025. The level of 10 % of blending of biofuels in diesel and petrol, including also fossil-free electricity sold from public charging stations, is assumed to be unchanged until 2050.

2.3.5 Emissions from Fugitive emissions

The emissions from fugitive emissions were 0.07 Mt CO_2-eq. in 2023[4] and are projected to remain around the same low level for the projections period.

Table 7. Historical and projected emissions of greenhouse gases from fugitive emissions (CRT 1B. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	0.3	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Methane	0.1	0.06	0.06	0.06	0.06	0.06	0.06	0.06
Nitrous oxide	0.001	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005	0.00005
Total emissions	**0.5**	**0.07**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**	**0.06**

[3] RCP: Reference Concentration Pathway

[4] The emissions in 1B are low due to part of emissions are included in 1A1b, due to prevailing confidentiality rules.

2.3.6 Domestic transport

The emissions from domestic transports were 14.2 Mt CO_2-eq. in 2023.[5] Road transportation contributes with the majority of emissions from the sector (approximately 90%), while emissions from navigation, civil aviation and railways are small. The total emissions from transport have decreased since 2010. The trend is mainly explained by an increase in energy efficiency and an increased use of biofuels.

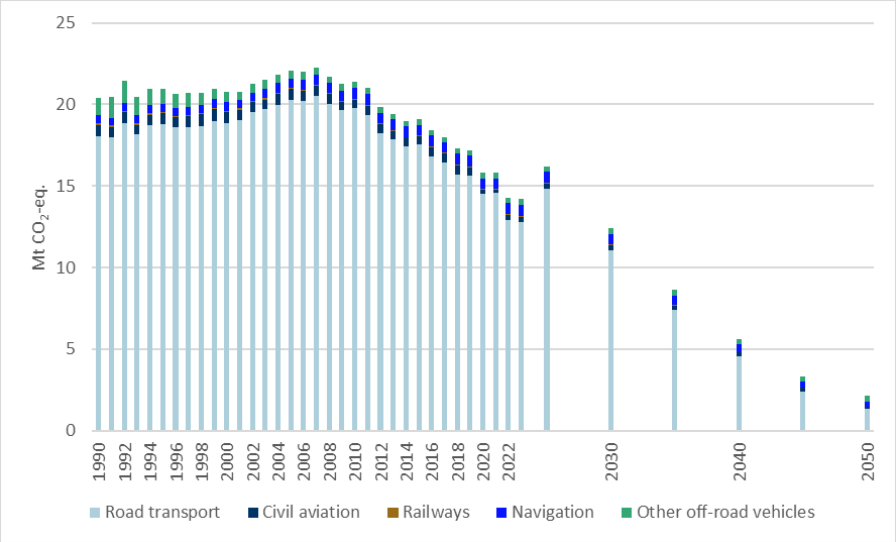

Figure 6. Historical and projected emissions of greenhouse gases from transport sector.

In the projection the emissions are estimated to increase in 2024 due to the reduction obligation leading to lower blending of biofuels but then continue to decrease until 2050. The emissions from road transport are assumed to continue to decrease mainly due to increasing adoption of electric vehicles and improvement of energy efficiency due to EU regulations that limits the emissions from new cars, light-duty lorries and heavy-duty vehicles, in combination with national polices and measures.

Emissions from domestic aviation have decreased during the last years, mostly due to higher efficiency, and low number of flights in 2020-2021 due to the covid-19 pandemic. The emissions are projected to increase after the pandemic but are then assumed to decrease mainly due to increased use of sustainable aviation fuels in accordance with the obligations in ReFuelEU Aviation and EU ETS.

Emissions from domestic navigation were 0.7 Mt CO_2-eq.in 2023. The emissions are projected to be around 0.3 million tonnes in 2050. The emissions are projected to decrease due to obligations in FuelEU Maritime to reduce emissions and EU ETS.

[5] National Inventory Report Sweden, Submission 2025

Emissions from railways were 0.04 Mt CO_2-eq. in 2023 and are projected to decrease during the entire projection period.

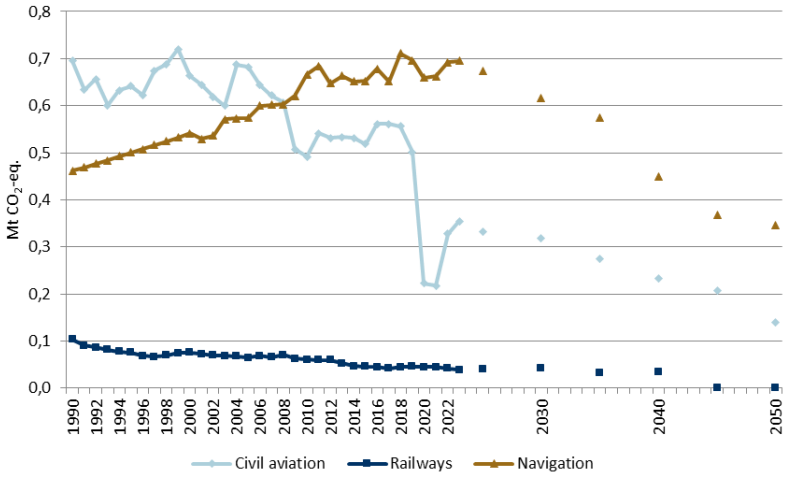

Figure 7. Historical and projected emissions of greenhouse gases from domestic aviation, navigation and railways.

Table 8. Historical and projected emissions of greenhouse gases from different transport modes (CRT 1A3. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Road transportation	18.1	12.8	11.1	7.4	4.6	2.4	1.3	1.3
Civil aviation	0.7	0.4	0.3	0.3	0.2	0.2	0.1	0.1
Navigation	0.5	0.7	0.6	0.6	0.4	0.4	0.3	0.3
Railways	0.1	0.04	0.04	0.03	0.03	0.0	0.0	0.0
Other off-road vehicles	1.1	0.3	0.3	0.3	0.3	0.3	0.3	0.3

Table 9 Historical and projected emissions of greenhouse gases from domestic transport (CRT 1A3. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	20.0	14.0	12.2	8.5	5.5	3.2	2.1	2.1
Methane	0.2	0.04	0.03	0.05	0.04	0.04	0.03	0.03
Nitrous oxide	0.2	0.2	0.2	0.1	0.1	0.05	0.03	0.03
Total emissions	**20.4**	**14.2**	**12.4**	**8.6**	**5.6**	**3.3**	**2.1**	**2.1**

2.3.6.1 ASSUMPTIONS ON WHICH ESTIMATES FOR TRANSPORT ARE BASED:

- The transport projections are based on several assumptions regarding number of inhabitants, disposable income of households, GDP, fuel price,

exports and imports. Of importance are also assumptions regarding technical development, energy efficiency, mileage and introduction of renewable fuels.

- Traffic volume for cars in the projections is based on the historical relationships between traffic volume trends, GDP and cost of driving.
- Traffic volumes for light-duty lorries and heavy-duty lorries in the projection are based on the respective relationships between the traffic volume trends and GDP.
- EU emission regulations set for cars, heavy-duty vehicles and light duty vehicles respectively. CO_2-emissions from new passenger cars and new light commercial vehicles are to be reduced by 55% and 50% respectively by 2030 compared to average emissions 2021. Emissions from new heavy-duty vehicles are to be reduced by 15% in 2025 and by 45% in 2030 compared to 2019.
- The emission reduction obligation establishes an obligation on petrol and diesel suppliers to reduce life-cycle carbon dioxide emissions, by blending with sustainable biofuels. Until 2022, there was a gradual increase in the reduction obligation, and in 2023 the reduction level was maintained at the 2022 level, 30% for diesel and 7.8% for gasoline. In 2024, the reduction obligation decreased to 6 percent and then increase to 10%, starting 1 July 2025. The level of 10 % of blending of biofuels in diesel and petrol is assumed to be unchanged and the volume of biofuels is thus solely dependent on the fuel usage.
- The emissions from aviation are assumed to decrease gradually aligned with obligation of the ReFuelEU Aviation to increase the blending of sustainable fuels from 3% to 70% until 2050. 75% of the energy use is assumed to be covered.
- The emissions from navigation are assumed to decrease gradually due to the obligation of FuelEU Maritime to reduce greenhouse gas intensity by 2% in 2025 and by 80% until 2050. 63% of the energy use is assumed to be covered.

2.3.7 Industrial processes and product use

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

The total emissions from the sector for industrial processes and product use were 6.6 Mt CO_2-eq. in 2023. Emissions in this sector have varied somewhat since 1990, mainly due to variation in production volumes and economic fluctuations. The greenhouse gas emissions are projected to decrease until 2050 to 63% below the 1990 level. The decrease compared to 1990 is mainly caused by a decrease in carbon dioxide from industrial processes and in emissions of fluorinated greenhouse gases.

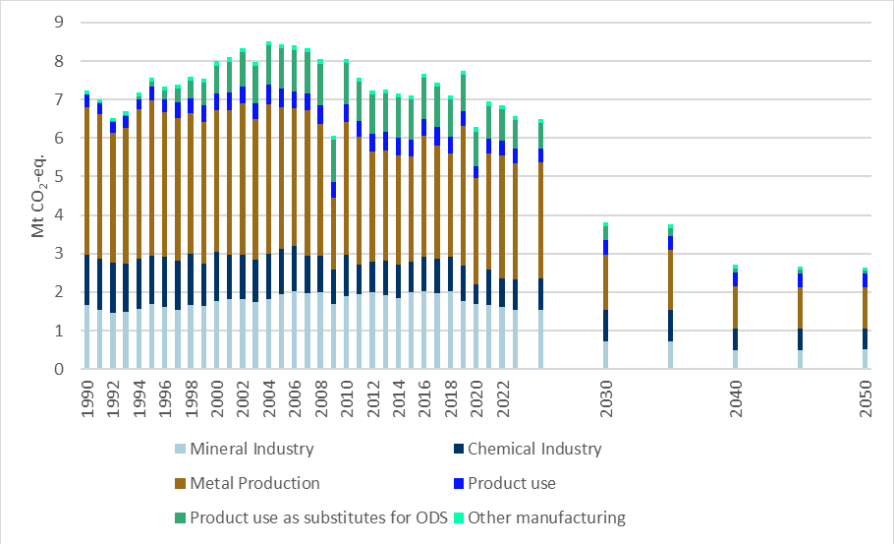

Figure 8 Historical and projected emissions of greenhouse gases from different industries and product use

The emissions of carbon dioxide equivalents from industrial processes were 21% lower in 2023 compared to the level in 1990 and are expected to decrease 68% until 2050. The decrease is mainly due to a decrease in emissions from the metal industry until 2050 and especially after 2030, due to a shift to fossil-free technology in the iron and steel industry. The emissions of carbon dioxide from the mineral industry are projected to decrease until 2050 compared with 1990 due to an assumed capture and storage of CO_2. The emissions of greenhouse gases from chemical industry are assumed to remain around the same level as in 2023. The emissions from fuel combustion in industry are reported in the energy sector.

The emissions from product use as substitutes for ODS[6] were 0.8 Mt CO_2-eq. in 2023. Emissions of fluorinated greenhouse gases are showing an increasing trend between 1990 and 2009 before starting to decrease. A decrease of emissions of fluorinated greenhouse gases until 2050 is expected due to a ban on their use that came into effect as a consequence of EU regulations. The EU regulation limits the total amount of fluorinated gases sold in the EU. Fluorinated greenhouse gases have also been banned in applications where less harmful alternatives are widely available. Furthermore, the regulation requires checks of current equipment to prevent leakages as well as recovery of the gases at the end of the equipment's lifetime.

[6] ODS: Ozone depleting substances

Table 10. Historical and projected emissions of greenhouse gases from industrial processes and product use sector (CRT 2. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	5.7	5.6	3.2	3.3	2.4	2.4	2.4	2.4
Methane	0.03	0.01	0.01	0.01	0.01	0.01	0.01	0.01
Nitrous oxide	0.8	0.1	0.1	0.1	0.1	0.1	0.1	0.1
HFC	0.006	0.8	0.4	0.2	0.1	0.1	0.1	0.1
PFC	0.5	0.03	0.04	0.04	0.04	0.04	0.04	0.04
SF6	0.1	0.04	0.04	0.04	0.03	0.03	0.01	0.01
Total emissions	**7.2**	**6.6**	**3.8**	**3.8**	**2.7**	**2.7**	**2.6**	**2.6**

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 the iron and steel industry, a shift to a fossil-free production technology with lower emissions are assumed for one installation after 2030 (based on information from industry)
- For mineral industry carbon capture and storage of CO_2 is assumed after 2030. (based on information from industry).
- Emissions of fluorinated greenhouse gases are assumed to decrease in line with EU-regulation on fluorinated greenhouse gases.[7]

2.3.8 Agriculture

In 2023, emissions of greenhouse gases from agriculture were to 6.3 Mt CO_2-eq. or 13% lower than in 1990. The decrease is largely due to an increased efficiency in the production and a reduced number of dairy cattle and swine. This in turn has led to lower methane emissions from the digestion process in ruminant and to reduced emissions of methane and nitrous oxide from manure management. Emissions of nitrous oxide from agricultural land have also declined as a result of a reduced acreage, reduced use of mineral fertilizers, and measures for reduced nitrogen leaching.

Greenhouse gas emissions are projected to decrease to 6.1 Mt CO_2-eq. in 2030 or by 16% compared with 1990 level and then further decrease by 19% in 2050 compared to 1990. Emissions are estimated to decrease mainly a result of continuous decline in the total cattle population. The reduced numbers of dairy cows until 2050 are mainly due to the assumptions of increased productivity and the development of product prices.

[7] Regulation (EU) 2024/573 on fluorinated greenhouse gases

Methane emissions from enteric fermentation are projected to decrease from 3.3 Mt CO_2-eq. in 2023 to 3.1 Mt CO_2-eq. in 2050. Emissions from manure management were 0.6 Mt CO_2-eq. in 2023 and are projected to be around the same level in 2050.

Emissions of nitrous oxides from agricultural soils are projected to decrease slightly, from 2.2 Mt CO_2-eq. in 2023 to 2.1 Mt CO_2-eq. in 2050 in this projection. Emissions of carbon dioxide from agriculture are relatively small and are related to liming and urea application. In 2023, the emissions amounted to about 0.1 million tonnes.

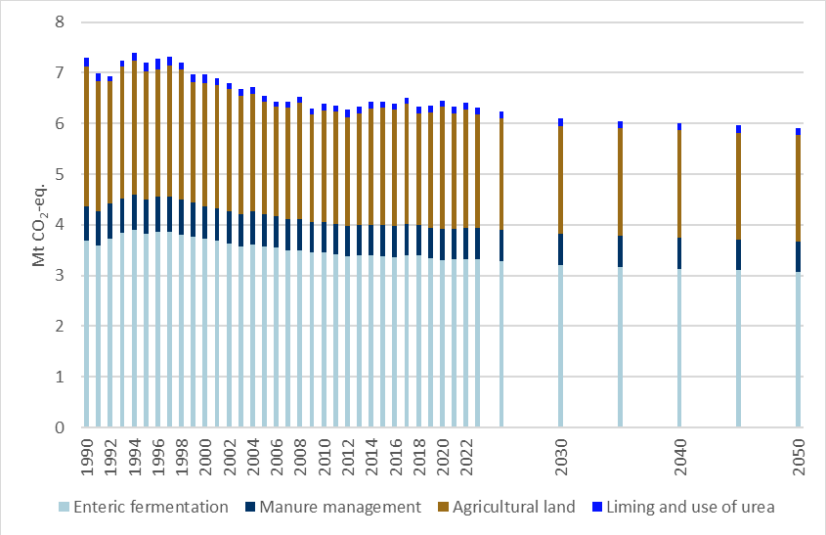

Figure 9. Historical and projected emissions of greenhouse gases from agriculture

Table 11. Historical and projected emissions of greenhouse gases from agriculture per gas (CRT 3. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Methane	3.9	3.7	3.5	3.5	3.5	3.4	3.4	3.4
Nitrous oxide	3.2	2.5	2.4	2.4	2.4	2.4	2.4	2.4
Carbon dioxide	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total agriculture	**7.3**	**6.3**	**6.1**	**6.0**	**6.0**	**6.0**	**5.9**	**5.9**

Table 12. Historical and projected emissions of greenhouse gases from agriculture (CRT 3, million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Enteric fermentation	3.7	3.3	3.2	3.2	3.1	3.1	3.1	3.1
Manure management	0.7	0.6	0.6	0.6	0.6	0.6	0.6	0.6
Agricultural soils	2.7	2.2	2.1	2.1	2.1	2.1	2.1	2.1
Liming/Use of urea	0.2	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Total agriculture	**7.3**	**6.3**	**6.1**	**6.0**	**6.0**	**6.0**	**5.9**	**5.9**

ASSUMPTIONS ON WHICH ESTIMATES FOR THE AGRICULTURAL SECTOR ARE BASED:

- The projections are based on assumptions on prices, productivity and available area of land and buildings.
- The prices are based on the average prices for 2024 in Sweden and price projections from OECD/FAO[8] until 2030, with an extrapolation to 2050.
- Assumed growth in productivity per year:

	Change per year
Harvest	+0.5%
Milk yield	+0.5%
Swine per sow	+1.5%
Supplies	-0.5%
Labour	-1.5%

- Assumed availability of buildings: 65% of current buildings are assumed to be in use in 2030 with only maintenance needed, 7% are disposed and 28% can be used if renovations are made.
- The current agricultural policy (CAP) in 2023-2027 is assumed to continue until 2050.

2.3.9 Waste

Total emissions from the waste sector in 2023 amounted to 1.1 Mt CO_2-eq., which is a reduction of 75% compared with 1990. Methane emissions from landfills are projected to decrease by 98% until 2050 compared with 1990. The main cause for the decrease is the ban on depositing combustible materials in landfills, which was introduced in 2002, and the ban on depositing organic materials in landfills, which was introduced in 2005. Furthermore, a tax on depositing waste in landfills was introduced in 2000.

The emissions of carbon dioxide from waste incineration and nitrous oxide from waste-water handling are low and are expected to remain stable during the entire projection period. However, emissions of nitrous oxide and methane from biological treatment of solid waste have shown an increasing trend and emissions are expected to increase slightly during the period due to increased production of biogas.

[8] OECD/FAO. 2024. OECD-FAO Agricultural outlook 2024-2033. OECD Publishing.

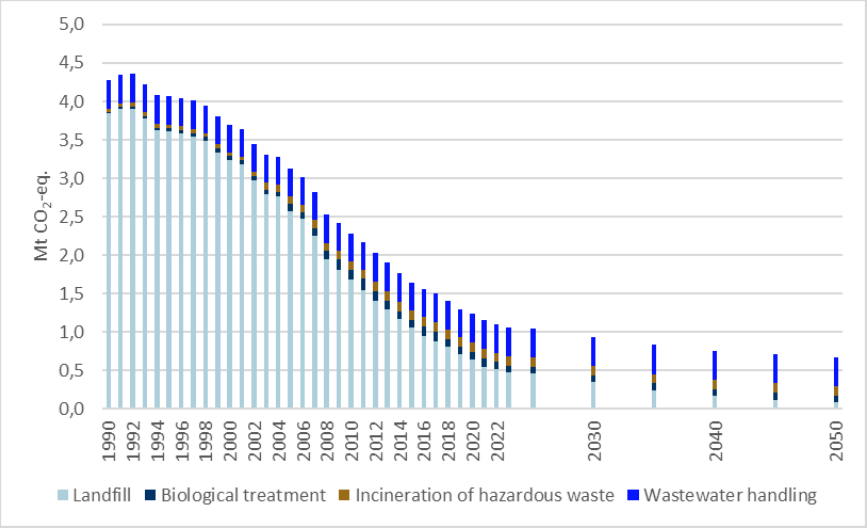

Figure 10. Historical and projected emissions of greenhouse gases from the waste sector.

Table 13. Historical and projected emissions of greenhouse gases from the waste sector (CRT 5. Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Carbon dioxide	0.04	0.1	0.1	0.1	0.1	0.1	0.1	0.1
Methane	4.0	0.7	0.6	0.5	0.4	0.4	0.4	0.4
Nitrous oxide	0.2	0.2	0.2	0.2	0.2	0.2	0.2	0.2
Total	**4.3**	**1.1**	**0.9**	**0.8**	**0.8**	**0.7**	**0.7**	**0.7**

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 assumed continued increasing production.
- The projections of emissions from waste-water handling and from incineration of hazardous waste are assumed to be at the same level as today.

2.3.10 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 1990-2023. During the period the annual net removals have varied, with a decreasing trend in the latest years ranging from around 60 to 30 Mt CO_2-eq.. The total size and variation of net removal in the LULUCF-sector is mainly affected by the carbon stock change in forest land. Changes in the carbon pool living biomass constitute a major part of

these changes in net removals. Net removals are influenced by inter alia growth, harvests and natural disturbances such as drought, spruce bark beetle, storms and fires on forest land.

The net removals for LULUCF were 31 Mt CO_2-eq. in 2023 and are estimated in the projections to be around 29 Mt CO_2-eq. in 2030 and 16 Mt CO_2-eq. in 2050, with assumptions made. The projections are based on several assumptions which are characterised by uncertainties, for example projections of future forest growth and harvesting levels and thus corresponding net removals are highly uncertain and dependent on weather and climate conditions. A sensitivity alternative has been produced for the LULUCF sector, simulating the forest using the same settings but assuming an average growth level. In the alternative projection, the net removals for the LULUCF-sector are calculated to be higher than in the WEM projections, resulting in around 35 Mt CO_2-eq. per year in 2030 and 25 Mt CO_2-eq. in 2050. See section 2.4.1.

The reported net removals from *forest land*, and in particular the carbon pool living biomass, show a decreasing trend which has been mainly attributed to a decline in forest growth. The decreasing forest growth in turn is explained mainly by changes in climatic conditions accentuated by a severe drought in 2018. In addition, the harvest rates have been high and continuously increasing, but after the peak in 2022 harvest rates decreased significantly 2023 and are predicted to decrease even further 2024. The projections for forest land indicate a decrease in the projection period. The result is uncertain, especially in the long term, due to uncertainties in assumptions and the net removals are largely determined by natural conditions.

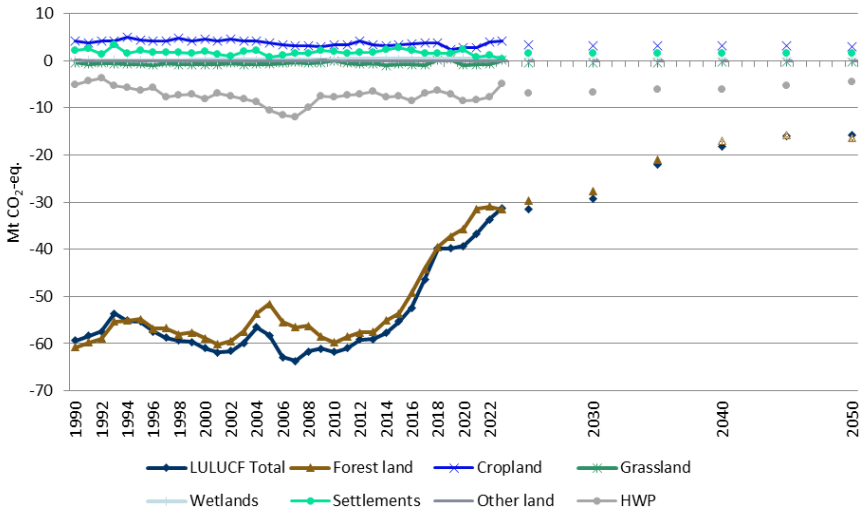

Figure 11 Historical and projected net emissions (+) and net removals (-) from the LULUCF-sector and its subcategories. The projections of net removals are based on several assumptions which are characterised by large uncertainties, especially in the long term after 2035. (Million tonnes of carbon dioxide equivalents per year)

Net emissions from *cropland* have varied between around 2.5-5 Mt CO_2-eq. per year during the period 1990 to 2023. The inter-annual variation in net emissions in cropland depends mainly on the variation in net emissions from mineral soils, which depends on climate variability and on the variation in the cultivated area and yields of different crops between years. The emissions of carbon dioxide from croplands originate mainly from the cultivation of drained organic soils. The net emissions from cropland are projected to decrease slightly based on a projected slight decrease in area and the average net emissions per area for the latest ten years.

Net emissions from *settlements* were in the range of around 0.5-3.5 Mt CO_2-eq. per year in the period 1990 to 2023. Emissions are caused by urbanisation, establishments of power lines and forest roads. These emissions are projected to be at the same level for the whole projection period as the average for the latest ten years.

The carbon stock changes in *grassland* and *wetlands* were small during the period 1990 to 2023 and are projected to stay low for the projection period.

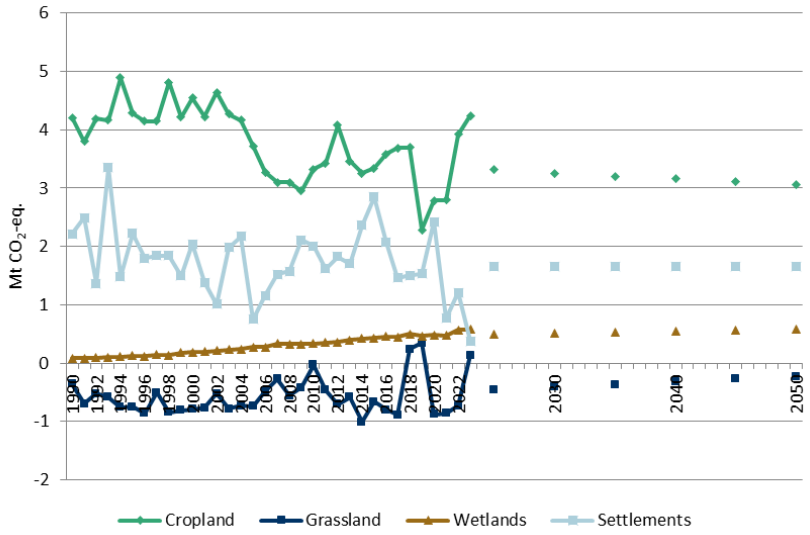

Figure 12. Historical and projected net emission (+) and net removals (-) from the LULUCF categories cropland, grassland, wetland and settlements (million tonnes of carbon dioxide equivalents per year)

Table 14. Historical and projected net emissions (+) and net removals (-) of greenhouse gases from LULUCF. The projections of net removals are based on several assumptions which are characterised by large uncertainties, especially in the long term after 2035 (CRT 4. Million tonnes of carbon dioxide equivalents. AR5. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Forest land	-60.7	-31.6	-27.6	-21.0	*-17.0*	*-15.7*	*-16.4*	*-16.4*
Cropland	4.2	4.2	3.3	3.2	*3.2*	*3.1*	*3.1*	*3.1*
Grassland	-0.4	0.1	-0.4	-0.4	*-0.3*	*-0.3*	*-0.2*	*-0.2*
Wetlands	0.1	0.6	0.5	0.5	*0.6*	*0.6*	*0.6*	*0.6*
Settlements	2.2	0.4	1.7	1.7	*1.7*	*1.7*	*1.7*	*1.7*
Other land	0.2	0.005	-0.005	-0.005	*-0.005*	*-0.005*	*-0.005*	*-0.005*
HWP	-5.0	-5.0	-6.7	-6.1	*-6.1*	*-5.3*	*-4.4*	*-4.4*
Total LULUCF	**-59.3**	**-31.2**	**-29.3**	**-22.1**	***-18.1***	***-15.9***	***-15.8***	***-15.8***

2.3.10.1 ASSUMPTIONS ON WHICH ESTIMATES FOR THE LULUCF-SECTOR ARE BASED:

Forest land,

- The reported projection is based on a scenario assuming an increase in annual harvest levels from the current level (90 M m^3sk). The harvest level was estimated to increase by 5 M m^3sk from the first simulated period (midyear 2022) to the third (midyear 2032) and thereafter with 0.35 M m^3sk per year.
- The annual growth was set to the relative growth[9] observed in the NFI 2015-2019 which represent a period of lower growth as compared to the long term average, the lower growth is representative for the current situation.
- Other settings were based on the scenarios in SKA-22 in terms of management, nature conservation and so forth (Eriksson et al 2022)[10].
- The structure of the standing stock at the start of the model simulation is based on the Swedish NFI which also forms the base for the annual reporting under the UNFCCC and the Kyoto protocol. NFI data from the inventories 2018-2022 was used for initial conditions representing 2020.
- In the projection until 2050, 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 1 333 000 ha is set aside for nature conservation through legal protection and

[9] Relative growth (%) = growth per year/wood storage

[10] A. Eriksson, J. Eggers, A. Lundström, J-M Roberge and P-E Wikberg. 2022. Skogliga konsekvensanalyser 2022 - material och metod. Tekniskt underlag. Skogsstyrelsens rapport 2022/08

3 200 000 ha is set aside through nature conservation measures in forest management and through voluntary measures by forest owners. Further 1 808 987 ha is left as retention patches within the forest used for timber production. The total forest land area used for timber production is 20 458 582 ha, including retention patches. The total simulated area consisted of productive forest land of 23 128 497 ha (including legally or voluntary set-aside areas and forest land used for timber production) and low-production forest land of 4 678 851 ha.

Cropland,

- The projection of *Cropland remaining cropland* assumes that the area continues to decrease, i.e the area was assumed to decrease by 0.4% annually according to the projection for the agriculture sector. The average net emissions 2014-2023 per area was assumed to persist and therefore used with the decreasing area to estimate the emissions for the projection years.
- For *land use change categories*, the annual conversion of land from and to cropland was assumed to persist at the same level as the last 10 years. Therefore, the projection for these categories have been calculated as the average of the last 10 years of reporting (2014-2023), as reported in the National Inventory Report, submission 2025.

Grassland,

- The projection *of Grassland remaining grassland* assumes that the area continues to decrease by 1.4% annually. The average net emissions 2014-2023 per area was assumed to persist and therefore used with the decreasing area to estimate the emissions for the projection years.
- For *land use change categories*, the annual conversion of land from and to grassland was assumed to persist at the same level as the last 10 years. Therefore, the projection for these categories have been calculated as the average of the last 10 years of reporting (2014-2023), as reported in the National Inventory Report, submission 2025.

Wetlands

- For *land converted to wetland*, the 10-year average for the period 2014-2023 was used for the projection, as reported in the National Inventory Report, submission 2025.
- For *peat production land*, a trend was extrapolated based on the assumption that the current production of peat for horticultural use continue.

Settlements

- The projected emissions/removals for each reported carbon pool are assumed to be constant and estimated as a mean for the period 2014-2023 as reported in the National Inventory Report, submission 2025.

Harvested Wood Products (HWP)

- The net removals for HWP are estimated based on the projected harvest from the Heureka-Regwise model and the assumption that the available biomass are distributed on the different product groups equally as today.

2.3.11 International transport

The emissions from international aviation and navigation, also known as international bunkers, were 7.6 Mt CO_2-eq. in 2023 and are 102% higher than in 1990. The emissions from international transport are projected to increase during the projection period, mainly due to increased emissions from international navigation.

The increased use of fuel for international navigation is due in part to changes in the passenger traffic between Sweden and the neighbouring countries and in part to goods transport to and from various parts of the world. The projection is based on the assumption that the transport volume will increase, at the same time as the transportation will be more efficient and emissions will decrease due to obligations in FuelEU Maritime and EUETS.

The greenhouse gas emissions from international aviation have increased by until 2019 but then decreased in 2020 and 2021 due to the covid-19 pandemic. The emissions are projected to increase until 2030 and then decrease until 2050 mainly due to increased use of sustainable fuels in accordance with the obligations in ReFuelEU Aviation and EUETS.

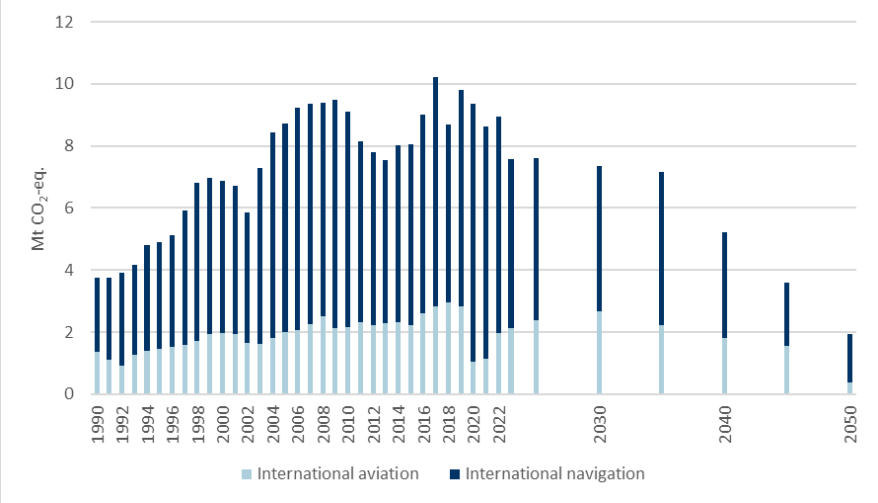

Figure 13. Historical and projected emissions of greenhouse gases from international transport.

Table 15. Historical and projected emissions of greenhouse gases from international transport (Million tonnes of carbon dioxide equivalents. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
Navigation	2.4	5.4	4.7	4.9	3.4	2.0	1.6	1.6
Aviation	1.4	2.1	2.7	2.2	1.8	1.6	0.4	0.4
Total	**3.7**	**7.6**	**7.3**	**7.2**	**5.2**	**3.6**	**2.0**	**2.0**

2.3.11.1 ASSUMPTIONS ON WHICH ESTIMATES FOR THE INTERNATIONAL TRANSPORT-SECTOR ARE BASED:

- The projections for international navigation are based on several assumptions GDP, fuel price, exports and imports. Of importance are also assumptions regarding technical development, energy efficiency, mileage and introduction of renewable fuels.
- The projections for international aviation are based on assumptions on number of passengers based on GDP, energy consumption and energy efficiency.

2.4 Sensitivity analysis

The sensitivity analysis includes an alternative projection for the LULUCF sector. However, this does not include uncertainty in the calculations, which may expand the span between the projections.

2.4.1 Sensitivity calculations for the LULUCF sector

The WEM projections for the LULUCF-sector are based on several assumptions which are characterised by large uncertainties, especially in the long term. The result should be interpreted with that in mind. For the projections a lower growth level was assumed which is representative for the current situation. A sensitivity alternative has been produced for the LULUCF sector, simulating the forest using the same settings but assuming an average growth level. In the alternative projection, the net removals for the LULUCF-sector are calculated to be around 35 Mt CO_2-eq. in 2030 and 25 Mt CO_2-eq. in 2050 per year. (see Figure 14 and Table 16). In both alternatives, the same harvest levels are assumed which also are characterised by large uncertainties.

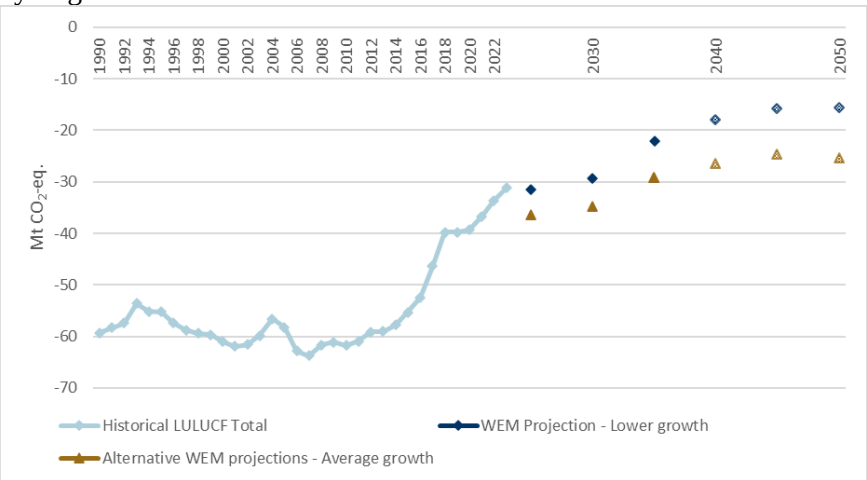

Figure 14 Historical total net removals (-) from the LULUCF-sector, WEM projections with lower growth and alternative WEM projections with average growth (Mt CO_2-equivalents per year.)

Table 16. Historical and projected net removals (-) of greenhouse gases from the different projections for the total LULUCF sector. The projections of net removals are based on several assumptions which are characterised by large uncertainties, especially in the long term after 2035. (CRT 4. Million tonnes of carbon dioxide equivalents per year. As numbers in the table are rounded the totals might not match).

	1990	2023	2030	2035	2040	2045	2050	2055
WEM projections - lower growth	-59.3	-31.2	-29.3	-22.1	*-18.1*	*-15.9*	*-15.8*	*-15.8*
Alternative WEM projections - average growth	-59.3	-31.2	-34.7	-29.3	*-26.6*	*-24.7*	*-25.4*	*-25.4*

ASSUMPTIONS ON WHICH ESTIMATES FOR THE SENSITIVE ALTERNATIVE FOR THE LULUCF SECTOR ARE BASED:

- In the projection "lower growth" (see section 2.3.10), the annual growth was set to the relative growth observed in the NFI 2015-2019 which represent a period of lower growth as compared to the long term average. The lower growth is representative for the current situation.
- In the alternative "average growth", the annual growth was set to the relative growth corresponding to the long term average.
- All simulations used the same settings related to forest management (except for the growth levels).

2.5 Projections for emissions covered by EU ETS and for emissions covered by ESR Effort Sharing Regulation.

Emissions covered by the EU ETS[11] were 17.6 Mt CO_2-eq.in 2023 including aviation. The emissions are projected to decrease until 2050 mainly due to an assumed shift to fossil-free technology in the iron and steel industry and assumed CO_2 capture and storage in mineral industry and refineries.

The emissions covered by the Effort Sharing Regulation (ESR)[12] were 26.8 Mt CO_2-eq. in 2023. The ESR-emissions have decreased since 2005 and are projected to be around 23.8 million tonnes in 2030.

[11] Directive 2003/87/EC

[12] Regulation (EU) 2018/842 of the European Parliament and of the Council of 30 May 2018 on binding annual greenhouse gas emissions reductions by Member States from 2021 to 2030 contributing to climate action to meet commitments under the Paris Agreement

Regulation (EU) 2023/857 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/842

Table 17. Historical and projected emissions of greenhouse covered by the EU ETS and ESR (Million tonnes of carbon dioxide equivalents, GWP according to IPCC AR5.).

	2023	2025	2030	2035	2040	2045	2050	2055
ETS incl. aviation	17.6	*16.8*	*10.1*	*9.3*	*7.8*	*7.6*	*7.5*	*7.5*
ESR WEM	26.8	*28.8*	*23.8*	*19.2*	*15.5*	*12.9*	*11.5*	*11.5*

Sweden's commitment according to the Effort Sharing Regulation

Sweden's commitment for the emissions covered by the Effort Sharing Regulation (ESR) is that emissions must decrease by 50% between 2005 and 2030. The commitment means that the ESR-emissions shall decrease from 31.3 Mt in 2021 to 21.6 Mt in 2030.

Furthermore, Member States can use flexibilities for reaching the targets. Transfer of emission allowances between Member States may be done. In addition to that, annual emissions allocation can be carried over from the next year, and if there is a surplus of allowances this can be transferred to the next year or to other Member States. Furthermore, Member States can also use surplus of net removals from LULUCF and some Member States can also have a limited cancellation of EU ETS allowances. Sweden has notified the Commission in 2023 to be able to use the EU ETS allowances.

For 2021, 2022 and 2023, Sweden's ESR-emissions were lower than the ESR-targets. The target was 31.3 million tonnes in 2021 and the emissions were preliminary 29.0 Mt CO_2-eq.. The target in 2022 was 30.7 million tonnes and the emissions were preliminary 27.2 Mt CO_2-eq. The target in 2023 was 29.6 million tonnes and the emissions were preliminary 26.8 Mt CO_2-eq.. This means a total surplus amount of AEAs of preliminary around 8.6 million tonnes compared to the Swedish ESR target.

The projections indicate a total gap in relation to the preliminary ESR-targets for the period 2021-2030 of around 0.5 million tonnes including the use of banked AEAs and the use of EUETS allowances. However, the results are not taking into account if there will be a preliminary debit for LULUCF-sector for 2021-2025. Note that these figures are uncertain and preliminary and will be final calculated for compliance in 2027 and 2032.

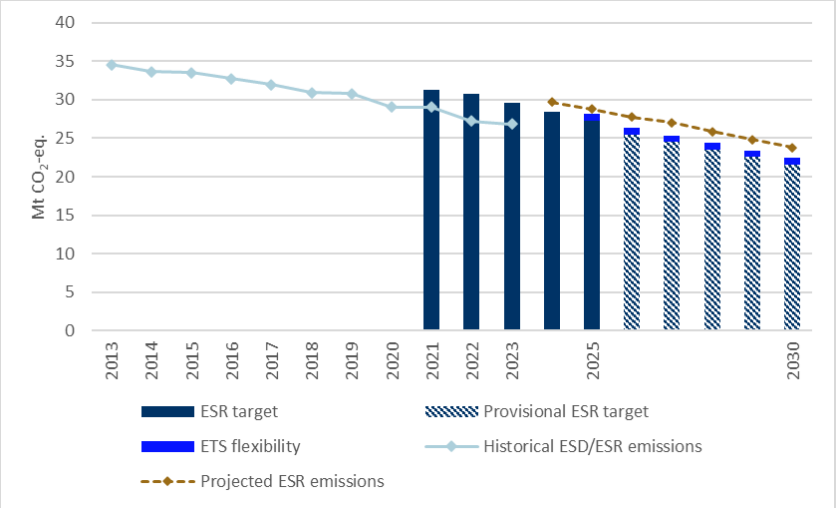

Figure 15. The ESR target 2021-2025, provisional ESR target 2026-2030, allocation from ETS flexibility, the historical emissions 2013-2023 and projected ESR emissions. (Million tonnes of carbon dioxide equivalents)

Target fulfilment in relation to the national targets

In June 2017 the Riksdag adopted a climate policy framework including targets until 2045. By 2045, the target for Sweden is to have no net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions. This means emissions from activities in Swedish territory are to be at least 85% lower by 2045 compared with 1990. Supplementary measures may count towards achieving zero net emissions, such as increased uptake of carbon dioxide in forests and land, bio-CCS and investments in other countries. International accounting guidelines will be followed for this. The projections, with existing measures, indicate that the total emissions of greenhouse gases, (excluding LULUCF) are estimated to decrease by around 70%. In addition, supplementary measures are estimated to be 1-2 Mt CO_2-eq. in 2030, mainly from bio-CCS but also from rewetting and investments in other countries.

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. The emissions outside EU ETS are projected to decrease by around 48% until 2030 and by around 66% until 2040. In addition, emissions from domestic transport (excl. CO_2 from aviation) are to be reduced by at least 70% by 2030 compared with 2010. The emissions are projected to decrease by around 43% between 2010 and 2030.

2.6 Projections for emissions and removals covered by the LULUCF-regulation.

The LULUCF-regulation[13] sets binding commitment for each Member State. For the accounting period from 2021 to 2025, taking into account the flexibilities, each Member State shall ensure that accounted changes in emissions do not exceed changes in removals, calculated as the sum of changes in total emissions and total removals on its territory in all of the land accounting categories, the EU "no-debit rule".

Based on the greenhouse gas inventory submission 2025 and the WEM projections the provisional accounted balance for 2021**–**2025 indicate preliminary that the accounted emissions could be higher than the accounted removals, meaning that Sweden will account debits. However, these figures for 2021**–**2025 are very uncertain and preliminary and will be final calculated for compliance in 2027. In addition, in accordance with the LULUCF-regulation, technical corrections of the forest reference level should be made which can further change the result.

Table 18. Provisional accounted balance for the period 2021-2025. Accounted credits (-) and accounted debits (+), excluding technical corrections of the forest reference level. Estimations are based on reported values for 2021-2023 and projected values for 2024-2025. Simulations are based on WEM projections with lower growth and alternative projections with average growth. (Million tonnes of carbon dioxide equivalents).

	2021–2025 Lower growth	2021–2025 Average growth
Deforested land	*10.0*	*10.0*
Afforested land	*1.0*	*1.0*
Managed forest land (1)	*4.6*	*-2,9*
Managed cropland	*0.8*	*0.8*
Managed grassland	*-0.1*	*-0.1*
Preliminary Total	*16.2*	*8.8*

(1) Preliminary calculation for managed forest land is uncertain and excluding technical correction of the forest reference level

For the accounting period 2026-2030, the target for 2030 for Sweden would be to increase the total net removal reported from the LULUCF-sector by 3.955 Mt CO_2-eq. compared to the average of 2016-2018. The projections for the LULUCF-sector indicate a gap to target for 2030 by around 15-21 Mt CO_2-eq. depending on the projection. Furthermore, net removals in the period 2026-2029 shall be less than a

[13] Regulation (EU) 841/2018 of the European Parliament and of the Council of 30 May 2018 on the inclusion of greenhouse gas emissions and removals from land use, land use change and forestry in the 2030 climate and energy framework.

Regulation (EU) 2023/839 of the European Parliament and of the Council of 19 April 2023 amending Regulation (EU) 2018/841

budget, the size of which is determined in 2025. The projections indicate a deficit for the budget period.
Note that these figures are very uncertain and preliminary and will be final calculated for compliance in 2032.

In addition to meeting the commitment, flexibilities can also be used. Sweden intends to use available flexibilities if needed.

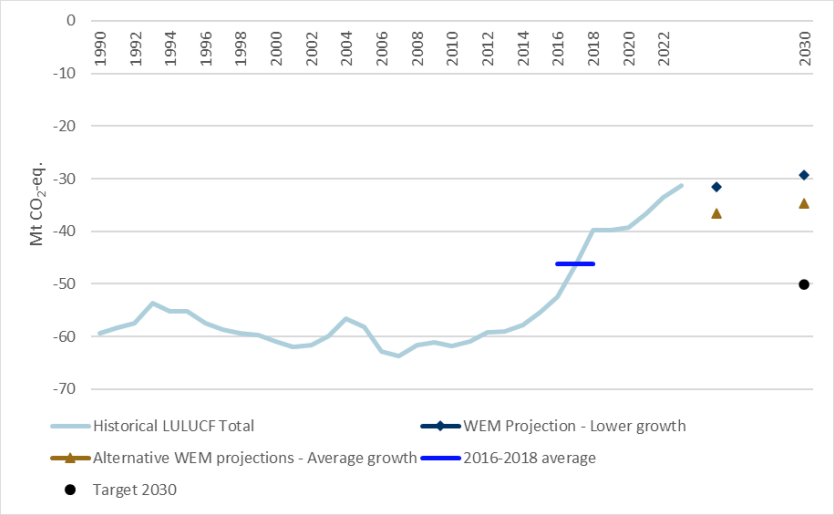

Figure 16. Historical net removals (-) from the total LULUCF-sector[14], WEM projections with lower growth and alternative WEM projections with average growth, preliminary average for 2016-2018 and preliminary target 2030. (Million tonnes of carbon dioxide equivalents per year)

2.7 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.

Energy sector

Projections for greenhouse gases for the energy sector are based on projections for the whole energy system. Projections for carbon dioxide emissions from the energy sector are drawn up by multiplying the total consumption of each fuel by the corresponding emissions factors. The energy projections, together with expert assessments of future emissions factors, have provided the basis for the projections of methane and nitrous oxide from incinerators.

Different models are used for each sub-sector in drawing up projections of trends in the energy system. The Times-Nordic model is used to make projections for electricity and heating production. Demand in the sub-sectors, taxes and other policy instruments, fuel prices and economic and technical development are used as

[14] National Inventory Report Sweden submission 2025

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 17. Expert assessments are an important element in all stages of the process.

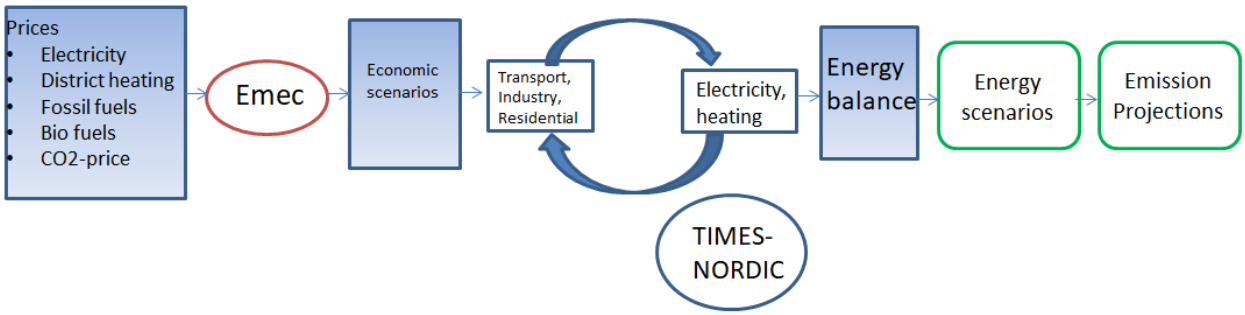

Figure 17 Projection process for emissions from the energy sector.

A starting point in the projection work on the development of the energy system in the short and long-term is assumptions on economic trends, both in Sweden and internationally. The economic variables included in the work on energy projections mainly consist of estimates of the trend in gross domestic product, private and public consumption, disposable income and trends in value-added for industry and commerce. For industry, estimates of economic development at the level of individual branches of industries are included.

Projections on economic development are drawn up using a general equilibrium model, EMEC, by the National Institute of Economic Research. Input data for projections on economic development are harmonized with projections on the development of the energy system by the National Institute of Economic Research and the Swedish Energy Agency. The economic growth generated by the EMEC model is governed firstly by access to production factors such as labor and capital and secondly by technical development, which are given exogenically in the model. The advantage in using this type of model is that it encompasses the whole economy. The model is therefore able to capture repercussions between sectors, for example a change of tax or the introduction of emission caps. The total economic impact is therefore captured in a more complete way than in partial models.

Another important basis for projections on trends in the energy system is the fossil fuel prices received from the EU. A model is used to convert international fossil-fuel prices for crude oil and coal to domestic user prices, paid by the final consumer, as crude oil has to be refined into finished motor fuels and fuels for heating before it can be used on the Swedish market.

Electricity and district-heating production
The projections on fuel use for electricity and district-heating production are based on the Times-Nordic model. The demand for electricity and district heating is exogenic data for the model which, through its optimisation algorithm, works out the most cost-effective fuel mix for the whole energy system, i.e. including energy use in the user sectors. Times-Nordic represents all Nordic countries (excluding Iceland) and permits electricity trade between neighboring countries.

Residential and commercial/institutional sectors
The projections of energy use in the residential and commercial/institutional sectors are drawn up by combining the model results from Times-Nordic and assessments by experts. Times-Nordic also models the competition for different heating systems in buildings. Different variables such as electricity and fuel prices, population development, potential for different heating systems, investment costs of heating systems, levels of efficiency and energy efficiency improvement are assumed. The projections for energy use from working machinery in agricultural sector are based on the projections in the agriculture sector. For working machinery the projections are based on projections from the Swedish Forestry Agency.

Industry sector
The projections on energy use in the industry sector come from an Excel-based model with the energy use in industries linked to economic relations (value added and production value) and energy prices. The energy use is primarily based on assumptions of economic development and energy prices. This result is harmonised through contacts with energy-intensive companies and industry organisations. Account is also taken of the results of the Times-Nordic energy system model.

Transport sector
The projections on carbon dioxide emissions from the transport sector are calculated on the basis of projections of energy use in the transport sector. The calculation of emissions of other greenhouse gases is based on the change in transport activity, number of vehicles in different vehicle types (e.g. fitted with catalytic converter) and emissions factors. The transport sector has been divided into four subsectors: 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 result of the HBEFA model. The projections for aviation, navigation and railways are based on assumptions on transport demand and future efficiency.

Industrial processes
Carbon dioxide emissions from industrial processes have been calculated using an Excel-based trend analysis of historical emissions. In addition to official statistics and economic projections, data and other information from industry organisations and companies have been used to obtain more detailed knowledge on the industries and emissions concerned.

Waste sector
Emissions from landfills in the waste sector are calculated using a model developed by the IPCC that has been partially modified to better represent conditions in Sweden. Results from the model calculations are also compared with results from field measurements. The method is based on figures on quantities of landfilled waste from 1952, the organic content of waste, the gas potentials of different types of waste and emissions factors.

Agricultural sector
Projections of activity data for the agricultural sector are based on results from an economic equilibrium model; the Swedish Agricultural Sector model (SASM), which is based on assumptions on production, productivity, prices and future agriculture policy. The projected activity data is used to calculate future emissions in the same way as is done for current emissions within the climate reporting process. Activity data includes figures related to numbers of livestock, manure production, stable period, methods for manure management and annual balances of nitrogen flows to and from agricultural land.

Land Use, Land-Use Change and Forestry sector
The projections for net removals in Forest land in the Land Use, Land-Use Change and Forestry sector are mainly estimated using the Heureka Regwise modelling tool. The model simulates the future development of the forests based on assumptions on how they are managed and harvested. The calculations encompass biomass in living trees and dead wood in productive forests. The development of the carbon stock in Living biomass and Dead wood is calculated in 5-year intervals. In the projection, net removals in these pools are calculated as the difference between the stocks at different times and represents the period between the simulated carbon stock. The soil organic carbon pool (mineral soils) and dead organic matter pool except dead wood (stumps, coarse litter, annual litter and the O-horizon) are based on simulations using the Q-model, which is a process-based model based on the continuous quality theory[15]. The Q-model is fed with the annual produced litter (harvest residues, annual litter fall and stumps) provided from the results of the Heureka-simulations.

[15] G. Ågren and E. Bosatta. 1996. Theoretical Ecosystem Ecology, Cambridge: Cambridge University Press, 1996.

For Cropland and Grassland, the average net annual emissions/removals per hectare for each carbon pool for the latest ten reported years are used together with the projected area of these land use categories. The projected emissions/removals for each reported carbon pool for Wetlands and Settlements are assumed to be constant and estimated as the mean over the latest ten years as reported in the latest submission. The net removals for HWP are estimated based on the projected harvest from the Heureka-Regwise-model and the assumption that available biomass is distributed to the different product groups in the same way as in current distribution, i.e. as an average of the five latest years in the latest submission.

3 Low Carbon Development Strategies

Sweden has reported a Low Carbon Development Strategy in January 2020. No changes have been made since then.

4 National system for reporting on policies and measures and projections

Under the MMR (Regulation (EU) 525/2013), Member States were required to report on national systems for policies and measures and projections.

According to Article 39 of Regulation (EU) No 2018/1999 of the European Parliament and the Council on the Governance of the Energy Union and Climate Action and to Article 36 of Commission Implementing Regulation (EU) No 2020/1208 on structure, format, submission processes and review of information reported by Member States pursuant to Regulation (EU) 2018/1999, Member States shall by 15 March 2021 provide a description of their national system for reporting on policies and measures and projections in the format set out in Annex XXIII.

As specified in the implementing regulation, the first report submitted in 2021 shall provide a full description and contain all the information listed in the Table. For subsequent reporting years, only modifications of the national system for policies and measures and projections need to be reported. There are no changes for submission 2025.

4.1 Name and contact information for the entities with overall responsibility for the National Systems for policies and measures and projections

The Swedish Ministry of Climate and Enterprise is the national entity with the overall responsibility for the national system for reporting on policies and measures and for the projections of anthropogenic greenhouse gas emissions.

4.2 Institutional arrangements in place for preparation of reports on policies and measures and of projections as well as for reporting on them, including an organogram

4.2.1 Institutional arrangements for projections

The Swedish Environmental Protection Agency has the responsibility for the reporting of projections of greenhouse gases, which includes compiling the underlying data, preparing the report and reporting files and for quality assurance. Several governmental agencies are involved in the process as well as a consortium of consultants, SMED[16], see Figure 17.

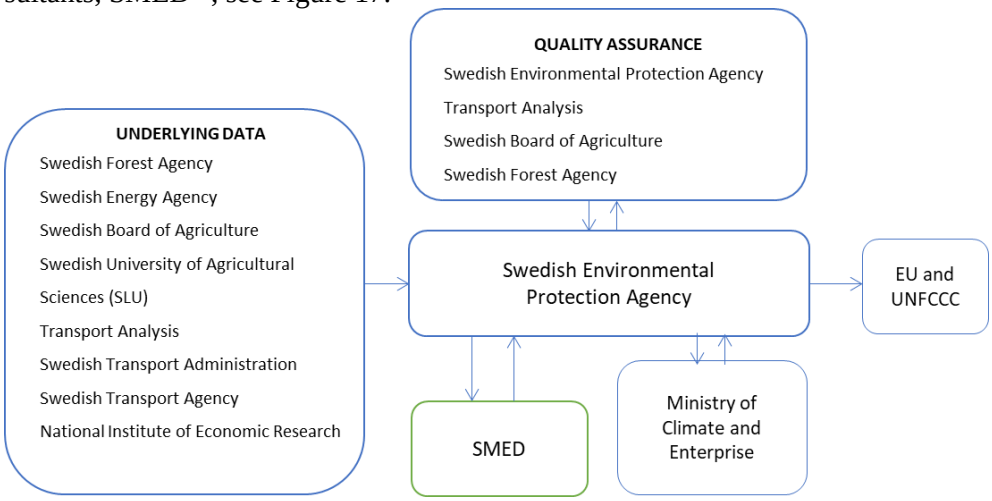

Figure 18. Institutional arrangements for the reporting of projections.

SMED is a consortium of consultants.

[16] Swedish Environmental Emissions Data (SMED), consisting of the Swedish Meteorological and Hydrological Institute (SMHI), Statistics Sweden (SCB), the Swedish University of Agricultural Sciences (SLU) and the Swedish Environmental Research Institute (IVL)

4.2.2 Institutional arrangements for reporting on policies and measures

The Swedish Environmental Protection Agency has the responsibility for the reporting of policies and measures, which includes producing the report and to report. As the governmental agencies have a sectorial responsibility for the implementation and assessment of policies and measures and a thorough know-how of policies and measures, these agencies are also involved in the process of quality assurance, see Figure 18.

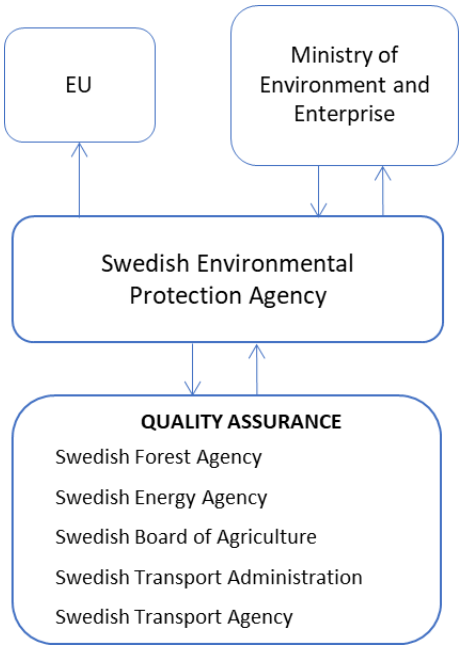

Figure 19 Institutional arrangements for the reporting on policies and measures

4.3 Legal arrangements in place for preparation of reports on policies and measures and of projections

The legal basis for Sweden's national system for reporting on policies and measures and projections is provided by the Ordinance on Climate Reporting[17] (SFS 2014:1434) which describes the roles and responsibilities of the government agencies in the context of climate reporting. The ordinance requires that sufficient resources are available for timely reporting. The ordinance supports all reporting requirements according to the Governance Regulation.

[17] http://www.lagboken.se/Views/Pages/GetFile.ashx?portalId=56&cat=24593&docId=2232659&propId=5

In addition, formal agreements including the details on content and timetable for providing data have been made between the Swedish Environmental Protection Agency and the relevant government agencies.

4.4 Procedural and administrative arrangements and timescales in place for the preparation of reports on policies and measures and of projections, to ensure the timeliness, transparency, accuracy, consistency, comparability and completeness of the information reported.

4.4.1 Procedural arrangements for projections

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.

Underlying projections on activity data are provided by several government agencies. The projections on emissions are then produced and compiled by the Swedish Environmental Protection Agency.

Projections of emissions and removals of greenhouse gas emissions shall be reported the 15th of March 2021 and every two years after that, according to article 18 in the Regulation (EU) 2018/1999

Planning

Year X is the reporting year. At the end of year X-2 planning begins together with all involved agencies and actors, and which continues during the first quarter of year X-1. The reporting cycle is finalized with a meeting where the process is discussed, quality control and quality assurance activities analyzed and evaluated and areas of improvement are identified. An assessment of models and methodologies for producing of the projections is also performed to identify areas of improvement or if there is a need to change models used. The outcome of the meeting serves as input to the planning of the next reporting cycle.

An overview of the process is given in Figure 19. A close cooperation between involved agencies and actors takes place to ensure that all underlying data will be available on time and that the projections build upon the same assumptions.

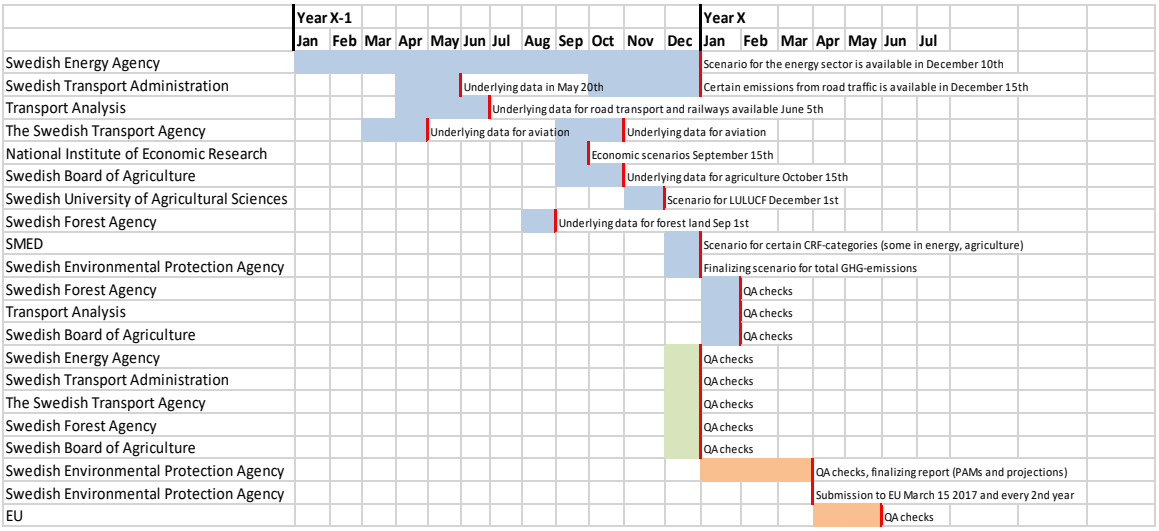

Figure 20 Overview of the process for the reporting of projections of greenhouse gases

Collecting data

During the second half of year X-1 the underlying data are received from the Swedish Energy Agency, the Swedish Transport Agency, the Transport Analysis, the Swedish Transport Administration, the Swedish Board of Agriculture and the Swedish University of Agricultural Sciences and compiled by Swedish Environmental Protection Agency. As the governmental agencies have a sectorial responsibility for the implementation and assessment of policies and measures and a thorough know-how of policies and measures, this ensures that all implemented policies and measures are taken into consideration when producing the projections.

Selecting methodologies and assumptions

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 developed and improved. Assumptions are made based on available data and on expert knowledge. The work is carried out in close cooperation between the Swedish Environmental Protection Agency and other relevant agencies. For projections, sensitivity analyses are performed by applying a range of lower and higher estimates to the key assumptions. These are chosen to reflect the sensitivity of the model when changing some key parameters over a range of values. The result of the sensitivity analyses is described in the textual part of the report.

Quality control and quality assurance

All data are subjected to general quality control activities throughout the production of data. The quality control and quality assurance cover transparency, completeness, consistency, accuracy and comparability. The quality checks also identify potential areas for improvement in future reporting. The findings are discussed

in a final meeting which concludes the reporting cycle and serves as input into the planning of the next.

The quality control and quality assurance activities are performed in two steps. The quality control is performed by the agencies and actors themselves, which provide underlying data to the projections. Then, when the report and reporting files are prepared, the quality assurance activities are performed by the Swedish Environmental Protection Agency, Transport Analysis, the Swedish Board of Agriculture and the Swedish Forest Agency.

The quality control and quality assurance activities are documented. The Swedish Environmental Agency provides a checklist that can be used during the quality procedures and for documentation.

4.4.2 Procedural arrangements for policies and measures

The national system is designed to ensure the quality of the reporting on policies and measures and projections, i.e. to ensure its transparency, consistency, comparability, completeness, accuracy and timeliness. The process for reporting applies a plan-do-check-act approach.

The planning of the compilation of the report on policies and measures starts approximately one year before reporting. The report is compiled and includes quality control activities. After quality assurance activities and, if needed, adjustments of the report, the Swedish Environmental Protection Agency sends the report to the Swedish Ministry of Climate and Enterprise before submitting the report to the EU on the 15th of March 2021 and every two years after that, according to article 18 in the Regulation (EU) 2018/1999, see Figure 20.

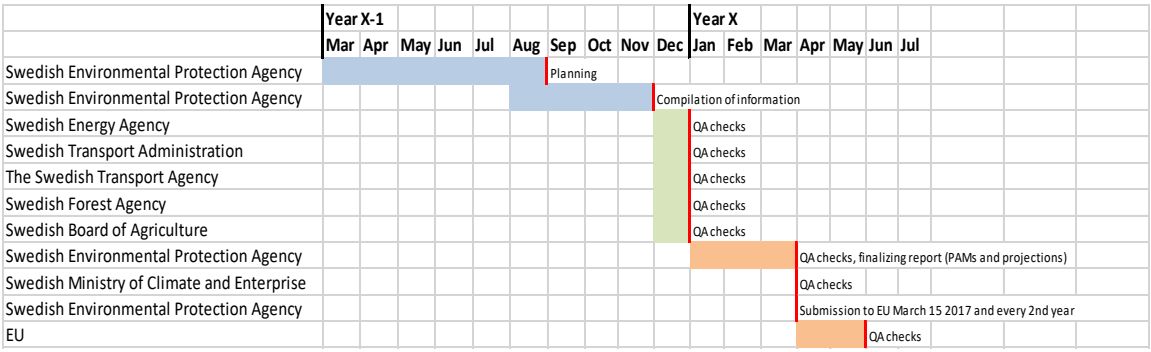

Figure 21 Overview of the process for the reporting of policies and measures

Planning

The work on the report on policies and measures is initiated one year before submission through planning activities. The reporting cycle is finalized with a meeting where the process is discussed, quality control and quality assurance activities analyzed and evaluated and areas of improvement are identified. The outcome of the

meeting serves as input to the planning of the next reporting cycle. The information on policies and measures is put together by the Swedish Environmental Protection Agency. Government Agencies, in accordance with the Ordinance, are then performing the quality assurance activities.

Collecting data
The Swedish Environmental Protection Agency collects the information needed for reporting on policies and measures and produces the reports.

Selecting methodologies and assumptions
The relevant assumptions, methodologies and models for producing the report on policies and measures, are selected when planning the report. The work is based on an assessment of the method to be the most relevant and suitable. The work is carried out in close cooperation between the Swedish Environmental Protection Agency and other relevant agencies.

Quality control and quality assurance
All information is subjected to general quality control activities throughout the production of the report. Quality assurance is carried by relevant government agencies, as provided in the Ordinance. The timetables for quality assurance are included in the agreements between the government agencies and the Swedish Environmental Protection Agency. The quality assurance covers transparency, completeness, consistency, accuracy and comparability. The quality control and quality assurance activities identify potential areas for improvement in future reporting. The findings serve as input to the planning of the next reporting cycle.

4.5 Description of the information collection process

4.5.1 Developing projections

During the process of producing the projections the underlying data are received from the Swedish Energy Agency, the Swedish Transport Agency, the Transport Analysis, the Swedish Transport Administration, the Swedish Board of Agriculture and the Swedish University of Agricultural Sciences and compiled by Swedish Environmental Protection Agency. As the governmental agencies have a sectorial responsibility for the implementation and assessment of policies and measures and a thorough know-how of policies and measures, this ensures that all implemented policies and measures are taken into consideration when producing the projections.

4.5.2 Evaluating policies and measures

The Swedish Environmental Protection Agency collects information of policies and measures mainly through scanning Government’s bills. Moreover, information on the policies and measures are collected on the implementing government

agencies' websites. As a complement, government agencies identify, in the quality check, if any decision of relevance is missing and provides, if requested, additional information. Information for evaluation of policies and measures is mainly collected from relevant Government agencies and, if relevant, from actors.

4.6 Description of the alignment with the national inventory system

The national system for reporting on policies and measures and projections is based on the national system for the national inventories. The legal arrangements are the same for reporting on policies and measures and projections as for the national inventory. The ordinance supports all reporting requirements according to the Governance Regulation. The institutional and procedural arrangements for reporting on policies and measures and projections are based on the national system for inventories but agencies involved and procedural arrangements and timescales are adjusted to be relevant for reporting on policies and measures and projections.

4.7 Description of the links to arrangements on integrated national energy and climate- reports pursuant to Art. 17 of Regulation (EU) 2018/1999

The information in the report on policies and measures and projections are used in the integrates national energy and climate reports.

4.8 Description of the quality assurance and quality control activities for reporting of policies and measures and projections

4.8.1 Quality control and quality assurance for reporting on projections

All data are subjected to general quality control activities throughout the production of data. The quality control and quality assurance cover transparency, completeness, consistency, accuracy and comparability. The quality checks also identify potential areas for improvement in future reporting. The findings are discussed in a final meeting which concludes the reporting cycle and serves as input into the planning of the next.

The quality control and quality assurance activities are performed in two steps. The quality control is performed by the agencies and actors themselves, which provide

underlying data to the projections. Then, when the report and reporting files are prepared, the quality assurance activities are performed by the Swedish Environmental Protection Agency, Transport Analysis, the Swedish Board of Agriculture and the Swedish Forest Agency.

The quality control and quality assurance activities are documented. The Swedish Environmental Agency provides a checklist that can be used during the quality procedures and for documentation.

4.8.2 Quality control and quality assurance for reporting on policies and measures

All information is subjected to general quality control activities throughout the production of the report. Quality assurance is carried by relevant government agencies, as provided in the Ordinance. The timetables for quality assurance are included in the agreements between the government agencies and the Swedish Environmental Protection Agency. The quality assurance covers transparency, completeness, consistency, accuracy and comparability. The quality control and quality assurance activities identify potential areas for improvement in future reporting. The findings serve as input to the planning of the next reporting cycle.

4.9 Description of the process for selecting assumptions, methodologies and models for making projections of anthropogenic greenhouse gas emissions

The relevant assumptions, methodologies and models for producing the report on 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 developed and improved. Assumptions are made based on available data and on expert knowledge. The work is carried out in close cooperation between the Swedish Environmental Protection Agency and other relevant agencies. For projections, sensitivity analyses are performed by applying a range of lower and higher estimates to the key assumptions. These are chosen to reflect the sensitivity of the model when changing some key parameters over a range of values.

4.10 Description of procedures for the official consideration and approval of the Member

States national system for policies and measures and projections

The Ministry of Climate and Enterprise is the national entity with the overall responsibility the national system for reporting on policies and measures and for the projections of anthropogenic greenhouse gas emissions.

The Swedish Environmental Protection Agency has the responsibility for the reporting of the national system for reporting on policies and measures and projections.

The Swedish Environmental Protection Agency sends the report to the Swedish Ministry of Climate and Enterprise for official consideration and approval of the Government Offices of Sweden before submitting the report to the EU.

4.11 Information on relevant institutional administrative and procedural arrangements for domestic implementation of the EU's nationally determined contribution, or changes to such arrangements

Sweden has set up a national climate policy framework consisting of a Climate Act, national climate targets and a Climate policy council. 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. The national climate targets are in line with, or more ambitious, than the EU's nationally determined contribution, wherefore the institutional set up should be sufficient.

4.12 Description of the stakeholder engagement undertaken in relation to the preparation of policies and measures and projections

In the preparation of reporting on policies and measures several government agencies are involved, as described in section 5.2. In the process of production of projections each government agency contacts relevant actors based on relevance and need for information. Also for evaluation of policies and measures relevant actors are contacted based on need for information.