

National Inventory Document Sweden 2026

Greenhouse Gas Emission Inventories 1990-2024

Submitted under the United Nations Framework
Convention on Climate Change and the Paris Agreement



Swedish Environmental Protection Agency
Telephone +46 10 698 10 00, telefax +46 10 698 10 99
E-mail: registrator@naturvardsverket.se
Address: Naturvårdsverket, SE-106 48 Stockholm, Sweden
Internet: www.naturvardsverket.se
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Preface

According to Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC), parties are required to annually submit national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol.

The National Inventory Document (NID) for the year 2024 (submission 2026) is prepared in accordance with the Reporting Guidelines agreed by the UNFCCC on its nineteenth session of the Conference of the Parties (COP) in Warsaw 2013 and subsequent decisions. It contains national greenhouse gas inventories for the period 1990 to 2024, and descriptions of methods used to produce the estimates. The combined effect of various greenhouse gases has been calculated using global warming potential factors from the Fifth Assessment report of the IPCC (GWP AR5). The methods used to calculate emissions and removals are in accordance with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, and the IPCC supplementary guidelines for Wetlands (*2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*).

This inventory is coordinated by the Swedish Environmental Protection Agency, on behalf of the Swedish Ministry of Climate and Enterprise.

Johan Kuylenstierna
Director-General, Swedish Environmental Protection Agency

Authors

Sammanfattning/Executive summary

Niklas Brännlund (Swedish Environmental Protection Agency)

Introduction

Malin Kanth (Swedish Environmental Protection Agency), Mikael Szudy, Simon Carlén, Martin Kellner, and Julia Hytteborn (Statistics Sweden), Ingrid Mawdsley (IVL Swedish Environmental Research Institute) and Carina Josefsson Ortiz (Swedish University of Agricultural Sciences)

Trends in greenhouse gas emissions

Niklas Brännlund, Emma Carlén, Malin Kanth, Frida Löfström, Amanda Hagerman, Anna Forsgren, and Joel Bengtsson (Swedish Environmental Protection Agency)

Energy (CRT sector 1)

Simon Carlén, Marcus Sundbom, Martin Kellner, Maya Sundsten (Statistics Sweden), Daniel Hammerlid, Ann Sjöblom, Ingrid Mawdsley, Katarina Yaramenka, and Cecilia Hult (IVL Swedish Environmental Research Institute)

Industrial processes and product use (CRT sector 2)

Ann Sjöblom, Daniel Hammerlid, Ingrid Mawdsley, Malva Laurelin, and Katarina Yaramenka (IVL Swedish Environmental Research Institute)

Agriculture (CRT sector 3)

Julia Hytteborn (Statistics Sweden)

Land use, land-use change and forestry (CRT sector 4)

Carina Josefsson Ortiz, Mattias Lundblad, Hans Petersson, Erik Karlton, Per-Erik Wikberg, Johan Stendahl and Martin Bolinder (Swedish University of Agricultural Sciences)

Waste (CRT sector 5)

Mikael Szudy (Statistics Sweden) and Katarina Yaramenka (IVL Swedish Environmental Research Institute)

Information on changes in national system

Malin Kanth (Swedish Environmental Protection Agency) and Sharmin Chian (Swedish Energy Agency)

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Sammanfattning

S 1. Bakgrund

Växthusgaser har alltid funnits i atmosfären, men på grund av mänsklig aktivitet har koncentrationen av många av dem ökat, vilket intensifierar växthuseffekten. 1988 bildades FN:s klimatpanel (Intergovernmental Panel on Climate Change – IPCC). Två år senare konstaterade panelen att antropogen klimatpåverkan utgör ett globalt hot och efterfrågade en internationell överenskommelse för att hantera problemet. FN:s generalförsamling inledde förhandlingar om en ramkonvention kring klimatförändringar (United Nations Framework Convention on Climate Change - UNFCCC), vilken trädde i kraft 1994. Det långsiktiga målet är att stabilisera halterna av växthusgaser i atmosfären på en nivå som förhindrar skadliga antropogena klimatförändringar från att äga rum.

Det viktigaste tillägget till konventionen förhandlades fram i Paris hösten 2015 då världens länder enades om ett globalt klimatavtal. Parisavtalets mål är att hålla ökningen av den globala medeltemperaturen till *väl under* två grader och att *sträva efter* att begränsa temperaturökningen till 1,5 grader. Inom avtalet har alla länder lagt ett nationellt fastställt bidrag till att nå avtalets mål. Ambitionen i bidragen ska skärpas successivt samt förnyas eller uppdateras vart femte år. Sveriges bidrag ingår i EU:s bidrag om att minska nettoutsläppen av växthusgaser inom unionen med minst 55% till 2030 jämfört med 1990. En global översyn för att följa upp framstegen mot avtalets mål sker vart femte år, från och med 2023. Principer för uppföljning och rapportering av parternas nationellt fastställda bidrag etablerades i Paris. Bara knappt ett år efter Paris hade tillräckligt många parter ratificerat Parisavtalet för att det skulle kunna träda i kraft. Regelboken för hur Parisavtalets olika delar ska tillämpas i praktiken, inklusive nya riktlinjer för hur bidragen ska följas upp och parternas rapportering, beslutades vid COP24 i Katowice samt vid COP26 i Glasgow. Det innebär att det för första gången finns en gemensam uppsättning rapporteringsriktlinjer för uppföljning och rapportering för alla länder. Första rapporteringen under Parisavtalet skedde 2024.

Innan Parisavtalet trädde i kraft var Kyotoprotokollet det viktigaste tillägget till konventionen. Kyotoprotokollet förhandlades fram år 1997 i Kyoto, Japan och trädde i kraft 2005. Kyotoprotokollet innebär bindande åtaganden, för utvecklade länder (Annex I) förutom USA. Kyotoprotokollet har haft två åtagandeperioder 2008 till 2012 och 2013 till och med 2020. Skillnaden mellan Parisavtalet och Kyotoprotokollet är att alla parter till Parisavtalet anger ett nationellt fastställt bidrag som definierats av parten själv och som ska uppdateras över tid. Kyotoprotokollets åtaganden gällde bara de rikaste länderna och fastställdes genom förhandlingar.

Kyotoprotokollets åtaganden gäller minskade utsläpp av växthusgaser från Annex I-parterna om minst 5% under åren 2008–2012 jämfört med basåret 1990. Under Kyotoprotokollets första åtagandeperiod åtog sig EU att minska utsläppen med 8 procent jämfört med 1990 (1995 för fluorerade gaser). I den andra perioden (2013–2020), enligt Dohaändringen, åtog sig EU tillsammans med Island att minska utsläppen med 20 procent till 2020 jämfört med 1990. Sveriges mål inom EU var att minska utsläppen med 17 procent till 2020 jämfört med 2005 i sektorer utanför EU:s utsläppshandel. År 2022 lämnade Annex I-parter in sin sista växthusgasinventering. Efter slutlig granskning 2022

slutfördes processen 2023 med en *True-up period report*. EU och medlemsländerna uppfyllde målet att minska utsläppen med 20 procent jämfört med 1990.

Enligt FN:s klimatkonventions fjärde och tolfte artiklar ska Annex I-parterna årligen rapportera sina utsläpp från källor och upptag i sänkor för alla växthusgaser som inte omfattas av Montrealprotokollet. Sveriges nationella inventeringsrapport (National Inventory Document – NID) för år 2026 utgör den årliga rapporteringen enligt FN:s klimatkonvention och Parisavtalet. Rapporten har förberetts utifrån de riktlinjer som FN:s klimatkonvention antog vid dess nittonde konferens (Conference of the Parties – COP 19) i Warszawa 2013 samt följande beslut under Parisavtalet. Rapporten innehåller den nationella växthusgasinventeringen för perioden 1990 till 2024 samt beskrivningar av metoderna som använts för att ta fram statistiken. Metoderna som använts följer FN:s klimatpanels riktlinjer för nationell växthusgasinventering från 2006, IPCC:s tilläggsriktlinjer för våtmarker samt de uppdaterade 2006 riktlinjerna från 2019. Växthusgasinventeringen är densamma som rapporteras till EU under Styrningsförordningen (2018/1999/EG) och som ligger till grund för uppföljning emot Sveriges åtagande under EU:s klimatpaket, Fit for 55.

Rapporten omfattar utsläpp till luft av de direkta växthusgaserna CO₂, CH₄, N₂O, HFC, PFC, SF₆ och NF₃ samt de indirekta växthusgaserna NO_x, CO, NMVOC och SO₂. Rapporten innehåller information om Sveriges inventering av växthusgaser för alla år från 1990 till 2024, inklusive beskrivningar av metoder, datakällor, osäkerheter, utförd kvalitetssäkring och kvalitetsstyrning (QA/QC) samt en trendanalys.

Vid en intern översyn 2016 upptäcktes att en utökad sekretessklassning var nödvändig jämfört med tidigare rapporteringar för att följa den svenska offentlighets- och sekretesslagen. Detta har påverkat underlagsdata i vissa undersektorer till stationär förbränning (CRT 1) och i industriprocesser och produktanvändning (CRT 2). Dessa har därför blivit klassificerade med sekretesskod (C). Sverige arbetar aktivt för att förbättra transparensen i rapporteringen och strävar efter att minimera sekretessklassningen av information i inventeringen.

Elektroniska utsläppsdata, aktivitetsdata samt emissionsfaktorer bifogas rapporten i det gemensamma rapporteringsformatet (Common Reporting Tables – CRT), på FN:s klimatkonventions begäran.

S 2. Översikt av utsläpps- och upptagstrender per gas

De totala utsläppen av växthusgaser i Sverige var 47,5 miljoner ton koldioxidekvivalenter år 2024 (exklusive LULUCF) (Tabell S.1 och Tabell S.2). Jämfört med 2023 är det en ökning med 7%. Utsläppen har minskat med 33% mellan 1990 och 2024. Nedan beskrivs först utsläppstrender per gas jämfört med totalen (exklusive LULUCF) följt av korta beskrivningar av trenden inom LULUCF.

De totala utsläppen av koldioxid (CO₂) 2024 var 38,8 miljoner ton vilket motsvarar cirka 82% av de totala utsläppen av växthusgaser. Energisektorn, inklusive transporter, stod för 85% av de totala koldioxidutsläppen och är därmed den största källan till koldioxidutsläpp i Sverige. Utsläppen av koldioxid 2024 var 32% lägre än 1990, men 10% högre än 2023.

Utsläppen av metan (CH₄) var 4,5 miljoner ton koldioxidekvivalenter år 2024 vilket motsvarar 10% av de totala utsläppen av växthusgaser. 80% av metanutsläppen kommer från jordbruket, resterande utsläpp kommer framför allt från avfallsdeponier och från förbränning av fossila bränslen inom energisektorn. Sedan 1990 har utsläppen av metan minskat med 48%, vilket främst beror på minskade utsläpp inom avfallssektorn och till viss del på minskade utsläpp från jordbrukssektorn. Mellan 2023 och 2024 har metanutsläppen minskat med 2,6%.

De totala utsläppen av lustgas (N₂O) 2024 var 3,4 miljoner ton koldioxidekvivalenter, vilket motsvarade 7% av de totala utsläppen av växthusgaser. Utsläpp av lustgas härrör huvudsakligen från jordbrukssektorn (cirka 75% av totala lustgasutsläppen). Sedan 1990 har utsläppen av lustgas minskat med cirka 28%. År 2024 ökade lustgasutsläppen med 0,7% jämfört med 2023.

De totala utsläppen av fluorerade växthusgaser (PFCs, HFCs och SF₆) var 0,8 miljoner ton koldioxidekvivalenter år 2024 vilket motsvarar cirka 2% av de totala utsläppen av växthusgaser. Utsläppen 2024 är 25% högre jämfört med 1990. Den högre nivån beror främst på att ozonförstörande ämnen ersatts av växthusgaser (HFCs). Utsläppen har dock planat ut sedan 2009 till följd av införandet av en ny EU-förordning 2006, och minskat de senaste åren. Mellan 2023 och 2024 var minskningen cirka 7%.

Nettoupptaget inom sektorn markanvändning, förändrad markanvändning och skogsbruk (LULUCF) uppskattades 2024 till cirka 54 miljoner ton koldioxidekvivalenter. Merparten av nettoupptaget sker i kolpoolerna levande biomassa och mineraljord. Den dominerande markkategorin är skogsmark, där merparten av nettoupptaget av koldioxid sker. Skogsmarken utgör 69% av Sveriges landareal. Inom denna marktyp har den totala nettoupptaget varierat under perioden 1990–2024, med ett genomsnitt på cirka 56 miljoner ton koldioxidekvivalenter. Mellan 2010 och 2020 minskade nettoupptaget i levande biomassa på grund av minskad tillväxt i kombination med hög avverkning och naturlig dödlighet. Efter 2020 har tillväxtminskningen upphört och tillväxten har nu ökat igen från den lägre nivån. Samtidigt var avverkningen under 2023 och 2024 de lägsta på tio år, och den naturliga dödligheten i träd har också minskat. Nettoupptaget i avverkade träprodukter följer trenden i levande biomassa, där högre avverkning leder till högre nettoupptag och lägre avverkning leder till lägre nettoupptag. År 2024 var nettoupptaget knappt 4 miljoner ton koldioxid, vilket var en minskning med 25%. De största utsläppen

i sektorn kommer från organisk mark i alla markkategorier, och 2024 uppgick dessa utsläpp till drygt 12 miljoner ton koldioxidekvivalenter. Åkermark, betesmark, bebyggd mark och våtmarker har alla nettoutsläpp 2024.

Tabell S.1. Utsläpp av växthusgaser per gas (kt CO₂ ekvivalenter).

Växthusgas- utsläpp	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023	2024
CO ₂ inkl. LULUCF	-3 976	2 161	-8 067	-5 988	-9 727	-13 849	-4 853	-2 934	-8 735	-12 296	-17 090
CO ₂ exkl. LULUCF	57 319	59 386	54 824	53 739	52 984	43 251	36 595	38 547	36 073	35 419	38 832
CH ₄ inkl. LULUCF	9 249	9 126	8 479	7 665	6 596	5 777	5 334	5 284	5 243	5 173	5 051
CH ₄ exkl. LULUCF	8 633	8 525	7 893	7 093	6 062	5 271	4 815	4 760	4 708	4 640	4 519
N ₂ O inkl. LULUCF	5 801	5 573	5 297	4 936	4 814	4 576	4 658	4 578	4 625	4 479	4 521
N ₂ O exkl. LULUCF	4 682	4 481	4 199	3 854	3 770	3 584	3 573	3 469	3 498	3 348	3 370
HFCs	6	129	725	1 045	1 064	1 059	889	851	816	757	707
PFCs	511	478	338	366	169	32	59	45	34	31	24
SF ₆	105	139	122	156	65	55	38	40	39	39	42
NF ₃	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Ospecificerat HFCs och PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (inkl. LULUCF)	11 696	17 607	6 895	8 181	2 982	-2 351	6 125	7 864	2 022	-1 816	-6 744
Total (exkl. LULUCF)	71 256	73 138	68 102	66 252	64 114	53 251	45 969	47 711	45 168	44 234	47 494

Tabell S.2. Utsläpp av växthusgaser per sektor (kt CO₂ ekvivalenter).

Källor till utsläpp & sänkor	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023	2024
1. Energy	52 311	54 191	49 404	48 102	47 362	38 041	31 988	33 261	30 790	30 312	33 673
2. Industrial Processes and Product Use	7 226	7 567	7 997	8 428	8 049	7 111	6 283	6 954	6 862	6 572	6 578
3. Agriculture	7 293	7 211	6 942	6 562	6 402	6 450	6 461	6 337	6 413	6 290	6 263
4. LULUCF	-59 560	-55 532	-61 207	-58 071	-61 132	-55 601	-39 844	-39 847	-43 146	-46 050	-54 238
5. Waste	4 426	4 170	3 758	3 161	2 301	1 648	1 236	1 160	1 103	1 060	981
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Totalt (inkl. LULUCF)	11 696	17 607	6 895	8 181	2 982	-2 351	6 125	7 864	2 022	-1 816	-6 744
Totalt (exkl. LULUCF)	71 256	73 138	68 102	66 252	64 114	53 251	45 969	47 711	45 168	44 234	47 494

S 3. Översikt av utsläppstrender per sektor

Utsläppen av växthusgaser i Sverige per sektor visas i Tabell S.2 ovan. Nedan beskrivs utsläppstrender per sektor och andelen av totalen (exklusive LULUCF). Därefter följer en kort beskrivning över vilka källor som används för inventeringen för olika sektorer.

Utsläppen från energisektorn (CRT 1), inklusive transporter, var cirka 34 miljoner ton koldioxidekvivalenter 2024, vilket motsvarar 71% av de totala utsläppen. Trenden för perioden 1990 till 2024 visar på minskade utsläpp om 36%. Utsläppsminskningen beror huvudsakligen på minskad oljeanvändning för uppvärmning av bostäder och lokaler som ingår i ”Övrig-sektorn” (CRT 1A4). Inom ”Övrig-sektorn” har utsläppen minskat med 82% sedan 1990 till omkring 2,2 miljoner ton koldioxidekvivalenter 2024. Utsläppen i energisektorn var 11% högre 2024 jämfört med 2023, främst på grund av ökade utsläpp från transporter.

Energiindustrins (CRT 1A1) totala utsläpp var 8,2 miljoner ton koldioxidekvivalenter 2024, vilket är 19% lägre med jämfört med 1990. Energiindustrin domineras av el- och fjärrvärmeproduktionen (CRT 1A1a) som stod för 5,2 miljoner ton koldioxidekvivalenter 2024, vilket är 34% lägre än 1990. Utsläppen från el- och värmeproduktionen varierar mellan åren, framför allt på grund av vädrets (temperatur och nederbörd) påverkan på utsläppen. Utsläppen från el- och fjärrvärmeproduktionen var 4% lägre år 2024 jämfört med 2023, vilket berodde på minskad användning av restgaser från järn- och stålsektorn. Utsläpp från förbränning i raffinaderier (CRT 1A1b) och koksverk (CRT 1A1c) var 3,1 miljoner ton koldioxidekvivalenter 2024.

Utsläpp från förbränning inom tillverkningsindustrin och byggsektorn (CRT 1A2) ökade med drygt 3% mellan 2023 och 2024. Utsläppen har minskat med motsvarande 45% sedan 1990, men varierar mellan åren med förändrade produktionsvolymerna som är kopplade till konjunktursvängningar. Utsläppsminskningen sedan 1990 beror till största delen på minskad oljeanvändning, som delvis kan förklaras av en övergång till el och biobränslen.

Utsläppen från transportsektorn (CRT 1A3) står för en dryg tredjedel av de nationella utsläppen av växthusgaser. Utsläppen från transportsektorn var 16,8 miljoner ton koldioxidekvivalenter under 2024, varav ungefär 15,9 miljoner ton från vägtransporter. Utsläppen från transportsektorn ökade med 21% mellan 2023 och 2024. Ökningen mellan 2023 och 2024 beror på att reduktionsplikten sänktes från den 1 januari 2024. Utsläppen var 12% lägre 2024 jämfört med 1990. Utsläppsminskningen mellan 1990 och 2023 beror i hög grad på att andelen biobränsle som används inom vägtrafiken har ökat under perioden, och att fordonen har blivit mer energieffektiva. Under senare år har även elektrifieringen av fordonsflottan, främst bilar, också bidragit. Utsläppsminskningen har dock samtidigt dämpats av att trafikarbetet har ökat.

Utsläppen av växthusgaser från industriprocesser och produktanvändning (CRT 2) uppgick till 6,6 miljoner ton koldioxidekvivalenter år 2024, vilket motsvarar 14% av Sveriges totala utsläpp. Inom sektorn är koldioxid den dominerande växthusgasen, följd av fluorerade växthusgaser och lustgas. Utsläppen härrör framför allt från produktion av järn och stål samt från mineralindustrin och är starkt kopplade till produktionsvolym. Utsläppen från sektorn var ungefär samma 2024 jämfört med 2023. Trenden för perioden 1990–2024 visar på en stabilisering sedan 2011 med undantag för 2020 där utsläppen minskade till följd av covid-19-pandemin. Utsläppen hade 2024 minskat med knappt 9%

jämfört med utsläppen 1990. Utsläppen från produktanvändning (2D, 2F och 2G) var tre gånger så stora 2024 jämfört med 1990, men visar på en minskande trend sedan 2004.

År 2024 var växthusgasutsläppen från jordbrukssektorn (CRT 3) knappt 6,3 miljoner ton koldioxidekvivalenter vilket motsvarar omkring 13% av Sveriges totala utsläpp. Av dessa utsläpp var drygt 57% metan, drygt 40% lustgas och resten koldioxid. Utsläppen från jordbrukssektorn har minskat med omkring 1 miljon ton koldioxidekvivalenter sedan 1990 vilket innebär cirka 14% lägre utsläpp. Minskningen beror framför allt på effektivisering och reducerad djurhållning (främst av mjölkkor och grisar) samt lägre utsläpp från organogena jordar och i viss utsträckning på minskad användning av mineralgödsel. Utsläppen från diko- och slaktkycklingproduktion har samtidigt ökat. De totala utsläppen från jordbrukssektorn har varit på en relativt stabil nivå under den senaste tioårsperioden. Mellan 2023 och 2024 minskade utsläppen från sektorn marginellt med 0,4% (motsvarande 0,03 miljoner ton koldioxidekvivalenter). Utsläppen från djurhållning minskade något på grund av lägre djurantal av nötkreatur och får samtidigt som utsläppen av lustgas från jordbruksmark var något högre till följd av högre skördar.

Nettoupptaget för sektorn markanvändning, förändrad markanvändning och skogsbruk (LULUCF - CRT 4) för 2024 uppskattades till cirka 54 miljoner ton koldioxidekvivalenter. Mellan 2023 och 2024 har nettoupptaget ökat med 18%. Större delen av nettoupptaget sker i kolpoolerna levande biomassa och mineraljord. Den dominerande markkategorin är skogsmark och det är där som det stora nettoupptaget av koldioxid sker. Skogsmark utgör 69% av Sveriges landareal. Inom denna marktyp har totala nettoupptaget varierat under hela perioden från 1990 till och med 2024 och i snitt varit runt 56 miljoner ton koldioxidekvivalenter. Mellan 2010 och 2020 minskade nettoupptaget i levande biomassa på grund av att tillväxten minskade samtidigt som avverkning och naturlig avgång var hög. Efter 2020 har tillväxtminskningen stannat upp och numera har tillväxten ökat igen från den lägre nivån. Samtidigt har avverkningen 2023 och 2024 varit de lägsta på 10 år, även den naturliga avgången har minskat. Nettoupptaget i avverkade träprodukter följer trenden i levande biomassa och när det är högre avverkningar ökar nettoupptaget och när det är lägre avverkningar minskar nettoupptaget. 2024 var nettoupptaget knappt 4 miljoner ton koldioxid vilket var en minskning med 25%. De största utsläppen inom sektorn kommer från organogen mark på alla markkategorier och 2024 var detta utsläpp drygt 12 miljoner ton koldioxidekvivalenter. Åkermark, Betesmark, Bebyggd mark och Våtmark har alla nettoutsläpp 2024. När det gäller nettoutsläppen på åkermark är trenden minskande.

Utsläppen från avfallssektorn (CRT 5) har minskat med ca 78% jämfört med 1990. 2024 var de totala utsläppen från avfallssektorn drygt 1 miljoner ton koldioxidekvivalenter, vilket motsvarar ungefär 2% av de totala växthusgasutsläppen. Från 2023 till 2024 minskade utsläppen med 7,4% till följd av fortsatt minskade utsläpp från avfallsdeponier. Utsläppen från avfallssektorn domineras av metangas från avfallsdeponier. Metangasutsläpp står för 67% av totala utsläppen i sektorn. Förbud har införts att deponera avfall och successivt har man övergått till framför allt förbränning av avfall för energiåtervinning. Utsläpp från förbränning av avfall för produktion av el och värme allokeras till energisektorn och inte till avfallssektorn.

Källorna som används för aktivitetsdata och/eller utsläppsdata i inventeringen för olika sektorer presenteras i Tabell S.3. Utsläppsstatistiken är hämtad direkt från dessa datakällor eller beräknade baserat på aktivitetsdata.

Tabell S.3. CRT-sektorer och datakällor som används i inventeringen.

CRT	Sektor	Primär källa till aktivitetdata/utsläppsdata
1	Energi -Stationär förbränning -Transport	Statistiska undersökningar av energiförbrukning Transportmyndigheter
2	Industriprocesser och produktanvändning	Miljörapporter Direktkontakt med företag EU:s system för handel med utsläppsrätter Nationella data från produktregistret på Kemikalieinspektionen och SPIN ¹ -databasen Nationell statistik, och Nationella experter
3	Jordbruk	Officiella statistiska rapporter Organisationer och forskare
4	Markanvändning, förändrad markanvändning och skogsbruk	Sveriges lantbruksuniversitet Skogsstyrelsen
5	Avfall	Avfall Sverige (fd RVF) Skogsindustrierna Statistiska centralbyrån Naturvårdsverket Energimyndigheten/Energigas Sverige Miljörapporter

¹ Substances in Preparations in Nordic Countries

S 4. Översikt av utsläppstrender för indirekta växthusgaser och SO₂

De indirekta växthusgaserna NO_x, NMVOCs, CO och SO₂ ingår inte i beräkningen av de totala nationella utsläppen av växthusgaser men redovisas separat. De visas i tabellen S.4.

Tabell S.4. Utsläpp av indirekta växthusgaser och SO₂ (tusentals ton).

Gas	Enhet	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023	2024
NO _x	kt	286	254	219	191	167	145	115	113	109	104	99
NMVOC	kt	366	279	223	205	178	159	139	136	139	131	126
SO ₂	kt	102	71	44	34	28	17	15	16	15	14	14
CO	kt	1 091	934	640	490	405	330	286	286	274	264	259

Utsläppen av kväveoxider (NO_x) var 99 kiloton år 2024. Energisektorn står för 74% av totalen medan industriprocesser och produktanvändningssektorn och jordbrukssektorn står båda för 13% respektive. NO_x-utsläpp har minskat med 65% sedan 1990. Mellan 2023 and 2024 minskade utsläppen med knappt 4,7%. Minskningen beror främst på de skärpta utsläppskraven för bilar inom EU. Den ökade användningen av fjärrvärme och införandet av NO_x-avgiftssystemet i början av 1990-talet har också bidragit till minskningen.

Utsläppen av flyktiga organiska ämnen utom metan (NMVOCs) var 126 kton år 2024. Industriprocesser och produktanvändningssektorn (framför allt från lösningsmedel och andra produkter) och energisektorn (framför allt vägtrafik och småskalig vedeldning för uppvärmning av bostäder) är de dominerande källorna till utsläppen, och bidrog med 43% respektive 33% av Sveriges totala utsläpp av NMVOC. Jordbrukssektorn bidrog med ca 24% av utsläppen. NMVOC-utsläpp har minskat kraftigt med 66% sedan 1990. Under 2024 minskade utsläppen med 4% jämfört med 2023. Den största minskningen av NMVOCs har skett inom transportsektorn där utsläppen 2024 är cirka 91% lägre än 1990. Här minskade utsläppen med cirka 1% mellan år 2023 och 2024. Inom produktanvändningssektorn har NMVOC-utsläppen minskat med 49% jämfört med 1990. De stora minskningarna inom båda sektorerna beror på introduktionen av nya avgasreningskrav för fordon samt minskade utsläpp från användning av lösningsmedel.

Utsläppen av kolmonoxid (CO) har minskat med 76% sedan 1990 och utgjorde totalt cirka 259 kton 2024. Utsläppen har minskat med 2% mellan 2023 och 2024. Nästan 89% av kolmonoxidutsläppen kommer från energisektorn, varav 30% från transporter och 51% från småskalig uppvärmning av bostäder, lokaler och inom jordbrukssektorn. Resten av utsläppen kommer från produktanvändningssektorn, där stod metallindustrin för 5% och massa- och pappersindustrin för 6%. Utsläppen av CO har minskat kraftigt genom åren. Detta beror på att nya bilar är försedda med katalysatorer, som omvandlar CO och kolväte till CO₂ och vattenånga.

Utsläppen av svaveldioxid (SO₂) var 14 kton år 2024 vilket innebär 86% lägre utsläpp jämfört med 1990. Mellan 2023 och 2024 minskade utsläppen med cirka 2%. År 2024 kom 58% av utsläppen från industriprocesser och produktanvändningssektorn, såsom metallproduktion och pappersmassaindustrin. Utsläpp från energisektorn, framför allt från

el- och fjärrvärmeproduktion och tillverkningsindustrier och konstruktionssektorn, utgjorde samma år cirka 42%. Den långsiktiga reduktionen av utsläppen beror främst på en övergång till bränslen med lägre svavelhalt samt att skatt på svavel i olja och kol införts 1991.

Executive Summary

ES 1. Background Information

Greenhouse gases have always been present in the atmosphere, but now concentrations of several of them are rising as a result of human activity, which intensifies the greenhouse effect. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 and two years later they concluded that anthropogenic climate change is a global threat, which needs to be addressed through an international agreement. The United Nations started negotiations on a framework convention on climate change (United Nations Framework Convention on Climate Change - UNFCCC), which came into force in 1994. The long-term goal of the convention is to stabilize the amount of greenhouse gases in the atmosphere at a level where harmful anthropogenic climate changes are prevented.

The most important addition to the convention was negotiated in Paris during the fall of 2015 and resulted in the adoption of a global climate agreement. The Paris agreement aims to hold the increase in the global average temperature to *well below* two degrees over pre-industrial levels and to *pursue efforts* to limit the temperature increase to 1.5 degrees. Within the agreement, all countries have provided nationally determined contributions (NDCs) to achieving the goal of the agreement and that the ambition of the contribution shall be gradually increased as the contributions are renewed or updated every five years. Sweden is part of the EU's contribution of reducing greenhouse gas net emissions within the union by at least 55 percent by 2030 compared to 1990. A global stocktake of the progress towards achieving the goal of the agreement takes place every five years, from 2023 and onwards. Principles for monitoring and reporting of the parties' nationally determined contributions were established in Paris. A year later, a sufficient number of parties had ratified the Paris agreement for its entry into force. The rules for the application of the different parts of the Paris Agreement, including new guidelines for tracking progress and reporting by parties, was adopted at COP24 in Katowice and COP26 in Glasgow. This means that for the first time there is a common set of reporting guidelines for monitoring and reporting for all countries. The first reporting under the Paris Agreement takes place in 2024.

Before the Paris agreement the most important addition to the convention was negotiated in 1997 in Kyoto, Japan and entered into force in 2005. The Kyoto Protocol provides binding commitments, for developed countries (Annex I) except for the United States. The Kyoto protocol has had two commitment periods 2008 – 2012 and 2013 – 2020. The difference between the Paris Agreement and the Kyoto Protocol is, therefore, that all parties to the Paris agreement provides a nationally determined contribution, which has been defined by the party and that is updated over time. The commitments under the Kyoto Protocol only applied to the richest countries and were determined via negotiations.

The first commitment period of the Kyoto Protocol involves binding obligations for the parties that ratified the protocol (the Annex I parties) to decrease their emissions of greenhouse gases (GHG) with at least 5% during 2008-2012 compared to the base year 1990. Under the first commitment period of the Kyoto Protocol the European Union, together with Iceland, agreed to reduce their emissions by 8 compared to the base year 1990 (for fluorinated greenhouse gases the base year is 1995). In 2012 the parties under

the Kyoto Protocol decided on a second commitment period (2013 to 2020) according to the Doha Amendment to the Kyoto Protocol 1/CMP.8. Under this commitment period the EU has, together with Iceland, committed to reduce the emissions by 20% by 2020 compared to the emissions of greenhouse gases in 1990. The Swedish commitment within the EU is to reduce national emissions by 17% until 2020 compared to 2005 within sectors that are not part of the EU Emissions Trading System. 2022 the last greenhouse gas inventory under the Kyoto protocol was submitted by Annex-I parties and for parties with a commitment this submission will form the base for the accounting and compliance. During autumn 2022 the final review under the Kyoto protocol took place. In 2023, the actual fulfilment took place and Annex -1 parties with a commitment have reported a "True-up period report". EU and all member states have fulfilled the commitment to reduce the emissions with 20% compared to 1990.

According to Articles 4 and 12 of the United Nations Framework Convention on Climate Change, parties are required to submit national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol annually. Sweden's National Inventory Document (NID) for the year 2026, constitutes the annual submission under UNFCCC and the Paris agreement. The report is prepared in accordance with the Reporting Guidelines agreed by the UNFCCC on its nineteenth session of the Conference of the Parties (COP) in Warsaw 2013 and subsequent decisions and also under the Paris agreement. It contains national greenhouse gas emission inventories for the period 1990 to 2024, and descriptions of methods used to produce the estimates. The methods used to calculate the emissions and removals are in accordance with the IPCC 2006 Guidelines for National Greenhouse Gas Inventories, and in some cases the updated 2006 guidelines from 2019, and also the IPCC supplementary guidelines for Wetlands (*the 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories*). This National Inventory Report is also reported under EU legislation (Governance regulation 20178/1999/EG) and is the basis for follow-up against Sweden's commitment under the EU's climate package, Fit for 55.

This report covers anthropogenic emissions of direct greenhouse gases CO₂, CH₄, N₂O, HFC, PFC, SF₆, NF₃ and indirect greenhouse gases NO_x, CO, NMVOC and SO₂. The report contains information on Sweden's inventories of greenhouse gases for all years from 1990 to 2024, including descriptions of methods, data sources, uncertainties, the quality assurance and quality control (QA/QC) activities carried out as well as a trend analysis.

An internal review performed during 2016 of the use of confidential data in the inventory showed that additional data should be considered confidential compared to previous submissions in order to comply with the Public Access to Information and Secrecy Act of the Swedish law. This has affected some sub-sectors in stationary combustion (CRT 1) and industrial processes and product use (CRT 2), which have been classified with the notation key Classified (C). Sweden is working continuously with improving the transparency of our reporting and strives to minimize the extent of confidentiality in inventory data.

Electronic data on emissions, activity data and emission factors are provided in the Common Reporting Format (CRT) as requested by the UNFCCC together with this report.

ES 2. Summary of national emission and removal trends per gas

Total greenhouse gas emissions in Sweden, expressed in CO₂-equivalents, were about 47.5 million tonnes in 2024, excluding LULUCF (Table ES.1 and Table ES.2). Total emissions 2024 have increased by 7% compared to 2023 and decreased by 33% compared to 1990. Below, emission trends per gas compared to the total (excluding LULUCF) are first described, followed by brief descriptions of the trend within LULUCF.

The total emissions of carbon dioxide (CO₂) 2024 were 38.8 million tonnes of carbon dioxide equivalents, which corresponds to 82% of the total emissions of greenhouse gases. The energy sector, including transport, accounted for 85% of the overall carbon dioxide emissions, which makes it the largest source of carbon dioxide emissions in Sweden. The emissions of CO₂ 2024 were 32% lower than 1990, but 10% higher than 2023.

Methane (CH₄) emissions were 4.5 million tonnes of carbon dioxide equivalents by 2024, which corresponds to 10% of total greenhouse gas emissions. 80% of methane emissions are from agriculture, the rest mainly comes from landfills and burning of fossil fuels in the energy sector. Between 2023 and 2024, the total methane emissions have decreased by 2.6%. Since 1990, methane emissions have decreased by 48%, mainly due to reduced emissions in the waste sector and to some extent due to reduced emissions from the agricultural sector.

Nitrous oxide emissions (N₂O) were 3.4 million tonnes of carbon dioxide equivalents in 2024 and accounted for about 7% of total greenhouse gas emissions. Emissions of nitrous oxide originate mainly from the agricultural sector (approximately 75%). Since 1990 there has been a decrease in N₂O emissions with about 28%. In 2024 the emissions of N₂O increased with 0.7% compared to 2023.

Emissions of fluorinated greenhouse gases (PFCs, HFCs and SF₆) were 0.8 million tonnes of carbon dioxide equivalents by 2024, which accounts for about 2% of total greenhouse gas emissions. The emissions in 2024 are 25% higher compared to 1990. This is mainly due to the replacement of ozone-depleting substances by greenhouse gases (HFCs). However, the trend of emissions of HFCs is showing a stabilisation since 2009 and decrease in the later years. Emissions dropped by 7% between 2023 and 2024.

The net removal within the land use, land-use change and forestry (LULUCF) sector was 2024 estimated at approximately 54 million tons of carbon dioxide equivalents. Most of the net removal occurs in the carbon pools living biomass and mineral soil. The dominant land category is forest land, which is where the majority of net carbon dioxide uptake occurs. Forest land accounts for 69% of Sweden's land area. Within this land type, total net removal has varied throughout the period from 1990 to 2024, averaging around 56 million tonnes of carbon dioxide equivalents. Between 2010 and 2020, net uptake in living biomass decreased due to reduced growth combined with high harvesting and natural mortality. After 2020, the decline in growth has stopped and growth has now increased again from the lower level. At the same time, harvesting in 2023 and 2024 has been the lowest in 10 years, and natural mortality has also decreased. Net uptake in harvested wood products follows the trend in living biomass, with higher harvesting leading to higher net uptake and lower harvesting leading to lower net uptake. In 2024,

net uptake was just under 4 million tonnes of carbon dioxide, which was a decrease of 25%. The largest emissions in the sector come from organic soil in all soil categories, and in 2024 these emissions amounted to just over 12 million tonnes of carbon dioxide equivalents. Cropland, grassland, built-up land and wetlands all have net emissions in 2024.

Table ES.1. Greenhouse gas emissions by gas (kt CO₂-eq.).

GREENHOUSE GAS EMISSIONS	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023	2024
CO ₂ incl. LULUCF	-3 976	2 161	-8 067	-5 988	-9 727	-13 849	-4 853	-2 934	-8 735	-12 296	-17 090
CO ₂ excl. LULUCF	57 319	59 386	54 824	53 739	52 984	43 251	36 595	38 547	36 073	35 419	38 832
CH ₄ incl. LULUCF	9 249	9 126	8 479	7 665	6 596	5 777	5 334	5 284	5 243	5 173	5 051
CH ₄ excl. LULUCF	8 633	8 525	7 893	7 093	6 062	5 271	4 815	4 760	4 708	4 640	4 519
N ₂ O incl. LULUCF	5 801	5 573	5 297	4 936	4 814	4 576	4 658	4 578	4 625	4 479	4 521
N ₂ O excl. LULUCF	4 682	4 481	4 199	3 854	3 770	3 584	3 573	3 469	3 498	3 348	3 370
HFCs	6	129	725	1 045	1 064	1 059	889	851	816	757	707
PFCs	511	478	338	366	169	32	59	45	34	31	24
SF ₆	105	139	122	156	65	55	38	40	39	39	42
NF ₃	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Unspecified HFCs and PFCs	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (incl. LULUCF)	11 696	17 607	6 895	8 181	2 982	-2 351	6 125	7 864	2 022	-1 816	-6 744
Total (excl. LULUCF)	71 256	73 138	68 102	66 252	64 114	53 251	45 969	47 711	45 168	44 234	47 494

Table ES.2. Greenhouse gas emissions by sector (kt CO₂-eq.).

GHG SOURCE & SINK CATEGORIES	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023	2024
1. Energy	52 311	54 191	49 404	48 102	47 362	38 041	31 988	33 261	30 790	30 312	33 673
2. Industrial Processes and Product Use	7 226	7 567	7 997	8 428	8 049	7 111	6 283	6 954	6 862	6 572	6 578
3. Agriculture	7 293	7 211	6 942	6 562	6 402	6 450	6 461	6 337	6 413	6 290	6 263
4. LULUCF	-59 560	-55 532	-61 207	-58 071	-61 132	-55 601	-39 844	-39 847	-43 146	-46 050	-54 238
5. Waste	4 426	4 170	3 758	3 161	2 301	1 648	1 236	1 160	1 103	1 060	981
6. Other	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO
Total (incl. LULUCF)	11 696	17 607	6 895	8 181	2 982	-2 351	6 125	7 864	2 022	-1 816	-6 744
Total (excl. LULUCF)	71 256	73 138	68 102	66 252	64 114	53 251	45 969	47 711	45 168	44 234	47 494

ES 3. Summary of national emission and removal trends per sector

The emissions of greenhouse gases in Sweden per sector are shown in Table ES.2 above. Emission trends per sector and the share of the total (excluding LULUCF) are described below. This is followed by a brief description of which sources are used for the inventory for various sectors.

Emissions from the energy sector (CRT 1), including transport, were approximately 34 million tonnes of CO₂-equivalents in 2024, which corresponds to about 71% of the overall national greenhouse gas emissions. The trend for the period 1990-2024 shows a general reduction in emissions of approximately 36%. This decrease is mainly due to a decrease in the use of oil for heating in residential, commercial and institutional buildings, included in “Other Sectors” (CRT 1A4). Emissions in “Other Sectors” have decreased by 80% to approximately 2.2 million tonnes of CO₂-equivalents in 2024. Emissions increased by 11% between 2023 and 2024 in the energy sector, mostly because of an increase of emissions from transport.

Greenhouse gas emissions from energy industries (CRT 1A1) were approximately 8.2 million tonnes in 2024, which is 19% lower compared to 1990. The energy industries are dominated by electricity and district heating production (CRT 1A1a) with emissions of around 5.2 million tonnes of CO₂-equivalents in 2024, which is 34% lower than in 1990. Emissions from electricity and district heating production fluctuate over the years mainly due to the influence of weather conditions (temperature and precipitation). Emissions from production of electricity and heat production totaled 5.2 Mt of CO₂-eq. in 2024. The emissions from electricity and heat production vary over time but have been reduced by 34% between 1990 and 2024. The emissions from electricity and district heating were 4% lower in 2024 compared to 2023 mainly due to decreased combustion of residual gases, produced as by-products in iron and steel production processes. Emissions from combustion in Petroleum Refining (CRT 1A1b) and Manufacture of solid fuels (CRT 1A1c) were 3.1 million tonnes of carbon dioxide equivalents in 2024.

Emissions from manufacturing industries and construction (CRT 1A2) increased with 3% in 2024 compared to the previous year. These emissions have decreased by 45% compared to 1990 but generally fluctuate with production volumes that are closely related to the economic development. The decrease in emissions since 1990 is mainly due to the decreased use of oil products, which can partly be explained by a shift towards electricity and biofuels.

Emissions from the transport sector (CRT 1A3) correspond to a little more than a third of the national emissions of greenhouse gases. In 2024, emissions were 16.8 million tonnes, of which approximately 15.9 million tonnes were from road transportation. Emissions from the transport sector increased by 21% between 2023 to 2024. In 2024 there was an increase in emissions due to reduced requirements to blend in biofuel in the reduction obligation. Emissions were 12% lower in 2024 compared to 1990. The reduction in emissions between 1990 and 2023 is primarily due to the fact that the proportion of biofuels used in road traffic has increased during the period, and that vehicles have become more energy efficient and in later years due to increased fleet of electrical

vehicles, mainly cars. However, the reduction in emissions has been dampened by an increase in traffic.

Greenhouse gas emissions from the industrial processes and product use (CRT 2) were 6.6 million tonnes CO₂-equivalents in 2024, representing approximately 14% of the national emissions. Emissions from industrial processes and product use are predominantly carbon dioxide, followed by fluorinated greenhouse gases and nitrous oxide. Metal (iron and steel) and mineral industries (cement) are the major sources of emissions. The emissions from the sector were around the same level 2024 compared to 2023. The trend for the period 1990-2022 shows a stabilization since 2011 with the exception of 2020 where emissions decreased as a result of the covid-19 pandemic. In 2024 emissions had decreased by 9% compared to 1990. Emissions from product use (2D, 2F and 2G) were three times as high in 2024 compared to 1990, although they show a decreasing trend since 2004.

In 2024, the total greenhouse gas emissions from the agricultural sector (CRT 3) were a bit less than 6.3 million tonnes of CO₂-equivalents, which corresponds to 13% of the total greenhouse gas emissions in Sweden. Of these, about 57% were methane, 40% nitrous oxide and the rest CO₂. Emissions from the agricultural sector have decreased by about 1 million tonnes of CO₂-equivalents since 1990, which means about 14% lower emissions. The reduction is due to several factors such as reduced number of animals (especially dairy cows and pigs) as well as lower emissions from organic soils and to some extent on reduced use of mineral fertilizers. Emissions from suckler cows and broiler production have increased during the same time. Total emissions from the agricultural sector have been at a relatively stable level over the past ten years. Between 2023 and 2024, emissions from the sector decreased marginally by 0.4% (corresponding to 0.03 million tonnes of carbon dioxide equivalents). Emissions from livestock farming decreased slightly due to lower numbers of cattle and sheep, while emissions of nitrous oxide from agricultural land were slightly higher due to higher harvests.

In 2024, the total net removal in the sector land use, land-use change and forestry (LULUCF) was 54 million tonnes of carbon dioxide equivalents. Most of the net uptake occurs in the carbon pools of living biomass and mineral soil. The dominant land category is forest land, which is where the majority of net carbon dioxide uptake occurs. Forest land accounts for 69% of Sweden's land area. Within this land type, total net uptake has varied throughout the period from 1990 to 2024, averaging around 56 million tonnes of carbon dioxide equivalents. Between 2010 and 2020, net uptake in living biomass decreased due to reduced growth combined with high harvesting and natural mortality. After 2020, the decline in growth has stopped and growth has now increased again from a lower level. At the same time, harvesting in 2023 and 2024 has been the lowest in 10 years, and natural mortality has also decreased. Net uptake in harvested wood products follows the trend in living biomass, with higher harvesting leading to higher net uptake and lower harvesting leading to lower net uptake. In 2024, net uptake was just under 4 million tonnes of carbon dioxide, which was a decrease of 25%. The largest emissions in the sector come from organic soil in all land categories, and in 2024 these emissions amounted to just over 12 million tonnes of carbon dioxide equivalents. Cropland, Grassland, Settlement and Wetlands all constituted net emissions in 2024. The emissions from croplands show a decreasing trend during the last years.

Emissions from the waste sector (CRT 5) have decreased by about 78% compared to 1990. In 2024, total emissions from the waste sector were approximately 1 million tonnes of carbon dioxide equivalents, which corresponds to approximately 2% of total greenhouse gas emissions. From 2023 to 2024, emissions have been reduced by 4.3% due to continued reduced emissions from landfills. Emissions from the waste sector are dominated by methane gas from waste landfills. Methane emissions account for 53% of emissions. A ban has been introduced on landfills which has created a shift towards incineration of waste for energy recovery. Emissions from the incineration of waste for electricity and heat production are allocated to the energy sector and not to the waste sector.

The sources used for activity data and/or emission data in the inventory for different sectors are presented in Table ES.3. Emission statistics are taken directly from these data sources or calculated based on activity data.

Table ES.3. CRT sectors and data sources used in the inventory.

CRT	Sector	Main source for activity/emission data
1	Energy -Stationary combustion -Transport	Statistical survey on energy consumption Transport authorities
2	Industrial processes and product use	Environmental reports Direct contact with companies CO ₂ Data from the European trading scheme (ETS) National data from the Products register at the Swedish Chemicals Agency and the SPIN ² database, National statistics, and National experts
3	Agriculture	Official statistical reports Organisations and researchers
4	Land Use, Land Use Change and Forestry	Swedish University of Agricultural Sciences Swedish Forest Agency
5	Waste	Swedish Association of Waste Management The Swedish Forest Industries Federation Statistics Sweden Swedish Environmental Protection Agency Environmental reports

² Substances in Preparations in Nordic Countries

ES 4. Overview of Emission Estimates and Trends of Indirect GHGs and SO₂

Indirect greenhouse gases (NO_x, NMVOC, CO and SO₂) are not included in the national total emissions but reported separately. They are shown in Table ES.4.

Table ES.4. Emissions of indirect greenhouse gases and SO₂ (kt).

Gas	Enhet	1990	1995	2000	2005	2010	2015	2020	2021	2022	2023	2024
NO _x	kt	286	254	219	191	167	145	115	113	109	104	99
NMVOC	kt	366	279	223	205	178	159	139	136	139	131	126
SO ₂	kt	102	71	44	34	28	17	15	16	15	14	14
CO	kt	1 091	934	640	490	405	330	286	286	274	264	259

Emissions of nitrogen oxides (NO_x) were about 99 kt in 2024. The energy sector accounted for 74% of the total emissions, while the industrial processes and product use sector as well as the agricultural sector accounted each for about 13% respectively. The emissions in 2024 were about 65% lower compared to 1990 and nearly 4.7% lower than in 2023. This reduction is mainly due to restrictions of the EU road vehicle emission regulation standards. The increased use of district heating and the “NO_x charge” introduced in the early 1990s have also contributed to the reduction in emissions of NO_x.

A total of about 126 kt of non-methane volatile organic compounds (NMVOCs) were emitted in 2024. About 43% of the emissions derived from the industrial processes and product use sector. The energy sector and the agricultural sector contributed with 33% and 24%, respectively. Since 1990, NMVOC emissions have decreased by 66%. Emissions in 2024 are about 4% lower compared to 2023. The largest reduction comes from the transport sector, in which emissions decreased by 91% compared to 1990 and by 1% compared to 2023. Emissions in the product use sector have been reduced by 49% since 1990. The main reason for the reduction is the introduction of stricter emission standards in the EU regulation for road vehicles and lower NMVOC emissions from solvents.

The aggregated emissions of carbon monoxide (CO) have decreased by 76% since 1990 and were around 259 kt in 2024. Emissions in 2024 were 2% lower than in 2023. About 89% of CO emissions came from the energy sector, of which 30% came from the transport sector and 51% from small-scale combustion in residential heating, premises and in the agricultural sector. The rest of the emissions derived from the metal industry (5%) and pulp and paper industry (6%). Emissions of CO have decreased substantially over the years due to new fuel-driven vehicles sold in Sweden that are equipped with catalytic converters that convert CO and unburned hydrocarbons to CO₂ and water vapor.

Sulphur dioxide emissions (SO₂) were about 14 kt in 2024 and have decreased by 86% since 1990. Between 2023 and 2024 emission decreased by about 2%. About 58% of SO₂ emissions are derived from the industrial processes and product use sector, mainly from metal production and the pulp industry. The energy sector was responsible for 42% of emissions in 2024, in which electricity and district heating production and manufacturing industries and construction were the main contributors. The reduction of emissions since 1990 is mainly due to a transition to lower sulphur fuels, as well as tax on sulphur in fossils fuels introduced in 1991.

PART 1: ANNUAL INVENTORY SUBMISSION 2026

1 Introduction

According to Articles 4 and 12 of the United Nations Framework Convention on Climate Change (UNFCCC), Annex I Parties are required to annually submit national inventories of anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol. The inventory submitted to the UNFCCC, through the secretariat, shall include emissions and removals in the Common Reporting Format (CRT) and a National Inventory Document (NID). The submission is prepared in accordance with the reporting guidelines 24/CP.19 under the UNFCCC.

This report constitutes Sweden's NID for submission 2026. The report contains information on Sweden's inventories for all years from 1990 to 2023, including descriptions of methods, data sources, uncertainties, quality assurance and quality control (QA/QC) activities carried out, and a trend analysis. In order to ensure the transparency, consistency, comparability, completeness and accuracy of the inventory, the report contains information on inventories for all years from the base year to the year of the current annual inventory submission.

This section presents background information on climate change, the Swedish national targets and a greenhouse gas (GHG) inventory. It also contains a description of institutional arrangements for the inventory preparation, brief descriptions of the process of inventory preparation, methodologies and data sources used and the key sources in the Swedish inventory. Finally, there is information about the progress of quality assurance/quality control (QA/QC) work, the general uncertainties in the inventory and on the completeness of inventoried emissions.

1.1 Background Information

1.1.1 Climate change

Some of the gases in the earth's atmosphere have an ability to absorb infrared radiation (heat). They do not prevent sunlight reaching the earth's surface and warming it, but they do trap some of the infrared outgoing radiation. Without the natural greenhouse effect of the atmosphere, the surface of our planet would be almost 35°C colder than it is now.

Greenhouse gases (i.e. gases which contribute to the greenhouse effect) have always been present in the atmosphere, but now the concentrations of several of these gases are rising as a result of human activity. This intensifies the greenhouse effect. The IPCC sums up the cause of the climate change we have witnessed over the last 50 years by stating that it is impossible to explain the change other than as the result of anthropogenic emissions of greenhouse gases (i.e. emissions resulting from human activity).

Apart from carbon dioxide, other greenhouse gases are being emitted in larger quantities now than in pre-industrial times. These gases include nitrous oxide and methane. Ground-level ozone also contributes to the greenhouse effect. The amount of ozone forming in the lower atmosphere has increased as a result of emissions of nitrogen oxides, hydrocarbons and carbon monoxide.

Entirely new, man-made greenhouse gases that are entering the atmosphere cause further intensification of the greenhouse effect. These include, in particular, a number of substances containing fluorine, among them HFCs (hydrofluorocarbons). HFCs are used instead of the ozone layer depleting CFCs (freons) in refrigerators and other applications.

Compared with carbon dioxide, all other greenhouse gases occur at very low concentrations. Per molecule, however, these substances are much more effective as greenhouse gases than carbon dioxide, which means that they also make a considerable contribution to the greenhouse effect. Furthermore, some of the fluorine compounds have such a long atmospheric lifetime that they will contribute to the greenhouse effect for ten thousand of years to come.

The threat of climate change is considered to be one of the most serious environmental problems faced by the humankind.

Following the scientific indications that human activities influence the climate and an increasing public awareness about local and global environmental issues during the middle of the 1980s, climate change was brought up on the political agenda. The Intergovernmental Panel on Climate Change (IPCC) was established in 1988 and two years later they concluded that anthropogenic climate change was a global threat and asked for an international agreement to deal with the problem.

The United Nations started negotiations to create a framework convention on climate change (UNFCCC), which came into force in 1994. Currently, 197 Parties (including the EU as one party) have ratified the UNFCCC. The long-term goal of the convention is to stabilize the amount of greenhouse gases in the atmosphere at a level where harmful anthropogenic climate changes are prevented. After the UNFCCC came into force, the framework convention has developed and every year a Conference of the Parties (COP) is held. The most important addition to the convention to date, the Paris agreement, was

negotiated in France in 2015. The agreement sets out a global action plan to put the world on track to avoid dangerous climate change by limiting global warming to well below 2 degrees and to pursue efforts to limit the temperature increase even further to 1.5 degrees. Before the Paris agreement the most important addition to the convention was negotiated in 1997 in Kyoto, Japan. The Kyoto Protocol involved binding obligations for the Annex I countries (including all EU Member States and other industrialized countries). In autumn 2020 the second commitment period of the Kyoto Protocol came into force just before the last year of the commitment period (2013 – 2020) ended. During 2023 the compliance of the second commitment period took place.

1.1.2 Greenhouse gas inventories

The inventory covers anthropogenic emissions of direct greenhouse gases CO₂, CH₄, N₂O, HFCs, PFCs, SF₆, NF₃ and indirect greenhouse gases NO_x, CO, NMVOC and SO₂. Indirect means that they do not contribute directly to the greenhouse effect but that their presence in the atmosphere may influence the climate in different ways. Indirect greenhouse gas emissions are not included in the total. Ozone (O₃) is also a greenhouse gas, but it is not necessary to report on O₃ separately since it is formed by the chemical reactions of nitrogen oxides, hydrocarbons and/or carbon monoxide. The estimated emissions and removals of greenhouse gases are calculated according to the UNFCCC reporting guidelines (decision 24/CP.19).

Emissions of the direct greenhouse gases CO₂, N₂O, CH₄, HFCs, PFCs, SF₆ and NF₃ are calculated as CO₂-eq. and aggregated to a national total. Emissions of the indirect greenhouse gases NO_x, CO, NMVOC and SO₂ are reported, but not included in the total.

When a method used to estimate emissions or removals is improved, a need to recalculate the whole time series arises in order to maintain consistency. This means that already reported data can be revised in subsequent submissions.

1.1.3 National emission targets

1.1.3.1 THE SWEDISH TARGET FOR 2045

In June 2017, the Riksdag adopted a proposal on a climate policy framework (Govt. Bill 2016/17:146) for Sweden which will give Sweden an ambitious, long-term and stable climate policy. The climate policy framework consists of a climate act, new climate targets (Figure 1.1) and a climate policy council. For more information about the climate policy framework, see Sweden's Seventh National Communication on Climate Change.

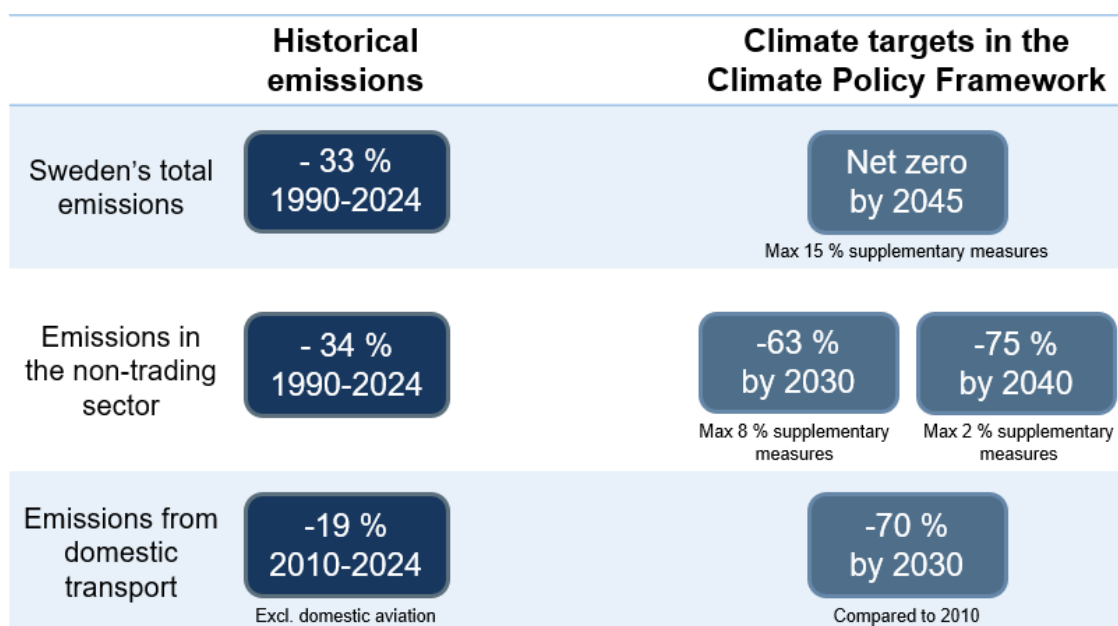


Figure 1.1. Sweden's national targets and historical emission up to 2024.

Targets

- By 2045, Sweden is to have no net emissions of greenhouse gases into the atmosphere and should thereafter achieve negative emissions. This means emissions from activities in Swedish territory are to be at least 85% lower by 2045 compared with 1990. F
- 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 to 2010. Domestic aviation³ is not included in the goal since this subsector is included in the EU ETS.

Supplementary measures may count towards achieving these goals. Supplementary measures are such as increased uptake of carbon dioxide in forests and land, climate investments in other countries in accordance with article 6 in the Paris agreement and negative emissions (for example bio-CCS). International accounting guidelines will be followed in order to account for these measures.

1.1.3.2 EFFORT SHARING DECISION: EU MEMBER STATES EMISSION TARGETS

The EU has decided on climate targets that apply to the entire Union. All countries that are part of the EU must participate and contribute to meet the climate goals and the EU's contribution to the Paris Agreement. The EU's overall climate goal is to be climate

³ The emissions only include CO₂.

neutral by 2050 at the latest. In 2030, the EU's net emissions must be at least 55 percent lower than they were in 1990.

The Effort Sharing Regulation (ESR) establishes binding annual greenhouse gas emission targets for Member States for the period 2021–2030. These targets concern emissions from sectors not included in the EU Emissions Trading System (EU ETS) such as transport, buildings, agriculture and waste. In order to reach the 55 percent target, emissions in the ESR sector must be reduced by 40 percent compared to 2005. This target has been distributed among the member countries based on the countries' GDP/capita level. According to the distribution, Sweden will reduce the greenhouse gas emissions by 50 percent by 2030 compared to 2005.

1.2 Institutional arrangements

Under Article 5 of the Kyoto Protocol each party in Annex 1 had to introduce a national system for estimating anthropogenic emissions by sources and removals by sinks of all greenhouse gases not controlled by the Montreal Protocol by 1 January 2007. The Swedish National system for the GHG inventory was established in 2006 in accordance with 19/CMP.1, 20/CP.7 and decision 280/2004/EC. The national system has to ensure the function of all the institutional, legal and procedural arrangements required to calculate emissions and removals of greenhouse gases. 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 Monitoring Mechanism Regulation was replaced in 2018 by the Governance regulation (2018/1999/EG) and from 2023 the new rules apply to the greenhouse gas inventory. The system is also relevant for the National inventory arrangements decided on in 24/CP.19 and also for the Paris agreement in accordance with 18/CMA.1.

The Swedish national system came into force on 1 January 2006, and its aim is to ensure that climate reporting to the secretariat of the Convention (UNFCCC) and the European Commission complies with specified requirements. This means, among other things,

- estimating and reporting anthropogenic GHG emissions and removals in accordance with the Kyoto Protocol,
- assisting Sweden in meeting its commitments under the Kyoto Protocol,
- facilitating the review of submitted information,
- ensuring and improving the quality of the Swedish inventory and
- guaranteeing that submitted data is officially approved.

The national system ensures annual preparation and reporting of the national inventory and of supplementary information in a timely manner and that the inventory fulfils all quality criteria, i.e. is transparent, accurate, consistent, comparable and complete. The national system has now been updated to fulfil the requirements under the Paris agreement and under EU law.

1.2.1 Legal arrangements

The legal basis for Sweden's national system is provided by the Ordinance on Climate Reporting (2014:1434), which describes the roles and responsibilities of the relevant government agencies in this area. The ordinance ensures that sufficient capacity is available for reporting. The previous ordinance concerning climate reporting (2005:626) was updated and expanded to fulfil the reporting requirements under the second commitment period under the Kyoto Protocol and the EU Monitoring Mechanism Regulation 525/2013/EC. The ordinance has been updated again and now to fulfil the requirements under the Paris agreement and under EU law, the Governance regulation (2018/1999). It also includes other improvements needed on the national level. The new ordinance came into force in 2021, superseding the previous ordinance.

Supplemental to the new ordinance, formal agreements between the Swedish Environmental Protection Agency and other national agencies have been signed, listing in detail what is required regarding content and timetable from each responsible agency.

Sweden also has legislation indirectly supporting climate reporting efforts by providing a basis for estimating greenhouse gas emissions and removals.

Environmental reports are submitted under the Environmental Code (SFS 1998:808), and the Official Statistics Act (SFS 2001:99) imposes an obligation for large industries to submit annual data. In addition, government agencies in Sweden must comply by the Information and Secrecy Act (SFS 2009:400).

The General Statistics Act (SFS 2001: 99) and the associated Ordinance (2001:100) Concerning Official Statistics impose an obligation on companies and other organizations to submit annual data. The data then serve as a basis for estimating greenhouse gas emissions and removals in several sectors.

According to Directive 2003/87/EC and national Act (2004:1199) on emission trading, emission data for plants included in the emission trading system should be reported annually. These data are used as a supplementary source within this greenhouse gas inventory.

1.2.2 Institutional arrangements

Preparing the annual inventory and other reports is done in collaboration between the Ministry of Climate and Enterprise, the Swedish Environmental Protection Agency and other government agencies and consultants. Sections 10-27 of the Ordinance on Climate Reporting (2014:1434) describe the tasks of the government agencies in the context of the yearly inventory and reporting activity. The illustration in Figure 1.2 and Table 1.1 and the associated text below describe in broad terms which organizations are involved in the work of compiling documentation for the yearly inventory report and for other reporting to the European Commission and the UNFCCC. Depending on the role of the government agencies in climate-reporting activity, this responsibility may range for example from supplying data and producing emission factors/calorific values to carrying out calculations to estimate emissions. Agencies that have a responsibility to participate in the national peer review are indicated by red text in Figure 1.2. Agencies that were added to formally participate from submission 2015 and onwards are indicated *in italics*. In addition to what is described in the Ordinance, the Swedish Environmental Protection Agency (Swedish EPA) engages the SMED consortium as consultants to conduct the greenhouse gas inventory.

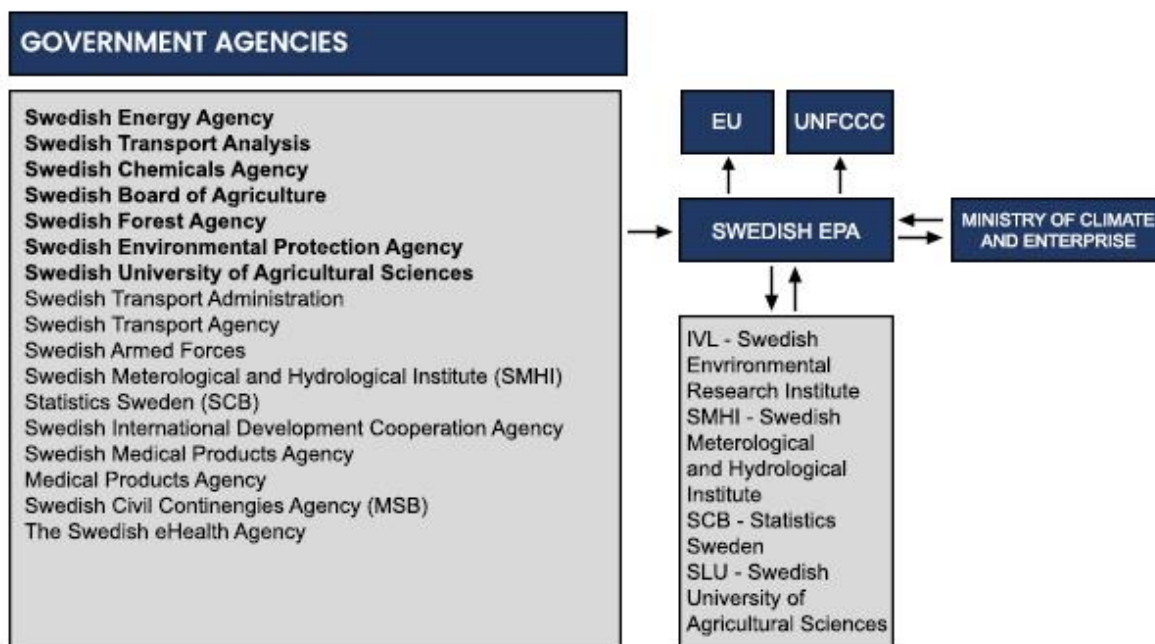


Figure 1.2. The Swedish national system on climate reporting.

To be able to report according to decision 24/CP.19 and IPCC methodology guidelines from 2006 and in accordance with 525/2013/EC the national system has been enlarged by three governmental agencies; the Medical Products Agency, the Swedish Civil Contingencies Agency and the Geological Survey of Sweden.

1.2.2.1 SINGLE NATIONAL ENTITY

The Swedish Ministry of Climate and Enterprise is the single national entity and has overall responsibility for the inventory.

Postal address SE 103 33 Stockholm, Sweden

telephone +46 8 405 10 00

UNFCCC focal point:

Mr. Mattias.Frumerie@gov.se

M.climate@regeringskansliet.se

Responsible for reporting to EU and UN:

Mrs. Sigrid Persson

sigrid.persson@gov.se

M.climate@regeringskansliet.se

1.2.2.2 SWEDISH EPA RESPONSIBILITIES

The Swedish EPA is responsible for co-ordinating the activities for producing the inventory, maintaining the national system and also for the final quality control and quality assurance of the inventory.

The Swedish EPA sends the inventory to Swedish Ministry of Climate and Enterprise and – on behalf of the Swedish Ministry of Climate and Enterprise – submits the inventory to the EU and to the UNFCCC. The Swedish EPA is also responsible for making the greenhouse gas inventory available to the public. The National inventory focal point at the Swedish EPA is Mr. Joel Bengtsson.

1.2.2.3 AGENCIES RESPONSIBILITIES

Agencies responsibilities according to Ordinance on Climate Reporting (2014:1434) are described in Table 1.1 below.

Table 1.1. Agencies responsibilities according to Ordinance on Climate Reporting (2014:1434). Only the Agencies involved in the GHG inventory are included.

Sector	Data and documentation provided by	Peer review conducted by
Energy	Swedish Energy Agency, the Swedish Transport Administration, the Swedish Transport Agency, Transport Analysis, the Swedish Armed Forces.	Swedish Energy Agency (energy sector excluding transports) Transport Analysis (transports)
Industrial Processes and Product Use	Swedish Chemicals Agency, Medical Products Agency.	The Swedish EPA (CO ₂ , CH ₄ and N ₂ O) Swedish Chemicals Agency
Agriculture	Swedish Board of Agriculture, Statistics Sweden (SCB).	The Swedish Board of Agriculture
Land Use, Land-Use Change And Forestry Sector	Swedish University of Agricultural Sciences (SLU), Statistics Sweden (SCB), the Swedish Forest Agency, the Swedish Meteorological and Hydrological Institute (SMHI), the Swedish Board of Agriculture, Swedish Civil Contingencies Agency (MSB), the Geological Survey of Sweden (SGU), the Swedish EPA.	Swedish Forest Agency The Swedish Board of Agriculture (agriculture related parts)
Waste	The Swedish EPA	The Swedish EPA – another unit, not the one responsible for data.

The Swedish Energy Agency also assists the Swedish EPA by providing information regarding flexible mechanisms and the national register.

1.2.2.4 THE SMED CONSORTIUM

The Swedish EPA engages consultants with documented expert skills to conduct the inventory in the area of climate change. During the spring of 2005, the Swedish EPA completed a negotiated procurement of services under the terms of the Public Procurement Act. After the procurement had been completed, a framework contract was signed with the consortium Swedish Environmental Emissions Data (SMED)⁴, 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). The contract between the Swedish EPA and SMED did run during nine years and covered the whole first commitment period under the Kyoto Protocol.

After a procurement in 2022 the contract with the consortium SMED was renewed for the period (2023 – 2030). The structure of the consortium is the same as the previous period with agency agreements for the national agencies (SMHI, SCB and SLU) and a negotiated procurement of services under the terms of the Public Procurement Act for the Swedish Environmental Research Institute (IVL).

⁴ <http://www.smed.se/>

SMED receives data and documentation from responsible authorities as described above (see Table 1.1) and produces the data and documentation in the Swedish inventory except for some parts of the introduction, the trend section in the NID (Swedish EPA) and the supplementary information under KP about the Registry and the KP flexible mechanisms (Swedish Energy Agency).

The regular inventory work is organized as a project involving all SMED organizations. The project is run by a project management team with one person from each organization. Statistics Sweden is main responsible for the energy sector, the agricultural sector and parts of the waste sector, but is also involved in industrial processes since these are closely connected to the energy sector. The Swedish University of Agricultural Sciences is responsible for the LULUCF sector. The Swedish Environmental Research Institute is main responsible for the industrial process and product use sector and also parts of the waste sector and energy sector. The Swedish Meteorological and Hydrological Institute is main responsible for production of gridded emission data. In addition to the ordinary inventory, SMED also conducts development projects necessary for improving the inventory on behalf of the Swedish EPA.

1.3 Inventory planning, preparation and management

The present Swedish greenhouse gas inventory was compiled according to the recommendations for inventories set out in the UNFCCC reporting guidelines according to decision 24/CP.19, decision 6/CMP.9, the 2006 IPCC Guidelines for National Greenhouse Gas Inventories, 2013 Supplement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories: Wetlands 2013 Revised Supplementary Methods and Good Practice Guidance Arising from the Kyoto Protocol.

It should be noted that the greenhouse gas inventory is integrated with the inventory of air pollutants for reporting to the UNECE (CLRTAP). This assures effective use of resources and consistency between the reporting to the UNFCCC and to the CLRTAP.

1.3.1 Quality system

The Swedish greenhouse gas inventory is compiled in accordance with the methodological guidelines drawn up by the Intergovernmental Panel on Climate Change (IPCC) and the UNFCCC reporting guidelines. 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, illustrated in Figure 1.3. This is an adopted model for how systematic quality and environmental management activity is to be undertaken according to international standards to ensure that quality is maintained and developed.

Procedural Arrangements



Figure 1.3. Structure of the quality system.

The quality system includes several procedures such as training of staff, inventory planning and preparation, QA/QC procedures, publication, data storage, and follow-up and improvements. All QA/QC procedures are documented in a QA/QC plan⁵. The QA/QC plan also includes a scheduled time frame describing the different stages of the

⁵ Swedish EPA, National Greenhouse Gas and Air Pollutants Inventory System in Sweden

inventory from its initial development to final reporting. The quality system ensures that the inventory is systematically planned, prepared and followed up in accordance with specified quality requirements so that the inventory is continuously developed and improved.

The responsibilities of the Swedish EPA and the other government agencies for the quality system are described in paragraph 9 of the Ordinance on Climate Reporting (2014:1434). The Swedish EPA and other government agencies which take part in the climate-reporting work have to ensure that the methodologies applied in the reporting and inventories of emissions and removals attain the quality required for it to be possible for Swedish climate reporting to be done in the correct manner and with correct information. The government agencies have to have internal routines to plan, prepare, check and act/follow up the quality work and consult one another with the aim of developing and maintaining a coordinated quality system.

The responsibility of SMED to maintain and develop an internal quality system is described in the framework contract between the Swedish EPA and the consultants. The SMED quality system is described in a detailed manual⁶. The manual is updated annually and lists all quality control steps that must be undertaken during inventory work (Tier 1 and where appropriate Tier 2). Source-specific quality assurance procedures for Tier 2 and Tier 3 methodologies are described in the QC checklists (appendix 5 to the manual) and in the work documentation (appendix 4). It also includes descriptions of roles and responsibilities, of databases and models, work manuals for each CRT category and documented procedures for uncertainty and key source analyses, as well as procedures for handling and responding to UNFCCC's review of the Swedish inventory. It also handles follow-up and improvement by procedures of non-conformity reporting and collection of improvement needs from all stages of the annual inventory cycle. This results in a planning document, which is used as a basis for planning and selecting further actions to improve the inventory. Figure 1.4 below shows a process description of the annual Swedish inventory.

⁶ Manual for SMED:s Quality System in the Swedish Air Emission Inventories, available at www.smed.se

SWEDISH ENVIRONMENTAL PROTECTION AGENCY
National Inventory Document Sweden 2026

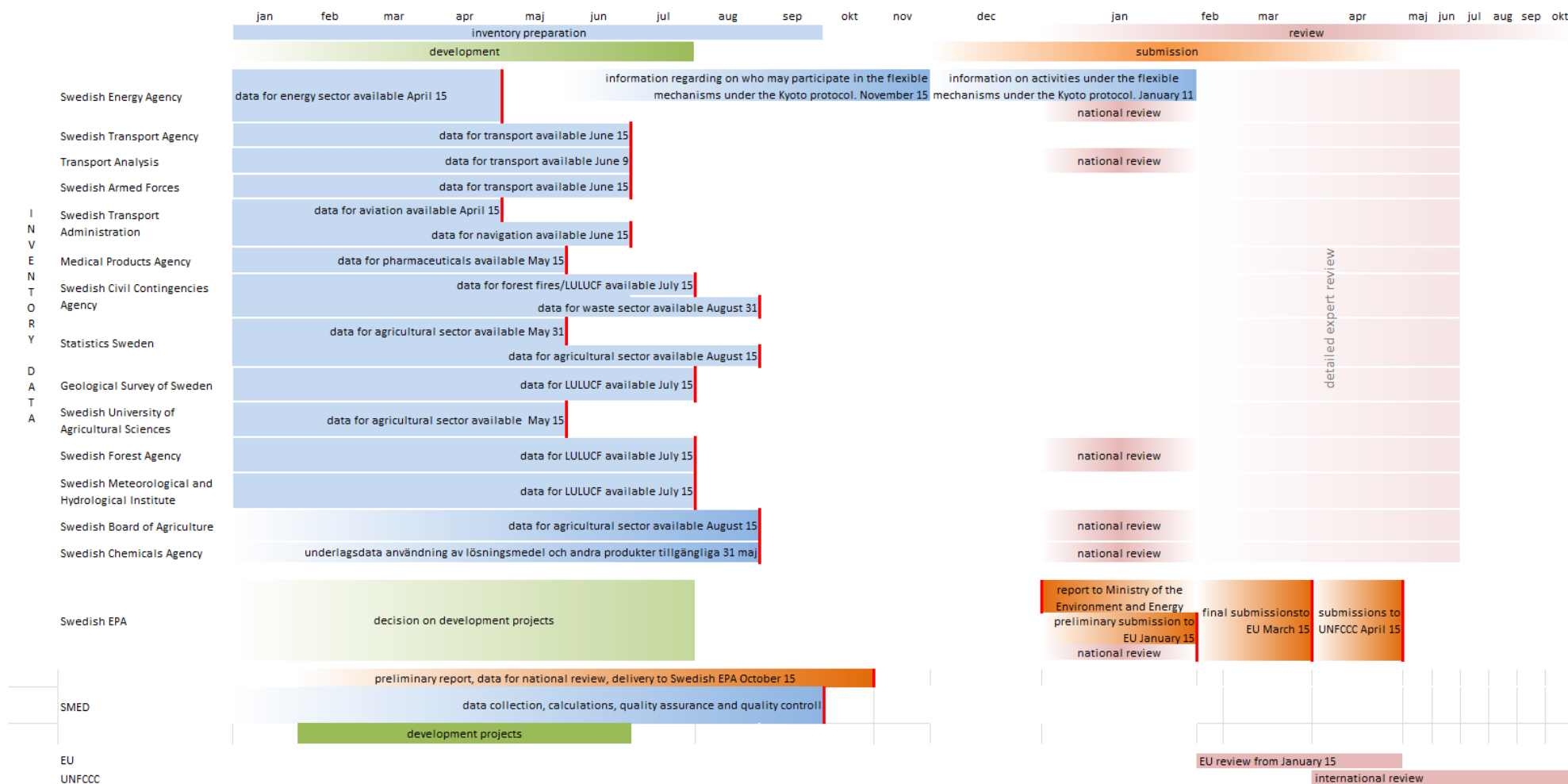


Figure 1.4. Overview of the Swedish GHG inventory planning, preparation and management.

1.3.2 Training, awareness and skills

To meet the quality criteria set out in the UNFCCC and IPCC guidelines, experts from different government agencies are participating in the inventory according to the Ordinance on Climate Reporting (2014:1434). By involving these agencies, it is ensured that the best expertise available in the country is involved. Skills of the part of SMED (consultants) are ensured in accordance with the requirements laid down in the framework contract between the Swedish EPA and the consultants. The levels of consultant's skills are continuously reviewed. There are about 20 active emission inventory experts in SMED involved in the preparation of the 2022 submission. In addition, SMED comprises several national experts and senior researchers involved in specific development projects.

Sweden actively takes part in the UNFCCC annual review process of greenhouse gas inventories. SMED has a few lead reviewers and at least one expert reviewer for each sector (Energy, Industrial Processes and Product Use, Agriculture, LULUCF, and Waste). Experience gained from participation in the UNFCCC reviews feeds into the process of improving the Swedish greenhouse gas inventory and helps to keep up-to-date when changes are made to relevant UNFCCC and IPCC guidelines.

1.3.3 Inventory planning (PLAN)

Planning of the inventory for the submission in year x starts in the fall of year x-2 when the Swedish EPA gets the preliminary budget for year x-1. General priorities for the inventory are decided by the Swedish EPA based on

- recommendations from international review not yet implemented in the inventory
- recommendations from national peer review not yet implemented in the inventory
- key category analysis (focus on major sources/sinks)
- uncertainty analysis (focus on sources/sinks that contributes significantly to the uncertainty of the inventory)
- ideas from SMED and the Swedish EPA on how to improve quality and effectiveness of the inventory
- new international and national requirements, decisions and guidelines

Based on the priorities and on detailed information in the updated list on suggestions for improvements, SMED compiles a gross list of development projects for the coming years. The gross list of development projects is discussed between SMED and the Swedish EPA. During December - February the Swedish EPA decides on which projects should be prioritized and performed. The final prioritization is made in December-February.

In January-June (approximately) SMED is working with development projects. Reports on the results and recommendations for implementation in the inventory are delivered to the Swedish EPA who then decides how these new methods/activity data/emission factors should be implemented in the inventory. In order to be able to implement results in the current inventory with sufficient QA/QC, the Swedish EPA has to decide on implementation in June.

From time to time, there is a need to change data provided by responsible authorities as discussed above. When relevant, the Swedish EPA contacts responsible authorities and discusses the needs for updates.

1.3.4 Inventory preparation (DO)

SMED collects data and information (as set out in Ordinance on Climate Reporting (2014:1434)) for the greenhouse gas emissions and removals calculations from various government agencies, organizations and companies over the period from April to August. The calculations are performed in models, statistics programs and calculation programs in April to September. Over the period from September to October, the material is put together in a reporting format. A short description of data collection and processing for each sector is provided below. See sections 3-8 for a detailed description. Preparation of the inventory is documented in detailed work documentation, which serves as instructions for inventory compilers to ensure quality and consistency and also serves as information in the national review process.

1.3.4.1 ENERGY- STATIONARY COMBUSTION

Energy industries: Data from Quarterly fuel statistics (KvBr), a total survey conducted by Statistics Sweden at plant level and by fuel type. For some petroleum refining plants, data from the European Union Emission Trading Scheme (ETS) is used.

Manufacturing industries: Data mainly from the Quarterly fuel statistics (KvBr), a sample survey conducted by Statistics Sweden. In some cases, data from the Energy use in the manufacturing industry (ISEN) or ETS is used as a complement. All data is at plant level and by fuel type. For some petrochemical plants and cement industry plants, data from the European Union Emission Trading Scheme (ETS) is used.

Other sectors: Data from official statistical reports prepared by Statistics Sweden at national level and by fuel type.

Activity data is multiplied by thermal values, mainly from Statistics Sweden and Swedish Energy Agency, and emission factors provided by the Swedish EPA

1.3.4.2 ENERGY- MOBILE COMBUSTION

Data on fuel consumption at national level and by fuel type is collected from Statistics Sweden and used in combination with emissions data and fuel data from the Swedish Transport Administration, the Swedish Transport Agency and the Swedish Military. Activity data is multiplied by thermal values, mainly provided by Statistics Sweden, and emission factors provided by the responsible authorities.

1.3.4.3 ENERGY – FUGITIVE EMISSIONS

For flaring, hydrogen production, and burning of make-up coke at refineries, activity data and CO₂ emissions from ETS are used for 2005 and later. For earlier years, national statistics and implied emission factor for CO₂ are used. For non-CO₂ emissions, emissions from environmental reports (if available) or regular emission factors for stationary combustion are used.

Fugitive emissions from refineries and from storage of petroleum products at storage depots are mainly compiled from the facilities' environmental reports. Estimates of fugitive emissions from gasoline stations are calculated from fuel data provided by the Swedish Transport Administration.

For flaring of coke oven gas at primary iron and steelmaking facilities, amounts of flared gas are obtained from environmental reports, and national emission factor for CO₂ is

applied. Fugitive emissions from coke production at the same facilities are calculated from coke production values provided in environmental reports.

Emissions from charcoal production are calculated based on production statistics from Food and Agriculture Organization of the UN.

Transmission and distribution losses of natural gas, natural gas and gasworks gas are estimated using national methods and data from environmental reports and directly from the companies. Emissions from venting and flaring of natural gas are mainly estimated using information from companies.

1.3.4.4 INDUSTRIAL PROCESSES AND PRODUCT USE

Greenhouse gas emissions from industrial processes and product use are based on information from various data sources.

The reported data for industrial processes is mainly based on information from plant-specific environmental reports, and from 2005 onwards, data from the EU ETS. For some minor plants, and when plant-specific environmental reports are not available, a combination of data sources are used to make approximate estimates; production statistics, national statistics and implied emission factors (IEFs) based on similar industries. Default IPCC methods and emission factors are used to some extent where national methods are not available.

Data used for estimating emissions from solvent and other product use are based on national activity data obtained from the Products Register kept by the Swedish Chemicals Agency and nationally derived emission factors.

Emissions of fluorinated greenhouse gases are estimated based on national import and export statistics from the Swedish Chemicals Agency, data from the SPIN database (Substances in Products in the Nordic Countries), national vehicle statistics, national emission factors, company-specific information, import of amounts of HFCs in products, and in some cases default IPCC emission factors.

1.3.4.5 AGRICULTURE

Data on animal numbers, crop areas, yields, sales of manure, manure management and stable periods are taken from official statistical reports published by the Swedish Board of Agriculture and Statistics Sweden. Some complementary information is collected from organisations and researchers, such as the Swedish Dairy Association, Swedish Poultry Meat Association, SLU and the Swedish Institute of Agricultural and Environmental Engineering.

1.3.4.6 LAND USE, LAND USE CHANGE AND FORESTRY

Estimates presented in the LULUCF sector are mainly based on data from the SLU and the Swedish EPA. The SLU provides data from the National Forest Inventory, and the Swedish EPA provides data from the Swedish Soil Inventory. The two inventories are integrated and use the same infra-structure for the field sampling. Apart from those two inventories, data from the Swedish Forest Agency, the Swedish Meteorological and Hydrological Institute (SMHI), the Swedish Board of Agriculture, Swedish Civil Contingencies Agency (MSB), Statistics Sweden (SCB) and the Swedish environmental reporting portal is used.

1.3.4.7 WASTE

Statistics on deposited waste quantities, methane recovery and nitrogen emissions from wastewater handling, are provided by the Swedish Association of Waste Management (Avfall Sverige, former RVF), Statistics Sweden, the Swedish Forest Industries Federation and the Swedish EPA. If new data on organic content in household waste or other relevant research is published, such reports are also considered. Profu, an independent research and consultant company in the areas of energy, environment and waste management, provided estimates of deposited organic fractions of industrial waste until year 2005.

Emissions reported for waste incineration are compiled from the facility's annual environmental reports.

1.3.5 QA/QC procedures and extensive review of GHG inventory

The national system is arranged according to decision 24/CP.19 and 19/CMP.1 (and all related decisions). This means that the same legal arrangements and the same QA/QC is used (but enlarged to deliver according to the demands under the Kyoto Protocol as well as under the convention).

1.3.5.1 QUALITY CONTROL

Quality control is the check that is made during the inventory on different types of data, emission factors and calculations that have been made. The quality control takes place according to general requirements (Tier 1) which apply to all types of data used as support material for the reporting, and specific requirements for quality control (Tier 2) which are applied to certain types of data and/or emission sources. In this inventory, general Tier 1 QC measures, according to Table 6.1 in 2006 IPCC Guidelines, have been carried out as follows:

- Documentation of assumptions and criteria for the selection of various parameters
- Transcription errors in data input and references
- Calculations are made correctly
- Parameters, units and conversion factors are correct
- Integrity of database files
- Consistency in data between source categories
- Correct movement of inventory data between processing steps
- Uncertainties are estimated and calculated correctly
- Time series consistency
- Recalculations, checked and documented
- Completeness check
- Trend and outlier analyses
- Review of internal documentation and archiving

In addition, source specific Tier 2 QC procedures are carried out for several categories (Table 1.2).

Table 1.2. Source specific Tier 2 QC procedures carried out in the inventory.

CRT		Action
1.A, 1.B and parts of 2	Energy amounts and emissions of CO ₂	Analysis of differences between the sectoral and reference approach. In order to check activity data and EF, several quality control projects have been carried out over time comparing the inventory data with information from environmental reports and EU ETS data.
2.A.1	Cement production, process emissions of CO ₂	Emissions are calculated both using the bottom-up and the top-down method, the results have been compared and differences explained. It is also stated that emission factors and activity data used are in accordance with internationally accepted methods.
2.A.2	Lime production, process emissions of CO ₂	Emissions are calculated using both the bottom-up (data from EU-ETS) and the top-down method (data from the Swedish Lime Association for most years and Statistics Sweden). The results have been compared and differences commented.
2.B.2	N ₂ O-emissions from Nitric Acid production	Bottom-up production data could not be compared to official data since official data were not available in the statistical database. Only one company produces nitric acid. Calculation methods, abatement technique and production capacity are based on information achieved directly from the company.
2.C.1	Iron and steel production	Activity data are checked with fuel combustion data in order to avoid double counting of emissions or omissions. Activity data is also compared to trade statistics. IEF are compared to IPCC default values.
2.C.3	PFC emissions from aluminium production	Documented process information obtained directly from the company enable plant-specific data checks.
2.F	Product uses as substitutes for ODS	Differences between country specific emission factors and default emission factors from IPCC Guidelines are documented.
5A	Solid waste disposal (CH ₄)	Survey data collection methods are reviewed, and data is cross-checked with the data for the previous years.
5B	Biological treatment of solid waste (CH ₄ and N ₂ O)	Input parameters are reviewed by waste experts.

In addition to the source specific QC procedures listed in Table 1.2, a cross-sectoral control tool was developed in submission 2018, aiming to allocate CO₂ emissions from industrial plants correctly between CRT 1 and 2 and to ensure that total emissions are accounted for across the entire inventory, by facility. When allocating emissions to respective CRT codes, the IPCC guidelines have been applied as far as possible. All industrial facilities where both energy and process related CO₂ emissions occur have been cross-checked between respective CRT sectors.

This includes refineries as well as facilities from the mineral, chemical and metal industry. For each of the relevant facilities, total emissions reported in the energy sector and IPPU are compared to both EU ETS data (if available) and environmental reporting provided by facilities. Quality control is therefore being conducted on a facility level. In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double counting. The tool is used on an annual basis.

When inventory data are compiled by SMED, detailed diagrams of trends are produced, together with tables showing the detailed data and a comparison with last year's submission. A review and QA/QC of trends and recalculations is then performed sector wise by sector experts at the Swedish Environmental Protection Agency and from SMED, at meetings where questions and explanations of data, trends and recalculations are

discussed. The review meetings are documented, including if any revisions to the data are needed.

When reviewed and final data from the database have been imported into the CRT tables, SMED's inventory staff responsible for the reporting database checks that the tables are correct.

The NID is reviewed by the SMED coordinator before delivery to the Swedish EPA.

Before delivery of the inventory to the Swedish EPA the SMED coordinator checks serve as both quality control and quality assurance in accordance with the 2006 IPCC guidelines.

1.3.5.2 QUALITY ASSURANCE

The Swedish QA/QC system includes several QA activities outside the SMED QA/QC procedures. At the final stages of completion of the inventory, the Swedish EPA performs a peer review for each sector.

The Swedish QA/QC system also includes national peer reviews by sectorial authorities. The peer review is defined in the Ordinance on Climate Reporting (2014:1434) and is, for all sectors, conducted by a person who has not taken part in the inventory preparation. The Swedish EPA is responsible for coordinating the peer reviews. From the 2016 submission, the national peer review is conducted in two steps:

- *Annual national review.* The aim of the review is to check the robustness of the national system and to guarantee that politically independent emissions and removals data is reported. The review is performed by sectorial authorities prior to submission to meet the demands in 19/CMP.1 annex paragraph 15 (b)
- *In-depth expert peer review.* Each year there will also be an in-depth peer review of one sector or part of a sector. The choice of sector depends on the outcome of the results from the EU and UNFCCC reviews and if the national review has identified problems or other needs discovered by SMED inventory experts or Swedish EPA. The aim of the in-depth expert peer review is to improve the inventory data quality. The review is performed by sectorial authorities and other national and international experts in order to meet the demands in 19/CMP.1 annex paragraph 15 (c).

The annual national review is organised as a desk review. Before the desk review the sectorial authorities have received the NID and the CRT data. After finalizing the review, the reviewers give feedback and inform the Swedish EPA if they find the inventory reliable and independent, if the trends are correct and if the national system is functional. Any recommendations for improvements are recorded in the list of suggested improvements described in section 1.3.5.5.

The in-depth expert peer review includes methodologies, models, activity data and emissions factors. The reviewers also identify areas for improvement, which consolidates the basis for improvements in coming submissions. Results from the national peer review are documented in review reports. Recommendations from the review reports are collected to the list of suggested improvements described in section 1.3.5.5.

Together with Denmark, Finland, Norway and Island, Sweden arranges annual expert meetings where GHG inventory compilers discuss common problems and needs for e.g. revised methods and further inventory development.

The UNFCCC secretariat administers an international peer review of Swedish reporting after submission. Recommendations from the review reports are collected to the list of suggested improvements described in section 1.3.5.5 (cf Chapter 10).

The submission will also be reviewed by the EU. Recommendations from this review will be handled in the same way as recommendations from the UNFCCC review and the national peer review.

1.3.5.3 FINALIZATION, PUBLICATION AND SUBMISSION OF THE INVENTORY

The results are published nationally by the Swedish Environmental Protection Agency in late November or early December each year. The Swedish EPA delivers the greenhouse gas inventory to the Ministry of Environment five working days before the preliminary reporting to European Commission (January 15th).

The Swedish EPA, on behalf of the Ministry of Environment, submits the inventory to the European Commission on January and March 15th and to the UNFCCC on April 15th. Reported data in the submission of year t relates to the series of emissions years from 1990 up to and including year $t-2$, in other words emissions which took place during 2021 are reported in early 2023.

1.3.5.4 DATA STORAGE

A system for handling data related to the inventory, entitled Technical Production System (TPS)⁷, has been developed and was implemented for the first time in submission 2007. It supports data input from text files and Microsoft Excel sheets. The system is owned and maintained by the Swedish EPA and allows data to be gathered from SMED. The system is encrypted and approved for handling data considered confidential. For all CRT-categories and sub-categories, time series from 1990 onwards of emission data, activity data, and implied emission factors where relevant, can be presented. The system allows for different types of data exports, e.g. to an xml-file or to MS Excel, that are used to produce national statistics as well as the import formats for CRT Reporter for submission to the EU and UNFCCC. CRT-tables are then generated using the export function in CRT Reporter.

The Swedish EPA is responsible for archiving data and documentation on the calculations of each submission. This is done in the archiving system of the agency following national rules and regulations.

1.3.5.5 FOLLOW-UP AND IMPROVEMENT (ACT)

Each year, all comments received from national and international reviews that are not already addressed and ideas from SMED and the Swedish EPA are compiled into a list for suggestions on improvements. From this list, development projects are formed each year as described in section 1.3.3. Suggestions not implemented one year is kept on the list for next year. In Table 1.3 below implemented improvements in this submission due to major development projects are presented. Other corrections, emission estimation

⁷ <https://tps.naturvardsverket.se/>

improvements and updates of various statistics are described under each source category in section 3-8 below. In addition, improvements related to transparency of the NID are continuously addressed in response to questions raised by national experts during the national peer review, and in response to previous ERT recommendations.

Table 1.3. Summary of implemented improvements in this submission due to major development projects.

Sector/CRT category	Implemented improvement	Quality criteria (TCCCA)	Need identified by	Reference to NID section
1A2gvii/1A3e/ 1A4a/1A4b/1A4c	Revised machine stock and scrapping rates	Accuracy	National experts	3.2.15/3.2.21-23
1.A.1.b/1.B.2.a.4/ 1.B.2.C.2.1	Consistent allocation of all refinery emission through the time series	Consistency	TERT	3.2.7/3.3.2
5.A.1	Implementation of newly available estimates on fraction of waste burned at SWDS 1952-1980.	Accuracy	TERT	7.2.2.5
5.B.1	Implementation of AD on quantities of home composted food waste for the years 1990-2023.	Completeness	TERT	7.3.1.5

Each year, the Swedish EPA follows up on delivered data from responsible agencies to ensure correct and appropriate data for next submission.

Development of TPS such as additional functions etc. is organized in a similar way as for the inventory: Ideas are compiled into a list, and from this list issues to be implemented are prioritized.

1.4 Brief general description of methodologies and data sources used

1.4.1 GHG inventory

Emission estimates are mainly based on data from national or official Swedish statistics, e.g. energy statistics, European Union Emission Trading Scheme (EU ETS)⁸, environmental reports⁹, agricultural and forestry statistics, as well as data on production (e.g. cement) and consumption (e.g. fluorinated gases: F-gases) obtained directly from the major producers and consumers, respectively.

Emission factors and thermal values used are either developed nationally or are internationally recommended default factors.

The methodologies used for Sweden's greenhouse gas emissions inventory are in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (2006 IPCC Guidelines)¹⁰. In some cases, the methodologies prescribed in the Revised 1996 IPCC Guidelines for National Greenhouse Gas Inventories (IPCC Guidelines)¹¹ and the IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories (Good Practice Guidance)¹², IPCC's supplementary guidelines for Wetlands (WL GL)¹³ are also used. Some parts of the methodologies are taken directly from the EMEP/EEA air pollutant emission inventory guidebook (formerly called the EMEP CORINAIR emission inventory guidebook).¹⁴

For an overview of the methods used in all sectors, see Summary 3 in the CRT tables and in each sector section, where a detailed explanation on data sources and methodologies is given.

The combined effect of various greenhouse gases has been calculated using global warming potential factors (GWP) according to decision 5/CMA.3 to the Paris Agreement and presented in Annex 8.4 to the NID. These are developed by the IPCC and are used as a means of comparing the relative significance of various gases in terms of their greenhouse effect, expressed in CO₂-equivalent. Decision 5/CMA.3 refers to the use of GWP from the Fifth Assessment report of the IPCC.

Emission factors and thermal values for the energy sector are provided in Annex 2.

⁸ See Annex 8.1

⁹ See Annex 8.3

¹⁰ The 2006 IPCC Guidelines can be found at: <http://www.ipcc-nggip.iges.or.jp/public/2006gl/index.html>

¹¹ The IPCC Guidelines can be found at: <http://www.ipcc-nggip.iges.or.jp/public/gl/invs1.htm>

¹² The Good Practice Guidance can be found at: <http://www.ipcc-nggip.iges.or.jp/public/gp/english/>

¹³ The WL GL can be found at <http://www.ipcc-nggip.iges.or.jp/public/wetlands/index.html>

¹⁴ The EMEP/Corinair Guidebook can be found at: <http://tfeip-secretariat.org/unece.htm>

1.5 Brief description of key categories, including for UNFCCC

1.5.1 GHG inventory (including and excluding LULUCF)

According to the 2006 IPCC Guidelines, key categories in a national inventory should be identified in order to prioritize the efforts in improving the quality of the inventory estimates. Key categories are defined as sources and/or sinks that have “a significant influence on a country’s total inventory of direct greenhouse gases in terms of the absolute level, the trend, or the uncertainty in emissions and removals”. The identification of level and trend key categories is done using two different approaches. The difference between the two approaches is that Approach 2 assessments besides magnitudes also account for emission uncertainties, whereas Approach 1 does not. According to the UNFCCC reporting guidelines, Annex I Parties shall identify their key categories for the base year and the latest reported inventory year, using Approach 1, level and trend assessment, including and excluding LULUCF. Parties are encouraged to also use Approach 2 and to add additional key categories to the result of Approach 1. The results from key category analysis by both approaches are summarized in Table 1.4 below and are also presented in each source category section (3-7) as well as in CRT table 7. In Annex 1, the methodology is discussed in more detail. Detailed background tables (Tables A1.1 – A1.8), according to the 2006 IPCC Guidelines and the 2019 refinements, are also found in Annex 1.

Table 1.4. Approach 1 and Approach 2 key categories 2024 in terms of level and trend.

IPCC Source Category	GHG	Including LULUCF		Excluding LULUCF	
		App. 1	App. 2	App. 1	App. 2
1.A.1.a Public Electricity and Heat Production: Biomass	N ₂ O	T		L,T	L
1.A.1.a Public Electricity and Heat Production: Gaseous Fuels	CO ₂	T		L,T	
1.A.1.a Public Electricity and Heat Production: Liquid Fuels	CO ₂	L,T		L,T	
1.A.1.a Public Electricity and Heat Production: Peat	CO ₂	T	T	L,T	T
1.A.1.a Public Electricity and Heat Production: Solid Fuels	CO ₂	L,T	L,T	L,T	L,T
1.A.1.a Public Electricity and Heat Production: Other Fuels	CO ₂	L,T	L,T	L,T	L,T
1.A.1.b Petroleum refining: Gaseous Fuels	CO ₂	L,T		L,T	
1.A.1.b Petroleum refining: Liquid Fuels	CO ₂	L,T	L,T	L,T	L,T
1.A.1.c Manufacture of Solid fuels and Other Energy Industries: Solid Fuels	CO ₂	L		L	L
1.A.2.a Iron and Steel: Gaseous Fuels	CO ₂			L	
1.A.2.a Iron and Steel: Liquid Fuels	CO ₂	L,T		L,T	L
1.A.2.a Iron and Steel: Solid Fuels	CO ₂	L,T		L,T	T
1.A.2.b Non-ferrous metals: Liquid Fuels	CO ₂			L	
1.A.2.c Chemicals: Gaseous Fuels	CO ₂	T		L,T	
1.A.2.c Chemicals: Liquid Fuels	CO ₂	L,T		L,T	
1.A.2.c Chemicals: Other Fuels	CO ₂				L,T
1.A.2.c Chemicals: Solid Fuels	CO ₂	T		T	

IPCC Source Category	GHG	Including LULUCF		Excluding LULUCF	
		App. 1	App. 2	App. 1	App. 2
1.A.2.d Pulp, Paper and Print: Liquid Fuels	CO ₂	L,T	T	L,T	L,T
1.A.2.d Pulp, Paper and Print: Other Fuels	CO ₂		T		T
1.A.2.d Pulp, Paper and Print: Solid Fuels	CO ₂	T		T	
1.A.2.e Food Processing, Beverages and Tobacco: Gaseous Fuels	CO ₂	T		L,T	
1.A.2.e Food Processing, Beverages and Tobacco: Liquid Fuels	CO ₂	T	T	T	T
1.A.2.e Food Processing, Beverages and Tobacco: Solid Fuels	CO ₂	T		T	
1.A.2.f Non-metallic minerals: Liquid Fuels	CO ₂	L,T	T	L,T	T
1.A.2.f Non-metallic minerals: Other Fuels	CO ₂	L,T	L,T	L,T	L,T
1.A.2.f Non-metallic minerals: Solid Fuels	CO ₂	L,T	T	L,T	L,T
1.A.2.g.vii Off-road vehicles and other machinery: Liquid Fuels	CO ₂	L,T	L,T	L,T	L,T
1.A.2.g.viii Other: Gaseous Fuels	CO ₂	T		T	
1.A.2.g.viii Other: Liquid Fuels	CO ₂	L,T	T	L,T	L,T
1.A.2.g.viii Other: Solid Fuels	CO ₂	L,T		L,T	
1.A.3.a Domestic Aviation: Jet Kerosene	CO ₂	L,T	T	L,T	L,T
1.A.3.b.i Road Transportation, Cars: Diesel oil	CO ₂	L,T	L,T	L,T	L,T
1.A.3.b.i Road Transportation, Cars: Diesel oil	N ₂ O		T		L,T
1.A.3.b.i Road Transportation, Cars: Gasoline	CH ₄	T	T	T	T
1.A.3.b.i Road Transportation, Cars: Gasoline	CO ₂	L,T	L,T	L,T	L,T
1.A.3.b.i Road Transportation, Cars: Gasoline	N ₂ O	T	T	T	T
1.A.3.b.ii Road Transportation, Light duty trucks: Diesel oil	CO ₂	L,T	L,T	L,T	L,T
1.A.3.b.ii Road Transportation, Light duty trucks: Gasoline	CO ₂	T	T	L,T	T
1.A.3.b.iii Road Transportation, Heavy duty trucks: Diesel oil	CO ₂	L	L	L	L
1.A.3.b.iii Road Transportation, Heavy duty trucks: Diesel oil	N ₂ O				L,T
1.A.3.b.iv Road Transportation, Motorcycles: Gasoline	CO ₂			L	
1.A.3.c Railways: Liquid Fuels	CO ₂			T	
1.A.3.d Domestic Navigation: Gas/Diesel Oil	CO ₂	L,T		L,T	
1.A.3.d Domestic Navigation: LNG	CO ₂	T		T	
1.A.3.d Domestic Navigation: Residual Oil	CO ₂			L	L
1.A.3.e Other Transportation: Total	CO ₂	L,T	T	L,T	L,T
1.A.4.a Commercial/Institutional: Gaseous Fuels	CO ₂	L,T		L,T	
1.A.4.a Commercial/Institutional: Liquid Fuels	CO ₂	L,T	T	L,T	L,T
1.A.4.b Residential: Biomass	CH ₄		T		L,T
1.A.4.b Residential: Biomass	N ₂ O				L
1.A.4.b Residential: Liquid Fuels	CO ₂	L,T	T	L,T	L,T
1.A.4.c Agriculture/Forestry/Fisheries: Domestic Heating Oil	CO ₂	T	T	T	T
1.A.4.c Agriculture/Forestry/Fisheries: Liquid Fuels	CO ₂	L,T		L,T	L
1.A.4.c Agriculture/Forestry/Fisheries: Solid Fuels	CO ₂	T		T	

IPCC Source Category	GHG	Including LULUCF		Excluding LULUCF	
		App. 1	App. 2	App. 1	App. 2
2.A.1 Cement Production	CO ₂	L,T		L,T	L
2.A.2 Lime Production	CO ₂	L		L	L
2.B.10 Other	CO ₂	L,T		L,T	L
2.B.2 Nitric Acid Production	N ₂ O	T	T	T	T
2.C.1 Iron and Steel Production	CO ₂	L	L	L	L
2.C.2 Ferroalloys production	CO ₂	T		L,T	
2.C.3 Aluminium production	CO ₂			L	
2.C.3 Aluminium production	PFCs	T		T	T
2.C.7 Other	CO ₂	L		L	
2.D.1 Lubricant use	CO ₂	L	L	L	L,T
2.F.1 Refrigeration and air conditioning	HFCs	L,T	L,T	L,T	L,T
2.H.1 Pulp and paper	N ₂ O			L	
3.A.1 Dairy cattle	CH ₄	L,T	L,T	L,T	L,T
3.A.1 Non-dairy cattle	CH ₄	L,T	L,T	L,T	L,T
3.A.2 Sheep	CH ₄			L	L
3.A.4 Horses	CH ₄	L	L	L	L
3.A.4 Raindeer	CH ₄			L	L
3.A.4 Swine	CH ₄				L
3.B Indirect N ₂ O emissions	N ₂ O		L,T		L,T
3.B.1 Dairy cattle	CH ₄				L
3.B.1 Dairy cattle	N ₂ O	T	T	T	L,T
3.B.1 Non-dairy cattle	CH ₄		L,T	L,T	L,T
3.B.1 Non-dairy cattle	N ₂ O			L	L
3.B.4 Poultry	CH ₄				L
3.D.a.1 Inorganic N fertilizers	N ₂ O	L,T	L,T	L,T	L,T
3.D.a.2.a Animal manure applied to soils	N ₂ O	L	L,T	L	L,T
3.D.a.2.c Other organic fertilizers applied to soils	N ₂ O		T		L,T
3.D.a.3 Urine and dung deposited by grazing animals	N ₂ O		L		L
3.D.a.4 Crop residues applied to soils	N ₂ O	L	L,T	L	L,T
3.D.a.6 Cultivation of organic soils (i.e histosols)	N ₂ O	L,T	L,T	L,T	L,T
3.D.b.1 Atmospheric deposition	N ₂ O		L,T	L	L,T
3.D.b.2 Nitrogen leaching and run-off	N ₂ O		L,T	L	L,T
3.G Liming	CO ₂			L	
4.A Drained organic soils	CH ₄	L	L	-	-
4.A Drained organic soils	N ₂ O	L	L	-	-
4.A.1 Forest land remaining forest land	CO ₂	L,T	L,T	-	-
4.A.2.2 Grassland converted to forest land	CO ₂	L,T	L,T	-	-
4.A.2.4 Settlements converted to forest land	CO ₂	L,T	T	-	-

IPCC Source Category	GHG	Including LULUCF		Excluding LULUCF	
		App. 1	App. 2	App. 1	App. 2
4.B Drained organic soils	CH ₄	L,T	L,T	-	-
4.B.1 Cropland remaining cropland	CO ₂	L,T	L,T	-	-
4.B.2.2 Grassland converted to cropland	CO ₂	T	T	-	-
4.C.1 Grassland remaining grassland	CO ₂	L	L	-	-
4.C.2.1 Forest land converted to grassland	CO ₂	L,T	L,T	-	-
4.C.2.2 Cropland converted to grassland	CO ₂	T	L,T	-	-
4.D.1.1 Peat extraction remaining peat extraction	CO ₂	L,T	L,T	-	-
4.D.2 Land converted to wetlands	N ₂ O		T	-	-
4.D.2.3.1 Forest converted to wetlands	CO ₂	T	T	-	-
4.D.2.3.2 Carbon pools converted to wetlands	CO ₂	T	T	-	-
4.E.1 Settlements remaining settlements	CO ₂	L,T	T	-	-
4.E.2.1 Forest land converted to settlements	CO ₂	L,T	L,T	-	-
4.E.2.2 Cropland converted to settlements	CO ₂	T	L,T	-	-
4.F.2 Land Converted to Other Land	CO ₂	T	T	-	-
4.G Total HWP from domestic harvest	CO ₂	L,T	L,T	-	-
5.A.1 Managed waste disposal sites	CH ₄	L,T	L,T	L,T	L,T
5.C.1 Waste Incineration	CO ₂			L	
5.D.1 Domestic wastewater	CH ₄	L	L,T	L	L,T
5.D.1 Domestic wastewater	N ₂ O	L	L	L	L

L=Level, T=Trend.

1.6 Information on QA/QC

See section 1.3.

1.6.1 QA/QC Procedures

See section 1.3.5.

1.6.2 Verification activities

See section 1.3.5.

1.6.3 Treatment of confidentiality issues

Several data sources that are used for producing emissions estimates for the inventory are confidential at micro level (e.g. company or plant level). This is the case for:

- statistical surveys on fuel consumption used in the energy and manufacture industries (CRT 1A1, 1A2)
- information collected for the EU Emissions Trading System
- data from the Products Register at the Swedish Chemicals Agency used in Solvent and other product use (CRT 2)
- data on sold medicines from Swedish eHealth Agency.
- data from the Swedish portal for environmental reporting (CRT 2, 5C)

A thorough confidentiality analysis, using a P%-rule¹⁵, has been conducted for sectors using statistics from statistical surveys on fuel consumption and information collected for the EU Emissions Trading System. Results based on micro-data from Swedish Chemicals Agency and Swedish eHealth Agency are not classified in the CRT-tables since the aggregation level is high enough to protect company data. When the confidentiality analysis showed that a certain category should be classified to protect data of one or more companies, the companies have been asked to give consent to publish the data. If the company declined or a consent could not be acquired, the data are considered confidential and marked using notation key 'C'.

Sweden has previously aggregated confidential data, in submission of 2015 and 2016 (e.g. between fuel groups within subcategories). While this method avoided using notation key 'C' in the CRT-tables, the aggregations resulted in inaccurate implied emission factors for those fuel categories. Furthermore, it is difficult to ensure that aggregations are made consistently from submission to submission since different sectors may be considered confidential for different years depending on (i) the quantity of energy use/production levels of specific plants or (ii) if companies have provided consent for publishing statistics for the specific year (consent is normally given for 2-3 years at a time).

An internal review performed during 2016 of the use of confidential data in the inventory showed that additional data should be considered confidential compared to previous submissions in order to comply with the Public Access to Information and Secrecy Act of the Swedish law. This had implications for emissions estimates and activity data based on data from the EU ETS and energy statistics. This has affected some sub-sectors in

¹⁵ This implies that it is mathematically impossible to derive a certain company's data within less than P% probability

stationary combustion (CRT 1) and industrial processes and product use (CRT 2), which have been classified with the notation key Confidential (C).

Sweden is working continuously with improving the transparency of our reporting and strives to minimize the extent of confidentiality in inventory data. This is done by contacting all companies, which causes confidentiality issues by email and/or phone. This has led to a decrease in the number of companies causing confidentiality issues. Whenever consent has not been acquired and the companies have a large impact on the number of confidential data points, Sweden also set up meeting with the companies. In submission 2026, some progress has been made in this regard, however there are a few companies not being able to consent to publishing of the data due to their internal policy. In submission 2026, allocation between CRT categories were again implemented to reduce the amount of “C” values in the CRT-tables (affecting CRT codes 1A1b and 1B). In addition, greenhouse gas emissions in CRT 2.B have been allocated to CRT 2.H.1 for emission year 2022 to allow summation of correct sector and national total while protecting confidential information.

1.7 General uncertainty evaluation

1.7.1 GHG inventory

An uncertainty analysis has been performed according to the approach 1 method described in Volume 1, Chapter 3 of the 2006 IPCC guidelines. See Annex 7 for the results and for a description of the method used. The analysis has been performed both including and excluding LULUCF. According to the IPCC Guidelines, uncertainty estimates are an essential part of an emission inventory. They should be derived for each variable used in the inventory (measured emissions, activity data and emission factors) and aggregated into uncertainty estimates in total national emissions and emission changes over time (trends). The 2006 IPCC Guidelines identify that: “An uncertainty analysis should be seen, first and foremost, as a means to help prioritise national efforts to reduce the uncertainty of inventories in the future, and guide decisions on methodological choice”.

The methodology is based on uncertainty coefficients for activity data and emission factors. The uncertainty coefficients have in many cases been assigned based on expert judgement or on default uncertainty estimates provided in the IPCC 2006 guidelines, if not enough background data was available to make actual statistical uncertainty calculations. Hence, some caution should be taken when interpreting and assessing the uncertainty results.

Uncertainties have been estimated for the base year 1990 and 2024 for the direct greenhouse gases CO₂, CH₄, and N₂O, and for F-gases. Uncertainties are presented as 95% confidence intervals.

When reporting the results in the NID, uncertainties are presented on the same aggregation level as the key categories. The purpose is to facilitate combined use of the two analyses, since both aim at showing what parts of the inventory are especially important and/or weak. This is important information when planning future inventories and, above all, when using and evaluating the inventory results.

Continuous efforts are made to improve the uncertainty estimates, for example by contacting external experts for better information on different sources. In every development project, uncertainties in estimated activity data and emission factors are overhauled and revised when needed.

1.7.1.1 RESULTS

The results of the uncertainty calculations according to the approach 1 for the base year (1990) and 2024 are presented in Annex 7. The overall uncertainty for the base year and latest reporting year, 2024 GHG emissions (in CO₂-eq., excl. LULUCF) in Sweden is calculated to be $\pm 4.61\%$ (1990) and $\pm 2.97\%$ (2024), respectively (Figure 1.5). A considerable part of the overall uncertainty stems from uncertainty in the agricultural sector (CRT 3). The national total emissions have considerably higher uncertainty with LULUCF included ($\pm 88.2\%$ in base year and $\pm 129\%$ in 2024), mainly because of the large and hard-to-estimate net removals in LULUCF (Figure 1.5).

Table 1.5 shows the ten sources with the largest uncertainty contributions in the inventory for 2024, excluding LULUCF.

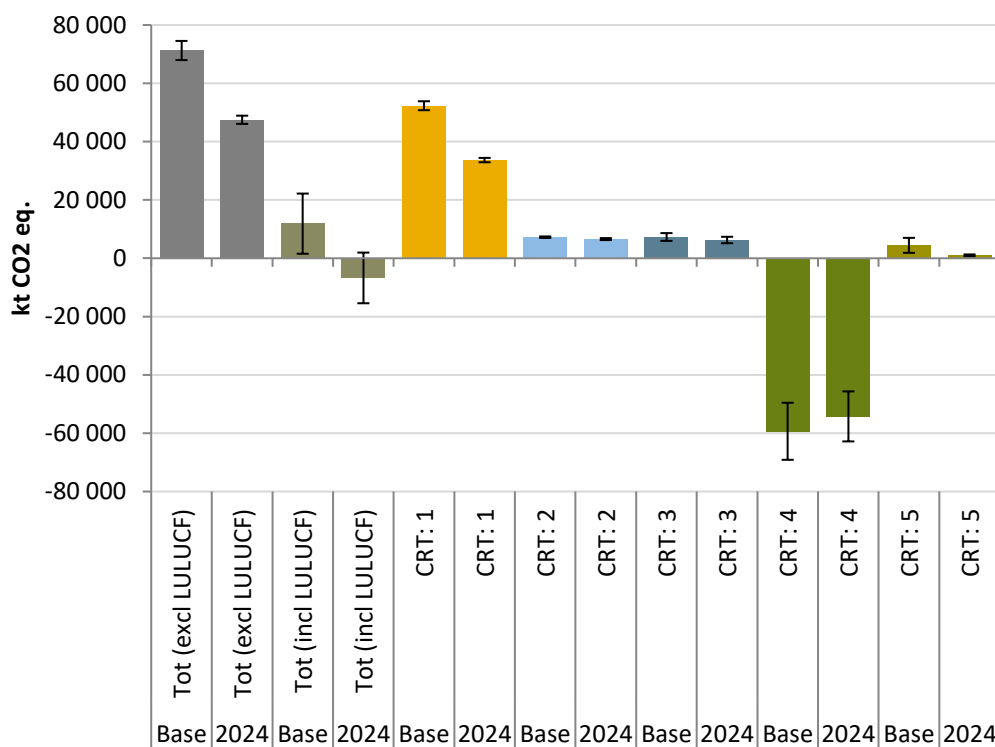


Figure 1.5. Estimated greenhouse gas emissions and uncertainties (95% confidence intervals) in years 1990 and 2024: national total emissions (excl. and incl. LULUCF) and by sector.

Table 1.5. The ten sources with the largest uncertainty contributions in the Swedish inventory for 2024, excluding LULUCF (Contribution to level approach 2).

IPCC Source Category	GHG	Year 2024 emissions or removals (kt CO ₂ -eq.)	Combined uncertainty (%)	Relative contribution to variance in year 2024 (%)
3.D.a.1 Inorganic N fertilizers	N ₂ O	770.0	80.2	7.8%
1.A.1.a Public Electricity and Heat Production:Other Fuels	CO ₂	3216.1	15.7	6.4%
3.D.a.6 Cultivation of organic soils (i.e. histosols)	N ₂ O	484.2	85.1	5.2%
3.A.1 Non-dairy cattle	CH ₄	1570.5	25.5	5.1%
3.D.b.1 Atmospheric deposition	N ₂ O	97.4	400.5	4.9%
3.D.a.4 Crop residues applied to soils	N ₂ O	341.5	82.5	3.6%
2.F.1 Refrigeration and air conditioning	HFCs	682.7	39.7	3.4%
3.B Indirect N ₂ O emissions	N ₂ O	66.7	400.5	3.4%
1.A.3.b.i Road Transportation, Cars: Gasoline	CO ₂	5201.1	5.0	3.3%
3.A.1 Dairy cattle	CH ₄	1249.9	20.6	3.3%
Total				46.3%

The uncertainty of the trend of national total greenhouse gas emissions, excluding LULUCF, was $\pm 2.1\%$. The uncertainty in the trend is a percentage point range, relative to the inventory trend and should be interpreted as $\pm 2.1\%$ being the estimated percentage point difference compared to the general trend. Thus, there is a 95% probability that the decrease in GHG emissions in Sweden (excluding LULUCF) between 1990 and 2024 (-33.3% or -23.8 Mt CO₂-eq.) is in the interval -32.6% to -34.0%.

Estimates of carbon stock changes originate mainly from a sampling design with the intention to keep systematic errors as low as possible. The systematic error is reduced by using representative functions, by direct measurements in field and laboratory measurements. We assume that the major source of uncertainty arises from random variation due to sampling. The sampling error is estimated using statistical theory for living biomass and partly for other carbon pools (all Tier 3). A consistent methodology for estimating carbon pools has been used from 1990 and onwards. Therefore, we expect the uncertainty to be the same for all years where all sample units are used to estimate the annual change. The uncertainties for other categories are based on IPCC default and expert judgment.

1.8 General assessment of completeness

In the following section, the completeness of the GHG inventory is described.

1.8.1 GHG inventory

The inventory covers all mandatory GHG sources and sinks in Sweden. All greenhouse gases are covered. The general completeness for each sector is discussed below. Detailed information is presented in Annex 5.

1.8.2 Energy

The estimates are in accordance with the requirements concerning completeness as laid out in the 2006 IPCC Guidelines.

1.8.3 Industrial Processes and Product Use

For most sources, and particularly for the most important ones, the estimates are in accordance with the requirements concerning completeness as laid out in the 2006 IPCC Guidelines. However, some exceptions do exist. These are primarily in sub-sectors with a large number of smaller facilities with minor emissions or for sources where no IPCC default methodology exists (see Annex 5, Table A5.1).

The estimated emissions from solvent and product use are considered to be complete, as national data from the Products Register and the SPIN¹⁶ database is used in the inventory.

1.8.4 Agriculture

All relevant agricultural emissions and sources are reported in the inventory. Reindeer, which sometimes are not considered as a part of the agricultural sector, are included in the inventory. All sales of fertilizers are included in the inventory, also quantities used in other sectors. N-fixing crops used in temporary grass fields, and sludge used as fertilizer is also included. This means that all anthropogenic inputs to agricultural soils are covered.

1.8.5 Land Use, Land Use Change and Forestry

All land areas are inventoried in the field except high mountains, military impediments and urban land. Their relative importance for the Swedish GHG inventory is assessed to be very small.

The inventory of the LULUCF-sector is complete in the sense that all carbon pools and other sources, where methods are provided in the 2006 GL, are reported for land use categories that are considered managed.

The reporting of woody biomass stocks refers to above and below ground parts of trees taller than 1.3 m. Other vegetation such as shrubs and herbs are not reported.

1.8.6 Waste

Accidental landfill fires occur in Sweden; however, emissions of CO₂, CH₄ and N₂O are reported as NE since there is no default method provided by the 2006 IPCC Guidelines that can be applied in this case and is below the threshold of 0.05% of national total emissions (which is about 30 kt CO₂ eq.). Emissions are estimated to be insignificant in

¹⁶ Substances in Preparations in Nordic Countries

relation to the amount of effort it would require obtaining activity and emission data. All other data are complete.

2 Trends in greenhouse gas emissions

2.1 Total greenhouse gas emissions and removals

In 2024, total greenhouse gas emissions (excluding LULUCF) in Sweden amounted to 47.5 Mt CO₂-eq. (Figure 2.1). The emissions show a decreasing trend although there are some annual fluctuations in a few sectors that affect the total emissions. In 2024 emissions increased by 7% compared to 2023. The increased emissions are mainly from the energy sector and is due to a large decrease of the percentage of biofuels mixed into diesel compared to the previous year.

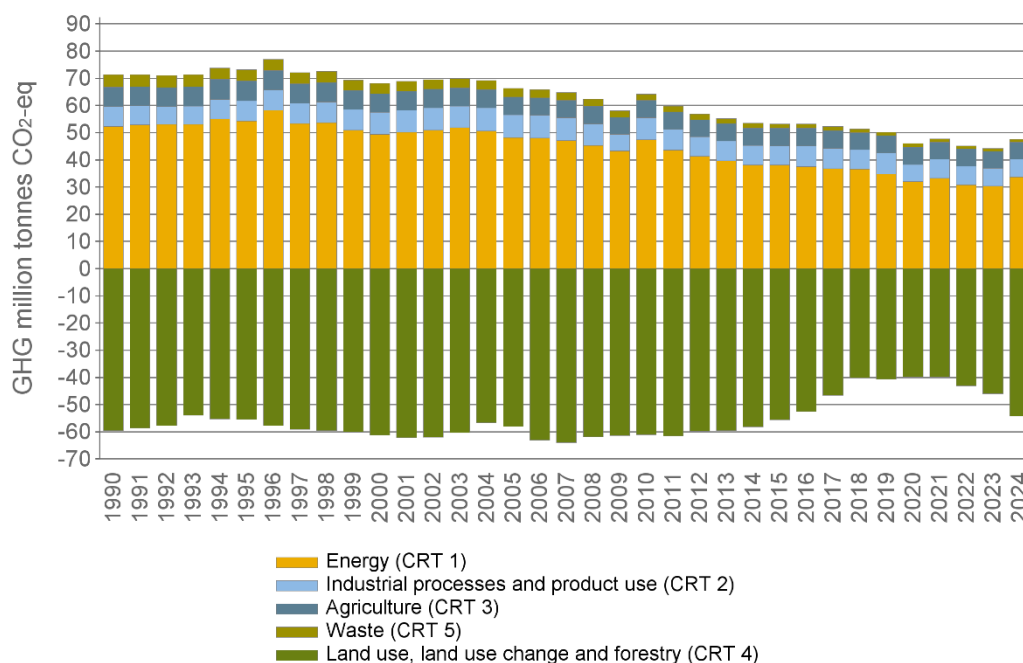


Figure 2.1. Total emissions and removals of greenhouse gases calculated as CO₂-eq. from Land use, land use change and forestry (LULUCF, CRT 4) and the other sectors (CRT 1, 2, 3 and 5), 1990-2024.

Total emissions have decreased by 33% (about 23.8 Mt CO₂-eq.) between 1990 and 2024. The energy sector contributed the most to the overall decrease in emissions, with a reduction of about 18.6 Mt CO₂-eq. between 1990 and 2024, primarily through reductions of about 8.7 Mt in the residential, commercial/institutional and agriculture, forestry and fisheries subsectors (CRT 1.A.4), about 3.0 Mt in the transport sector (CRT 1.A.3), 4.8 Mt in manufacturing industries and construction (CRT 1.A.2) and 2.0 Mton in energy industries (CRT 1.A.1). The main reason to decreased emissions from the residential and commercial/institutional sectors is the replacement of combustion of fossil fuels for heating with district heating and electricity, including heat pumps. Emissions in the manufacturing industries and construction have decreased due to a reduction in the use of fossil fuels, mainly as a result of a shift to biofuels and electricity. Moreover, electricity

and heat production are increasingly based on renewable energy so although the use of district heating has increased, emissions have decreased. In recent years, the emissions in the transport sector have decreased, mainly due to the use of more energy efficient cars and increased use of biofuel. Other sectors also contributed to the overall decreased emissions during the period; waste (CRT 5) by 3.4 Mt, agriculture (CRT 3) by 1.0 Mt and industrial processes and product use (CRT 2) by 0.6 Mt.

Between 2023 and 2024 the total greenhouse gas emissions increased by 7% (about 3.3 Mton CO₂-eq.). Most of the increased emissions are in the energy sector, with the transport sub-sector (CRT 1.A.3) being the major contributor. This is due to a lower amount of biofuel mixed into diesel as the Swedish reduction mandate was lowered during 2024. The largest emission reduction was seen for energy industries at 0.02 Mt CO₂-eq. whereas there were increased emissions from other sectors in the energy sector. There was little change in emissions from industrial processes and product use, and decreased emissions in agriculture (about 0.03 Mton) and from the waste sector (about 0.08 Mton).

The land use, land-use change and forestry sector (LULUCF, CRT 4) has generated annual net removals during the whole inventory period (1990-2024). The net removals show substantial annual fluctuations. In 2024 the net removal was 54 Mton CO₂-eq. which is 9% lower than 1990 and 18% (8.2 Mton CO₂-eq.) larger than 2023.

2.1.1 Overview of emissions by sector

Figure 2.2 shows the greenhouse gas emissions from different sectors in 2024. The energy sector (CRT 1) is comprised by emissions from transport (CRT 1.A.3), which accounted for 36% of the total emissions, energy industries (CRT 1.A.1), 17% of total emissions, and combustion in manufacturing industries and construction (CRT 1.A.2), 13% of total emissions. Emissions from fugitive emissions (CRT 1.B) accounted for 0.17% of total emissions, and other sectors (CRT 1.A.4) for 4.7% of total emissions. Industrial processes and product use (CRT 2) accounted for 14%, agriculture (CRT 3) for 13% and waste (CRT 5) for 2.1% of total emissions.

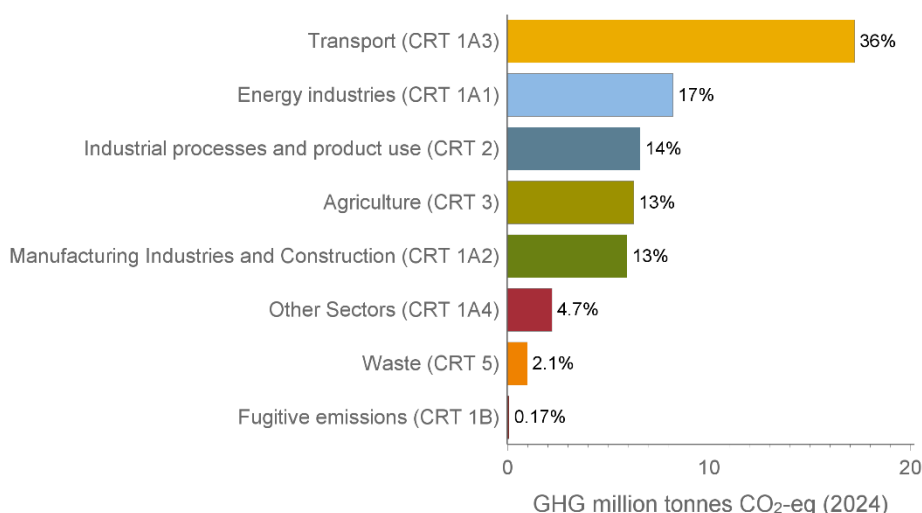


Figure 2.2. Greenhouse gas emissions by sector, 2024.

The historical trends (1990-2024) of the largest emission categories are shown in Figure 2.3.

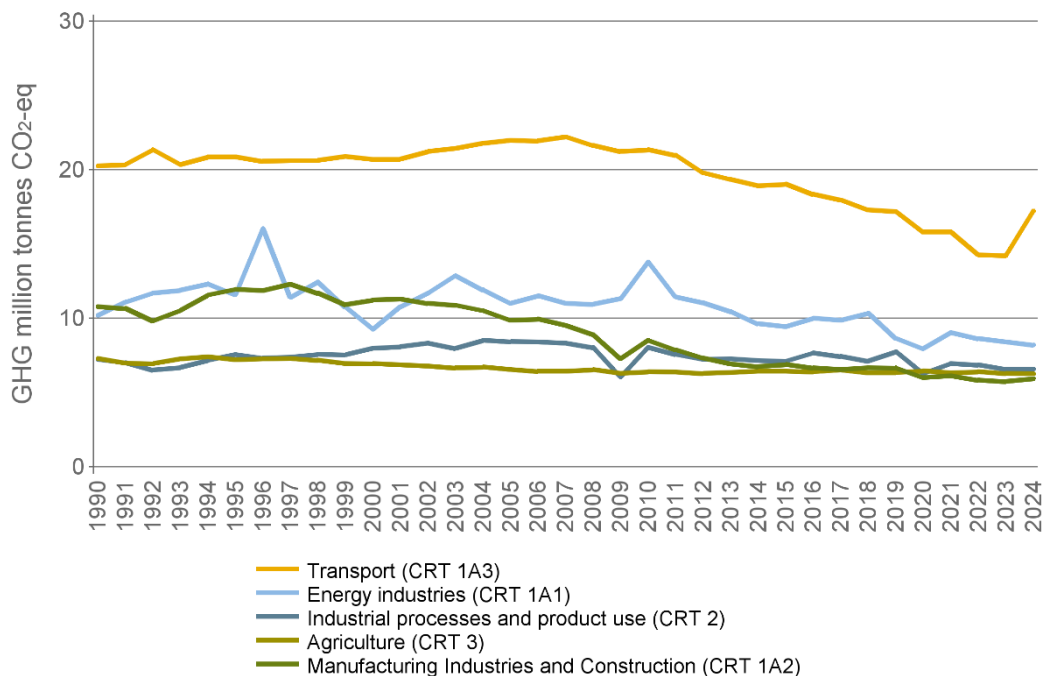


Figure 2.3. Total emissions of all greenhouse gases calculated as CO₂-eq. for transport (1A3), energy industries (CRT 1A1), industrial processes and product use (CRT 2), agriculture (CRT 3) and manufacturing industries and construction (CRT 1A2), 1990-2024.

Emissions from transport (CRT 1.A.3) are dominated by road transport. The emissions were lower in 2024 than in 1990. The decrease over the years is due to more energy efficient cars and an increased use of biofuels and in later years due to increased electrification. The impact of these measures on emissions reductions have been suppressed by an increased trend in the amount of traffic. Between 2023 and 2024 the emissions increased with about 3 Mton CO₂-eq. The main reason for the increase is the lowering of the reduction obligation for biofuels from 30.5 percent to 6 for diesel and from 7.8 to 6 percent for petrol. This led to substantial increase in use of fossil fuels in 2024, mainly in the road transport sector. At the same time this in combination led to considerably lower prices of fuels, especially diesel.

Emissions from energy industries (CRT 1.A.1) primarily come from the production of electricity and heat. The fluctuations in emissions between different years are large, due to the weather conditions' influence on the need for heating. Emissions from manufacturing industries and construction have decreased since the late 90's. They depend on the economic development but there is also a long-term decrease as a result of a switch from oil to biomass, especially in the pulp and paper industry. Between 2023 and 2024 emissions from energy industries were reduced with 0.2 Mton CO₂-eq mainly due to decreased combustion of residual gases, produced as by-products in iron and steel production processes.

Emissions from IPPU (Industrial Processes and Product Use, CRT 2) consist of emissions from industrial processes as well as emissions from product use, mainly fluorinated greenhouse gases in, for example, cooling systems. Emissions from IPPU emanate from industrial processes which fluctuate with the level of production. The chemical industry has decreased its emissions due to enhanced production technologies. Between 2023 and 2024 there was little change in emissions with a marginal increase of about 0.1% (0.005 Mton CO₂-eq.)

Emissions from agriculture (CRT 3) have decreased slightly since 1990 mainly due to increased efficiency and a decrease in livestock numbers and to a lower extent also due to reduced amounts of fertilizers used. The last decade, however, emissions from agriculture have remained rather constant. Between 2023 and 2024 the emissions from this sector decreased marginally with about 0.4% (0.03 Mton CO₂-eq). Emissions from livestock farming decreased slightly due to lower numbers of cattle and sheep, while emissions of nitrous oxide from agricultural land were slightly higher. The latter was due to higher harvests, which resulted in higher amounts of crop residues in the fields, compared to the year before with poor harvest results.

2.2 Description and interpretation of emission trends by gas

In 2024, emissions of carbon dioxide (CO₂) amounted to 38.8 Mt in total, which is equivalent to about 82% of total greenhouse gas emissions (excl. LULUCF), see Figure 2.4. Methane (CH₄) accounted for 4.5 Mt of CO₂-eq. (about 10%), nitrous oxide (N₂O) accounted for 3.4 Mt (about 7%), fluorinated greenhouse gases 0.8 Mt (about 2% of total emissions). The shares of the different greenhouse gases have remained relatively stable over the period 1990 to 2024.

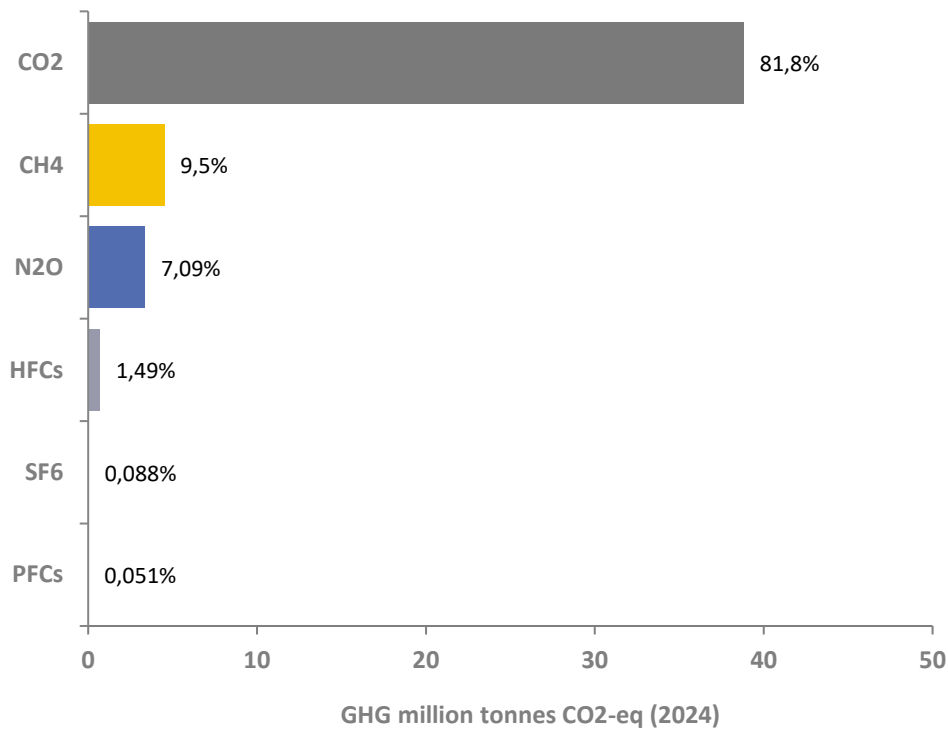


Figure 2.4. Share of greenhouse gases of total emissions in CO₂-eq, in 2024.

2.2.1 Carbon dioxide (CO₂)

In 2024, the carbon dioxide (CO₂) emissions in Sweden amounted to 38.8 Mt in total, excluding LULUCF (Figure 2.5). The main source for emissions of carbon dioxide is the combustion of fossil fuels, which mainly takes place in the energy sector (CRT 1). Another important source is the raw material used in the industry processes. Emissions of carbon dioxide were 32% lower in 2024 than in 1990.

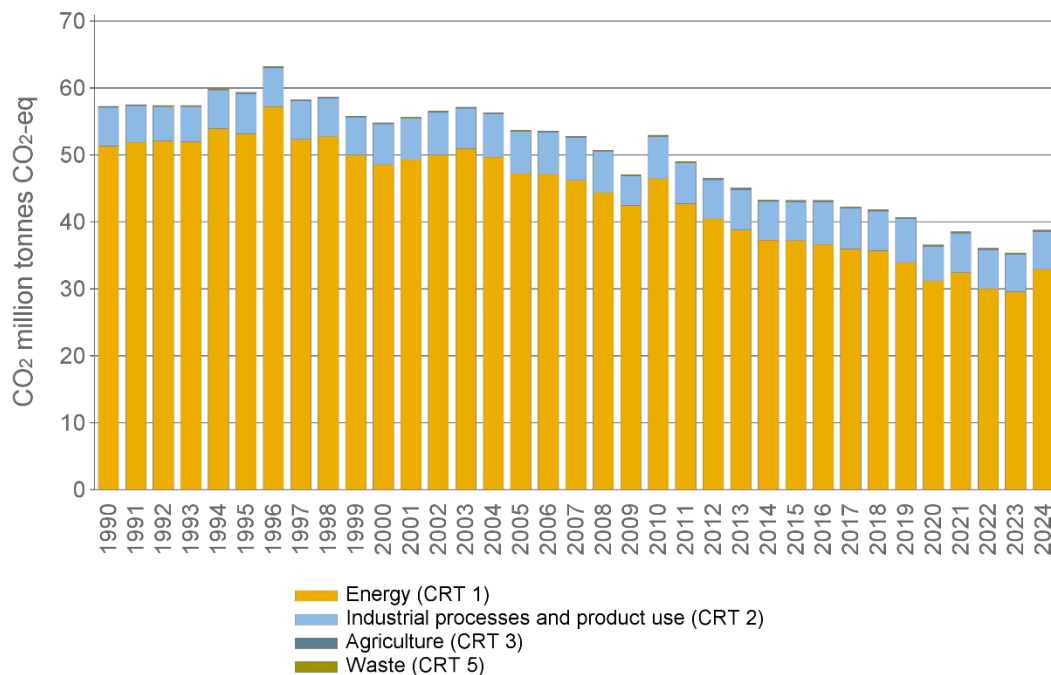


Figure 2.5. Total emissions of carbon dioxide 1990-2024 (excluding LULUCF).

2.2.2 Methane (CH₄)

The total emissions of methane (CH₄), excluding emissions from LULUCF, were 4.5 Mt CO₂-eq. in 2024, see Figure 2.6. The main sources of methane are agriculture (CRT 3) (80%), the waste sector (CRT 5) (15%) and the combustion of fossil fuels in the energy sector (CRT 1) (6%). Emissions of methane have decreased by 48% since 1990. The main reason for the decrease is mitigation measures undertaken in the waste sector, for example reduced deposition of organic waste in landfills and collection of landfill gas for combustion. The waste sector has decreased its emissions of methane by 84% between 1990 and 2024, while emissions in the agricultural sector dropped by 9% during the same period.

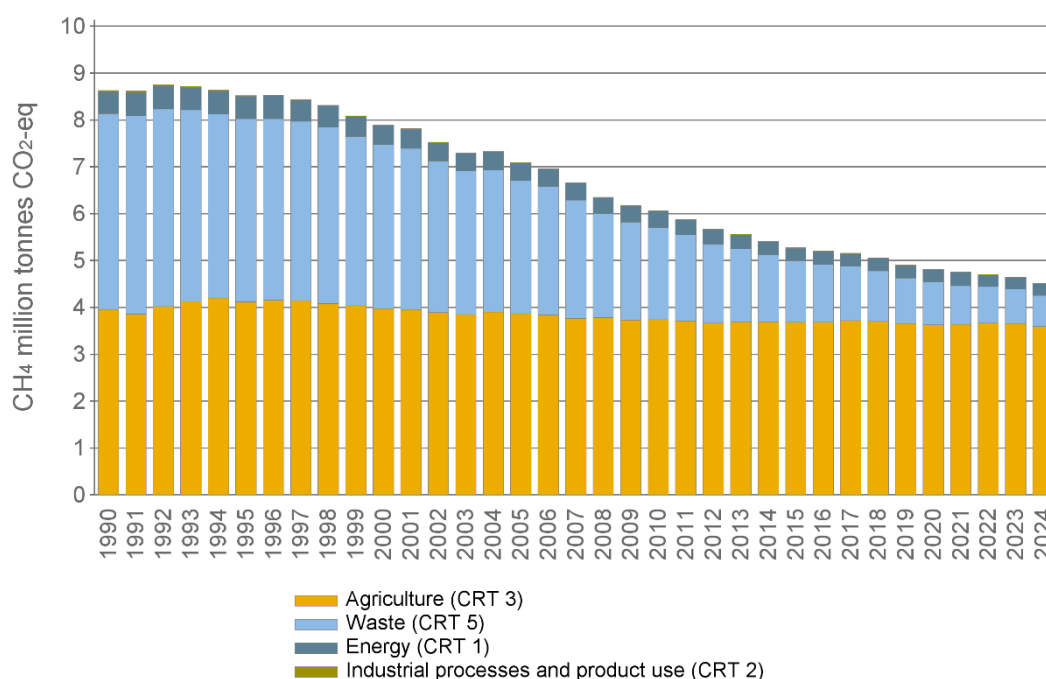


Figure 2.6. Total emissions of methane (CH₄) by sectors 1990-2024 (excluding LULUCF).

2.2.3 Nitrous oxide (N₂O)

In 2024, emissions of nitrous oxide (N₂O) amounted to 3.4 Mt CO₂-eq. (excl. LULUCF), see Figure 2.7. Compared to 1990, the overall emissions of N₂O have decreased by 28%. The main source of nitrous oxide emissions is the agricultural sector (CRT 3), which accounted for 75% of the emissions in 2024. Other emissions arise from the energy sector (CRT 1, 14%), industrial processes and product use (CRT 2) and the waste sector (CRT 5). The industrial processes and product use sector accounts for the largest part of the decrease in emissions of nitrous oxide and has dropped by approximately 83% since 1990. Emissions in the agricultural sector dropped by 20% during the same period.

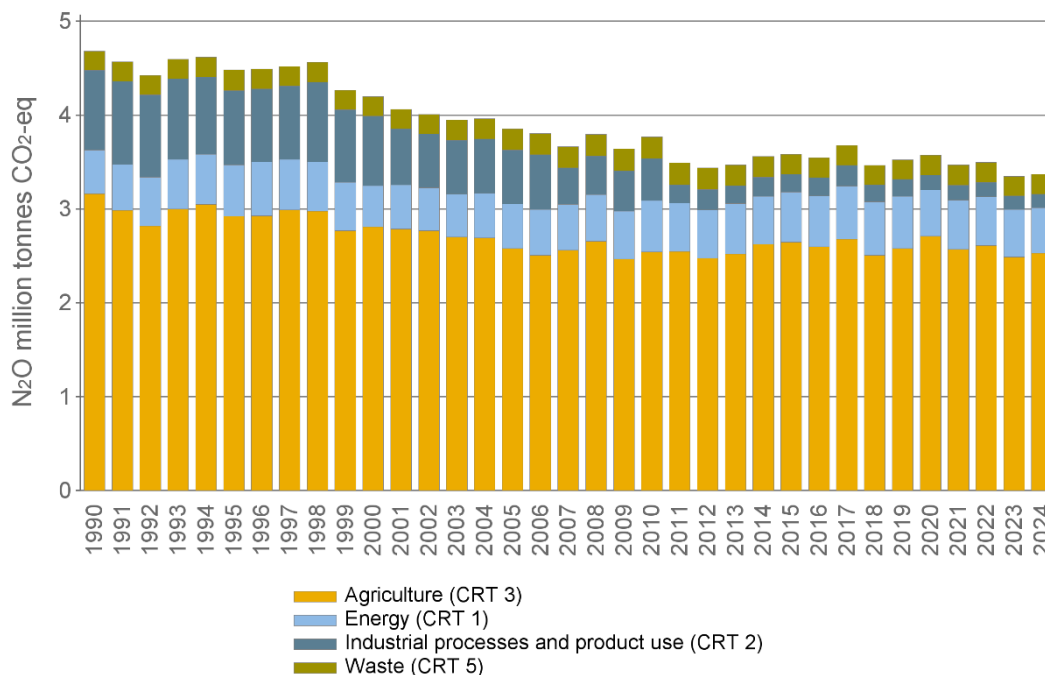


Figure 2.7. Total emissions of nitrous oxide (N₂O) by sectors 1990-2024 (excluding LULUCF).

2.2.4 Fluorinated greenhouse gases

The emissions of fluorinated greenhouse gases come mainly from their use in various applications, but also from emissions of perfluorocarbons (PFC) from primary aluminium production processes. Emissions of fluorinated greenhouse gases are only reported in the industrial processes and product use sector (CRT 2).

Total emissions of fluorinated greenhouse gases in 2024 amounted to 0.8 Mt CO₂-eq, see Figure 2.8, and accounted for about 2% of total greenhouse gas emissions. There has been a large increase in emissions since 1990, from around 0.6 Mt of CO₂-eq. in 1990 to almost 1.6 Mt in 2007, but since then the emissions have decreased. The overall increase is mainly due to increased emissions of HFCs, which accounted for 91% of the total fluorinated greenhouse gases in 2024.

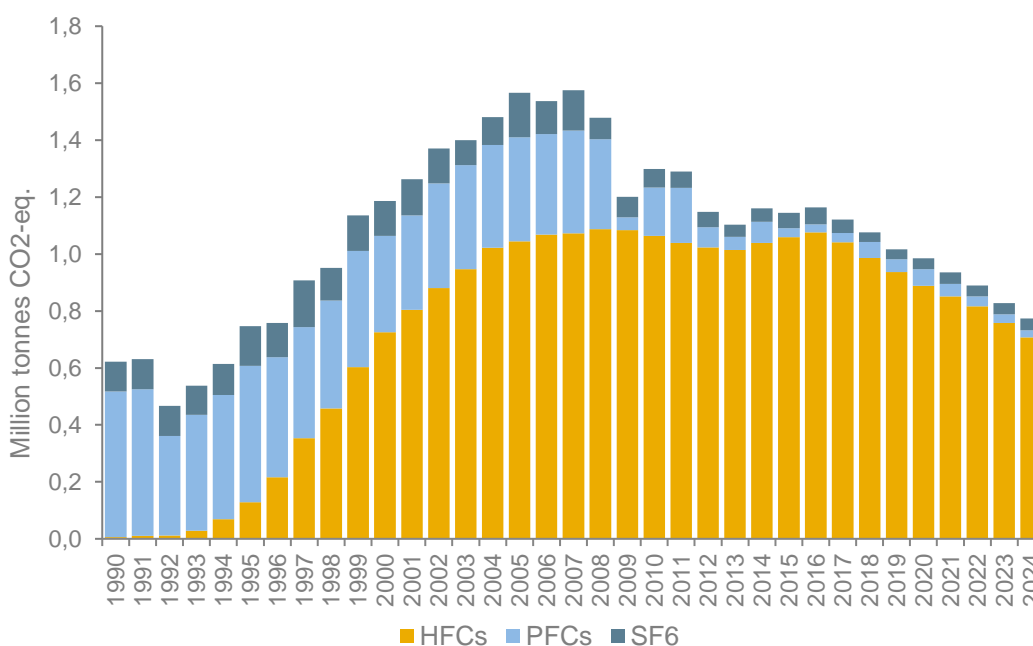


Figure 2.8. Total emissions of HFC, PFCs and SF₆, 1990-2024 (excluding LULUCF).

The emissions of HFCs increased by 1.1 Mt of CO₂-eq. between 1990 and 2009, mostly as a result of the use of HFCs as refrigerants in refrigerators, freezers and air-conditioning equipment in later years. Since 2009, the trend is showing a stabilisation and in recent years a decrease in emissions. Emissions dropped by about 6% between 2023 and 2024.

PFCs emissions, on the other hand, have decreased by 95% during the period 1990 to 2024. Emissions of SF₆ decreased by 60% between 1990 and 2024. However, there are inter-annual fluctuations throughout the period.

2.3 Emissions by CRT sector

2.3.1 Energy (CRT sector 1)

The majority of the emissions in the Energy sector arise from transports, electricity and heat production and combustion in manufacturing industries and construction. Since 1990 there has been a decrease in total emissions by 36%. The main reason is due to decreased emissions from the residential and commercial/institutional sectors due to the replacement of combustion of fossil fuels for heating with district heating and electricity, including heat pumps. Emissions in the manufacturing industries and construction have decreased with more than one third compared to 1990 due to a reduction in the use of fossil fuels, mainly as a result of a shift to biofuels and electricity. Moreover, electricity and heat production are increasingly based on renewable energy so although the use of district heating has increased, emissions have decreased. In long term perspective the emissions from the transport sector have decreased, mainly due to the use of more energy efficient cars and increased use of biofuel. However, in 2024 the emissions from transports increased due to less usage of biofuels in gasoline and diesel. For the same reason there was an increase in emissions from off-road vehicles and other machinery in 2024, which resulted in increased emissions from Other Sectors.

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

The lion's share of emissions come from transports (CRT 1A3), followed by energy industries (CRT 1A1) and combustion in manufacturing industries and construction (CRT 1A2), see Figure 2.9. The production of electricity and heat are important subsectors within the energy industries sector (CRT 1A1), as are heating in the residential and commercial/institutional sectors in "Other sectors" (CRT 1A4).

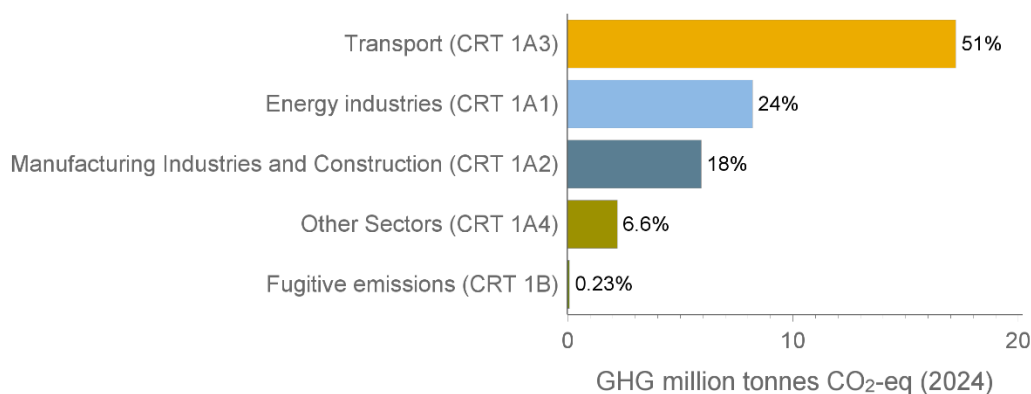


Figure 2.9. Share of emissions within the Energy sector, by subsector in 2024.

Total emissions in the energy sector have decreased over the period 1990-2023, from 52.3 to 33.7 Mt CO₂-eq (Figure 2.10). This is a decrease with 36% which mainly depends on a decreased use of fossil fuels in residential and commercial/institutional, included in “Other Sectors” (CRT 1A4) and manufacturing industries and construction (CRT 1A2). Transport (1A3) increased emissions in 2024, but in the long term there has been a decrease. Between 2023 and 2024 there was 11% increase in emissions within the energy sector, mostly because of an increase in emissions from transport.

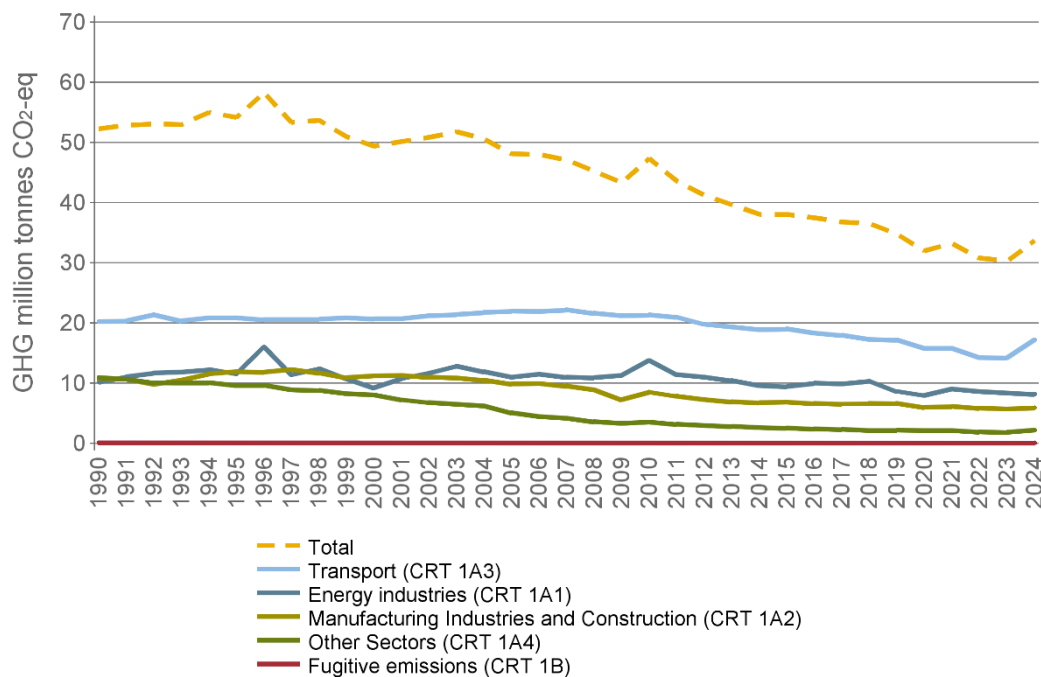


Figure 2.10. Emissions from the Energy sector, total and by subsector, in 2024.

2.3.1.1 ENERGY INDUSTRIES (CRT 1A1)

Energy industries are dominated by the electricity and heat production with by far the largest part of the emissions and also the only subsector where emissions fluctuate over the years. The fluctuations between different years are large, due to the weather conditions’ influence on electricity and heat production (CRT 1A1a). In 2024, there was a decrease in emissions from the energy industries with almost 3% compared to 2023. Total emissions from energy industries (CRT 1A1) were 8.2 Mt CO₂-eq. in 2024 (Figure 2.11), which is 19% lower than in 1990.

Sweden’s electricity and heat production is largely composed by renewable energy and district heating is mainly based on biofuels and waste. Therefore, these emissions are 34% lower than in 1990, even though the supply of district heating has increased by around 40% in the same period. Electricity and heat production (CRT 1A1a) account for the larger part of the emissions with 63% (5.2 Mt) in 2024. Emissions from Refineries (1A1b) amounted to 2.7 Mt in 2024 and Manufacture of solid fuels (CRT 1A1c) amounted to 0.4 Mt.

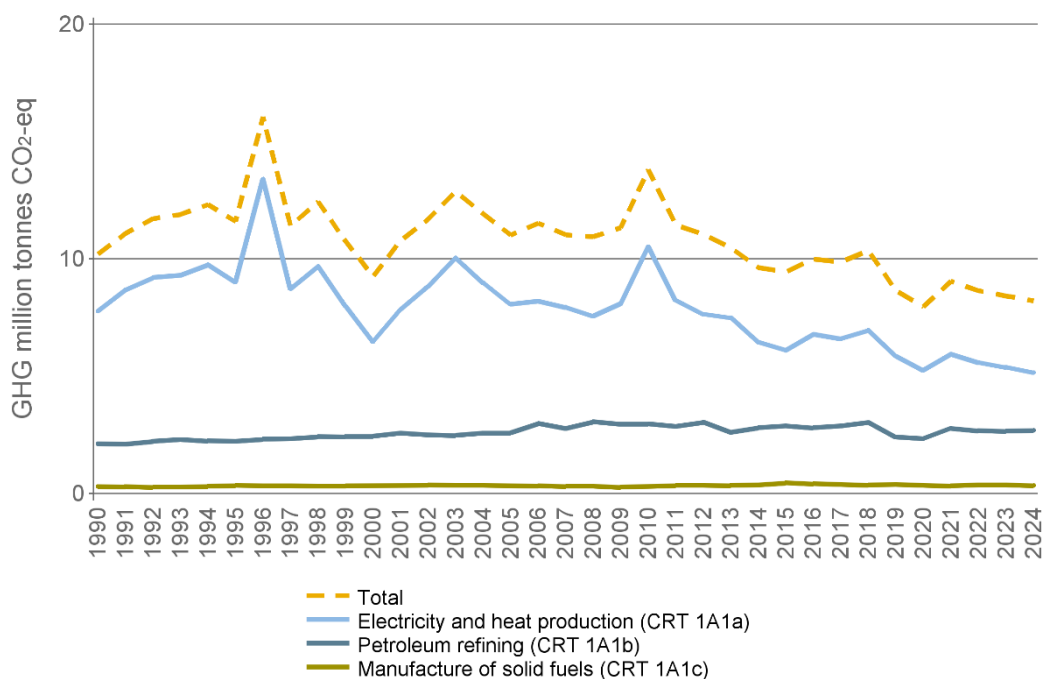


Figure 2.11. Emissions from Energy industries by subsector and total, 1990-2024.

2.3.1.1.1 Electricity and heat production (CRT1A1a)

Emissions from production of electricity and heat production totaled 5.2 Mt of CO₂-eq. in 2024. The emissions from electricity and heat production vary over time but have been reduced by 34% between 1990 and 2024. There is a decrease in emissions in 2024 of 4% compared to 2023 mainly due to decreased combustion of residual gases, produced as by-products in iron and steel production processes.

The main reason behind the variations between years is the weather conditions' impact on the demand for electricity and heat. Sweden's electricity and heat production are based largely on hydropower, nuclear power and biofuels. Fossil fuels serve as a complement, especially by cold weather. Temperature and precipitation conditions, which vary between years, have an impact on hydropower production and heating needs, which leads to a variation in emissions between years. This is illustrated by the high emissions in 1996, which was a cold and dry year, and by the low emissions in 2000, which was a warm year with heavy precipitation and thus good availability of hydropower. Also 2010 was a very cold year, with increased emissions as a result. However, in the latest years electricity prices and fuel prices also contributed to yearly fluctuations.

In years with low hydropower production, the emissions depend on the kind of electricity production that offsets the hydropower shortage. As an example, the emissions were much lower in 2003 when the deficient production of hydropower primarily was offset by imports of electricity, compared to 1996 when the shortage of hydropower to a larger extent was offset by increased oil-fuelled condensing power production.

Emissions in this sector are also affected by iron and steel production as residual gases from the iron and steel industry are used to produce electricity and district heating, and these emissions have increased compared to 1990.

The production of district heating generates the largest greenhouse gas emissions in this sector. Since 1990 the supply of district heating has increased by around 40%. Even so, the emissions have decreased as the expansion has principally taken place through increased use of biomass fuels at the same time as the use of coal and oil has decreased. The transition to waste fuels have also led to a decrease in emissions, however now the majority of the emissions in the sector come from waste. It is mostly waste from fossil plastic that contributes to the emissions from waste incineration.

2.3.1.1.2 Refineries (CRT 1A1b)

Emissions from refineries amounted to 2.7 Mt CO₂-eq. in 2024.

The emissions mainly originate from refinery gas, which is a by-product in the refining process. The use has increased since the 1990's due to higher demand of refined products, but emissions have in recent years been quite stable. Emissions in 2020 were unusually low, mainly due to low demand and reduced production due the restrictions from covid-19-pandemic. In 2014 the emissions for gaseous fuels increased. This was due to the combustion of liquified natural gas implemented in one of the refineries.

2.3.1.1.3 Manufacturing of solid fuels (CRT 1A1c)

Emissions from manufacture of solid fuels (CRT 1A1c) amounted to 0.4 Mt CO₂-eq. in 2024. Emissions from manufacturing of solids (1A1c) have increased since 1990, by 18%. Compared to 2023 emissions decreased by 5% in 2024. Emissions in this category emerge from the production of coke to be used in blast furnaces for production of iron. The trend for emissions therefore follows a similar pattern as emissions from iron and steel production industry.

2.3.1.2 MANUFACTURING INDUSTRIES AND CONSTRUCTION (CRT 1A2)

The mining, iron and steel as well as pulp and paper industries are examples of historically important industries for Sweden. Emissions from combustion in manufacturing industries and construction were 5.9 Mt CO₂-eq. in 2024 (Figure 2.12). Emissions in 2024 were 45% lower than in 1990. Emissions in 2024 increased by 3% compared to 2023. Although increasing slightly up until 1997, the emissions have a steady decreasing trend until 2014. The lower emissions in 2009 and higher emissions in 2010 were due to the financial crisis impact on production levels and their subsequent recovery. The decreasing trend is primarily related to a lower use of oil. Oil has been replaced by electricity or biofuels, partly depending on the difference in relative prices between electricity and oil.

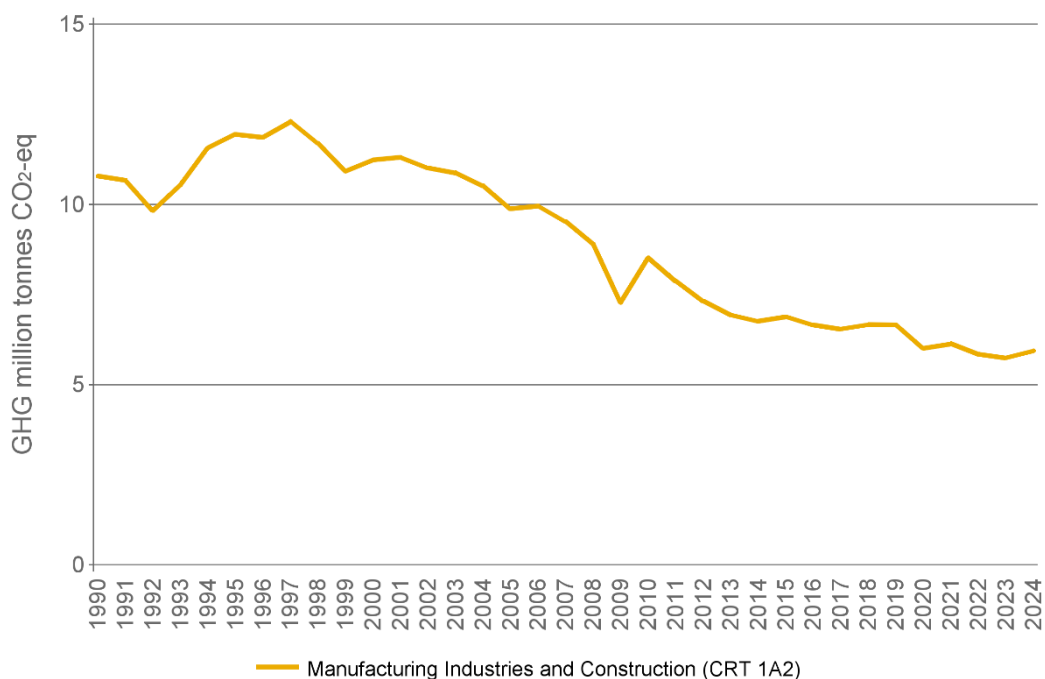


Figure 2.12. Total emissions from manufacturing industries and construction (CRT 1.A.2), 1990-2024.

A small number of energy-intensive industries account for a large share in the sector’s greenhouse gas emissions. The off-road vehicles and other machinery (CRT 1A2g (vii)), iron and steel industry (CRT 1A2a) and the non-metallic minerals industry (CRT 1A2f) account for 27%, 17% and 15% respectively of the emissions in 2024 (Figure 2.13).

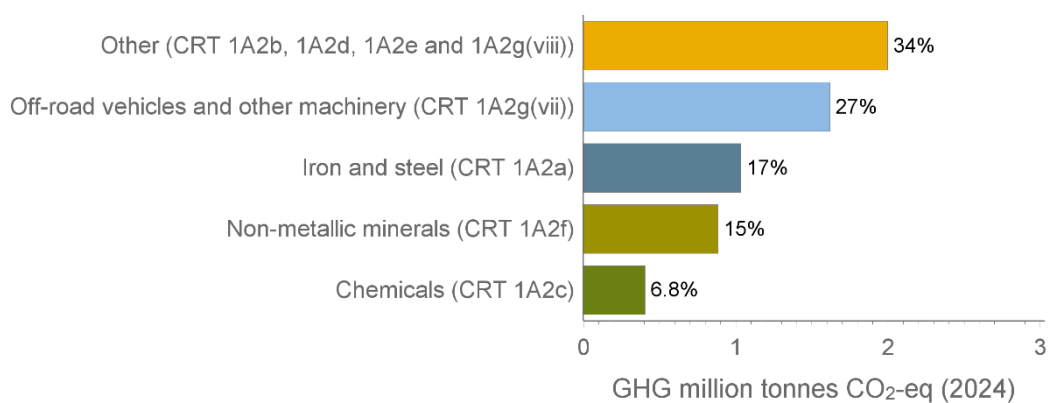


Figure 2.13. Emissions from the Energy sector; Manufacturing industries and construction in year 2024.

Other manufacturing industries, including non-metallic minerals (CRT 1A2f), paper, pulp and print (CRT 1A2d), food processing, beverages and tobacco (CRT 1A2e), and stationary combustion in other industries (CRT 1A2g(viii)), show overall decreasing emissions between 1997 and 2015 (Figure 2.14).

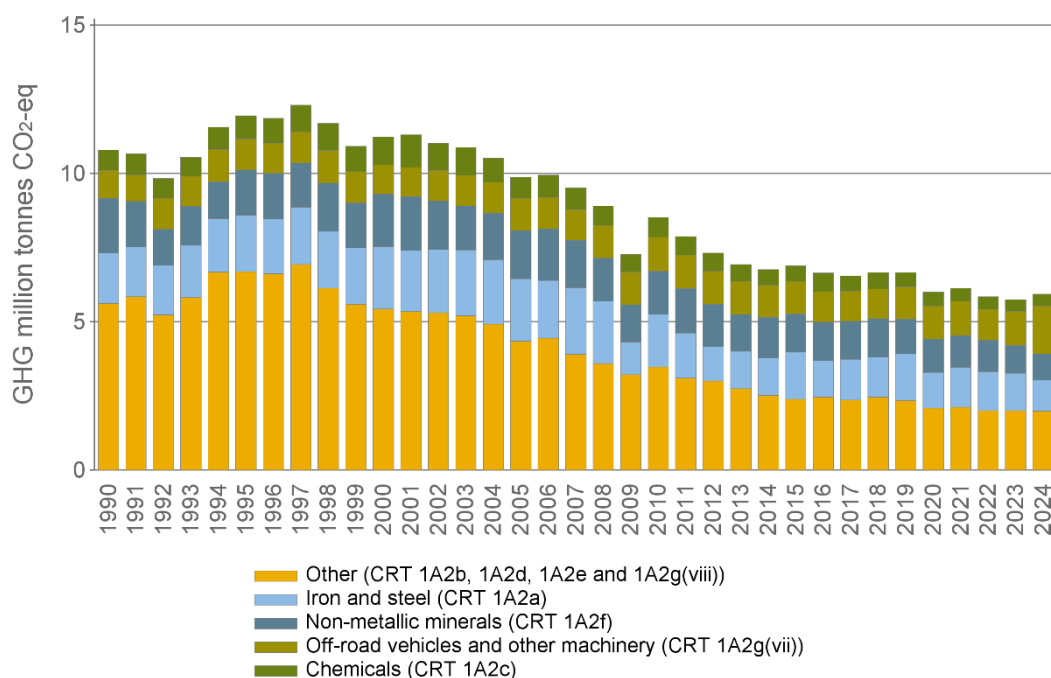


Figure 2.14. Emissions from combustion in manufacturing industries by subsector, 1990-2024.

The emission level of non-metallic minerals (CRT 1A2f) is significantly lower in 2023 than in 1990 due to high emissions from use of coal in 1990-1991.

The decreasing emissions shown for the iron and steel industry (CRT 1A2a) are strongly linked to production levels in response to market fluctuations. The financial crisis of 2009 had a severe impact on the industry's production level¹⁷ as well as the covid-19-pandemic during 2020. It should also be noted that the significant amount of emissions from the combustion of energy gases, produced as by-products in iron and steel production processes is sold to electricity and heat producers are reported in 1A1a, see further discussion in section 3.2.9.

Emissions from chemicals (CRT 1A2c) and non-ferrous minerals (CRT 1A2b) have yearly variations in response to market fluctuations but the long-term trends have remained relatively stable since 1990.

2.3.1.3 TRANSPORT (CRT 1.A.3)

Most of the emissions in this subsector come from road traffic, mainly from cars and heavy-duty vehicles. The emissions from cars decreased between 2009 and 2023, with the exception of a slight increase between 2014 and 2015. The decrease in emissions during

¹⁷ Jernkontoret, 2015

this period was largely due to increased use of biofuels and increased energy efficiency and in later years due to increased electrification of the fleet. In 2024 there was an increase in emissions due to reduced requirements to blend in biofuel in the reduction obligation. For diesel the reduction obligation was reduced from 30.5 to 6 percent and for petrol from 7.8 to 6 percent.

Emissions from transport include emissions from domestic aviation (CRT 1A3a), road transport (CRT 1A3b), railways (CRT 1A3c), national navigation (CRT 1A3d) and other working machinery and off-road equipment (CRT 1A3e). The sub-sectors' shares of the total emissions of the sector are shown in Figure 2.15. In 2024, the greenhouse gas emissions from road transport were 15.9 Mt, 0.3 Mt from domestic aviation, 0.7 Mt from domestic navigation and 0.4 Mt from working machinery. Emissions from railways were less than one tenth Mt in 2024.

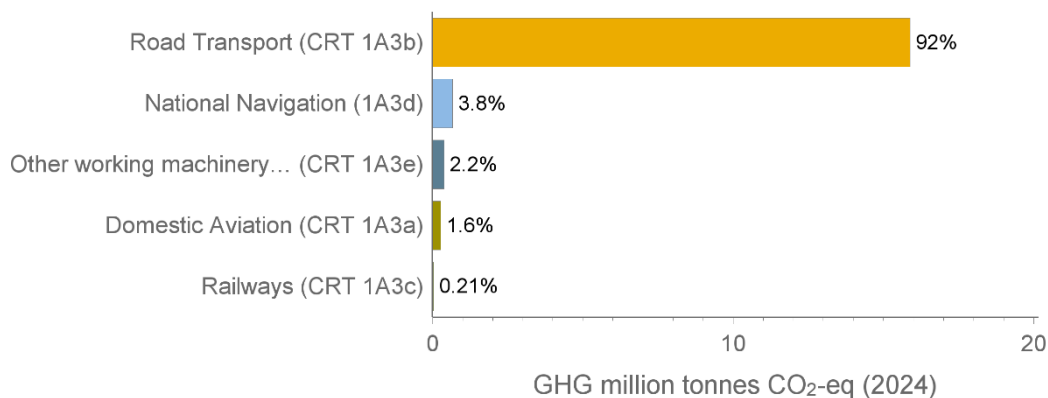


Figure 2.15. Share of emissions from sub sectors in the transport sector 2024.

Carbon dioxide accounts for the largest share of greenhouse gas emissions from the transport sector. Methane emissions were 0.05 Mt CO₂-eq. in 2024 and have fallen 71% since 1990 as a result of better exhaust emissions control. Nitrous oxide emissions totalled 0.2 Mt of CO₂-eq. in 2024. From 1990 to 1995 there was a general increase in emissions of nitrous oxide due to the increased use of cars fitted with catalytic converters. Emissions decreased during the early 2000s following the introduction of enhanced exhaust treatment technology but started to increase again from 2007 and onwards due to an increased number of diesel cars. The increasing trend levelled off in 2019.

2.3.1.3.1 Road transport

Emissions from road transport includes emissions from passenger cars (CRT 1A3b i), light duty vehicles (CRT 1A3b ii), heavy goods vehicles (1A3b iii), buses (CRT 1A3b iii) and mopeds and motorcycles (CRT 1A3b iv). The emissions in 2024 and the share of the

emissions from road traffic are shown in Figure 2.16. Emissions from road transport by sub-sector are shown in Figure 2.17.

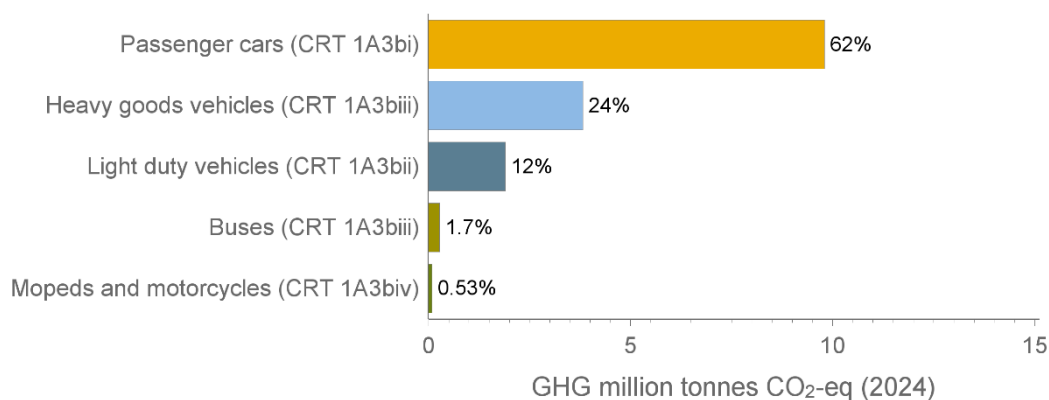


Figure 2.16. Share of emissions from subsectors of road transport in 2024.

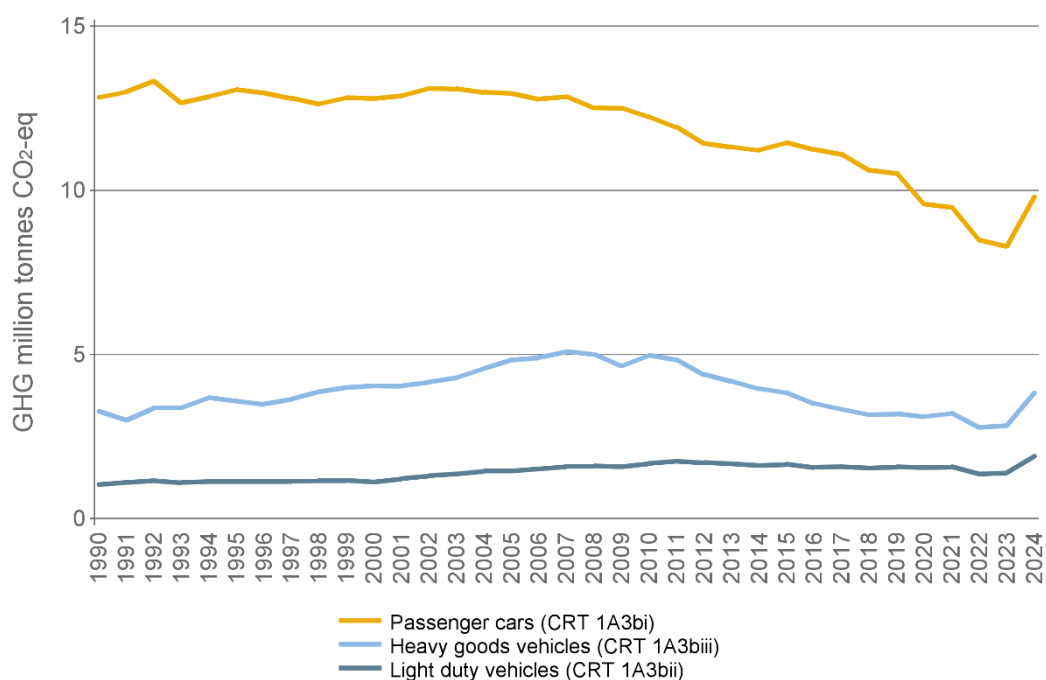


Figure 2.17. Emissions from road traffic by sub-sector, 1990-2024.

Emissions from passenger cars were 9.8 Mt CO₂-eq. in 2024, which is 24% lower than in 1990. Emissions from passenger cars were on a relatively constant level until 2007 when they started to decrease. Besides a slight increase between 2014 and 2015 the emissions

have decreased since 2009. Until 2007 the growth in transport activity was offset by a greater use of renewable fuels, more energy efficient vehicles and reduced fuel consumption which kept the level of emissions constant. The decrease in emissions after 2007 is much due to increased use of renewable fuels and more energy efficient vehicles and in later years due to increased electrification of the fleet. In 2024 there was a large increase in emissions due to reduced requirements to blend in biofuel in the reduction obligation. For diesel the reduction obligation was reduced from 30.5 to 6 percent and for petrol from 7.8 to 6 percent.

Emissions from heavy duty vehicles were 3.8 Mt CO₂-eq. in 2024. Emissions from heavy duty vehicles follow the fluctuations of economic activity. They increased, in general, from the mid-1990s to 2008 and subsequently started to decrease. Since 2011 emissions have declined due to more efficient vehicles and a larger share of renewable fuels. In 2024 the emissions increased by 35%, following the road transportation trend.

The switch from petrol-powered to diesel-powered cars is leading to a more energy efficient car fleet, which since the mid-2000s has been reinforced by a general improvement in energy efficiency for new cars. The average carbon dioxide emissions per km for new cars decreased since early 2000, with the largest reduction between 2005 and 2012. From 2012 and onwards the energy efficiency rate has levelled off due to the increased share of four-wheel drive vehicles among new cars.¹⁸ In recent years the average carbon emissions from new cars have decreased due to the increased number of sold electric vehicles.

There are several policy measures contributing to the trend for emissions from passenger cars: the EU-requirements limiting the carbon dioxide emissions from new cars, increased fuel taxes, tax exemption for transport biofuels, carbon dioxide-based vehicle tax, tax relief for green cars and green car rebates, together with rising market price for petrol and diesel. Large-scale blending of ethanol into petrol began in 2003, with the result that almost all petrol sold in Sweden now contains 5% ethanol. Blending of biodiesel, such as FAME and HVO, into diesel has also increased considerably during recent years. This trend was broken in 2024 when there was reduced requirements to blend in biofuel in the reduction obligation. For diesel the reduction obligation was reduced from 30.5 to 6 percent and for petrol from 7.8 to 6 percent. High-blended biofuels with lower levels of fossil fuels are still exempted from energy tax and carbon dioxide tax.

2.3.1.3.2 *Domestic aviation, national navigation and railways*

In 2024, emissions from domestic aviation totalled 0.3 Mt of CO₂-eq, see Figure 2.20, which is 61% lower than the level in 1990. Emissions have varied since 1990. The large increase in emissions from domestic aviation between 2021-2023 was a rebound effect after the large decrease during the covid-19-pandemic. In 2024 a decrease of emissions from domestic aviation have been observed.

Emissions from national navigation were 0.7 Mt of CO₂-eq. in 2024, see Figure 2.20. This is 43% higher than in 1990 and 5% lower than in 2023, emissions have varied since 1990 but with an increasing trend.

¹⁸ Swedish Transport Administration, 2015

¹⁸ Trafikverket, 2018

Sweden's railways are largely electrified, with only a few smaller lines served by diesel-hauled trains. Emissions from rail transport have been more than halved since 1990 and were 40 kt of CO₂-eq. (Figure 2.18) in 2024.

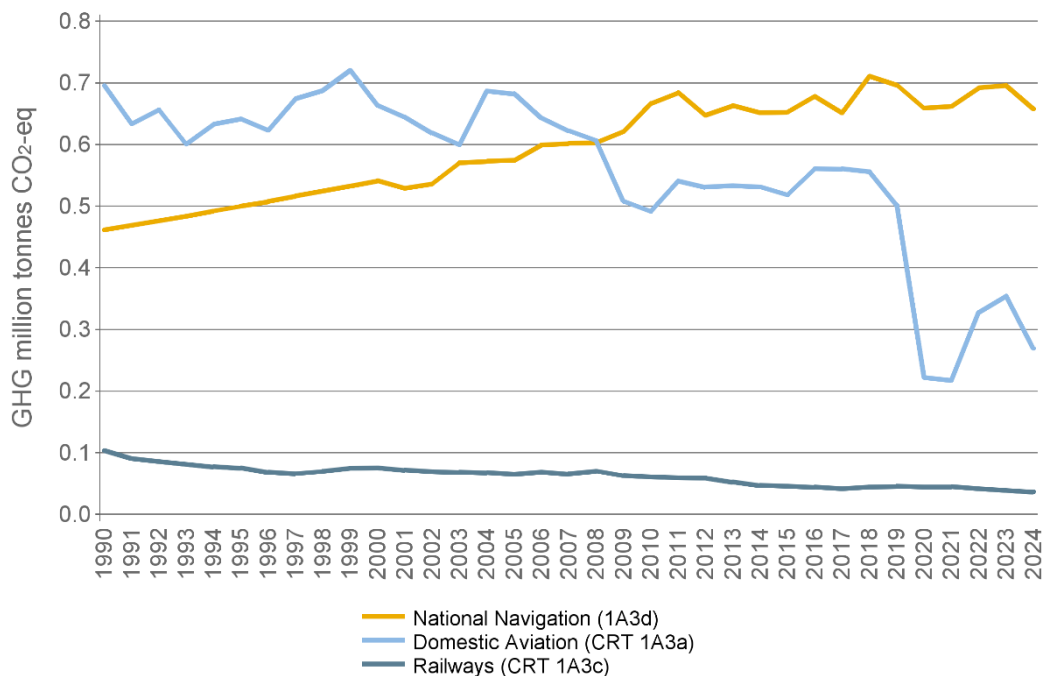


Figure 2.18. Emissions of greenhouse gas in CO₂ eq. from aviation, navigation and railways, 1990-2024.

2.3.1.4 OTHER SECTORS (CRT1A4)

In other sectors, emissions have decreased by 80% during 1990-2024 mainly due to a strong decrease in combustion of fossil fuels for heating in the residential and commercial/institutional sectors. Fossil fuels have been replaced by district heating, some biomass, and electricity, including increased usage of heat pumps in recent years. Since emissions from stationary combustion for heating purposes has decreased significantly, the main emissions within the sector now come from working machinery and off-road vehicles. For stationary combustion the activity data for 2023 is used for 2024, since updated data is not available in time. Emissions increased with 20% between 2023 and 2024 due to increased emissions from off-road vehicles and other machinery.

Combustion for heating purposes within the residential (CRT 1A4b), commercial/institutional (CRT 1A4a) and agriculture, forestry and fisheries sectors (CRT 1A4c) are included. Emissions from stationary combustion and working machinery and off-road vehicles (mobile combustion) are also included for all subsectors. The highest emissions come from off-road vehicles and other machinery used in agriculture, forestry and fisheries, see Figure 2.19.

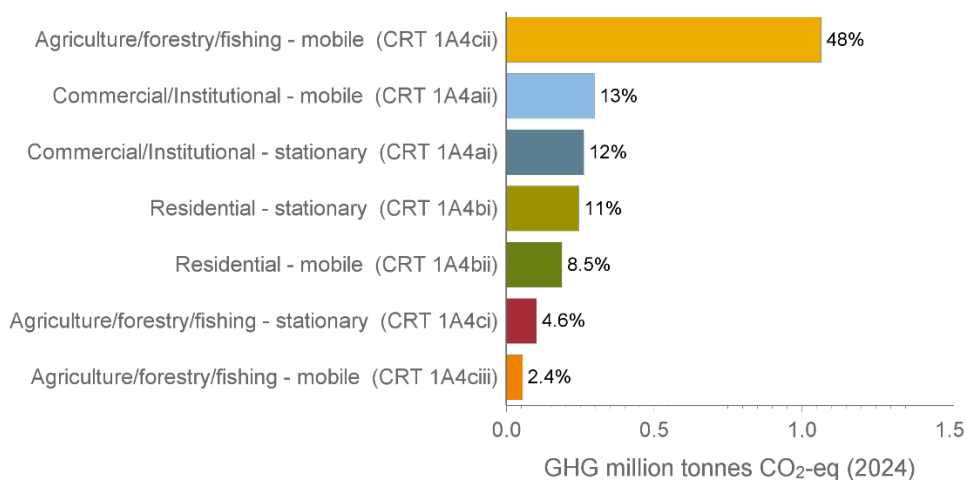


Figure 2.19. Share of emissions within Other sectors by subsector in 2024, with mobile and stationary combustion shown separately for each subsector.

Emissions in Other sectors were approximately 2.2 Mt of CO₂-eq. in 2024. The reduction is due to a strong decrease in emissions in the commercial/institutional and residential (CRT 1A4a and 1A4b) sectors between 1990 and 2024 (Figure 2.20) of 80% and 93%, respectively. In comparison with 2023 the total emissions from the residential sector increased with almost 3%. Emissions from the commercial/institutional sector increased with 14% between 2023 and 2024. The emissions from agriculture, forestry and fisheries (CRT 1A4c) increased by 31% in 2024 and were 1.2 Mt CO₂-eq., which is 27% less than in 1990.

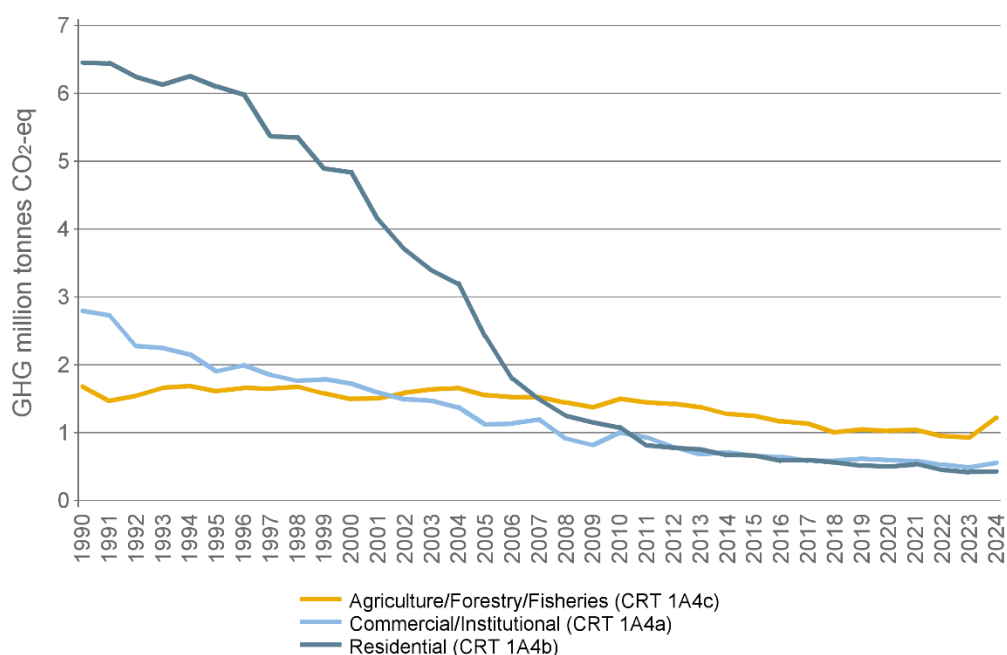


Figure 2.20. Emissions from Other sectors, total and by subsector, 1990-2024.

Distribution between stationary and mobile combustion sources, as well as total emissions, is shown in Figure 2.21 below.

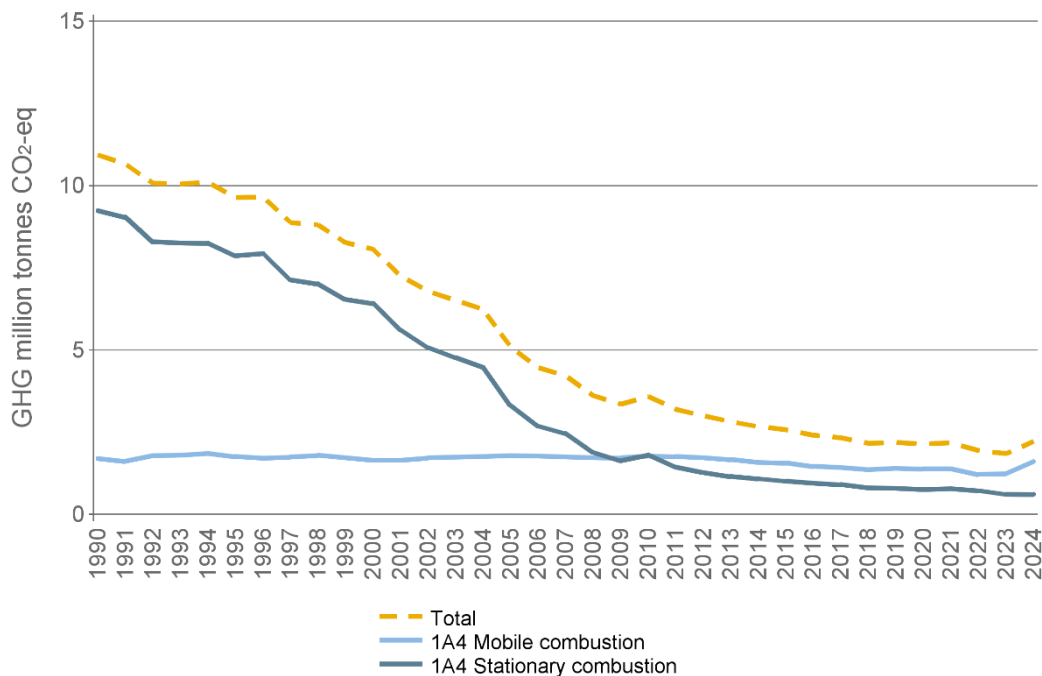


Figure 2.21. Emissions from mobile combustion, stationary combustion and emissions in total, 1990-2024.

Emissions from working machinery and off-road vehicles (mobile combustion) have decreased by 6% in total since 1990 (Figure 2.22). In 2024 there was a large increase in emissions compared to previous years (30%), this is mainly due to a lower use of biofuels compared to previous years. This is because of the Swedish reduction mandate for diesel was lowered during 2024 allowing for lower percentage of biofuel mixed into diesel. Emissions from the residential sector (CRT 1A4b) were 26% lower in 2024 compared to 1990 and were 0.19 Mt of CO₂-eq. in 2024. Emissions from mobile combustion in agriculture were 13% higher in 2024 compared to emission levels in 1990. Emissions from mobile combustion in forestry (1A4c) have varied over the years and were around 3% higher in 2024 compared to 1990. In the commercial/institutional sector (CRT 1A4a) emissions from mobile combustion have varied during the period and were 17% higher in 2024 compared to 1990. In fisheries (CRT 1A4c) the emissions have been declining during the past decades, following the trend with a shrinking fleet of fishing vessels in Sweden. Emissions from mobile combustion from fishing were 73% lower in 2024 compared to 1990. It should be noted that the emissions from working machinery and off-road vehicles are model-based and there is a high uncertainty connected to these emissions. The model is described in Annex 2.

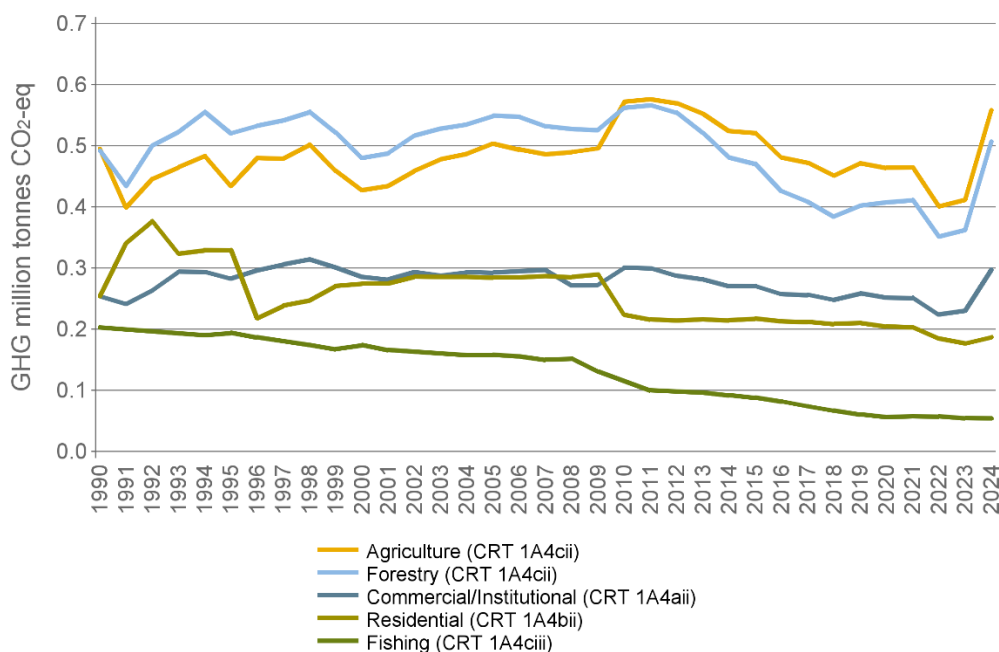


Figure 2.22. Emissions from off-road vehicles and other machinery in each subsector, 1990-2024.

In the residential sector (CRT 1A4b), the emissions from stationary combustion have decreased by 96% since 1990, and in the commercial/institutional sector (CRT 1A4a) emissions from stationary combustion have decreased by 90%. Emissions from stationary combustion in agriculture, forestry and fisheries (CRT 1A4c) are small and have decreased by 79% compared to 1990. Due to problems with available updated activity data for the last year for stationary combustion in this sector, the activity data for 2023 is used also for 2024. Emissions from stationary combustion within each subsector are shown in Figure 2.23.

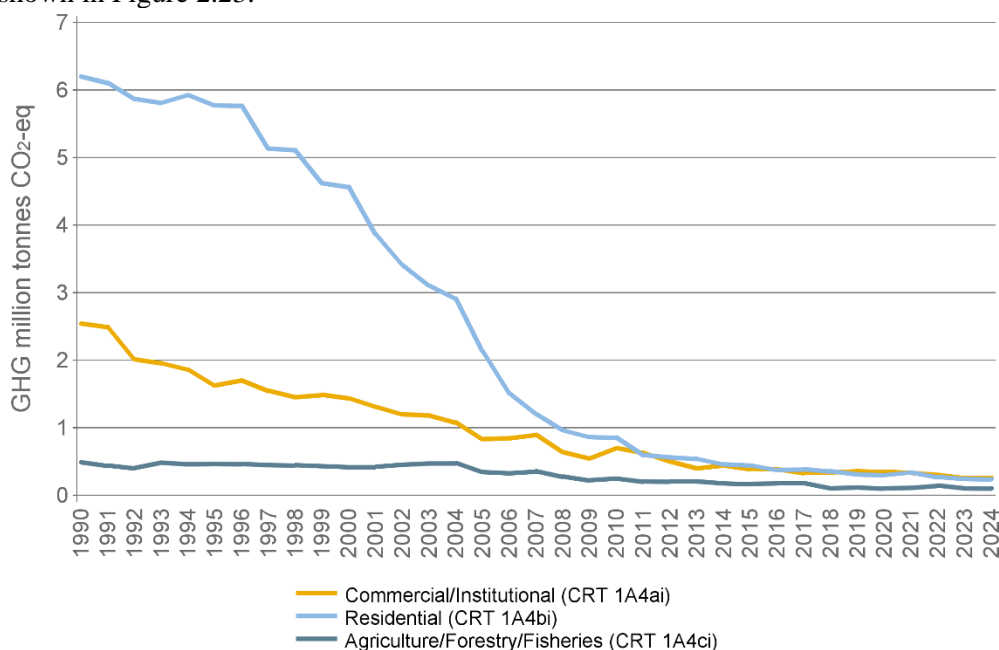


Figure 2.23. Emissions from stationary combustion in each subsector, 1990-2024.

The large reduction in emissions from stationary combustion in the residential and commercial/institutional sector depends on a large decrease in total use of fossil fuels since 1990, see Figure 2.24. There are several reasons for this development: the shift from oil to district heating and electric heating as well as increased usage of heat pumps. The most common source of heating in the residential sector is district heating followed by electric heating and these emissions are included in the electricity and heat production sector (section 2.3.1.1.1). Increased energy efficiency has also contributed to the decrease in emissions.

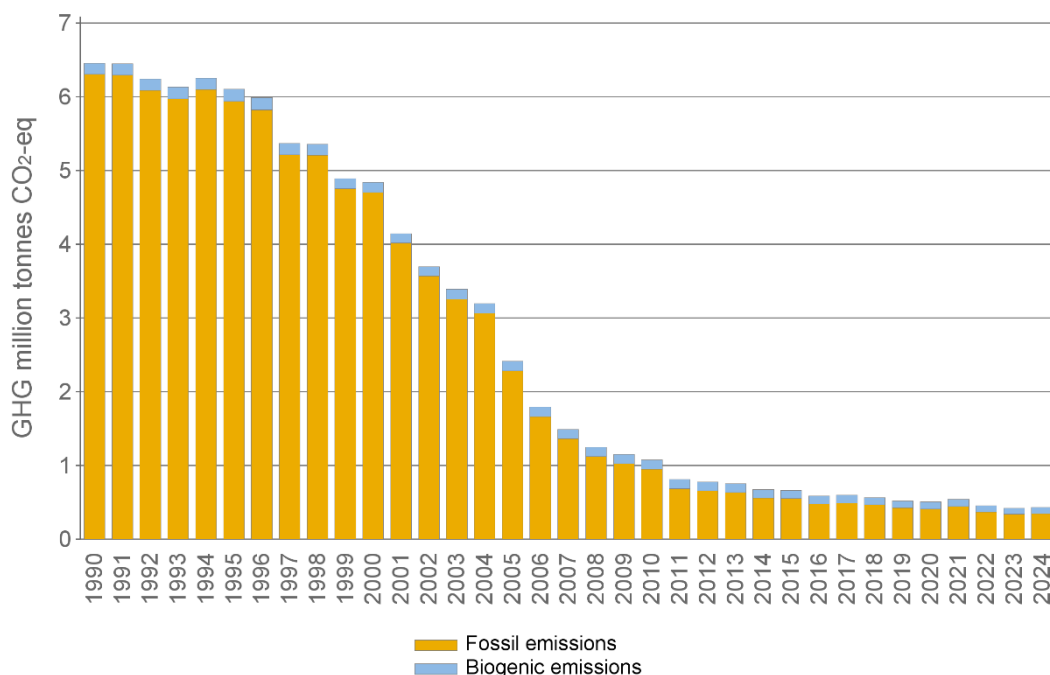


Figure 2.24. Emissions from Residential sector (1A4b) fossil and biogenic, stationary combustion, 1990-2024.

Another contributing factor to the favourable development has been the generally warm weather since 1990. The outdoor temperature affects the need for heating, which leads to variations in energy usage between years. However, it is mainly usage of district heating and electric heating that increase during cold years in this sector. More information about the weather and normal-year-corrected emissions can be found in Annex 8:2.

Increased energy efficiency has also contributed to the decrease in emissions. One example of increased energy efficiency is a continued decrease in energy use for heating per unit of floor space area in one and two-dwelling buildings.

2.3.1.5 FUGITIVE EMISSIONS FROM FUELS (CRT 1B)

Fugitive emissions occur for example in processing, storage and use of fuels, flaring of gas, transmission and distribution of gas.

Emissions were around 0.08 Mt of CO₂-eq. in 2024. A major part of the fugitive emissions has been allocated to petroleum refining (CRT 1A1b) due to prevailing confidentiality rules (see section 3.3).

The decrease in emissions during 2019 (Figure 2.25) is mainly an effect of reduced production due to maintenance at two facilities. During 2020, demand from the sector has been low due to the covid-19-pandemic, and therefore production has also been low. The increase of fugitive emissions from oil (CRT 1B2a), observed in the time series from 2006, is related to the establishment of hydrogen production facilities at two oil refineries.

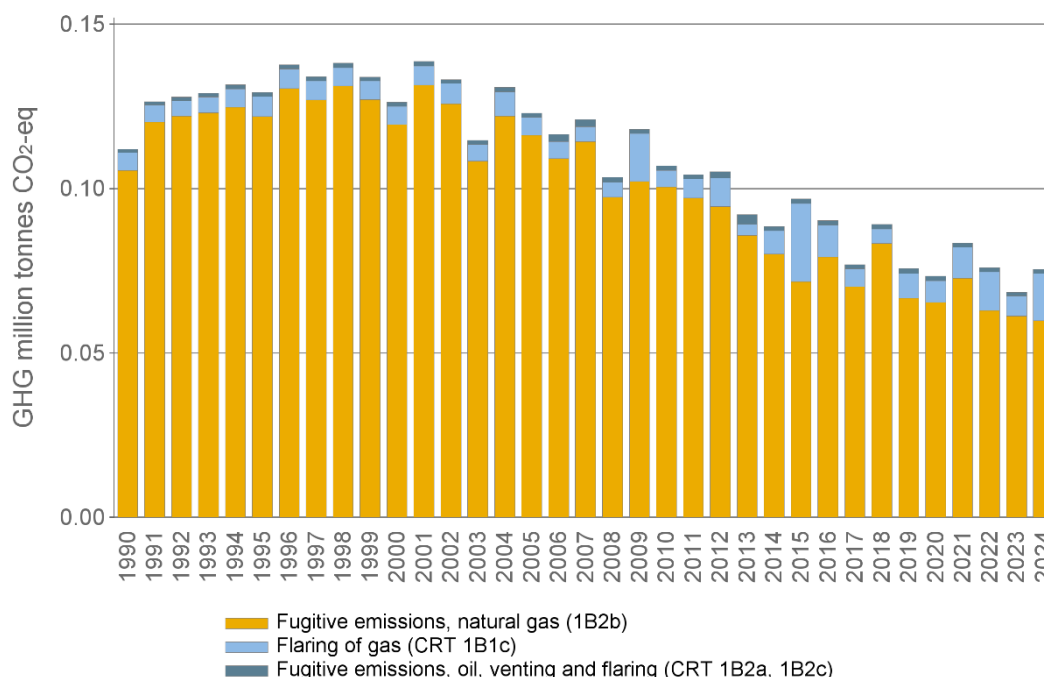


Figure 2.25. Emissions of greenhouse gases from fugitive emissions, total and by major subsectors, 1990-2024.

2.3.2 Industrial processes and product use (CRT sector 2)

Greenhouse gas emissions within the sector industrial processes and product use (CRT 2) stem from the materials used in industrial processes as well as the use of various products such as fluorinated gases, solvents, lubricants and paraffin waxes. Production levels in response to market fluctuations are the main reason for fluctuations within the sector. Emissions from the industrial processes and products use sector represented 14% of the total national emissions in 2024, The main sources of emissions in the industrial processes and product use sector are the production of iron and steel (included in metal industry; 2C) and the cement and lime industries (included in mineral industry; 2A), see Figure 2.26. Note that emissions from combustion in manufacturing industries and construction are allocated to CRT 1A2. Also, note that combustion of energy gases produced as by-products in iron and steel production processes that are sold to electricity and heat producers are allocated to CRT 1A1a, see further discussion in section 3.2.9.

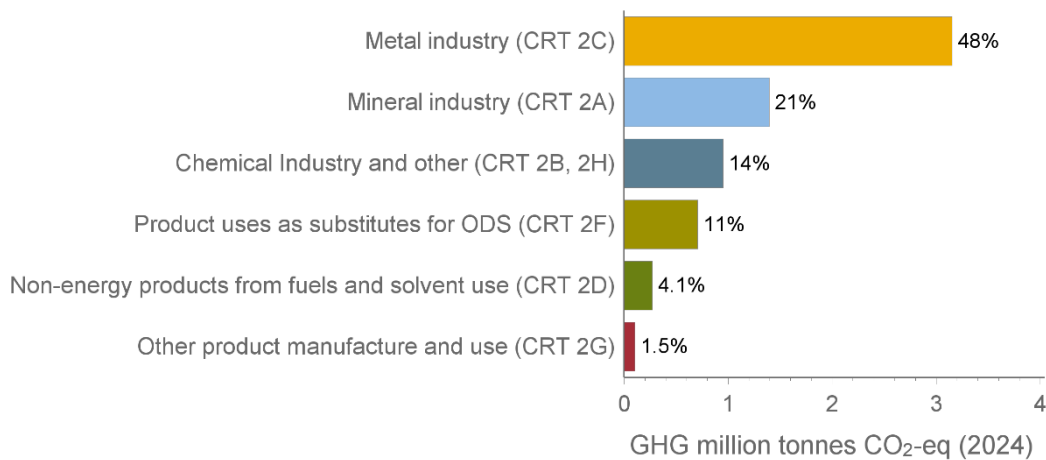


Figure 2.26. Emissions from the industrial processes and product use, 2024.

In 2024 greenhouse gas emissions from the industrial processes and product use sector had decreased by 9% compared to 1990. Emissions from the sector did however increase during the 90's and early 00's but peaked in 2004 and has since had an overall decreasing trend with some interannual variations, see Figure 2.29

During 2024 there were little change in emissions from the sector with only a small increase of around 5 kt CO₂-eq compared to 2023 (0.1%), see Figure 2.27. Greenhouse gas emissions from industrial processes (CRT 2A, 2B, 2C, 2E, 2H) have many interannual variations but shows an overall decreasing trend since 1995. Between 2023 and 2024 there was a small increase in emissions of around 1%. Greenhouse gas emissions from product use (CRT 2D, 2F, 2G) increased a lot between 1990 and 2004 but has been relatively stable since then. Greenhouse gas emissions from product use were about three times as high in 2024 compared to 1990 and decreased with 4% compared to 2023.

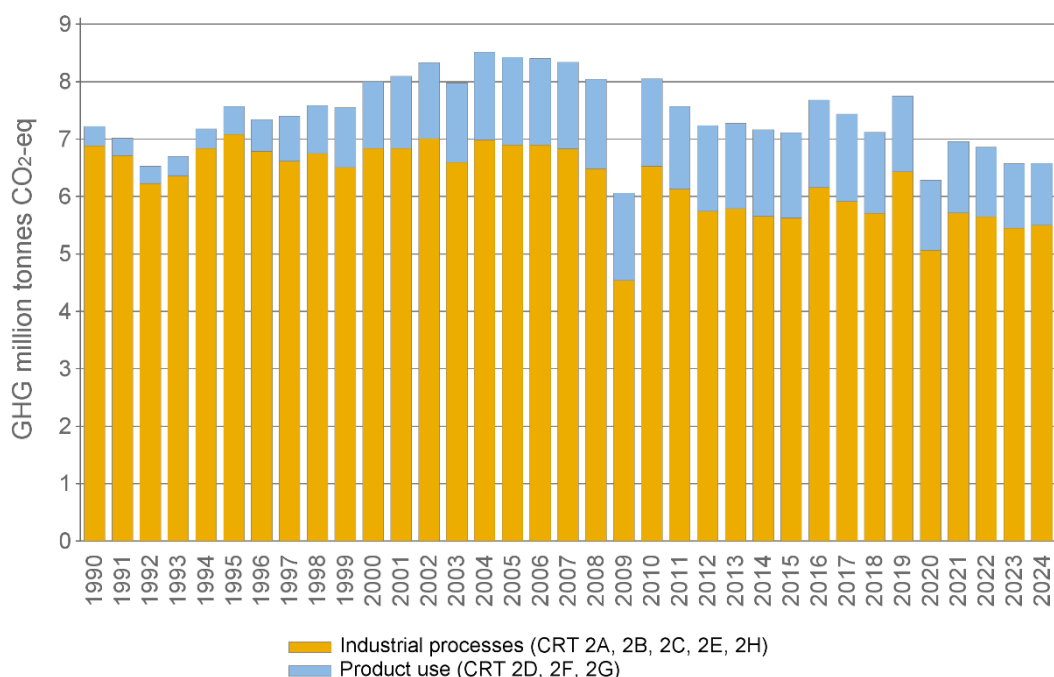


Figure 2.27. Emissions from the industrial processes (CRT 2A, 2B, 2C, 2E, 2H) and product use (CRT 2D,2F,2G), 1990-2024.

2.3.2.1 EMISSIONS PER GAS

Carbon dioxide (CO₂) dominates the emissions of this sector with 5.7 Mt of CO₂-eq. in 2024, representing 86% of the sector's emissions, see Figure 2.30. CO₂ emissions stem from the use of various materials in industrial processes, the use of solvents, lubricants, paraffin waxes and other types of products.

The sector also emits significant amounts of nitrous oxide (N₂O) and fluorinated gases (HFCs, PFCs and SF₆). N₂O emissions were 0.14 Mt of CO₂-eq. in 2024 and mainly originate from the production of nitric acid. In 2024, the N₂O emissions have decreased by 83% since 1990. Emissions of fluorinated gases were 0.8 Mt of CO₂-eq. in 2024 and have increased by 25% since 1990 (Figure 2.28).

All emissions of fluorinated gases in Sweden are found in the industrial processes and product use sector. Although the fluorinated gases are emitted in relatively small amounts compared to CO₂, they have a much higher GWP (global warming potential) due to their chemical structure and therefore contribute significantly to global warming. The new EU regulation from 2015 on fluorinated greenhouse gases aims to cut the emissions of fluorinated gases in the EU by two thirds by 2030, by ensuring that fluorinated gases are replaced by safer alternatives^{19,20}. More information on fluorinated gases is provided in section 2.2.4.

¹⁹ EU, 2014

²⁰ EU, 2012

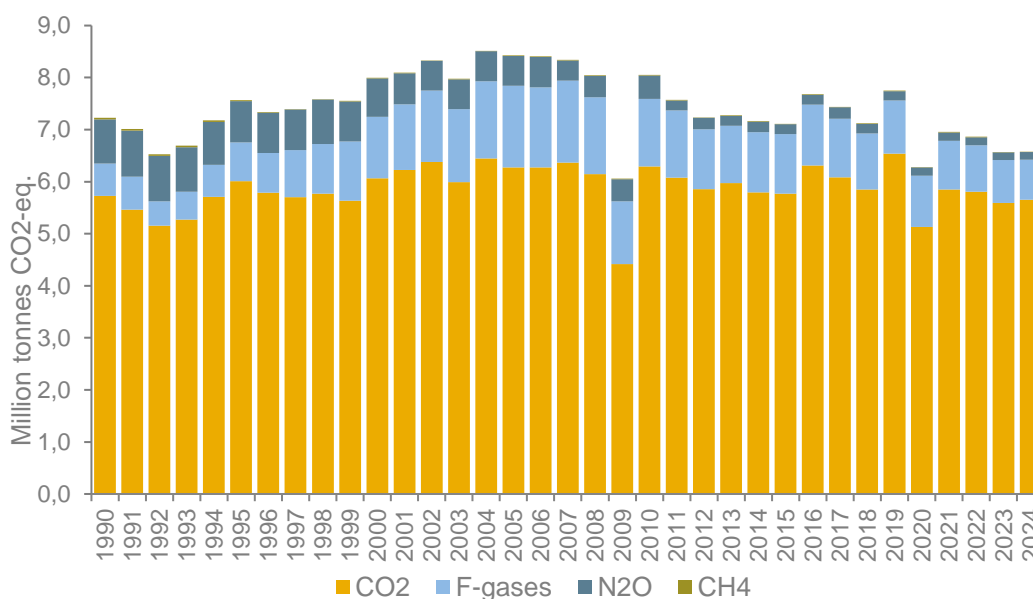


Figure 2.28. Emissions from the industrial processes and product use sector per gas, 1990-2024.

2.3.2.2 INDUSTRIAL PROCESSES (CRT 2A, 2B, 2C, 2E, 2H)

Greenhouse gas emissions from industrial processes have varied since 1990, mainly due to variation in production volumes in response to market fluctuations, see Figure 2.29. The exception is the chemical industries (2B) that reduced their emissions significantly over the period through enhanced emission abatement in their processes. In 2009, the global economic recession caused production to slow down and hence emissions to decrease rapidly, especially in iron and steel (2C). Emissions reverted to previous levels in 2010 and then continued decreasing.

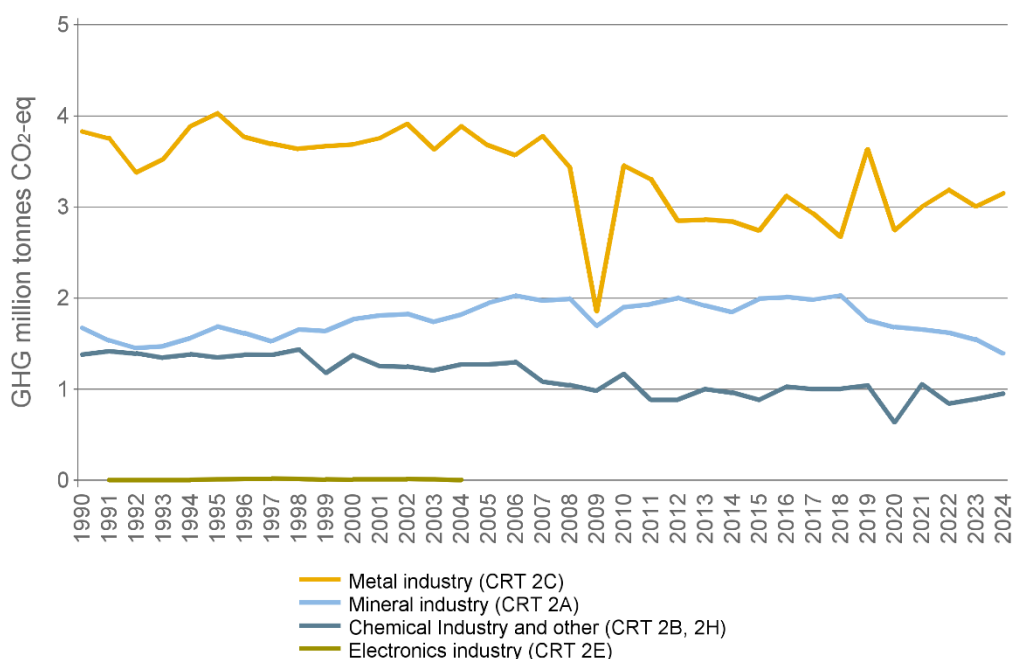


Figure 2.29. Emissions from industrial processes, per subsector, 1990-2024.

The subsector with the largest emissions is the metal industry (2C) with 48% of the industrial process and product use sector's total emissions in 2024, see Figure 2.29. The emissions were fairly stable until 2008, with the exception of some inter-annual variations. In 2009, emissions decreased rapidly due to reduced production levels in response to the global economic recession. Although production levels (and emission levels) increased again in 2010, the metal industry has not fully reverted to the emission levels prior to the recession (Figure 2.29). However, prior to 2020, the emissions started reaching pre-recession levels. The increase in emission was due to increased production of iron and steel.

Production of aluminium (CRT 2C3) also causes emissions of perfluorocarbons (PFCs) under conditions where the amount of alumina falls below a critical level in the process (commonly referred to as "anode effects"). These emissions have decreased in recent years, primarily as a result of investments in new technology in primary aluminium production²¹ since 2007.

Mineral industry (2A) is the second largest subsector, accounting for 21% of the sector's (CRT2) total emissions in 2024, see Figure 2.29. Cement production (2A1) accounts for 15% of the sector's (CRT2) total emissions. The industry also includes production lime (2A2) and glass (2A3).

Emissions from the chemical industry (2B) show a decreasing trend in emissions from 1990 to 2011 with few minor exceptions. The decrease since 2007 is primarily a result of a new treatment technology for nitric acid production²². The new technology has resulted in reduced emissions of nitrous oxide. The technology has been further developed resulting in additional emissions reductions in 2010. Together with other production (2H), that primarily includes process emissions from the pulp and paper industry and mineral wool production, the activities accounted for 14% of the sector's total emissions in 2024.

The electronics industry (2E) generated insignificant greenhouse gas emissions during the period 1991 to 2004.

2.3.2.3 PRODUCT USE (CRT 2D, 2F, 2G)

Greenhouse gas emissions from product use (CRT 2D, 2F, 2G) represent 2% of the national total emissions in 2024. The emissions stem from products used as substitutes for ozone depleting substances (2F), non-energy products from fuels and solvent use (2D) and from other product manufacture and use (2G).

The subsector with the largest emissions from product use, as seen in Figure 2.30, is product uses as substitutes for ozone depleting substances (2F). In 2024, the emissions in this subsector (2D, 2F, 2G) accounted for around 1.1 Mt of CO₂-eq, which represents 16% of the total emissions from industrial processes and product use. The emissions have more than tripled since 1990. The increase between 1990 and 2004 was more than 1 Mt of CO₂-eq. and is primarily due to increases in HFC emissions. HFCs have replaced the use of ozone-depleting substances (CFCs and HCFCs), which have been phased out following the Montreal Protocol, in products like refrigerators, freezers and air-

²¹ Ny Teknik, 2014

²² Yara, 2007

conditioning equipment. At the same time the number of refrigeration and air-conditioning systems, air conditioning in vehicles and heat pumps has increased, particularly in the recent years²³. Since 2009 the emissions have decreased, which may be a result of the implementation of an EU regulation limiting the use of fluorinated gases.

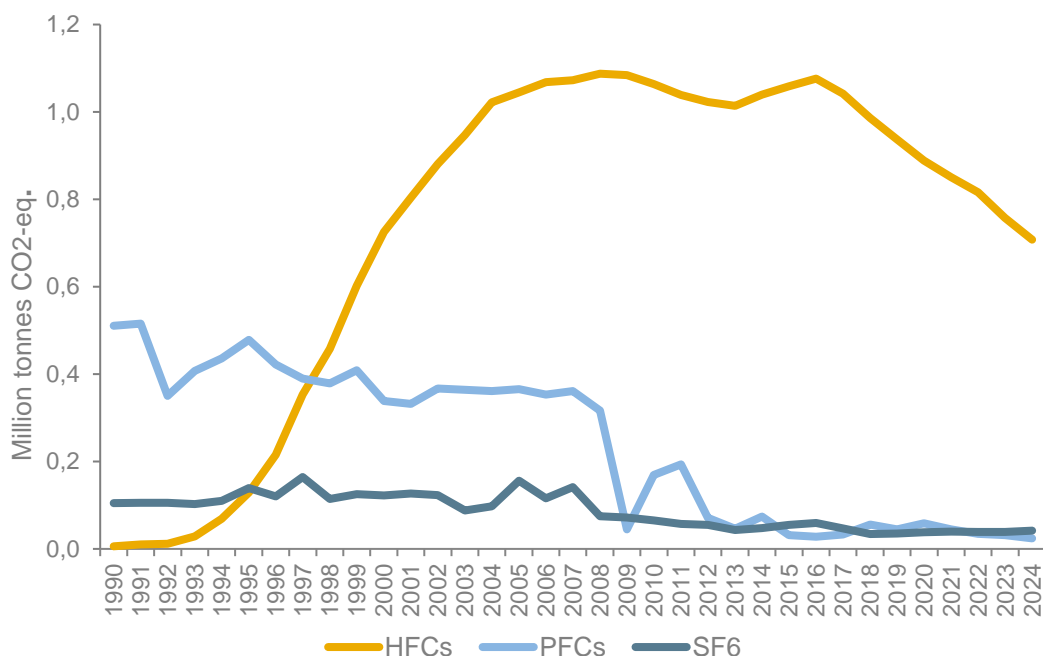


Figure 2.30. Emissions from product use, per subsector, 1990-2024.

Greenhouse gas emissions from non-energy products from fuels and solvent use (2D) comprise emissions from a large number of applications of solvents, lubricants, paraffin waxes, etc. as well as urea used in catalysers of for example cars and trucks. More details are given in section 4.5. The emissions of this subsector were 0.3 Mt of CO₂-eq in 2024 and represented 4% of the industrial processes and product use sector.

The estimated greenhouse gas emissions from other product manufacture and use (2G) consist of fluorinated greenhouse gases from electrical equipment and sound-proof windows as well as N₂O from product use in medical applications. The greenhouse gas emissions in this subsector accounted for around 0.1 Mt of CO₂-eq. in 2024. The trend was increasing until 1995 but has since gradually decreased, with a total decrease of 36% since 1990.

2.3.3 Agriculture (CRT 3)

The main sources of greenhouse gas emissions from the agricultural sector are methane from enteric fermentation of livestock, nitrous oxide and methane from manure management and nitrous oxide from agriculture soils. Liming and urea application emit a small amount of carbon dioxide. The aggregated emissions from the sector in 2024 were a bit less than 6.3 Mt CO₂-eq., which equals about 13% of the total national greenhouse gas emissions (excluding LULUCF). In addition, there are emissions related to

²³ Swedish Chemicals Agency, 2017

agricultural activities that are reported in other sectors (energy use in the energy sector and emissions and removals of carbon dioxide on agricultural soils in LULUCF).

Emissions in the agricultural sector in 2024 were about 14% lower compared to the emissions in 1990. This corresponds to a decrease of about 1 Mt CO₂-eq. The emission reduction was mainly due to increased efficiency and a decline in livestock numbers, especially dairy cattle and swine. Some of the decreasing trends can be explained by a decrease in emissions from agricultural soil, particularly from the reduced use of mineral fertilizers (until about 10 years ago) and continuously reduced emissions from organic soil due to reduced arable land. During the last decade, the emissions have been on a more stable level. In 2024, the overall emissions decreased marginally by about 0.4% compared to the previous year (Figure 2.31). Emissions from animal husbandry decreased slightly in 2024, especially due to lower numbers of cattle and sheep. On the other hand, emissions of nitrous oxide from agricultural land were slightly higher due to higher harvests which resulted in a higher amount of crop residues in the field than in the poorer harvest year 2023. Several other factors affected emissions slightly in different directions.

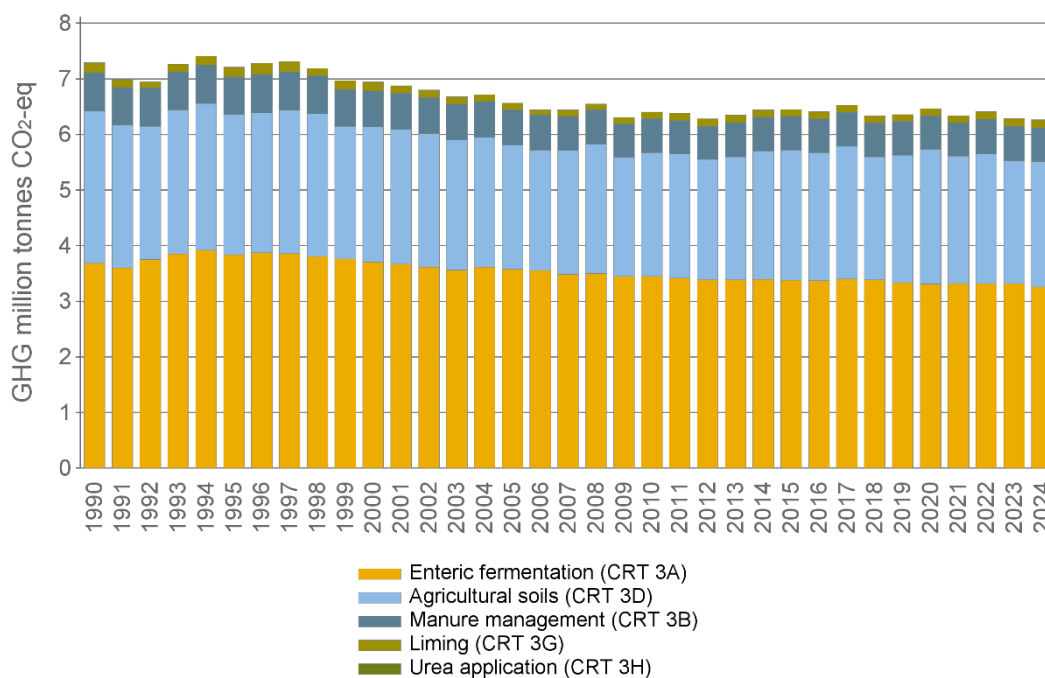


Figure 2.31. Emissions from agricultural subsectors 1990-2024.

Enteric fermentation (3A) and agricultural soils (3D) are the dominant sources of greenhouse gas emissions in the sector, and in 2024 they accounted for about 52% and 36% of the emissions, respectively. Manure management (3B) and liming (3G) accounted for about 10% and 2% of the sector's emissions, respectively. Emissions from urea application (3H) are very small (Figure 2.32).

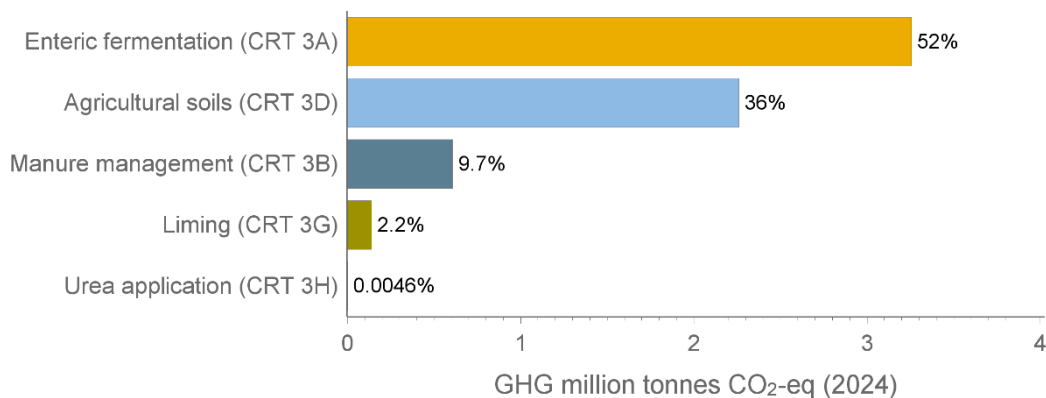


Figure 2.32. Emissions of greenhouse gases in the agricultural sector in 2024.

Animal husbandry and crop production are major sources of non-CO₂ greenhouse gas emissions (CH₄ and N₂O). In 2024, the agricultural sector accounted for 80% and 75% of the total national emissions (excluding LULUCF) of CH₄ and N₂O, respectively.

Approximately 57% of the sector's emissions come from CH₄, about 40% from N₂O and about 2% from CO₂. The trend of the emissions per greenhouse gas can be seen in Figure 2.33.

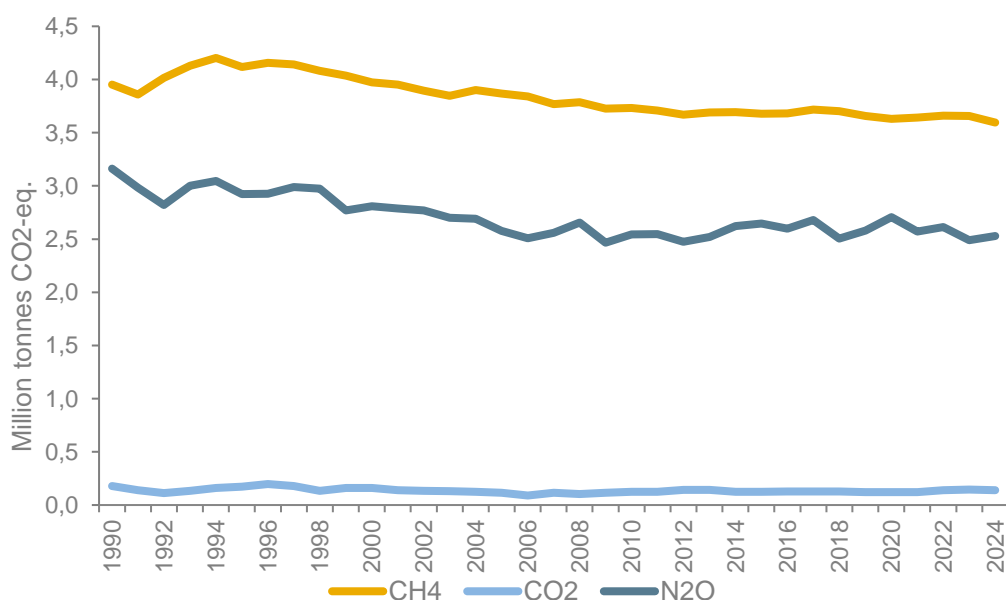


Figure 2.33. Emissions from agricultural sector per greenhouse gas 1990-2024.

2.3.3.1 ENTERIC FERMENTATION (CRT 3A)

The aggregated CH₄ emissions from enteric fermentation (3A) in 2023, were slightly less than 3.3 Mt CO₂-eq. which corresponds to about 52% of the sector's emissions (Figure 2.32). Cattle is the main source of emissions from enteric fermentation, accounting for nearly 87% of the total (38% from dairy cattle and 48% from non-dairy cattle). The emissions from enteric fermentation in 2024 were about 12% (0.4 Mton CO₂-eq.) lower compared to 1990 levels (Figure 2.31). In 2024 the emissions were about 1.8% (60 kton CO₂-eq.) lower than in 2023.

The main driver for emission reduction since 1990 is a decline in livestock numbers, mainly dairy cattle, whose population has decreased steadily during this period²⁴. For this reason, emissions from enteric fermentation from dairy cattle decreased by just over 30% since 1990. Higher milk production per dairy cow gives lower CH₄ emissions per kg milk produced. The trend in Sweden is that the number of dairy cows has been halved since 1990, whereas the milk production per cow has increased with over 60% during the same time period. Therefore, the total amount of milk produced has not been affected to the same degree. Production has become more efficient through improved feeding, breeding and animal health. Cows with a higher production have a larger feed intake and thus emits more methane through enteric fermentation. Even so, the large decrease in the number of dairy cows has led to reduced methane emissions from dairy cattle. In 2024 the emissions from dairy cattle decreased by 1% compared to 2023. The explanation for this small decrease in emissions was a decrease in the number of dairy cows while the milk production per cow continued to increase.

Emissions of CH₄ from non-dairy cattle (includes suckler cows as well as bulls, steers, heifers and calves from both dairy and beef cattle production) has increased by about 11% since 1990. This can be explained by a major increase in the number of sucklers cows during the same period, even if the total number of animals in this category decreased slightly. In 2024 the emissions from non-dairy cattle decreased by slightly more than 2% compared to 2023 due to a reduction in number of animals in this category.

2.3.3.2 MANURE MANAGEMENT (CRT 3B)

In 2024, the aggregated emissions from manure management (3B) were slightly less than 10% (or approx. 0.6 Mt CO₂-eq.) of the emissions from the agricultural sector (Figure 2.32). The distribution was about 56% CH₄ and 44% N₂O. The total emissions from manure management in 2024 was about 12% lower than in 1990 (Figure 2.31). The reduction in emissions is mainly due to a reduced number of dairy cows and swine and to some extent also to improved storage of manure. During the same time period there has been an increase in emissions from especially non-dairy cattle and poultry (due to increased numbers of especially suckler cows and broilers).

In 2024, more than one-third (36%) of the emission from manure management originated from non-dairy cattle and these emissions have increased by 33% since 1990, due to increased beef production from suckler cows. Emission from manure management of dairy cattle and swine in 2024 accounted for about 22% and 10%, respectively. These emissions have decreased since 1990, mainly due to reduced population sizes. Emissions from poultry accounted for 12% in 2024, which is an increase by about 120% since 1990 due to an increased poultry population size. The rest of the emissions from manure

²⁴ Jordbruksverket 2024. Lantbrukets djur i juni 2024 - Jordbruksverket.se

management originated from indirect emissions, i.e., atmospheric deposition (about 11%), horses (7%) and small emissions from other animal categories, especially sheep.

In 2024 the emissions from manure management were 1.7% (10 kton CO₂-eq.) lower than in 2023. This was mainly due reductions in numbers of most animal categories and thus less manure to store.

2.3.3.3 AGRICULTURAL SOILS (CRT 3.D)

Agriculture soils (3D) is the largest source of the national N₂O emissions. Emissions are mainly derived from the supply and conversion of nitrogen from the use of inorganic fertilizers, cultivation of organic soils, crop residues and animal manure applied to soils or deposited by grazing animals. Other sources include emissions from other organic fertilizers, such as sewage sludge, as well as indirect emissions from atmospheric deposition and nitrogen leaching and run-off.

In 2024, emissions from agriculture soils were slightly less than 2.3 Mt CO₂-eq. and accounted for 36% of the sector's total (Figure 2.32). Emissions have decreased by about 17% since 1990 (Figure 2.31). The main reasons are a continuous reduction in cultivated area of organic soils as a result of reduced arable land and a reduced use of especially mineral fertilizers (until about 10 years ago when this trend was stabilized). Within the agricultural sector the yearly variation in emissions is usually largest from agricultural soils, partly due to the variation in sales of inorganic N-mineral fertilizers and in harvest results.

The use of inorganic N-fertilizers has a large effect on the emissions and is based on sales statistics. Since 1990, emissions from the use of inorganic N-fertilizers declined as sales have fallen. However, the sales of, and thus also the emissions from, inorganic fertilizers have started to increase again since around 2012. One explanation is an increased area of autumn sown, high yielding crops which requires more nutrients. Further, the general trend with larger harvests in later years have also increased the need of fertilizers. However, there is a large yearly variation in sales of, and thus the emissions from, fertilizers. Factors that can affect the sales of fertilizers a certain year includes prices of fertilizers and crops, harvest yields and the amount of saved fertilizers from previous year. The last three years the sales of, and thus the emissions from, inorganic N-fertilizers have been on a stable level.

Between 2023 and 2024 there was an increase in emissions from agricultural soils by 2.2%. This is primarily explained by higher harvests, which resulted in higher amounts of crop residues in the field than in the poorer harvest year 2023. Several other factors affected emissions slightly but in different directions. For example, sales of nitrogen in mineral fertilizer for the fertilizer year 2023/2024²⁵ were slightly higher compared to the previous fertilizer year, while the use of urea decreased from a high level in 2023.

2.3.3.4 LIMING (CRT 3.G) AND UREA APPLICATION (CRT 3.H)

Liming and the use of urea fertilizers give rise to emissions of carbon dioxide in the agricultural sector. Liming is mainly applied to counteract acidification, improve soil structure and to reduce phosphorus losses. Total emissions of CO₂ from liming were about 0.14 Mton in 2024, which is about 2% of the sector's emission (Figure 2.32). The

²⁵SCB, 2025. [Försäljning av mineralgödsel för jord- och trädgårdsbruk 2023/24](#)

emissions from liming have decreased by about 20% since 1990. However, there is some yearly variation. For example, the last three years the emissions from liming (based on the same survey result) were somewhat higher than the preceding eight-year period.

The amount of urea used in Sweden is generally small compared to many other countries because urea is a slow-release fertilizer, which does not fit well in areas with a short growing season in northern latitudes such as Sweden. With some yearly variation the emissions from urea show a downward trend compared to 1990. For example, in 2023 the emissions from urea application were unusually high, but in 2024 the level was again low.

2.3.4 Land Use, Land Use Change and Forestry – LULUCF (CRT sector 4)

This sector consists of source and sink categories linked to land use, land use change and forestry. The total net removal was 54 million tonnes of CO₂-eq. in 2024. Forest land covers more than half of the Swedish total land area and is therefore the dominant category in this sector. The largest net removals occur on forest land and amounted to almost 55 million tonnes of CO₂-eq in 2024, followed by harvested wood products with total net removals of 4 million tonnes of CO₂-eq. The largest net emissions in this sector occur in settlements, cropland and wetlands. This sector has been a net sink the whole period from 1990 until 2024.

Sweden reports carbon stock changes from forest land (CRT 4 A), cropland (CRT 4B), grassland (CRT 4C) and settlements (CRT 4E) and associated land-use transfers and also a small part of wetlands (CRT 4D) where peat extraction occurs on already drained peat lands. These land use categories are considered managed. Since 2019 Sweden also report on other land since the ERT recommended us to do so. Sweden report on land change from managed land to unmanaged land. Since 2023 Sweden has included carbon stock change from mountainous forest land. Since submission 2025 Sweden has updated methodology for estimating carbon stock change in mineral soils on forest land, grassland and cropland. When it comes to organic soils on cropland, we updated the area in 2023 and the emissions factors. Sweden has also updated the method for calculating living biomass, mineral soils and emissions factors for drained organic soils. More on this in the LULUCF chapter below.

The calculation of net emissions and removals in the LULUCF sector also includes HWP (Harvested Wood Products) (CRT 4G), emissions of nitrous oxide associated with nitrogen fertilization of forest land (4I), nitrous oxide and methane from drained and rewetted organic soils and methane from ditches (4II), carbon dioxide from dissolved organic carbon (DOC), nitrous oxide emissions due to mineralization due to land use conversions and management change (4III), indirect nitrous oxide emissions (4IV) and nitrous oxide, methane emissions from biomass burning (4V).

Net emissions and net removals per category

The LULUCF sector has generated annual net removals in Sweden during the whole period 1990-2023 (Figure 2.34 and 2.35). In 2023, total net removal from the sector was estimated to 31 million tonnes of CO₂-eq. During the period 1990 – 2024 total net removals have varied between 40 to 64 million tonnes of CO₂-eq. The total net removal in 2024 was 18% higher than in 2023. 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 and mineral soil constitute the major parts of these changes, followed by carbon stock changes in dead organic matter.

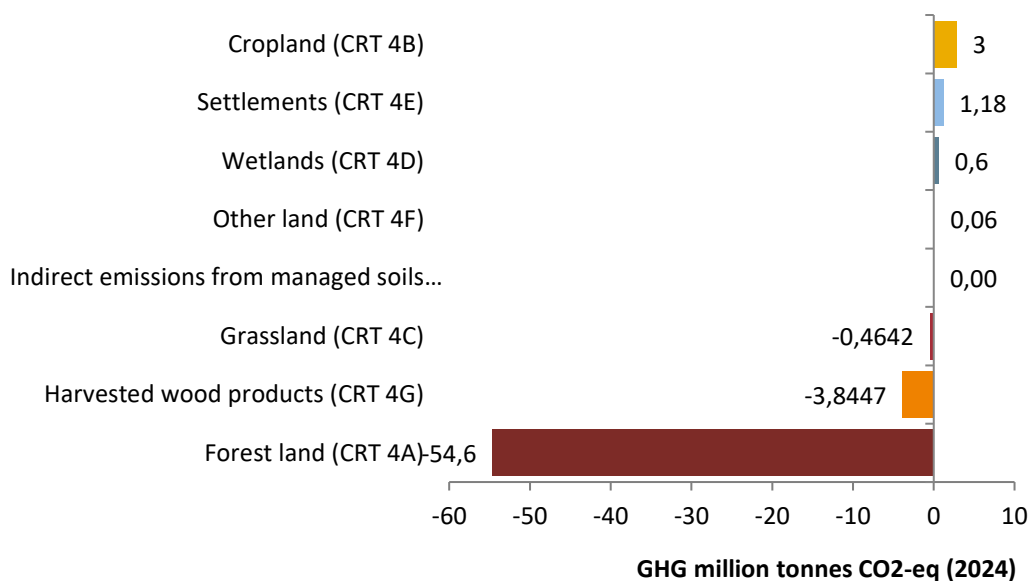


Figure 2.34. Emissions (+) and removals (-) in the LULUCF sector; for the categories, Forest land (CRT4A), Cropland (CRT 4B), Grassland (CRT 4C), Wetland (CRT 4D), Settlements (CRT4F) and HWP (CRT 4G) in 2024.

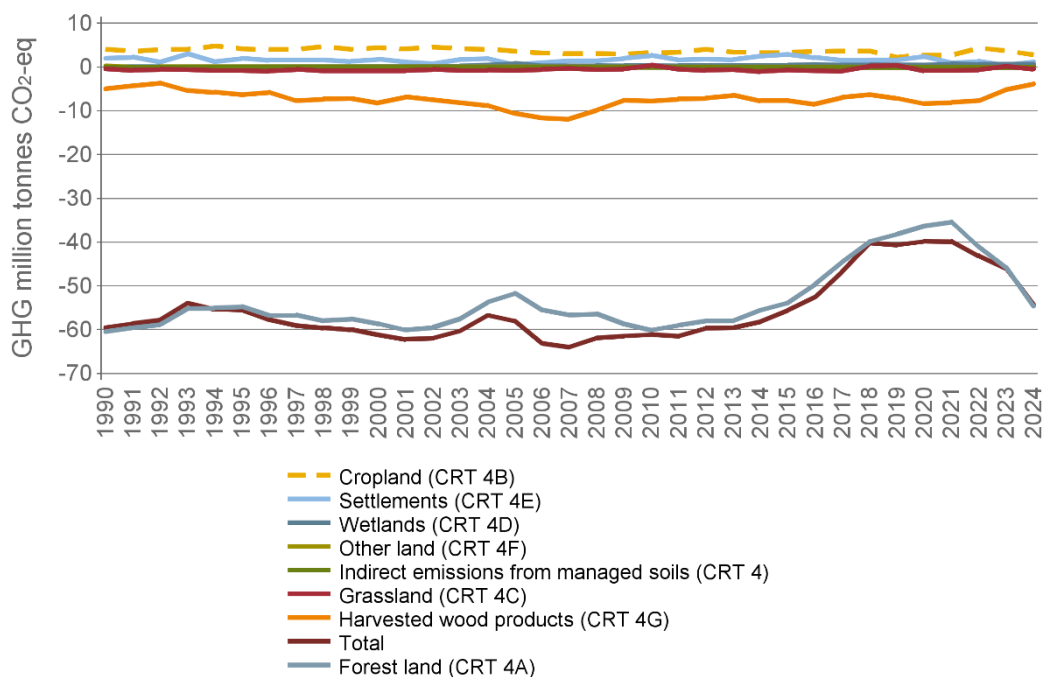


Figure 2.35. Net emissions (+) and removals (-) of greenhouse gases in the LULUCF sector from different land-use categories and total net removals for the LULUCF-sector, 1990-2024.

The most dominant category in this sector is forest land since forest land covers 69% of the total Swedish land area. What happens in forest land governs the developments for the entire sector. On forest land the carbon pool living biomass dominate the outcome.

In 2024 the net removal in living biomass was 32 million tons of carbon dioxide, this is an increase since 2020 when the net removal was only 5 million tons of carbon dioxide. The mean during 1990 until 2024 was 28 million tons of carbon dioxide. Between 2013 and 2023 the total net removal on forest land decreased by nearly 26 million tonnes of CO₂-eq. The decrease in net removal in living biomass is due to a decrease and slowing down in forest growth, high harvest and high mortality. After 2020 the growth increased again and the harvest in 2023 and 2024 were the smallest during a teen year period. The mortality has also decreased. In 2005 and 2007 there were decreases in the net removal because of two severe storms. According to the Swedish National Board of Forestry, the felling, including wood felled by storms, was estimated at 122 Mm³sk in 2005. The HWP-pool was smaller in 2024 than in 2023, around 4 million tonnes of carbon dioxide.

Inter-annual fluctuations in harvest rates are large. In 2024 the gross harvest was approximately 87 Mm³ stemwood²⁶ and this is a decrease of 9 Mm³ stemwood since 2021. Since the early 1990s, Sweden has had an increase in growth that has been relatively steady, without any clear declines, until 2010/2011. After that, a historically long-term decline began. The decline broke around 2020 and now an increase in growth is visible again²⁷. Since harvest level is below growth there is still a growing carbon stock in living biomass, which prevailed since the beginning of the 21st century. The negative trend has been reversed for now. The mineral soil pool on forest land is a steady net removal. In 2024 the net removal was 20 million tonnes of carbon dioxide. The carbon stock change in mineral soil is hard to estimate since the pool is very large and the changes very small, which entails high uncertainties. The emissions from organics soil on forest land has increased over the period 1990 – 2024 and in 2024 the emissions amounted to nearly 8 million tonnes of carbon dioxide.

The categories grassland and wetlands account for very small areas and small net removals and net emissions and especially compared to forest land. The net emissions and removals in the category grassland have varied during the period and the variation in the net removal is due to the variation in harvest of trees (living biomass) in the grassland category. There is no trend since there has been both net emissions and net removals between 1990 and 2024. In 2024 it was a net source of about 0.5 million tonnes of CO₂-eq (uncertainties are big). The emissions from wetlands are due to drainage of organic soils for peat production and decay of peat for cultivation. The net emissions in 2024 were 0.6 million tonnes of CO₂-eq. The peat production for energy has decreased but the peat production for cultivation has increased.

The largest net emissions in this sector come from cropland and settlements. Net emissions from cropland have been almost 4 million tonnes of CO₂-eq. as a mean value between 1990 and 2024. The annual variation in net emissions in cropland is connected to the variation in mineral soils. The variations in mineral soils depend on variations in the total area grown and the areas of which crops that are grown between years, together with the variation in climatic conditions (air temperature and precipitations). The emissions

²⁶ Avverkningsstatistik - Skogsstyrelsen

²⁷ Skogsdata_2025_web.pdf

come from the cultivation of drained organic soils have been decreasing since the areal has decreased. Emissions from drained organic soils in 2024 amounted to 3.4 million tonnes of CO₂-eq.

Total net emissions from settlements were on average 1.6 million tonnes of CO₂-eq. during the period 1990 to 2024. The highest total net emission was in 1993 and amounted to 3 million tonnes of CO₂-eq. Emissions are mainly caused by urbanisation and establishments of power lines and forest roads and in connection with harvest of living biomass.

Net emissions and net removals by carbon pool

Net removals in the LULUCF-sector are calculated as the total carbon stock change in living biomass, dead organic matter (dead wood and litter including the humus layer of soil), soil organic carbon, harvested wood products (HWP) and other emissions (fertilization N₂O, indirect (N₂O), mineralization (N₂O), biomass burning (N₂O and CH₄) and drainage (N₂O and CH₄) for different land use categories (Figure 2.36).

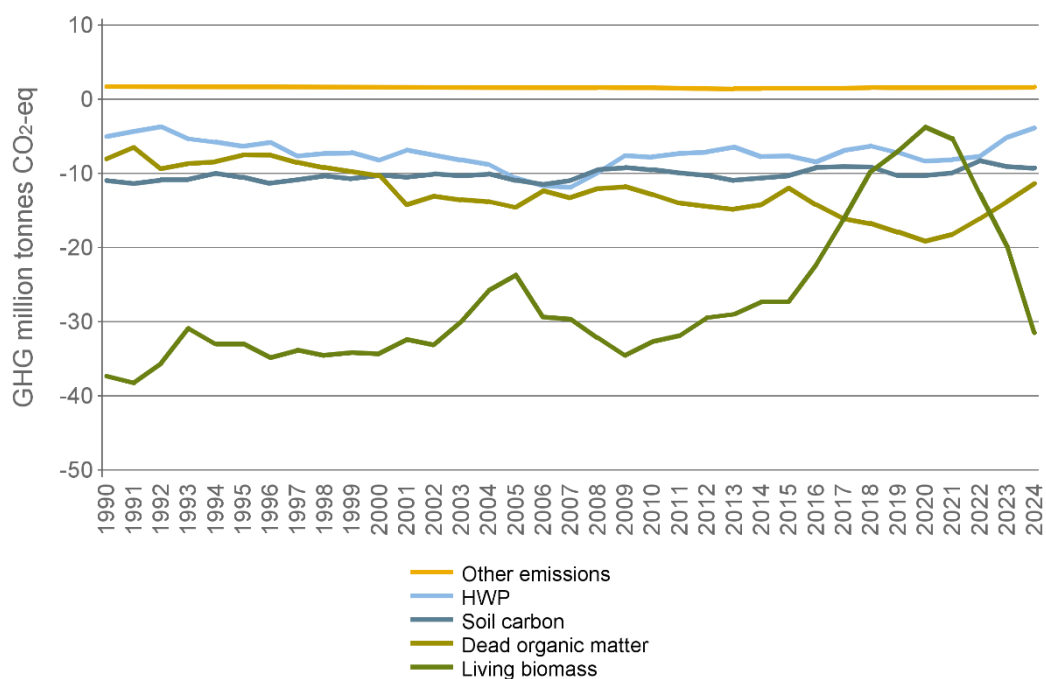


Figure 2.36. Emissions (+) and removals (-) of carbon dioxide from different carbon pools, 1990-2024.

Net removals in living biomass and mineral soil are significant and primarily given by the net removals on primarily forest land. The net removal in the carbon pool living biomass in 2024 was almost 32 million tonnes of carbon dioxide, and this is much higher than in 2020 when the total net removal in living biomass was only 3.5 million tonnes of CO₂-eq. The low total net removal in living biomass depends on low growth rate, high harvest and high mortality (increased by bark beetles). The trend in growth has shifted from low during the 2010-ies and is now growing again and at the same time the harvest²⁸ has decreased and also the mortality. The HWP pool stock change depends on the estimated

²⁸ Avverkningsstatistik - Skogsstyrelsen

difference between the inflow of carbon in terms of new products and the modelled outflow of discarded products. At present, the estimated pool therefore covariates with the living biomass net removals in the category forest land. The largest net removals in the pool/category HWP, occurred after the big storm in 2005 resulting in increased stock of timber the year after the storm. The net removal in the pool HWP was about 4 million tonnes of carbon dioxide in 2024 and this is a decrease since 2020.

The uncertainty of estimates in the LULUCF sector is generally larger than in other CRT sectors in the inventory and the uncertainties are generally larger for the smaller categories (area) in the LULUCF sector than for larger ones. Due to our methods the latest three years have a greater uncertainty. For more information, please read in NID annexes.

2.3.5 Waste (CRT sector 5)

Two thirds of the emissions from the waste sector come from solid waste disposal which generates methane. These emissions have decreased by approximately 78% since 1990 and several policy instruments – both legislative and economic – have had significant impact on this trend. The most important mitigation measures are an expansion of methane recovery from landfills, reduced landfill disposal of organic material, increased levels of recovery of materials and waste incineration with energy recovery.

Emissions from waste (CRT 5) include emissions from solid waste disposal (CRT 5A), wastewater treatment and discharge (CRT 5D), biological treatment of solid waste (CRT 5B) and incineration and open burning of waste (CRT 5C). The shares of the sub sectors of the total emissions of the sector are shown in Figure 2.37. Greenhouse gas emissions from the waste sector amounted to 0.98 Mt CO₂-eq. in 2024, or 2% of the national total of greenhouse gas emissions. Out of this, approximately 0.38 Mt CO₂-eq. came from solid waste disposal.

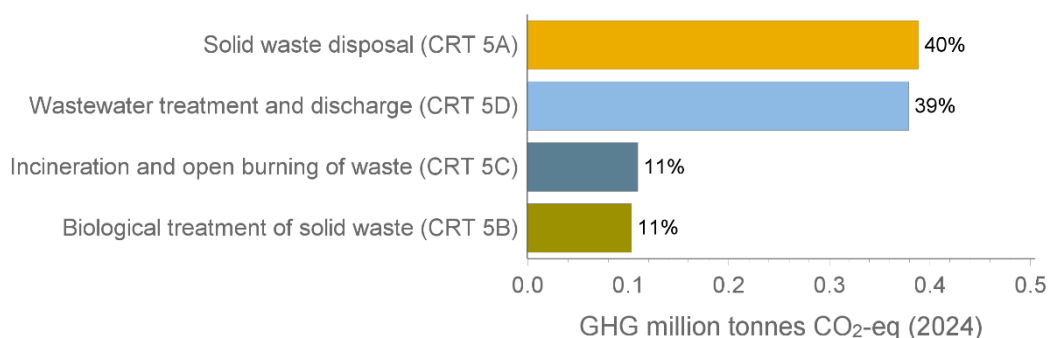


Figure 2.37. Share of emissions from sub sectors in the waste sector 2024.

Emissions in the sector are predominantly methane (CH₄), 68% in 2024, as seen in Figure 2.38. Emissions of methane from the waste sector decreased by 84% in the period 1990 to 2024, due to an increased level of collection and management of methane gas from landfills and reduced amounts of organic material being deposited in landfills.

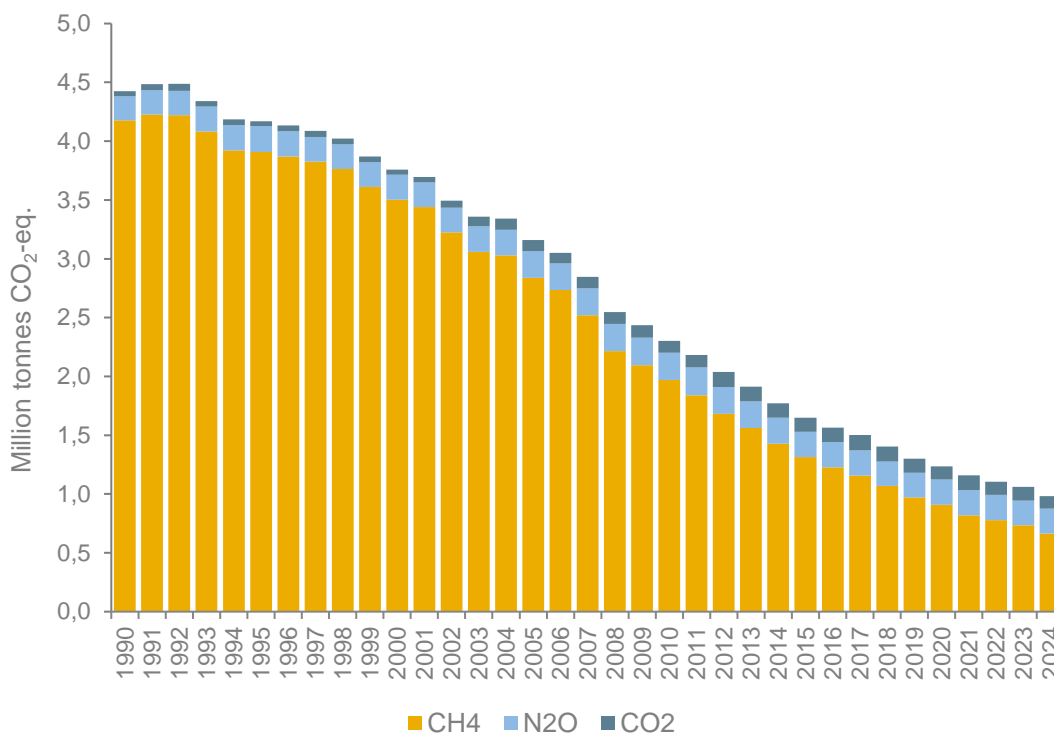


Figure 2.38. Emissions from the waste sector, per gas, 1990-2024.

In 2024, nitrous oxide (N₂O) emissions amounted to 22% of the greenhouse gas emissions. There has been a reduction in the quantity of nitrogen discharged from municipal wastewater treatment plants from the mid-1990s, when nitrogen treatment in wastewater treatment plants in Sweden was developed. The waste sector also emits small amounts of carbon dioxide (CO₂) emissions, 11% of the sector’s emissions in 2024. These emissions come from the incineration of waste, of which a minor part is reported in the waste sector and the major part is reported in the energy sector.

Emissions from the waste sector have decreased by 78% since 1990, see Figure 2.39 for a sub sectoral breakdown of emissions over time. The most significant emissions in the waste sector occur as a result of solid waste disposal. However, the trend also shows the most significant emission reductions within this subsector – a decrease of 90% between 1990 and 2024.

While emissions from wastewater treatment and discharge increased by 2% from 1990 until 2024, emissions emanating from biological treatment of solid waste and incineration and open burning of waste both show increasing trends from 1990 to 2024, by 721% and 145% respectively.

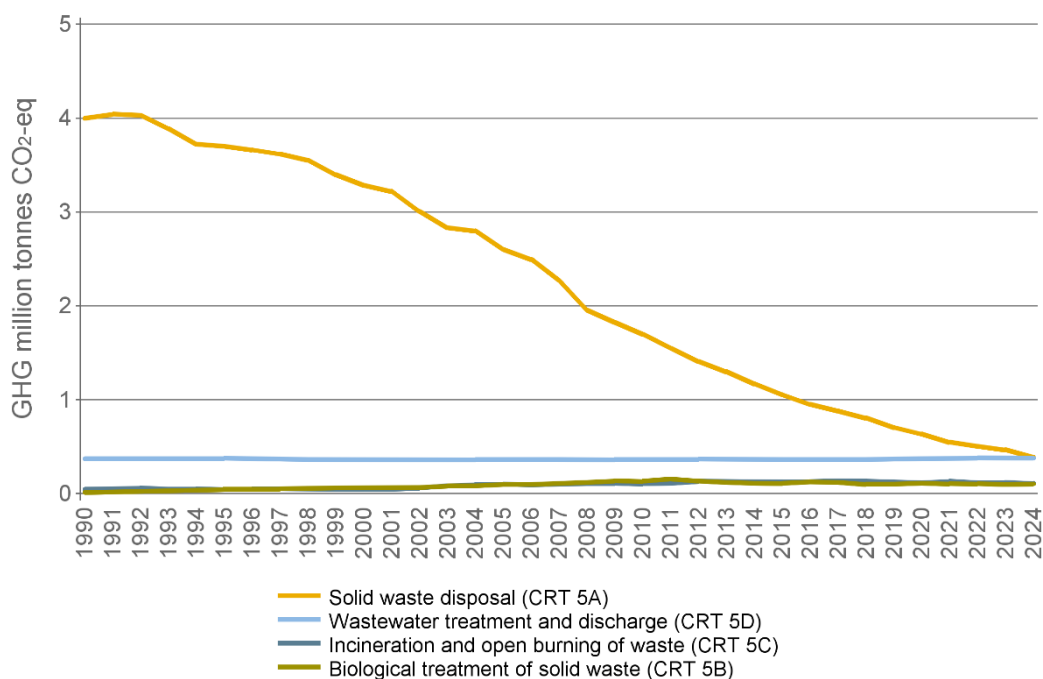


Figure 2.39. Emissions from the waste sector, per subsector, 1990-2024.

2.3.5.1 SOLID WASTE DISPOSAL (CRT 5A)

In 2024, 40% of the emissions from the waste sector came from solid waste disposal (CRT 5A). Between 2023 and 2024 the emissions decreased by 17% from this subsector. Solid waste disposal covers managed, unmanaged and uncategorized waste that has been deposited in landfills. Landfills are the second largest source for emissions of methane gas in Sweden, after livestock farming (in agriculture, CRT 3). Methane is formed when organic waste deposited in landfills starts to decay. Increased collection levels and management of methane gas from landfills and reduced amounts of organic material being deposited in landfills have led to steadily declining methane emissions from Swedish landfills since the early 1990s.

Waste management has developed considerably over the past twenty years. Several policy instruments have had a significant impact on this trend. Producer responsibility was introduced for several groups of products in the 1990s and, today, eight groups of products are covered (i.e. batteries, cars, tires, electric and electronic products, packaging, paper, pharmaceuticals and radioactive products)²⁹. A tax on depositing waste in landfills was introduced in 2000³⁰. Bans on landfill disposal of combustible waste (in 2002) and organic material (in 2005) have also been introduced³¹. These bans contributed to substantial shifts in Swedish waste management. The landfilling of other types of waste has also fallen sharply.

²⁹ Swedish EPA, 2017

³⁰ Avfall Sverige, 2017

³¹ Swedish EPA, 2012

Finally, the obligation for municipal waste planning that was introduced in 1991³² may also have contributed to the increased collection of methane from landfills as well as to the reduced deposits of degradable material.

2.3.5.1 WASTEWATER TREATMENT AND DISCHARGE (CRT 5D)

About 39% of the emissions in the waste sector are emitted from wastewater treatment and discharge. The emissions were approximately 0.4 Mt CO₂-eq. in 2024. Wastewater treatment facilities have been continuously improved since the late 1960s³³. Emissions from Swedish wastewater treatment and discharge have decreased by approximately 8% since 1990, which may be explained by the improvement of facilities during the period as well as increased biogas generation from sewage sludge (Figure 2.39).

2.3.5.2 BIOLOGICAL TREATMENT OF SOLID WASTE (CRT 5B)

Biological treatment of solid waste accounted for 8% of the total emissions in the waste sector in 2024 (approximately 0.1 Mt CO₂-eq). Biological treatment of solid waste includes composting (aerobic digestion) and anaerobic digestion of organic waste. While composting generates methane and nitrous oxide, the anaerobic digestion is designed to produce methane for use in other sectors.

The use of methane for combustion is reported in the energy sector, but emissions emanating from production (e.g. leakages when upgrading biogas) are reported in the waste sector. The emissions from biological treatment of solid waste have shown an increasing trend over the last two decades. In fact, the emissions have increased by almost 721% since 1990, especially in recent years when also production of biogas using anaerobic digestion was scaled up³⁴. This may explain the increasing trend together with the fact that composting and digestion overall has become more important treatment methods of municipal waste during the time period (Figure 2.39).

2.3.5.3 INCINERATION AND OPEN BURNING OF WASTE (CRT 5C)

In 2024, 11% of the total emissions in the waste sector occurred in incineration and open burning of waste. Emissions have shown an increased trend since 1990, and especially since 2003. The total generation of municipal waste has increased over the period and incineration has become the most important treatment option for municipal waste (Figure 2.39). However, the main incineration of municipal waste uses energy recovery, and the emissions are therefore accounted for in the energy sector (CRT 1). Nevertheless, this has led to a higher incineration capacity which together with larger quantities of waste being categorized as hazardous may explain the trend also for incineration and open burning of waste in the waste sector.

2.3.6 International shipping and aviation

International bunkers include refuelling in Sweden by international shipping and aviation. These emissions are reported as memo items and are not included in the total Swedish emissions calculated in relation to the Convention. Greenhouse gas emissions from international shipping and aviation, also known as international bunkers, are considerably larger than those from domestic shipping and aviation. In 2024, they amounted to 6.9 Mt

³² Swedish EPA, 1991

³³ Swedish EPA, 2009

³⁴ Swedish Energy Agency, 2015

of CO₂-eq, which is a decrease of 9% since 2023 (Figure 2.40). Greenhouse gas emissions from international shipping continued to decrease during 2024.

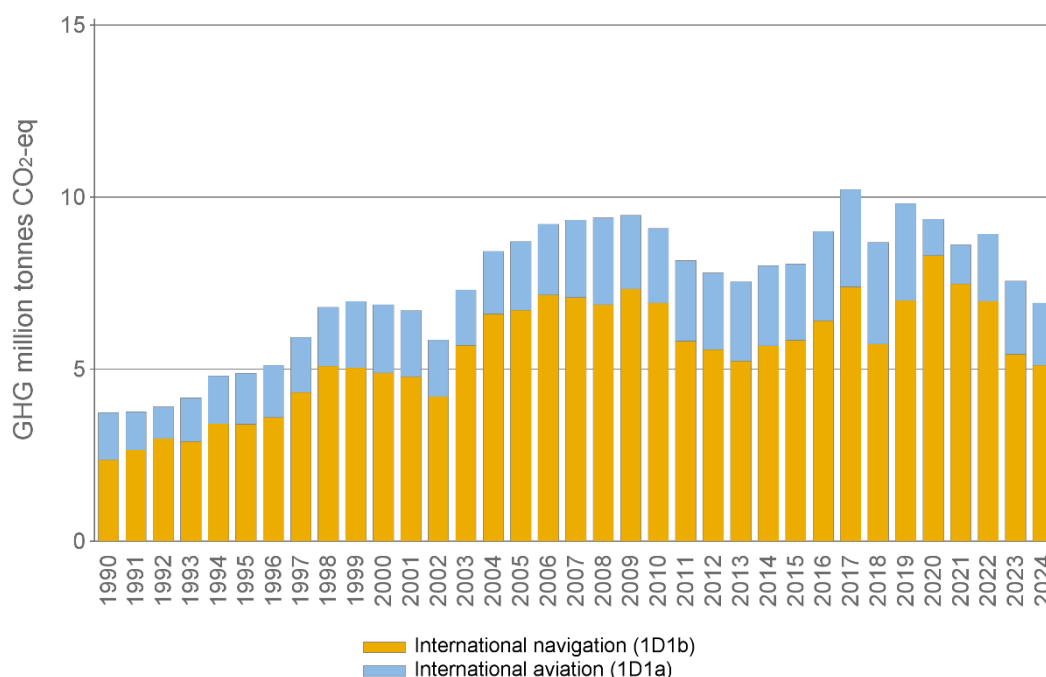


Figure 2.40. Emissions from international bunkers, total and per subsector, 1990-2024.

Emissions from international shipping reached a total of 5.1 Mt of CO₂-eq. in 2024. This is a decrease by 38% compared to 2020 when emissions from international shipping peaked during the pandemic. Emissions have doubled compared to 1990. Fluctuations in bunker volumes between years are also dependent on fuel prices in Sweden compared to the prices in ports in other countries.

Greenhouse gas emissions from international aviation bunkers were 1.8 Mt of CO₂-eq. in 2024. This is a decrease of 15% compared to 2023, and 32% higher than in 1990. The large increase in emissions from international aviation between 2020 and 2023 was a rebound effect after the covid-19-pandemic. Emissions are still not back at pre-pandemic levels. Emissions from international bunkering of aviation have varied over time, but the trend points to a rise in these emissions, owing to growth in international travel.

2.4 Precursors and indirect emissions

The indirect greenhouse gases in Sweden include nitrogen oxides (NO_x), non-methane volatile organic compounds (NMVOCs), carbon monoxide (CO) and sulfur dioxide (SO₂). The first three gases influence the concentration of ozone in the lower troposphere and hence have an influence on the radiative forcing. Sulfur dioxide contributes to aerosol formation in the atmosphere. Sulfate aerosols affect the climate as they reflect sunlight, and they also have an indirect effect on climate in that they influence the “seeding” of clouds which have a negative net radiative forcing effect and therefore tend to cool the surface.

There has been a long-term decrease in the emissions of the indirect greenhouse gases and SO₂ in Sweden as their emissions have declined strongly since 1990.

2.4.1 Non-methane volatile organic compounds (NMVOCs)

A total of 126 kt of non-methane volatile organic compounds (NMVOCs) were emitted in 2024. Approximately 43% of the emissions were derived from the industrial processes and product use sector (CRT 2). The shares of the energy sector (CRT 1) and the agricultural sector (CRT 3) were about 33% and 24%, respectively. The remaining emissions (0.2%) were derived from the waste sector.

Within (CRT 2) most of the NMVOCs emissions were derived from solvent use (2D3), accounting for 35% of the national total in 2024. Most of the emissions in CRT 1 were derived from Other sectors (1A4) and the transport sector (1A3) as well as from fugitive emissions of oil and natural gas (1B) and accounted for about 10%, 10% and 3% of the national total, respectively. Emissions from manure management (3B) accounted for about 17% of the national total in 2024, see Figure 2.41.

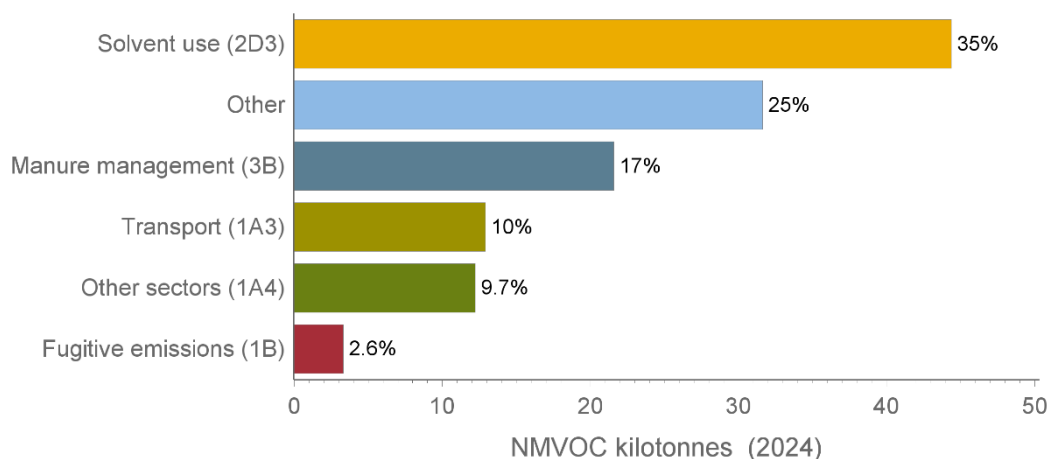


Figure 2.41. Emission sources of NMVOC in 2024 (kt).

The aggregated emissions of NMVOCs have declined by approximately 66% since 1990. Most of the emission reduction occurred in the energy sector (CRT 1) followed by the industrial processes and product use sector (CRT 2). The aggregated emissions in 2024 decreased by approximately 4% compared to 2023 and most of the decrease occurred in CRT 2, see Figure 2.42.

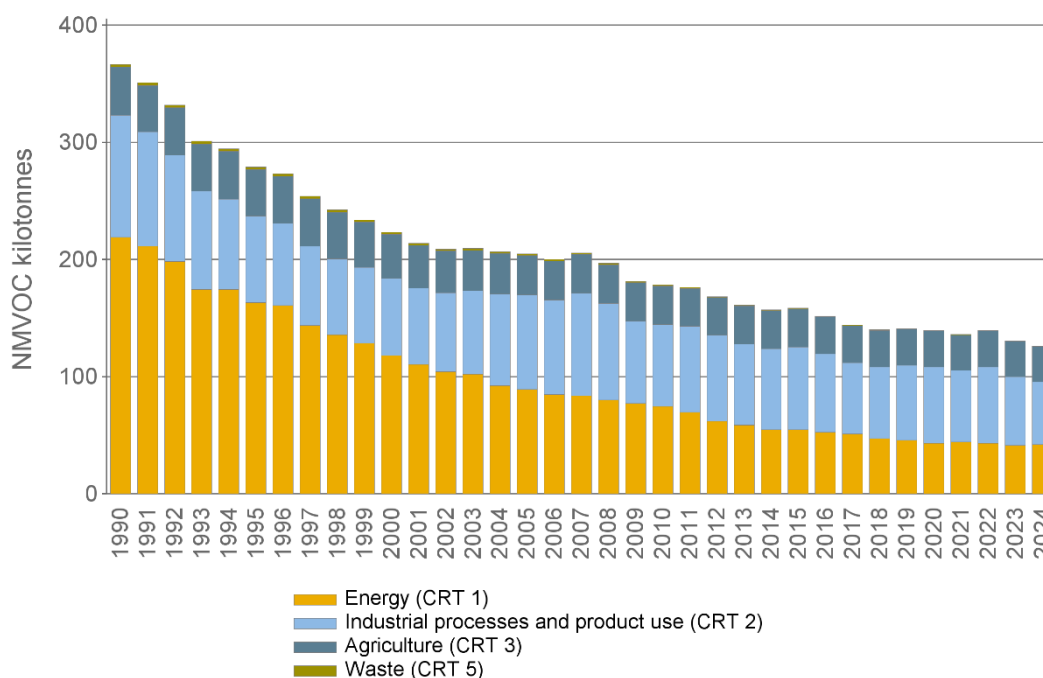


Figure 2.42. Emission trends of NMVOC 1990-2024 (kt).

Within the energy sector, the largest reduction of NMVOCs emissions occurred in the transport sector (CRT 1A3) as emissions decreased by about 91% since 1990. The main reason behind the reduction was the introduction of stricter emission standards in the EU regulation for road vehicles. Between 2023 and 2024, emissions from the transport sector decreased by 1%. Emissions from oil refineries (1B) have also decreased since 1990; by 78% due to technological improvements in the sector.

Since 1990, NMVOCs emissions from solvent use (2D3) have decreased by 51% due to national abatement measures, such as the reduction of solvents content in paints and coatings. Emissions from the agricultural sector (CRT 3) have declined by about 27% since 1990, mainly due to decreased numbers of livestock and hence reduced amounts of manure, especially from dairy cattle.

2.4.2 Nitrogen oxides (NO_x)

In 2023, the total emissions of NO_x were about 99 kt. The energy sector (CRT 1) accounted for most of the emissions (74%). The industrial processes and product use sector (CRT 2) and the agricultural sector (CRT 3) were responsible for about 13% each. Emissions from the waste sector (CRT 5) were insignificant.

In 2024, the transport sector (1A3) was responsible for 40% of total emissions. The manufacturing industries and construction (1A2) and the heat production and public electricity sector (1A1a) were responsible for about 13%, respectively, other sectors (1A4) contributed to 8% of the total emissions.

The pulp and paper industry (2H1) was the major source of NO_x emission in the CRT 2 sector. Most of the emissions in the agricultural sector were derived from agricultural soils (3D), see Figure 2.43.

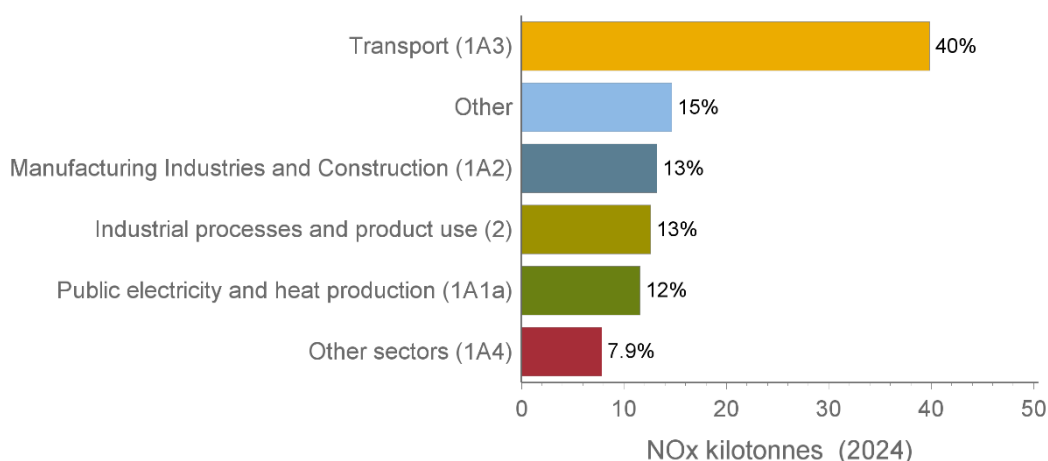


Figure 2.43. Emission sources of NO_x in 2024 (kt).

Since 1990, the aggregated NO_x emissions have declined by 65% and the emissions in 2024 were 4.7% lower compared to the previous year, see Figure 2.44. NO_x emissions from the transport sector (1A3) have declined by about 77% since 1990. Between 2023 and 2024, emissions from the transport sector decreased by 8%, mainly from road transportation. In urban areas, road traffic is the most significant contributor to emissions of NO_x but the introduction of catalytic converters on cars in the late 1980's and the subsequent gradually more stringent emission standards have contributed to the reduction of nitrogen oxide levels in urban areas.

NO_x emissions from energy industries (1A1) have been reduced by about 25% since 1990. However, the annual NO_x emission from (1A1) varies due to variable weather conditions. Weather influences the demand for heating of houses, public and commercial buildings, resulting in emission patterns that mirror the inter-annual variability of weather. The increased use of district heating and the introduced "NO_x charge" in the early 1990s have also contributed to reduction of NO_x emissions.

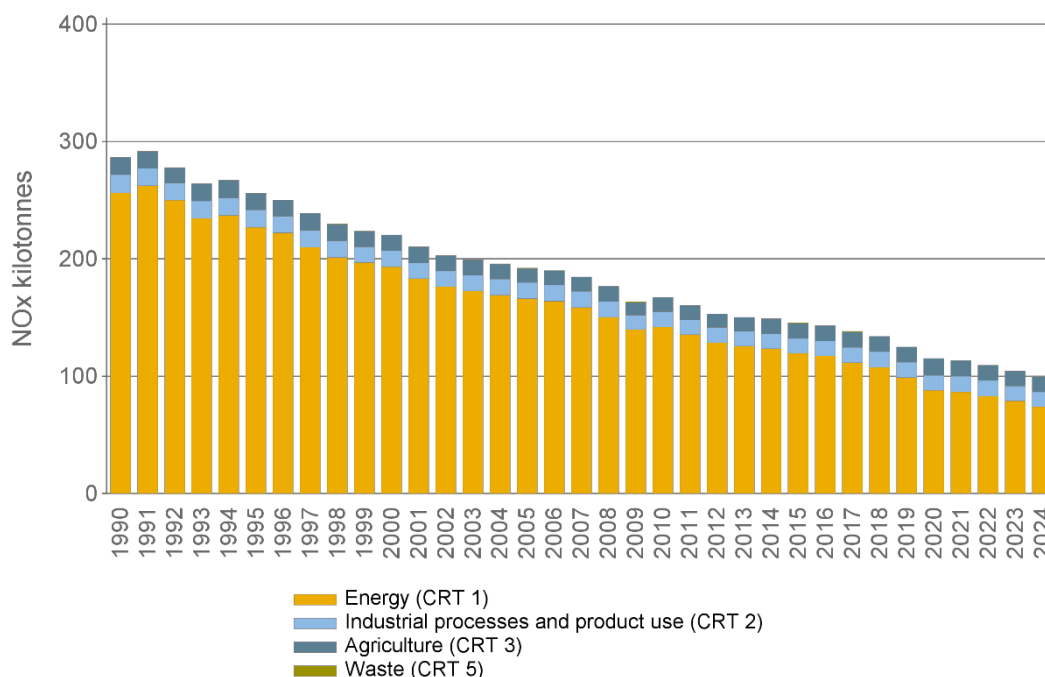


Figure 2.44. Emission trends of NO_x 1990-2024 (kt).

Emissions of NO_x from the industrial processes and product use sector (CRT 2) have decreased by about 18% since 1990. Mineral- chemical- and metal industries are responsible for this reduction. Since 1990, emissions from the agricultural sector have declined by 13% due to reduced use of N-fertilizer and the reduction of the amount of manure following a decreasing number of livestock, especially in dairy cattle and swine. There have also been improvements in manure management at the national level.

2.4.3 Carbon monoxide (CO)

The aggregated emissions of carbon monoxide (CO) have decreased by 76% since 1990 and were around 259 kt in 2024. Emissions in 2024 were 2% lower than 2023.

In 2024, the energy sector (CRT 1) accounted for most of the emissions (89%). Most of the remaining emissions were derived from the industrial processes and product use sector (CRT 2). Emissions from the waste sector (CRT 5) were insignificant.

In 2024, Other sectors (1A4, mainly residential heat production (1A4b) and commercial /institutional (1A4a)) accounted for 51% of the total emissions. The share of the transport sector (1A3) was 30%. Emissions from manufacturing industries and construction (1A2) and the industrial processes and product use sector (mainly metal industry (2C) and pulp and paper industry (2H1)), accounted for about 5.7% and 11%, respectively of the emissions in 2024, see Figure 2.45.

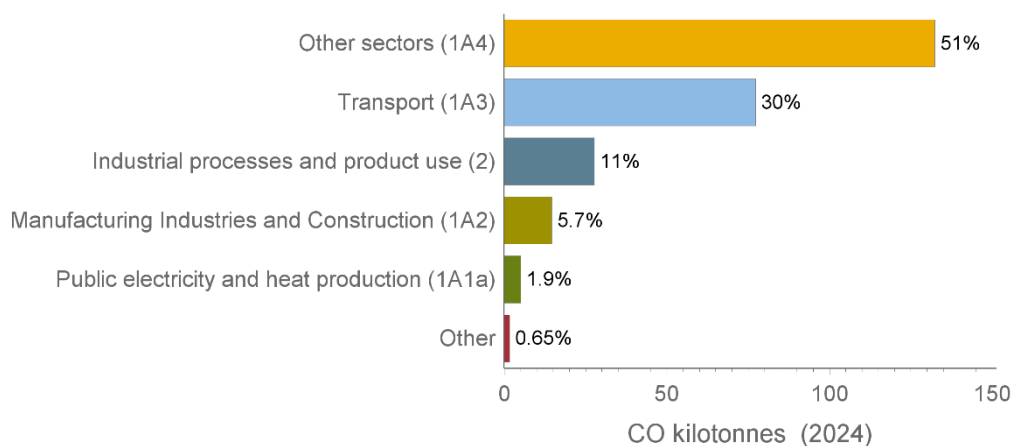


Figure 2.45. Emission sources of CO in 2024 (kt).

Since 1990, emissions from the energy sector (CRT 1) have declined by 78% of which the transport (1A3) was responsible for most of the reduction. This was achieved as new fuel-driven vehicles sold in Sweden have been equipped with catalytic converters that convert CO gas and other unburned hydrocarbons to CO₂ and water vapor. Emissions of CO from the industrial processes and product use sector (CRT 2) have increased by about 27% since 1990, mainly from aluminum production (2C3) and pulp and paper industry (2H1), due to increased production, see Figure 2.46.

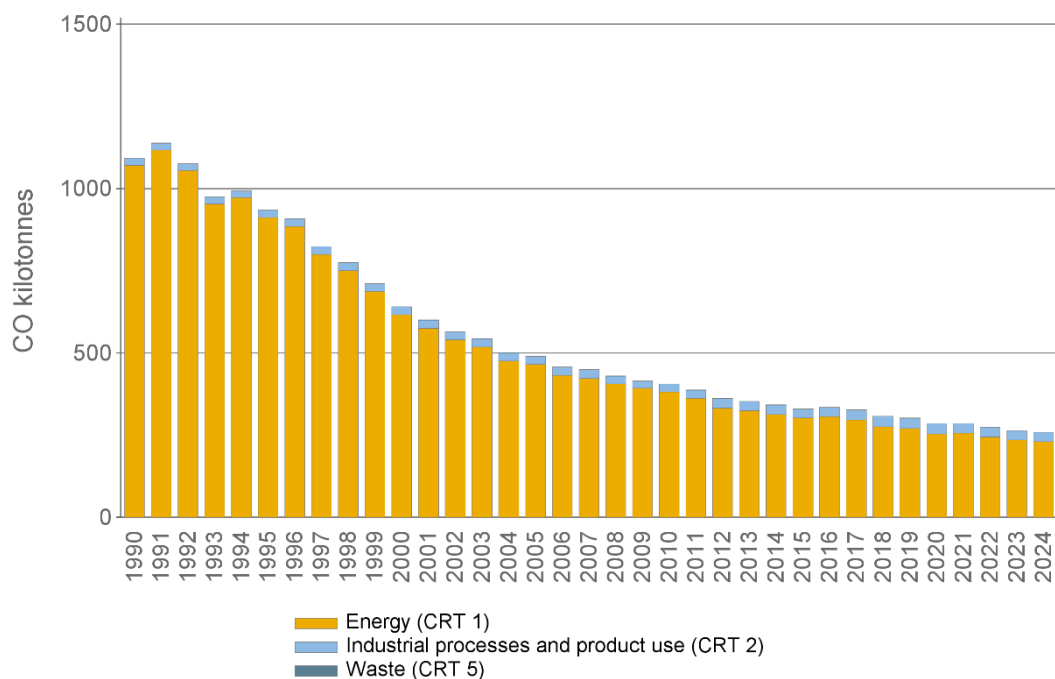


Figure 2.46. Emission trends of CO 1990-2024 (kt).

2.4.4 Sulphur dioxide (SO₂)

Emissions of SO₂ have decreased from about 103 kt in 1990 to about 14 kt in 2024, a reduction of 86%. Emissions in 2024 were about 2% lower than the previous year. In 2024, 42% of the emitted SO₂ was derived from the energy sector (CRT 1), while the industrial processes and product use sector (CRT 2) was responsible for the remaining emissions (58%). Emissions from the waste sector (CRT 5) were insignificant.

Most of the SO₂ emissions were derived from Metal industry (2C) and public electricity and heat production (1A1a), accounting for 30% and 17%, respectively. The manufacturing industries and construction sector (1A2) was responsible for 15% and the Other sectors (1A4) for 4% of the total emissions in 2023. The transport sector accounted for 2% of the emissions. see Figure 2.47.

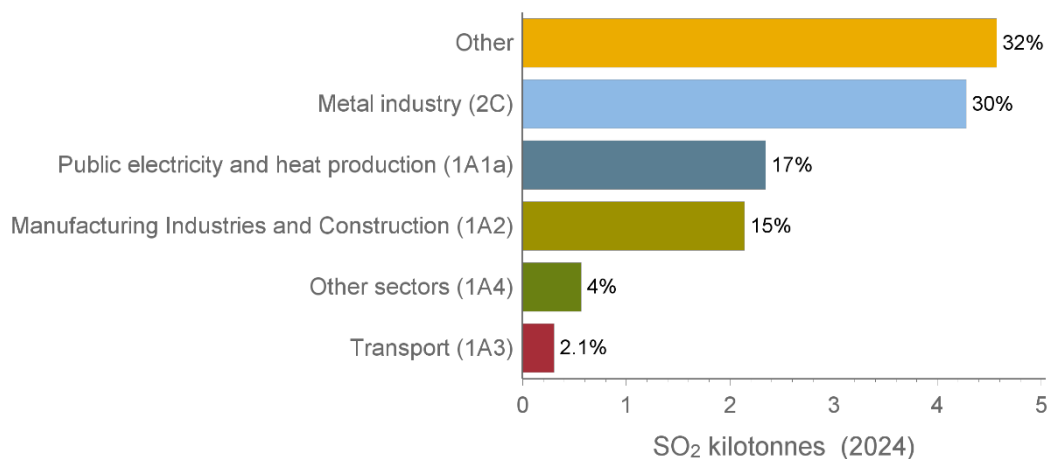


Figure 2.47. Emission sources of SO₂ in 2024 (kt).

Emission of SO₂ from transport (1A3) has declined by 97% since 1990. A similar trend can be observed in other subsectors within the energy sector, such as the energy industries (1A1), the manufacturing industries and construction (1A2) and Other sectors (1A4), which have declined between 87% and 96%. Emissions from the industrial processes and product use sector (CRT 2) have declined by 76% since 1990, see Figure 2.48. The main reason for the reduction of emission was a transfer from fuels with high-sulfur content to very low-sulfur content fuels. A tax on sulfur, introduced in 1991, has been important in this transition.

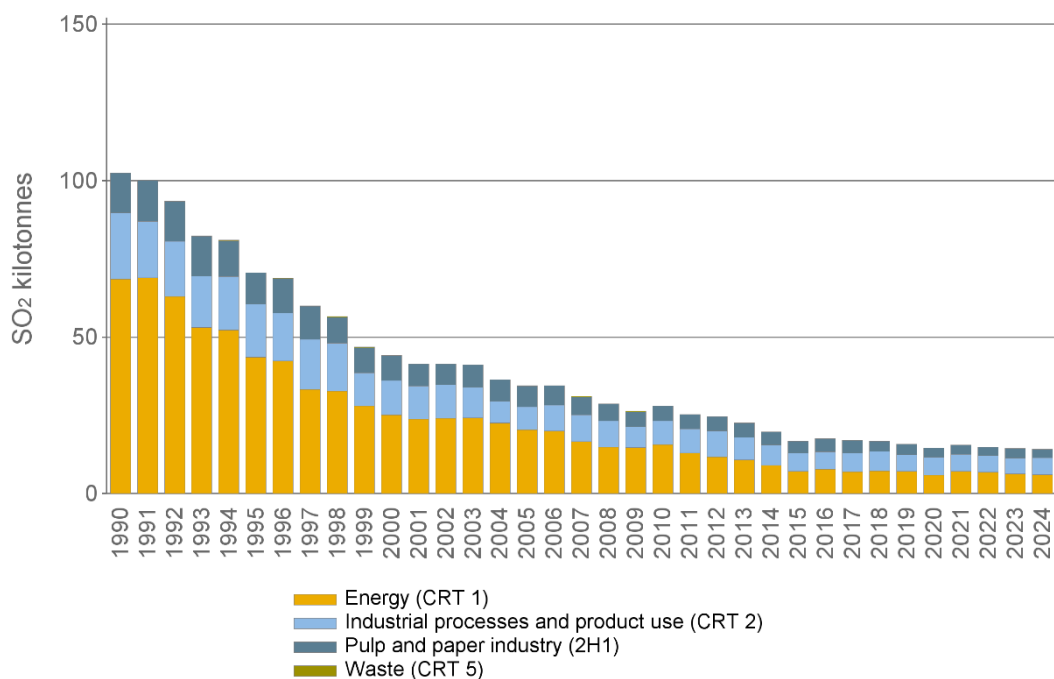


Figure 2.48. Emission trends of SO₂ 1990-2024 (kt).

The pulp and paper industry (2H), and the metal industry (2C) were responsible for most of the SO₂ emission reduction within CRT 2. Domestic navigation (within Water-borne navigation CRT 1A3d) contributed to about 1% of the aggregated SO₂ emissions in 2024 and decreased by 92% compared to 1990, due to a switch to oils with lower sulphur content.

3 Energy (CRT sector 1)

3.1 Overview of sector

The energy sector includes emissions from fuel combustion (CRT 1.A) and fugitive emissions from fuel production and handling (CRT 1.B). Energy consumption per capita is high in Sweden compared to other OECD countries. This is because of the availability of natural resources such as forests and hydropower, which led to the early and rapid expansion of energy-intensive industries. Sweden's geographical location, with low mean annual temperatures also explains the high demand for energy for heating. The energy sector, including transport, has long accounted for a major part of Swedish greenhouse gas emissions and emissions of carbon dioxide dominate overwhelmingly in this sector. However, carbon dioxide emissions per capita from the energy sector are relatively low in Sweden compared with other industrialized nations. This is due to a relatively high use of hydropower and nuclear power and low use of fossil fuels, as well as the use of energy and carbon dioxide taxation for limiting the emissions of carbon dioxide³⁵.

As can be seen in Figure 3.1, in the energy sector, emissions of CO₂ contribute about 98% of the total greenhouse gas emissions (in CO₂-eq.) in 2024. Emissions of total greenhouse gases from the energy sector have decreased by 27% from 57 041 kt CO₂-eq. in 1990 to 41 451 kt CO₂-eq. in 2024, mainly due to reduced fossil fuel consumption in the residential sector (CRT 1.A.4) and the manufacturing and construction sector (CRT 1.A.2) (Figure 3.2).

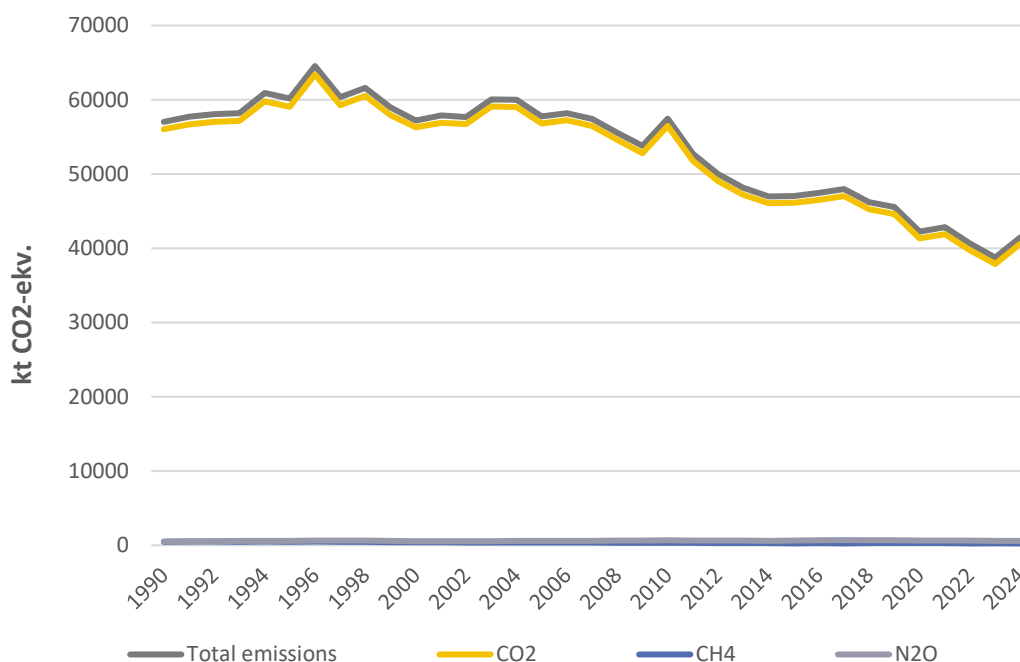


Figure 3.1. Total emissions of all greenhouse gases calculated as Gg CO₂-eq. from CRT 1 Energy.

³⁵ Ministry of the Environment, 2001

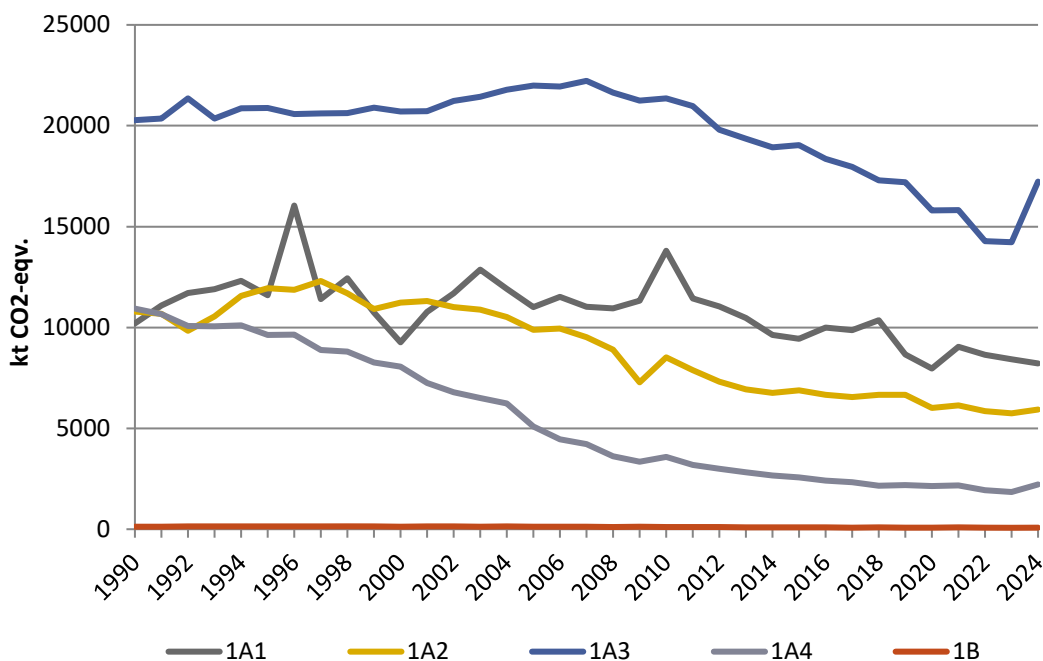


Figure 3.2. Total emissions of all greenhouse gases calculated as CO₂-eq. from the different sub-sectors within the Energy sector. 1A1 Energy industries. 1A2 Manufacturing industries and construction. 1A3 Transport. 1A4 Other sectors. B Fugitive emissions.

As shown in Figure 3.2, the transport sector (CRT 1.A.3) accounts for the largest part of the GHG emissions from the energy sector. In 2024, the CO₂-eq emissions from the transport sector rose sharply. This increase is due to a lowered reduction mandate for diesel and gasoline, leading to increased emissions of fossil CO₂. Emissions from public electricity and heat production (CRT 1.A.1) varies mainly because of temperature variations between years. As mentioned earlier, the emissions from residential heating (CRT 1.A.4) are decreasing due to a shift from usage of heating oils to district heating. In manufacturing industries and construction (CRT 1.A.2), the three largest industries in terms of fuel consumption are the pulp and paper industry, the chemical industry and the iron and steel industry. Despite rising industrial production, oil consumption has fallen sharply since 1970. This has been possible due to increased use of electricity and improved energy efficiency.

The large emissions from CRT 1.A.1 in 1996 and 2010 are mostly due to the cold winters those years and low production of nuclear energy, which meant that the demand of electricity and heat had to be met by combustion-based energy. In 2011, conditions were less extreme and emissions, especially from electricity and heat production, decreased considerably. The dip in emissions from manufacturing industries and construction in 2009 reflects the economic conditions resulting in lower demand of e.g. iron and steel. The covid pandemic influenced almost all sectors and led to a decrease in emissions in 2020. The increase of emissions between 2020 and 2021 are due to increased consumption of liquid and gaseous fuels in the energy production sector. There are two refinery facilities producing hydrogen. One started in the 1980s. The increase in fugitive emissions from oil and natural gas (CRT 1.B.2) from 2006 is caused by the other facility that put into operation full scale production of hydrogen.

3.2 Fuel combustion (CRT 1.A)

Emissions from fuel combustion, CRT 1.A, are allocated to a number of subsectors.

CRT 1.A.1 energy industries, e.g. public electricity and heat production plants, combustion activities within oil refineries, and combustion related to solid fuel production, i.e. coke ovens.

CRT 1.A.2 manufacturing industries, combustion-related emissions in manufacturing industries and construction and working machinery within the construction sector allocated to this subsector. Emissions from working machinery within the construction sector are allocated to CRT 1.A.2, but apart from that, CRT 1.A.2 includes only stationary combustion.

CRT 1.A.3, emissions from **domestic transport** include aviation, road traffic, railways and navigation.

CRT 1.A.4, emissions from **other sectors**, include stationary and mobile sources in households, service, agriculture, forestry and fisheries.

CRT 1.A.5, emissions from **other combustion**.

Emissions from **International aviation and international navigation (international bunkers) and multilateral operations**, CRT 1.D, are not included in the national total.

Emissions from fuel combustion in Sweden are, if not otherwise stated, determined as the product of fuel consumption, thermal value and emission factors (EF) as shown in the formula:

$$\text{Emissions}_{\text{fuels}} (\text{unit}) = \sum \text{Fuel consumption} (\text{unit}) * \text{thermal value}_{\text{fuels}} * \text{EF}_{\text{fuels}}$$

Different tier methods are used for different sub-sectors as discussed in the sections below. Activity data sources, thermal values and emission factors are described in detail in Annex 2.

Please note that some fuel types are used in industrial processes rather than for energy purposes. This is for example the case for coal and coke in the metal industry. Emissions from these fuels are thus accounted for under CRT 2 and methods used are described in section 4.

3.2.1 Comparison of the sectoral approach with the reference approach

The 2006 IPCC Guidelines states that it is good practice to compare the sectoral bottom-up estimation of emissions from fuels with a top-down approach based on fuels supply statistics. Figure 3.3 shows the differences in fuel consumption and CO₂ emissions between the Reference and Sectoral Approach for all fossil fuels 1990-2024.

Fuel consumption and CO₂ emissions from the reference approach differ with more than 2% from the sectoral approach for most years. However, the energy consumption and emissions in reference approach is mostly lower than the sectoral approach. This is mainly due to differences in definitions of fuels for non-energy purposes between the Swedish energy balances and the 2006 IPCC Guidelines, as well as large statistical

differences in fuel supply reported in the Swedish energy balances but not taken into account in the reference approach. A more detailed discussion on the reference approach and the differences compared to the sectoral approach is provided in Annex 4.

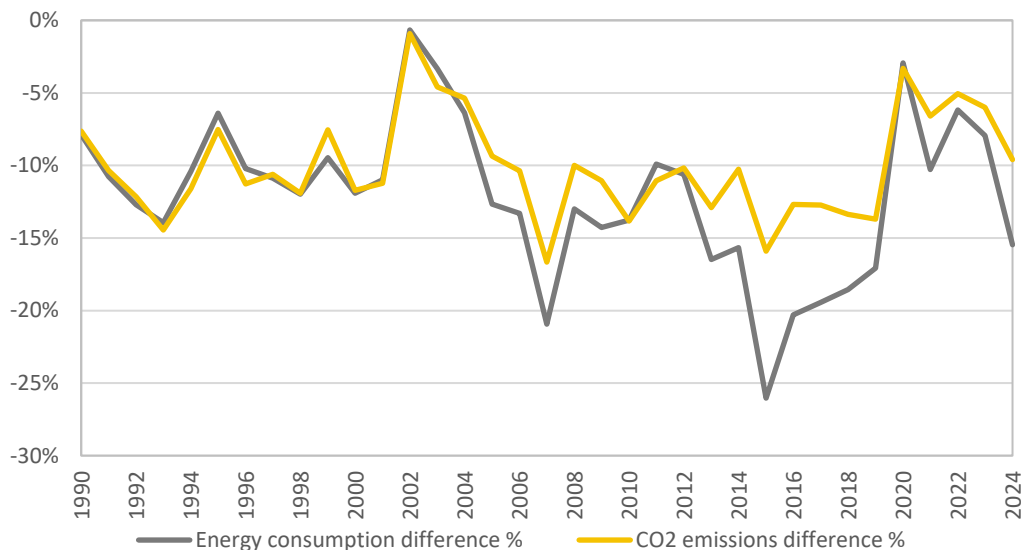


Figure 3.3. Differences between Reference Approach and Sectoral Approach (Reference minus Sectoral expressed as percent of sectoral approach).

3.2.2 International bunker fuels

This sector covers emissions from fuel bought in Sweden and used for international navigation and aviation as well as multilateral operations.

Emissions from international bunkers for aviation and navigation are not included in the national total but instead reported separately as a memo item in CRT 1.D. This is in accordance with the IPCC Guidelines. However, when the Swedish emissions are evaluated, international bunkers are important, as greenhouse gas (GHG) emissions from international bunkers are almost ten times higher than from domestic navigation and aviation and have increased significantly since 1990. The increase of GHG emissions can be explained by increased travel abroad by flight, an increase in freight transport by shipping and an increased market share for Swedish bunker companies. For more information regarding the increase of GHG as a result of an increase in consumption of bunker fuels, see chapter 2.3.6. The corona pandemic had a profound impact on international aviation in 2020.

3.2.2.1 INTERNATIONAL AVIATION, CRT 1.D.1.A

Bunker fuel for aviation is defined as fuel used for international aviation purchased in Sweden and used for flights with a destination abroad. This includes emissions from the whole flight cycle, i.e. both the LTO and the Cruise phase.

- LTO (Landing and Take-Off): aircraft emissions that occur *below* an altitude of 3000 feet)
- Cruise: aircraft emissions that occur *above* an altitude of 3000 feet.

The emissions from both domestic and international aviation, reported to the UNFCCC, are based on activity data from the monthly survey on supply and delivery of petroleum

products from Statistics Sweden (see Annex 2) as well as fuel and emission data reported by the Swedish Transport Agency (STAg). The methodology for calculating national emissions is the same for all years with a few exceptions for the earlier years.

In 2020, the corona pandemic had an unprecedented impact on international aviation, causing emissions to fall below the levels of 1990 for the first time since 1993. In 2024, the greenhouse gas (GHG) emissions from international aviation decreased for the first time since the pandemic. The GHG emissions from international aviation were 1813 kt CO₂-eq. in 2024, which is a 32% increase compared to 1990 but a decrease by 15% since 2023. See Figure 3.4 below. Biogenic jet kerosene is included in the emissions calculations from 2018, but the Swedish government did not introduce a mandatory reduction obligation until the year 2021. The same emission factors are used for biogenic as for fossil jet kerosene.

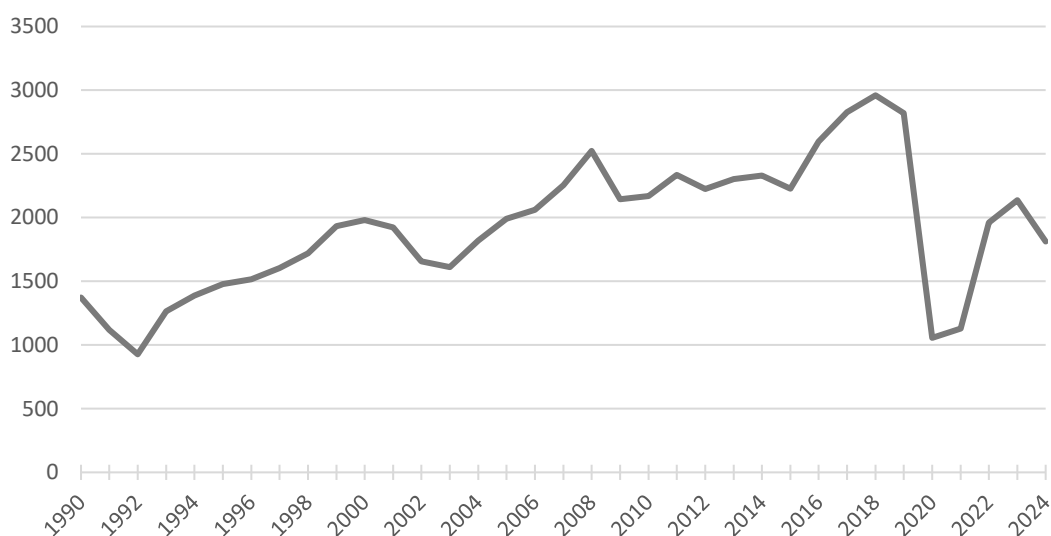


Figure 3.4. Total emissions of all greenhouse gases calculated as CO₂ eq. from international aviation 1990-2024 (kt).

The Swedish Transport Agency (STAg) have an obligation to report the emissions from aviation in accordance with the Swedish climate regulation. The fuel consumption and emissions published by STAg, are calculated by the Swedish Defence Research Agency (FOI) by using an estimation model and input data provided by STAg regarding:

- Airport of departure and arrival
- Type of aircraft
- Number of flights
- Number of passengers
- International or domestic flight

A database with information regarding 200 different types of aircraft is also used. The emission data regarding different types of aircrafts in the database originates from “ICAO Engine Exhaust Emission Data Bank”. All this data is used to calculate emissions and amounts of burnt fuel for total flight time as well as for aircraft movements below 3000

feet at the airports, the so called LTO cycle. The FOI has in a published report described their method for estimating the emission from aviation³⁶.

Due to the fact that Swedish airports generally are smaller than international airports in other countries; taxi times are much shorter for domestic flights as well as climb-out and take-off times compared to the International Civil Aviation Organization (ICAO) standards that the IPCC guidelines follow³⁷. As a result, the traffic from Swedish airports consumes less fuel and gives rise to less emissions.

The results from the emission calculations are aggregated into four groups: domestic landing and take-off (LTO), domestic cruise, international LTO and international cruise. The estimated fuel consumption and emissions are then adjusted to correspond to the fuel statistics from the monthly survey on supply and delivery of petroleum products from Statistics Sweden (see Annex 2).

This is in line with 2006 IPCC Guidelines, and data of good quality exists from 1995 and onwards.

Net calorific values and emission factors for CO₂ and SO₂ are obtained from FOI. The emissions of HC are estimated by STAg and split into NMVOC and CH₄ based on the ratio according to the EMEP/EEA Air Pollutant Emission Inventory Guidebook 2013³⁸. N₂O emissions from LTO are estimated by using the number of LTO cycles reported by FOI together with emission factors from EMEP/EEA Guidebook 2013. N₂O emissions from the Cruise phase are based on delivered amounts of fuel for cruise activities estimated by FOI, together with emission factors according to the EMEP/EEA Guidebook 2013. All emissions estimated by STAg are adjusted to be in line with the national fuel delivery statistics.

The number of LTO cycles in 1990-1994 was estimated by measuring the mean value for LTO cycles for domestic and international flights in 1995-2000. Emissions of CO for 1990-1994 were calculated by comparing the ratio between CO and CO₂ emissions in 1995. The same ratio was applied for 1990-1994. The calculation of NO_x emissions was made in a similar way as for CO emissions. The emissions of HC in 1990-1994 were estimated by extrapolation.

3.2.2.2 INTERNATIONAL NAVIGATION, CRT 1 D1B

International bunkers from navigation are defined as fuels bought in Sweden, by Swedish or foreign-registered ships, and used for transportation to non-Swedish destinations.

International freight transport activity has increased, as the volume of goods transported has grown and globalisation of trade and production systems has led to goods being transported over greater distances. Another factor for the increased emissions could be that more shipping companies choose to refuel in Sweden, as Swedish refineries produce low-sulphur marine fuels meeting strict environmental standards. Fluctuations in bunker volumes between years are also dependent on fuel prices in Sweden compared to ports in other countries. See chapter 2.3.6. for more information.

³⁶ Mårtensson, T. & Hasselrot, A., 2013.

³⁷ Gustafsson, 2005.

³⁸ In EMEP/EEA Guidebook 2016 and 2019 the methodology has changed and requires more precise input data. Therefore, Sweden still uses the methodology described in the 2013 edition.

The emissions from international navigation are estimated applying Tier 2 and the emissions of GHG from international shipping was 5112 kt CO₂-eq. in 2024. This is a decrease by 6% compared to 2023 but the emissions of greenhouse gases have more than doubled since 1990. The total emissions of all greenhouse gases calculated as CO₂-eq. from international navigation can be seen in Figure 3.5.

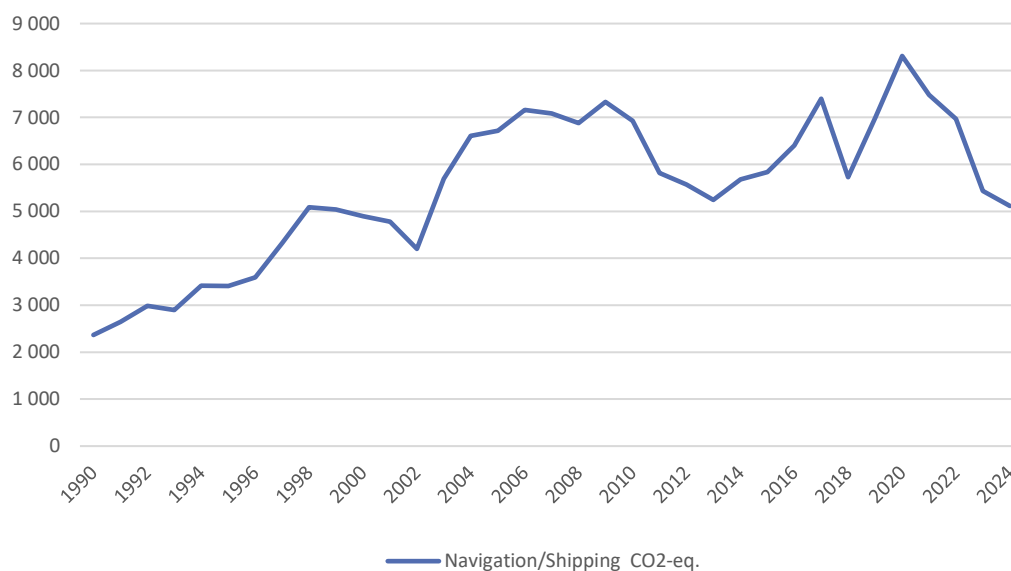


Figure 3.5. Total emissions of all greenhouse gases calculated as CO₂ eq. from international navigation 1990-2024 (kt).

The split between fuel used for national and international navigation, except for leisure boats, was based on the monthly survey on supply and delivery of petroleum products³⁹ until submission 2020. However, as it was problematic for fuel suppliers to separate fuel distributed to national respectively international navigation, the monthly survey of fuel supply statistics was revised in 2018. The reported fuel for national and international navigation was merged in the survey to represent the total fuel supply for navigation.

As from submission 2020, the fuel consumption by international navigation is estimated as the difference between the fuel used by domestic navigation, which is based on the Shipair model, and the total supply of fuel for navigation in the monthly survey of fuel supply statistics. For more information regarding the methodology for domestic navigation, see section 3.2.19.2. The exception to the rule is the consumption of liquefied natural gas (LNG), which is based on a survey.

The use of LNG as a shipping fuel increased rapidly until 2021 but has since declined due to increasing gas prices. The volumes of LNG are small compared to other fuels in international navigation, but the amount of LNG has a big impact on the methane emissions from shipping due to methane slip. A survey to estimate the use of LNG by shipping has been conducted annually since 2020 and shows a consumption of LNG since 2018. The Shipair model can distinguish LNG powered ships, and their consumption of

³⁹ Statistic Sweden. Monthly fuel, gas and inventory statistics. See annex 2 for more information regarding different surveys.

LNG is subtracted from the Shipair model to avoid double counting, as this data is taken from the LNG survey. The emission factors for LNG are based on a study from 2020⁴⁰.

3.2.2.3 MULTILATERAL OPERATIONS, CRT 1.D.2

Emission from multilateral operations should be reported separately as a memo item in CRT 1.D.2, in accordance with 2006 IPCC Guidelines.

The fuel for military operations abroad is, according to information from the National Defence, not bought in Sweden but in the country where the operation takes place and therefore not included in the Swedish inventory.

3.2.3 Feedstocks and non-energy use of fuels

The carbon in fuels used for non-energy purposes should not be reported under the fuel combustion activities in the CRT 1A. The 2006 IPCC Guidelines group fuels used for non-energy purposes in three categories: feedstocks, reductants and other non-energy products. In Sweden, examples of fuels used for non-energy purposes are coal and coke for iron and steel production processes, natural gas and naphtha as feedstock in refineries and chemical industries, bitumen for asphalt making, and lubricants and paraffin waxes as products use.

Fuel quantities 1990-2024 on feedstocks, reductants and other non-energy use of fuels reported in CRT 1Ad are based on data on fuels used for CO₂ emission estimation in CRT 1B and CRT 2, i.e. based on several types of data sources.

The carbon emission factors used in CRT 1Ad is consistent with those used in other parts of the emission inventory.

3.2.4 CO₂ capture from flue gases and subsequent CO₂ storage

So far, storage of CO₂ does not occur in Sweden⁴¹. There are, however, several facilities with newly acquired environmental permits or in process for acquiring environmental permits for carbon capture⁴².

3.2.5 Country-specific issues

No country-specific issues are reported in this submission.

3.2.6 Public electricity and heat production (CRT 1.A.1.a)

3.2.6.1 SOURCE CATEGORY DESCRIPTION

Swedish electricity production is characterized by large shares of hydropower and nuclear energy. Wind power also constitutes a significant part of the electricity mix, and has increased significantly over time, although annual production shows minor fluctuations. Wind power affects the electricity balance and is also affected by the weather. The power generated by wind power might need the use of reserve power in cases of limited wind. For reserve power, in some cases fossil fuels are used. Only a small share of the electricity production is based on fuels used in conventional power plants. Public

⁴⁰ Hult, C. et al. 2020. Emission factors for methane engines on vehicles and ships

⁴¹ Geological Survey of Sweden, 2010.

⁴² Swedish Environmental Protection Agency 2025-02-20.

electricity and heat use vary between years, due to variations in ambient temperatures for instance. In addition, production of electricity based on fuels depends to a large extent on the actual weather conditions. Years with dry weather and cold winters have a significant effect on the use of fuel in electricity production since less electricity can be produced by means of hydropower and more electricity is needed for heating. The largest emissions from electricity production were thus in 1996, due to very dry and cold weather. The winters of 2009/2010 and 2010/2011 were unusually cold, leading to increased fuel consumption, particularly in 2010. Liquid fuels and natural gas accounted for most of this increase, although the higher use of natural gas during these years can largely be explained by the commissioning of new gas-fuelled facilities. The use of solid fuels also increased substantially between 2009 and 2010, but in this case the explanation is the recovery from the dip in production in the iron and steel industry in 2009, which thus affected the amounts of energy gases sold to the public electricity and heat production plants.

In Sweden, electricity and district heating are used to a large extent to heat homes and commercial premises. Increased use of district heating since 1990 to heat homes and commercial/industrial premises has led to increased energy efficiency and thus lower emissions. Emissions of methane and nitrous oxide have increased from electricity and heat production because of the increased burning of biomass fuels.

Electricity is an important energy source in the manufacturing industry, where the most important industries are the pulp and paper and the steel industry.

Since submission 2015, CRT 1.A.1.a is split in three categories according to the 2006 IPCC guidelines: 1.A.1.a.i= Electricity Generation, 1.A.1.a.ii = combined heat and power plants (CHP), and 1.A.1.a.iii = heat plants. The allocation to the three subcategories is based on the classification of the plant according to the Swedish Business Register. For the years before 1999, the classification of the categories CHP and electricity generation is doubtful and not transparently documented. Because of this, emissions from electricity generation are reported as IE, included in CHP, 1990-98. It should be noted that fuel combustion for electricity generation is very minor compared to fuel consumption in CHP plants.

The trend in fuel consumption in this sector varies depending on the production of hydroelectric power and weather variations between years. The largest changes in fuel consumption are for biomass fuels, where the consumption has increased significantly, mainly due to increased district heating. Between 2013 and 2024, the consumption of natural gas in this sector decreased by 91%, which resulted in a notable decrease in emissions for this sector total.

Production of district heating is currently to a large extent based on biomass and waste. There has been a shift from fossil fuels towards biomass since 1990. In 1990, 23% of fuels used were biomass including biogenic waste, and 5% was fossil waste. In 2022, 77% of all fuels used for district heating were biomass (including the biogenic fraction of waste), while waste (fossil fraction) accounted for 15%⁴³. These proportions have been quite similar during the last six years.

Since 1990, there has been a large increase in the use of district heating from 89 PJ (24.7 TWh) to 190.8 PJ (53.0 TWh) in 2024⁴⁴. However, due to the increased use of biomass,

⁴³ All numbers are according to data used in the greenhouse gas inventory this submission. The proportions given are calculated for heat production and may include plants in both 1.A.1.A.ii and 1.A.1.A.iii

reported greenhouse gas emissions from district heating were lower in 2024 than in 1990 since emissions from biomass are reported in the LULUCF sector rather than the energy sector.

The number and distribution of Swedish power stations in 2024 are presented in Table 3.1⁴⁴. Changes in number of plants and their installed effect have been minor in the production of electricity, but due to growing wind power the number of plants in the electricity sector have increased.

Table 3.1. Number and distribution of Swedish power stations 2024.

Type of plants	Number of plants	Gross Production GWh	Gross Production TJ
Total power stations	299 665	172 352	620 467
Power generation not based on fuels	299 466	109 432	393 955
Wind power	5 547	40 622	146 239
Hydropower	900	64 664	232 790
Solar power	293 019	4 146	14 925
Power generation based on fuels	199	62 920	226 512
Nuclear power	3	50 665	182 394
Conv. thermal power	196	12 255	44 118

A summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.2.

Table 3.2. Summary of source category description, CRT 1A1a, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1A1a	CO ₂	X (Gaseous fuels, Liquid fuels, Other fuels, Peat, Solid fuels)	X (Gaseous fuels, Liquid fuels, Other fuels, Peat, Solid fuels)		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	X (Biomass)	X (Biomass)		T2	CS	Yes

CS Country Specific. T2 Tier 2.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.6.2 METHODOLOGICAL ISSUES

Plant-specific activity data and country- and sector-specific emission factors are used, which is considered to be Tier 2 methodology. The activity data source for emissions in CRT 1.A.1.a is the Quarterly fuel statistics (KvBr), further described in Annex 2. Emission factors, also further described in Annex 2, are generally country-specific, but in a few cases, plant-specific emission factors are used. For energy gases purchased from the iron and steel works and combusted by public electricity and heat production plants, CO₂ emission estimates provided by the iron and steel works are used, which results in aggregate year-specific implied emission factors for blast furnace gas, coke oven gas and

⁴⁴Energimyndigheten 2025 (Slutgiltig statistik för el och fjärrvärme 2024, total heat production in Sweden).

steel converter gas that are used to calculate CO₂ emissions from the plants using these fuels in CRT 1A1a.

The most important fuels in recent years are wood fuels followed by solid waste. Greenhouse gas emission factors for wood are national⁴⁵. In submission 2015, solid waste was for the first time split into a biogenic and a fossil fraction, and the emission factors for CO₂ were revised. This is further described in Annex 2.

Since the Quarterly fuel statistics (KvBr) do not contain information on the fossil versus biogenic fractions of the waste, these fractions have been investigated separately. Emission factors for fossil and biogenic CO₂ were calculated using data collected by the Swedish Waste Management Association specifically for this purpose. Since 2015, eight facilities measured biogenic CO₂ emissions in the flue gas using the ¹⁴C method⁴⁶, creating a better basis for national emission factors than estimates of waste content. The new facility-specific emission factors are used to calculate emissions from each of the eight waste incinerators that measure biogenic CO₂ in flue gases, and weighted averages in respect to energy consumption are used for the rest of Sweden. The emission factor was updated for the years after 2015 (based on nine and ten facilities measuring the biogenic fraction, respectively).

The net calorific value (NCV) for waste varies due to the heterogenous nature of waste. In conjunction with the update of the emission factors, the national NCV was updated according to a survey made by the Swedish Waste Management Association that included specific data from 21 waste incineration facilities, covering 80-90% of the total incinerated waste. The resulting NCV was assumed to represent all incinerated waste in Sweden. However, the NCV values used were the ones reported from the facilities to the Quarterly fuel statistics (KvBr).

In emission year 2024, the fractions of biogenic and fossil waste for the eight largest plants were 51% and 49% respectively. These fractions vary in time and are applied since year 2015. The proportions 64% biogenic and 36% fossil are applied for the emission years from 1990 to 2014 for all plants. For the other plants, not included in the ETS⁴⁷, the average emission factor from the eight largest plants is used with a one-year delay.

Emissions from energy plants integrated with the iron and steel industry are allocated to CRT 1.A.2.a. This is discussed in chapter 3.2.9 and in detail in chapter 4.4.1.

Since submission 2015, emissions from combustion in manufacturing of nuclear fuels are included in CRT 1.A.1.a due to confidentiality reasons. These emissions are however extremely small and thus this reallocation from CRT 1.A.1.c does not affect any trends or conclusions on CRT level.

Due to confidentiality reasons:

- Liquid and gaseous fuels activity data and emissions are reported as C in CRT-tables in the codes 1.A.1.a.ii and 1.A.1.a for 2024.

⁴⁵ Boström et al, 2004.

⁴⁶ The ¹⁴C method measures the ¹⁴C isotope in the flue gases. ¹⁴C only exist in biogenic material as the isotope over time decays to mainly ¹²C, which is the isotope found in fossil material.

⁴⁷ Stripple et al, 2014.

3.2.6.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The Quarterly fuel statistics (KvBr) is a total survey for ISIC (International Standard Industrial Classification of All Economic Activities) 40 and the response rate is almost 100%. This provides the inventory with data of very good quality.

The variations in IEFs (implied emission factors) between years are normally small. The IEFs for solid fuels, however, are considerably more variable than for other fuel types due to the variable supply of energy gases from the iron and steel industry. As blast furnace gas has a much higher CO₂ EF than other solid fuels, the share of blast furnace gas has a very large influence on the aggregate CO₂ IEF for solid fuels. As the production in the iron and steel industry was much lower in 2009 than in other recent years, the share of blast furnace gas in CRT 1.A.1.a dropped, which explains the drop in CO₂ IEF for solid fuels in 1.A.1.a in 2009. The IEF for N₂O varies between the years. This is mainly because the use of coal, with a relatively high EF compared to e.g. steelwork gases, has decreased during the time series.

The IEFs for the group other fuels also vary between years because the emission factors for the fossil fraction of municipal solid waste are different from the emission factors for other fuels in this group. In recent years, municipal waste accounts for 75-82% of the consumption of “other fuels”. The remaining 18-25% is in most cases specified as “recycled fuel”, but before 2007 there is no such information. As the composition of “recycled fuel” is unknown, there are no specific emission factors for this fuel, so the general emission factors for “other non-specified fuels” are used. The CO₂ emission factor for this fuel is considerably lower than the emission factor for municipal waste. The emission factors are further discussed in Annex 2. There is no reliable information about the composition of municipal waste in the 1990’s, so the composition calculated by Stripple et al (2014)⁴⁸ is used for all years as described above.

Emissions of NO_x and SO₂ in relation to fuel consumption fluctuate slightly between years due to variations in the fuel mix. In the latest years, especially the SO₂ emissions in relation to fuel consumption have decreased due to a shift from residual fuel oils towards natural gas.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. Wood fuels are the most common fuels in this sector, but as CO₂ emissions from biomass are not included in the sectoral total of GHG emissions, CO₂ from combustion of peat, blast furnace gas and “other fuels” accounts for the largest contributions to the aggregate uncertainty of GHG emissions in CRT 1.A.1.a.

The activity data uncertainties are relatively low, 2% for all fuel groups except for other fossil fuels that are 3%. The CO₂ emission factor uncertainties are 2-5% for Liquid fuels, 10% for Solid fuels and 30% for Other fossil fuels and Peat and 30% for Biomass. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group.

⁴⁸ Stripple et al. 2014

3.2.6.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All quality procedures according to the Swedish QA/QC plan (including the Manual for SMED's Quality System in the Air Emission Inventories) have been implemented during the work with this submission.

All Tier 1 general inventory level QC procedures and all QC procedures listed in Good Practice Guidance section 8.1.7.4 applicable to this sector are used. The activity data has been subject to QA/QC procedures prior to the publishing of Quarterly fuel statistics (KvBr). In addition, the consumption of every type of fuel in the last year is checked and compared with previous years. If large variations are discovered for certain fuels, the consumption of these fuels is studied on facility level and if necessary, the staff responsible for the quarterly fuel survey is contacted for an explanation. IEFs are calculated per fuel, substance and CRT-code and checked against the emission factors to make sure that no calculation errors have occurred when emissions were computed.

The time series for all revised data have been studied carefully in search for outliers and to make sure that levels are reasonable. Remarks in recent review reports from the UNFCCC have been carefully read and taken into account whenever time limits allow. The results are verified by calculating CO₂ emissions with the reference approach and comparing results with the sectoral approach (see Annex 4).

A comparing study⁴⁹ from 2011 concluded that the Quarterly fuel statistics (KvBr) is of very good quality, and also the only data source that is ready in time for use for the last emission year.

3.2.6.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2026.

3.2.6.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.7 Petroleum refining (CRT 1.A.1.b)

3.2.7.1 SOURCE CATEGORY DESCRIPTION

Refineries process crude oil into a variety of hydrocarbon products such as gasoline and kerosene. During the refining process, dissolved gases are separated, some of which may be leaked or vented during processing. These emissions belong to CRT 1.B.2.a.iv and CRT 1.B.2.C.2.1 and are described in detail in section 3.3.2. However, due to confidentiality issues, all refinery emissions are reported in CRT 1.A.1.b. Disaggregated emissions are shown in Table 3.31 (section 3.3.2) for the years 1990-2020. Recent years cannot be presented disaggregated due to confidentiality reasons.

There are five refineries in Sweden. Three of these refineries produce fuel products such as gasoline, diesel and heating oils. The other two refineries mainly produce bitumen products and naphthenic special oils. One facility has a catalytic cracker; four facilities have hydrogen production plants (one of them was taken in use in 2020), and four of the

⁴⁹ Andersson, M., Eklund, V., Gerner, A., Gustafsson, T. Quality assurance of calculations for Reference approach. SMED Report 2012.

facilities have sulphur recovery plants. The five refineries account for more than 99% of the fuel consumption and emissions reported in CRT 1.A.1.b. In addition to the refineries, there are a few small manufacturers of e.g. lubricants which are also classified as International Standard Industrial Classification (ISIC) 23200. The emissions from these plants are also reported in CRT 1.A.1.b.

The fuel consumption in this sector consists mainly of refinery gas (liquid fuels), which is a by-product in the refining process. The energy use in this sector is between 26000 TJ (2019) and 38800 TJ (2015).

The implied emission factor for CO₂ for refinery gas is slightly lower for 2008 and later years when plant-specific emission factors are used. However, since the national emission factor used for earlier years is based on information from the refineries, the decreasing IEF is considered to reflect changes in production conditions which in turn alter the composition of the refinery gas.

A summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.3.

Table 3.3. Source category description, CRT 1.A.1.b, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1A1b	CO ₂	X (Gaseous fuels, Liquid fuels)	X (Gaseous fuels, Liquid fuels)		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. T2 Tier 2.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.7.2 METHODOLOGICAL ISSUES

Activity data for the five refineries was collected directly from each company for 1990-1999, since the Energy use in the manufacturing industry (ISEN) and Quarterly fuel statistics (KvBr) did not account for all fuels produced within refineries during these years. The corresponding energy content of all fuels was also collected, and individual thermal values were calculated for each operator and fuel. For 2000-2004, i.e. before the EU Emission Trading System (EU-ETS) was established, energy statistics was used as the data quality was improved compared to the 1990's and is considered to be sufficient for these years.

Data from the EU-ETS are used for four refinery plants for 2005 and 2007⁵⁰. For the fifth plant, data from environmental reports were used due to lack of transparency in ETS data in the early years. In 2008 and later years, the quality of EU-ETS data is considered to be very high for all five of the refineries, and thus this is the primary data source for the GHG inventory. However, most of the refineries report refinery gas and natural gas aggregated to the EU-ETS, and for these facilities, data from the environmental reports are used to allocate the proper amount of this fuel to gaseous fuels. Environmental reports

⁵⁰ Backman & Gustafsson, 2006.

are used for verification for all five refineries. For refinery gas, plant specific CO₂ emission factors reported to the EU-ETS⁵¹ are used for 2008 and later, since they are considered to be more accurate than the older national emission factor. The CO₂ emission factors for refinery gas are generally quite stable for each of the refineries, but the differences between the refineries are large.

For the smaller plants in ISIC 23200 mentioned above, activity data from the Quarterly fuel statistics (KvBr) are used together with national emission factors.

Due to confidentiality reasons:

- Reported emissions from the refineries under CRT 1B are included in 1A1b for the entire time series.
- Liquid and gaseous fuels activity data and all emissions are reported as C in the CRT code 1.A.1.b.

3.2.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The use of many different sources for this sector could lead to consistency problems. Data used in the inventory has been analysed and no (significant) signs of inconsistency have been found. E.g. the slight dip in fuel consumption in 2007 is visible in all available data sources and is thus real and not caused by the shifting of data sources.

CO₂ from refinery gas is by far the largest source of uncertainty due to the fact that refinery gas accounts for about 90% of the energy from fuel combustion in this sector. The assigned uncertainties are based on information directly from the facilities. These are updated regularly but not annually. The uncertainties for stationary combustion were revised in submission 2020 and set on fuel group aggregation level. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group. The uncertainty of the activity data for Liquid fuels is around 2%, but the uncertainty of the NCV is unknown, so the total uncertainty for the activity data was estimated to 10%. The uncertainty of the activity data for Gaseous Fuels is lower, 2%.

3.2.7.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for CRT 1.A.1.b as for 1.A.1.a described above. For each of the five refineries, EU-ETS data for the latest year are verified against the refineries' legal environmental reports. During the national peer review remarks have been made that gaseous fuels are reported as "NO" (Not occurring) for 2003 and questioned if this is the correct notation key. Investigations of activity data files used in earlier submissions show that in 2001 to 2003, sweet gas (a by-product from the cryogen plant) was probably miscoded as natural gas in submission 2005. Data for 2003 has been revised in later submissions, i.e. sweet gas has been re-coded as refinery gas. Environmental reports show that natural gas has been used in CRT 1.A.1.b in 2004 and later, but not in 2003, and hence "NO" is considered to be the correct notation key for 2003. The environmental reports for 2001-2002 are no longer available, and hence there is not enough information to recode the natural gas reported in 2001 and 2002, even though it might be miscoded refinery gas.

⁵¹ Technically, the emission factors are implied emission factors since amounts of fuel, NCV:s and emissions are reported.

Quality control and established procedure for annual cross-sectoral control of reported emissions on a facility level is being conducted annually to improve emission allocation between the energy sector (CRT 1.A) and IPPU (CRT 2). In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double counting using a developed quality control tool. For further detailed information see section 1.3.5 concerning QA/QC and Verification in general.

3.2.7.5 SOURCE-SPECIFIC RECALCULATIONS

All emissions from refineries are reported in CRT 1A1b for year 2021 onwards due to confidentiality. To keep a consistent time series, emissions from refineries for all years are reported in CRT 1A1b starting from submission 2026. Minor corrections for fugitive emissions are described in section 3.3.2.5.

3.2.7.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.8 Manufacture of solid fuels and other energy industries (CRT 1.A.1.c)

3.2.8.1 SOURCE CATEGORY DESCRIPTION

This category includes emissions from two plants belonging to one company, producing coke to be used in blast furnaces for production of iron. The plants are integrated into the iron and steel production industry⁵². The trend is related to the amounts of iron and steel produced, and hence there was a dip in 2009. Since 2009, the production and the emissions have increased gradually, and in 2012 the emissions were about the same level as in the early 2000's.

Charcoal production in Sweden and the related emission from the activity is derived from small companies that are included in the emission estimates from small industries (CRT 1.A.2.g). Since the activity data for this sector is aggregated from the national energy balances, it is thereby not possible for Sweden to separate the emissions that are related to charcoal production from the aggregated data. Hence, the CH₄ emissions from charcoal production are reported in CRT 1.A.2.g. The notation key for CH₄ emissions in 1.A.1.c is reported as IE. Fugitive emissions from charcoal production are reported in CRT 1.B.1.b.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.4.

⁵² Fuel combustion in manufacturing of nuclear fuels was included in CRT 1A1c in previous submissions, but for confidentiality reasons the very small emissions from these facilities have been included in CRT 1A1aiii instead.

Table 3.4. Summary of source category description, CRT 1A1c, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1A1c	CO ₂	X (Solid fuels)	-		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. T2 Tier 2.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.8.2 METHODOLOGICAL ISSUES

Activity data on coke production is taken from environmental reports. CO₂ emissions are estimated based on carbon balances for the two integrated iron and steel production facilities and information on allocation on different categories from the facilities' environmental reports.

Emissions of N₂O, CH₄, NMVOC and CO are estimated with Tier 2 methodology with national emission factors. Estimates of emissions of SO₂ and NO_x are available from environmental reports on an aggregate level, and these emissions are distributed over the different CRT codes (1.A.1.c, 1.A.2.a, 1.B.1.c and 2.C.1, SO₂ also 2.B.5 and 1.B.1.b) according to the activity data distribution. The methodology is described in more detail in the section (CRT 2.C.1.2.).

3.2.8.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time series is considered to be very consistent as all data on emissions from the coke producing plants has been collected directly from the facilities. The IEF for coke oven gas and blast furnace gas starts to vary from 2003. The reason for the interannual variability of the IEF for coke oven gas and blast furnace gas are the relative amounts that vary in time. Between 1990 and 2002, this variability is not seen since the shares of coke oven gas and blast furnace gas were constant within the same oven due to aggregated activity data. There is no new measurement technique introduced in 2003. The reason for the introduced variability of data from 2003 is due to the facility starting to measure emissions at a finer level than before. The constant proportions of the gases are used for 1990-2002 but not for the years 2003 onwards, since the facility started to report the fuel types at finer level than before (for 1990-2002, only the total amounts of fuels are available, without division into coke oven gas, LD gas, BF gas). Sweden has tried to retrieve the detailed information on the amounts of the gases for 1990-2002 without success – it was therefore decided to extrapolate average values of the shares calculated for the period 2003-2007. The data for 1990-2002 is thus already disaggregated using actual information from 2003 onwards – and the assumption on the constant values of shares results in much lower variation in the IEF for 1990-2002 than for the years from 2003 onwards, when the actual data and different shares for different years are used. In submission 2021 Sweden tried again to retrieve the detailed AD at finer level with no result. The information needed of distribution of internal gases and energy consumed is of bad quality and would require large resources to retrieve. However, the total emissions are known and believed to have good certainty, which leaves to the decision that introducing estimated variability in the 1990-2002 time series will increase the overall uncertainties.

Solid fuel consumption decreased considerably in 2009 due to lower production of coke caused by lower demand of primary iron and steel. In 2010, the demand increased and thus the fuel consumption increased to about the same level as before 2009.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. CO₂ from blast furnace gas and coke oven gas are the dominating sources of uncertainty. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group.

3.2.8.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The estimation of emissions from coke production is based on carbon balance calculations and the methodology is thoroughly described in chapter 4.

3.2.8.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2026.

3.2.8.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.9 Iron and steel (CRT 1.A.2.a)

3.2.9.1 SOURCE CATEGORY DESCRIPTION

The iron and steel industry are, together with the pulp and paper industry and the chemical industry, one of the most energy intensive industrial branches in Sweden. In 2009, fuel consumption in the iron and steel industry fell sharply as a consequence of decreased production (2.8 Mt of steel) due to the global recession. In 2024, the production of raw steel was 4.025 Mt⁵³, and decrease with 5.5% compared to 2023. Emissions from iron and steel companies with less than 10 employees are allocated to CRT 1.A.2.g because the model estimate of fuel consumption for these small companies is produced at an aggregate level and not separated by ISIC code.

A summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.5.

⁵³ The Swedish Steel Producers' Association, 2025-01-31. Ståläret 2024 – en kort översikt. 2024. [stalaret-2024---en-sammanställning-slutversion-v1.pdf](#)

Table 3.5. Summary of source category description, CRT 1.A2a, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.2.a	CO ₂	X (Gaseous fuels, Liquid fuels, Solid fuels)	X (Liquid fuels, solid fuels)		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. PS Plant Specific. T2 Tier 2. T3 Tier 3.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.9.2 METHODOLOGICAL ISSUES IRON AND STEEL, CRT 1.A.2.A

During 2009, a new methodology was implemented for the two largest primary iron and steel works. This is described in section 3.2.9.2.1.

Activity data for all other facilities is, if not otherwise stated, collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 onwards, further described in Annex 2.

Emissions reported from primary steel works and other iron and steel works are reported in both CRT 1.A.2.A and in CRT 2.C.1 since some emission arises from fuel combustion and some from reducing agents in the process. The text in this section is hence closely connected to the text in the section CRT 2.C.1.a (secondary steel) and CRT 2.C.1.b (primary pig iron and steel).

Due to confidentiality reasons, activity data and emissions of CO₂ emissions, CH₄ and N₂O for liquid fuels and biomass are reported as C in the CRT-tables in 2020.

3.2.9.2.1 Primary iron and steel works

In Sweden, there are two plants for integrated primary iron and steel production basing their production on iron ore pellets. The integrated iron and steel production consists of material flows between coke oven, blast furnace and steelworks, and in one plant, rolling mill (see Table 3.6). Emissions from fuel combustion (oils, LPG (Liquefied Petroleum Gas) and recovered energy gases, i.e. coke oven gas and blast furnace gas) used in the rolling mills and for in-house power and heat production is allocated to this sub-sector in accordance with the IPCC Guidelines. From one of the facilities, large amounts of recovered energy gases are sold to a public heat and power plant, and the emissions from combustion of these gases are hence reported in CRT 1.A.1.a.

Detailed carbon mass balances, simplified energy balances and carbon and energy flowcharts according to EU-ETS are compiled for the two integrated plants but are not presented in the NID due to confidentiality reasons.

The allocation of total CO₂ emissions and energy consumption (TJ) on plant stations and consequently CRT sub-sector is based on measured fuel consumption and associated carbon emissions.

Table 3.6. Allocation of fuel consumption and CO₂ emissions in 2024 from iron ore-based iron and steel industry to different CRT codes.

CRT	Plant station	CO ₂ emissions (kt)	Energy consumption (TJ)
1.A.1.a	Power and Heat Production (sold amount of energy gases)	1 144	5 051
1.A.1.c	Coke Oven	354	4 237
1.A.2.a	Combustion in Rolling Mills + Power and Heat Production	387	2 356
1.B.1.c	Flare in Coke Oven (COG)	14	284
2.C.1.b	Blast Furnace + Steelworks (including Flaring of BFG and LD-gas)	2 235	9 027
NA	Products and losses	NA	30 643
Total		4 135	51 598

3.2.9.2.2 Secondary iron and steel works

Except for the primary iron ore-based iron and steel works, this sector includes emissions from for instance electric arc furnaces plants, iron ore pellet plants and iron powder plants. For these facilities, data on fuel consumption for energy purposes is from the Quarterly fuel statistics (KvBr). National NCVs and emission factors are used.

3.2.9.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For the two largest facilities, the time series is considered to be very consistent since the time series developed in 2009 was compiled in close cooperation with the facilities. For CRT 1.A.2.a in total, the time series is also considered to be consistent, even though the quarterly fuel survey is used for most years and the annual industrial energy survey for some years. The quarterly fuel survey data is weighted to cover the same population as the yearly industrial energy survey. A discussion on the reasons for changing data sources can be found in Annex 2.

The CO₂ implied emission factors for solid fuels in CRT 1.A.2.a are higher than for solid fuels in other industries, since a large proportion of the fuel used is blast furnace gas which has a high carbon content compared to other solid fuels. This also implies that the IEF varies between years, and it is considerably lower in 2009 than recent years because of the drop in blast furnace gas consumption. See also section 3.2.8.3. The IEF for coke oven gas and blast furnace gas starts to vary from 2003. The reason for the interannual variability of the IEF for coke oven gas and blast furnace gas are the amounts that vary in time. Between 1990 and 2002 this variability is not seen since the shares of coke oven gas and blast furnace gas were constant due to aggregated activity data. The share of the gases was constant within the same oven. Since 2003 the proportion of gases are enabled due to disaggregated activity data. The reason for the introduced variability of data from 2003 is due to that the facility started to measure emissions at a finer level than before.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group.

3.2.9.4 SOURCE SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for CRT 1.A.2.a as for 1.A.1.a described above. In addition to this, fuel consumption for the year t-2 is verified against

the annual industrial energy survey on an aggregate level to check that the weight factors for the year t-1 are reasonable. For the two largest facilities, all data is collected directly from the company.

Quality control and established procedure for annual cross-sectoral control of reported emissions on a facility level is being conducted annually to improve emission allocation between the energy sector (CRT 1.A) and IPPU (CRT 2). In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double counting using a developed quality control tool. For further detailed information see section 1.3.5 concerning QA/QC and Verification in general.

3.2.9.5 SOURCE SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2026.

3.2.9.6 SOURCE SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.10 Non-Ferrous Metals (CRT 1.A.2.b)

3.2.10.1 SOURCE CATEGORY DESCRIPTION

This source category covers combustion-related emissions from five aluminium producers (ISIC 27420), three copper producers (ISIC 27440) and three facilities producing various other metals.

As for all subcategories to CRT 1.A.2, for companies with less than 10 employees the Tier 1 method is used, since current data does not allow the Tier 2 methods to be used. Emissions from companies with less than 10 employees are allocated to CRT 1.A.2.g.

Fuel consumption shows a decreasing trend for the period 1990-2002, but from 2003 onwards, the inter-annual variations in fuel consumption for energy production are relatively small. In recent years, the copper producers account for 40-50% of the fuel consumption in 1.A.2.b and the aluminium producers account for 32-45%. The most common fuel is LPG (44-61% in recent years), followed by heating oils and natural gas.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.7.

Table 3.7. Summary of source category description, CRT 1A2b, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.2.b	CO ₂	X (Liquid fuels)	-	-	T2	CS	Yes
	CH ₄	-	-	-	T2	CS	Yes
	N ₂ O	-	-	-	T2	CS	Yes

CS Country Specific. T2 Tier 2.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.10.2 METHODOLOGICAL ISSUES

Activity data is taken from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For more details on these surveys see Annex 2. National emission factors are used. For more information, see Annex 2.

Due to confidentiality reasons activity data, CH₄ and N₂O emissions for gaseous fuels and biomass are reported as C in the CRT tables for 1.A.2.b.

3.2.10.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for CRT 1.A.2.a, time series consistency despite the changes in activity data source is discussed in Annex 2.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. In 1990, the largest contribution to the aggregate uncertainty arises from CO₂ from “other solid fossil fuels” due to the fact that the emission factor uncertainty for this quite unspecified fuel is as high as 100%. In later years, this fuel is not used in CRT 1.A.2.b, and CO₂ from LPG accounts for most of the uncertainty. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group. The uncertainty of AD and CO₂ is 5% for all fuel groups.

3.2.10.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The same QA/QC procedures are used for CRT 1.A.2.b as for 1.A.2.a described above. In addition to this, a detailed quality study of the non-ferrous metal industry was performed in 2010⁵⁴.

Quality control and established procedure for annual cross-sectoral control of reported emissions on a facility level is being conducted annually to improve emission allocation between the energy sector (CRT 1.A) and IPPU (CRT 2). In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double counting using a developed quality control tool. For further detailed information see section 1.3.5 concerning QA/QC and Verification in general.

3.2.10.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculation occurred in this sector in submission 2026.

3.2.10.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.11 Chemicals (CRT 1.A.2.c)

3.2.11.1 SOURCE CATEGORY DESCRIPTION

The chemical industry produces a number of different products such as chemicals, plastics, solvents, petrochemical products etc. In total, around 50 plants are included, of which ten use more than 90% of the energy according to the activity data used for emission calculations for this sector. The fuel consumption trend is increasing since 1990, especially for liquid fuels, mainly due to increased use within the basic plastic industry.

⁵⁴ Skårman et.al, 2008.

For 2024, liquid fuels accounted for about 60% of the total energy use, solid fuels about 0.5%, gaseous fuels about 13%, other fossil fuels about 9% and biomass about 17%.

As in other subcategories of CRT 1A2, emissions from companies with less than 10 employees are allocated to CRT 1.A.2.g.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.8.

Table 3.8. Summary of source category description, CRT 1A2c, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.2.c	CO ₂	X (Gaseous fuels, Liquid fuels)	X (Gaseous fuels, Liquid fuels, Solid fuels)		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. T2 Tier 2.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.11.2 METHODOLOGICAL ISSUES

Activity data is, with exceptions mentioned below, collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For more details on these surveys, and explanations of choice of data sources, see Annex 2.

Generally, plants classified as ISIC Division 24 according to ISIC Rev.3⁵⁵ in the energy statistics are included in this sector, as recommended in 2006 IPCC Guidelines.

One calcium carbide manufacturing facility uses coke both as a fuel and as a reducing agent in the production process. In submission 2013, it was revealed that the reporting of this coke consumption is not properly allocated in the energy statistics, and several years the total amounts reported were obviously too low. For this reason, activity data from environmental reports and in later years from the EU ETS is used for this coke consumption since submission 2013.

According to environmental reports, the “other petroleum fuels” used in this sector is a process by-product consisting mainly of methane. The fuel is produced at one facility and used by several chemical industries in the same municipality. ERT has remarked that this fuel is probably partly originating from natural gas, which is also indicated by the environmental reports. It has, however, not been possible to determine how much of the gas mixture that should be allocated to gaseous fuels, so presently all consumption of this fuel is allocated to liquid fuels. Both natural gas and petroleum products are used as feedstock, and hence the by products as well as the actual desired products are partly of liquid origin and partly of gaseous origin. A major part of the raw material is, however, of liquid origin. This assumption is supported by the comparison between the reference and

⁵⁵ United Nations Statistics Division, 2010

sectoral approach for gaseous fuels. In later years, apparent consumption of gaseous fuels according to reference approach is in fact lower than in the sectoral approach, which indicates that there are no major underestimations of the consumption of gaseous fuels in the sectoral approach.

For the years 2007-2013, plant-specific CO₂ emission factors for by product gases from the petrochemical industries are used. The emission factors are based on total emissions for each plant minus process emissions and emissions from combustion of fuels other than by product gases, i.e. they are in fact implied emission factors based on reliable information on total emissions from the environmental reports.

In submission 2023, the combustion of carbide furnace gas was reallocated to CRT 1A2c from 2B10a (IPPU sector), according to the results from a developing project regarding improvements of the allocation of stationary and process-based emissions between CRT 1 and 2⁵⁶. The reallocation resulted in increased emission from liquid and gaseous fuels.

Due to confidentiality reasons:

- Solid, biomass, and other fossil fuels activity data and emissions are reported as C in CRT-tables for 1.A.2.c.

3.2.11.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time series is considered to be consistent despite the changes in activity data sources. This is discussed in Annex 2.

As mentioned above, fuel consumption in 2008 was higher than in 1990. However, since 2008 there is no distinct trend. Except for 2009, when the production and hence also the fuel consumption dipped, the annual fuel consumption 2001-2013 in CRT 1.A.2.c is 25-27 PJ.

As noted by the ERT, the implied emission factors for “other fuels” vary, especially in the early years. This is explained by the fact that municipal waste has occasionally been combusted within the chemical industry, and most years also “other non-specified fuels”. As these fuels have quite different emission factors for CO₂, the relative amounts of these two fuels cause inter-annual variations in IEFs. The outlier value of 28.4 kg/GJ in 1992 is explained by the fact that a small amount of municipal waste was combusted that year, but no “other non-specified fuels”. It should be noted that the group “other fuels” accounts for a relatively low share of the emissions compared to other fuel groups; typically, around 5% of the emissions of fossil CO₂ within CRT 1.A.2.c.

The ERT, submission 2012, also noted variable CH₄ IEFs for biomass fuels. This is because the relative amounts of landfill gas, tall oil and other biomass fuels such as wood vary over time, and the fuels have quite different emission factors for CH₄. The exact amounts of the different biomass fuels cannot be shown due to confidentiality reasons.

In 2011, a consistent time series of the CO₂ emission factor for the by-product fuel was developed in cooperation with the facility that produces the fuel and hence it is plant specific. The emission factor used in submission 2011, namely 55 kg CO₂/GJ, was

⁵⁶ Helbig, T., Yaramenka, K., Josefsson Ortiz, C., Guban, P. 2022. Omallokering för Borealis. SMED memorandum.

verified by the company for the period 1990-2000. In 1999 to 2001, the process that produces the gas was gradually modified by technological improvements, resulting in an altered composition of the fuel. The proportion of hydrogen increased which gave a higher calorific value and lower CO₂ emissions. The company also provided a time series of CO₂ emissions covering the period 2001-2010, which was used to calculate the year specific emission factors. These new emission factors were implemented in submission 2012. For non- CO₂ emissions, emission factors for natural gas are used as no specific emission factors are available and both fuels consist mainly of methane.

The uncertainty analysis tables are presented in Annex 7, and a general description of the uncertainties is presented in section 1.7. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group. The uncertainty of AD is 2-5% for all fuel groups except for Other Fossil Fuels that is 10%. Uncertainty of CO₂ emission factors is high, 100%, for Other Fossil Fuels, 30% for Biomass and 5% for the other fuel groups.

3.2.11.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for CRT 1.A.2.c as for 1.A.2.a and 1.A.2.b described above. For the largest plants in terms of emissions and fuel consumption, both environmental reports and EU ETS data are used for verification of the estimates based on energy statistics.

Quality control and established procedure for annual cross-sectoral control of reported emissions on a facility level is being conducted annually to improve emission allocation between the energy sector (CRT 1.A) and IPPU (CRT 2). In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double counting using a developed quality control tool. For further detailed information see section 1.3.5 concerning QA/QC and Verification in general.

3.2.11.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2026 no recalculation occurred in this sector.

3.2.11.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.12 Pulp, Paper and Print (CRT 1.A.2.d)

3.2.12.1 SOURCE CATEGORY DESCRIPTION

In 2021, there were 50 paper mill and pulp industry plants and 120 sawmills (production capacity >10 000 m³/year) in Sweden. In total, they produced 8.9 Mt of paper, 19 Mm³ of sawn timber and 11.7 Mt of pulp⁵⁷. Since 1990, production has had an increasing trend, but not in the latest few years. There is no apparent trend in total fuel consumption since 1990, but the share of energy from biomass fuels has increased, from 82% of fuel consumption in 1990 to 96.5% in 2024 at the same time as liquid fuels has decreased from 15% of total fuel consumption in 1990 to 3.2% in 2024. As for CRT 1.A.2 in

⁵⁷ The Swedish Forest Industries Federation, 2022-11-29. 2022.
<https://www.skogsindustrierna.se/skogsindustrin/skogsindustrin-i-korthet/fakta--nyckeltal/>

general, emissions from companies with less than 10 employees are allocated to CRT 1A2g.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.9.

Table 3.9. Summary of source category description, CRT 1A2d, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.2.d	CO ₂	X (Liquid fuels)	X (Liquid fuels, Solid Fuels)		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. T2 Tier 2.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.12.2 METHODOLOGICAL ISSUES

Emissions from processes in the Pulp, paper and print industry are reported under CRT 2.H.1 according to the IPCC Guidelines (see chapter 4.9). Although emissions from combustion of black liquor are regarded to be process-related, the amount of combusted black liquor and related CO₂ emissions are reported in CRT 1.A.2.d in order to account for the biogenic CO₂ emissions in the memo item “CO₂ emissions from biomass”. Activity data for fuels reported in CRT 1.A.2.d is collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For more details on these surveys, see Annex 2.

3.2.12.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for CRT 1.A.2 in general, time series consistency despite the changes in activity data source is discussed in Annex 2. The fluctuating IEFs for liquid fuels reflect variations in the fuel mix. In the 1990s, petroleum coke was used in some facilities, and in the latest years, combustion of residual fuel oil has decreased somewhat. Fuels classified as “other fuels” are scarcely occurring in this CRT category, and as in 1.A.2.c, the large variations in IEFs are caused by occasional use of municipal waste.

In recent years, the relative amount of biomass has increased, and the relative amounts of liquid fuels has decreased. One effect of the increasing share of biomass is that emissions of fossil CO₂ per TJ of total fuel consumption is decreasing.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. N₂O from wood fuels and CO₂ from residual fuel oil are the greatest contributors to the aggregate uncertainty in this sector (except for biogenic CO₂ from Biomass). The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group. The activity data uncertainty is lowest for Biomass and Other Fossil Fuels with 8-10%. The N₂O emission factor uncertainty for wood is 40% and the CO₂ emission factor for Liquid Fuels is 5%.

3.2.12.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In general, the same QA/QC procedures are used for CRT 1.A.2.d as for 1.A.1.a and 1.A.2.a – 1.A.2.c described above.

Quality control and established procedure for annual cross-sectoral control of reported emissions on a facility level is being conducted annually to improve emission allocation between the energy sector (CRT 1.A) and IPPU (CRT 2). In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double counting using a developed quality control tool. For further detailed information see section 1.3.5 concerning QA/QC and Verification in general.

3.2.12.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2026, methanol has, after communication with relevant facilities, been reallocated from a fossil fuel to a biogenic fuel, which results in a slight increase in the share of emissions from biogenic fuels sources since 2007 and onwards, with a corresponding decrease in emissions from other fossil fuel sources.

3.2.12.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.13 Food Processing, Beverages and Tobacco (CRT 1.A.2.e)

3.2.13.1 SOURCE CATEGORY DESCRIPTION

The food and drink industry are the third largest branch of industry measured as production value and number of employees. There are about 4600 companies, of which only around 650 have more than 10 employees⁵⁸. The largest number of companies and employees are found in the bakery industry, but the most energy intensive branch is the sugar industry which accounts for about 25% of the fuel consumption in 1.A.2.e. Dairies, breweries, producers of refined vegetable fats and potato products are other industries with significant fuel consumption (around 7-12% each of the fuel consumption in 1.A.2.e). The fuel consumption varies between years. A slight decrease can be observed since 1990. Lately, the use of gaseous fuels is decreasing from 45-49% to 43% in 2024, while biomass is increasing steadily from 2% 1990 to 42.6% in 2024, liquid fuels account for about 13% in 2024 of the total fuel consumption. As for CRT 1.A.2 in general, emissions from companies with less than 10 employees are allocated to CRT 1.A.2.g.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.10.

⁵⁸ The Swedish Food Federation 2025-02-20

Table 3.10. Summary of source category description, CRT 1A2e, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.2.e	CO ₂	X (Gaseous fuels)	X (Gaseous fuels, Liquid fuels, Solid fuels)		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. T2 Tier 2.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.13.2 METHODOLOGICAL ISSUES

Activity data is collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. National emission factors are used. For more details on these surveys and emission factors see Annex 2.

3.2.13.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for CRT 1.A.2 in general, time series consistency despite the changes in activity data source is discussed in Annex 2. The IEFs vary slightly between years due to variations in the fuel mix. The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group. Activity data uncertainty is 5% for all fuel groups except for Other Fossil Fuels which is 10%. CO₂ emission factor uncertainty varies between the fuel groups with highest for Other Fossil Fuels, 100%, 30% for Biomass and 5% for the other fuel groups.

3.2.13.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Generally, the same QA/QC procedures are applied for 1.A.2.e as for other 1.A.2 categories described above.

Quality control and established procedure for annual cross-sectoral control of reported emissions on a facility level is being conducted annually to improve emission allocation between the energy sector (CRT 1.A) and IPPU (CRT 2). In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double-counting using a developed quality control tool. For further detailed information see section 1.3.5 concerning QA/QC and Verification in general.

3.2.13.5 SOURCE-SPECIFIC RECALCULATIONS

Minor corrections due to re-classification of fuels have been made in submission 2026, resulting in changes of CH₄, N₂O and CO₂ emissions of less than 1% of total source category emissions.

3.2.13.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.14 Non-metallic minerals (CRT 1.A.2.f)

3.2.14.1 SOURCE CATEGORY DESCRIPTION

This source category includes stationary combustion of fuels in non-metallic mineral industries (ISIC 26). Cement production accounts for a major part of the emissions. The summary of the latest key category assessment, methods and EFs used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.11.

Table 3.11. Summary of source category description, CRT 1A2f, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.2.f	CO ₂	X (Liquid fuels, Other fuels, Solid fuels)	X (Liquid fuels, Other fuels, Solid fuels)		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. T2 Tier 2

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.14.2 METHODOLOGICAL ISSUES

Tier 2 methodology is used for emissions from stationary combustion for CRT 1.A.2.f, because country-specific emission factors for the source category and fuel for each gas are used.

Activity data is collected from Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For 2008 and later, activity data for the three plants within the cement production industry is taken from the EU ETS system, as this data source provides more detailed information on fuel types. The total amount of fuels combusted is consistent with the Quarterly fuel statistics (KvBr).

National emission factors are used, except for CO₂, where emission factors at facility level from EU ETS are used for the largest cement production plants. These emission factors were revised and updated in submission 2021⁵⁹. The revised emission factors for CO₂ are made only for the years 2010-2018, since the emission factors before 2010 are not divided in fraction of biomass and fossil fuels. For more details on these surveys and emission factors see Annex 2.

Due to confidentiality reasons:

- Activity data for solid fuels and other fossil fuels are reported as C in CRT-tables in the CRT code 1.A.2.f for 2024.
- Emissions of CH₄, CO₂, N₂O for the 1.A.2.f code for solid fuels and other fossil fuels are reported as C in the CRT-tables for 2024.

⁵⁹ Josefsson Ortiz, C. & Guban, P. 2020. Revidera AD och EF för Cementa för CO₂-utsläpp. SMED PM.

3.2.14.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

As for CRT 1.A.2 in general, time series are considered consistent despite the changes in activity data source as discussed in Annex 2. The IEFs vary slightly between years due to variations in the fuel mix. The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group.

3.2.14.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Generally, the same QA/QC procedures are applied for 1.A.2.f as for other 1.A.2 categories described above. In some earlier submissions, extensive QA/QC and verification efforts have been made for the other sectors including the construction industry. This is described in section 3.2.21.4.1 below.

Quality control and established procedure for annual cross-sectoral control of reported emissions on a facility level is being conducted annually to improve emission allocation between the energy sector (CRT 1.A) and IPPU (CRT 2). In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double counting using a developed quality control tool. For further detailed information see section 1.3.5 concerning QA/QC and Verification in general.

3.2.14.5 SOURCE-SPECIFIC RECALCULATIONS

In submission 2026 no recalculation occurred in this sector.

3.2.14.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.15 Other Industries (CRT 1.A.2.g)

3.2.15.1 SOURCE CATEGORY DESCRIPTION

This source category is by nature quite heterogeneous. Both stationary and mobile emission sources are included. For 1.A.2.g, Sweden has chosen not to use the drop-down list in the CRT Reporter due to confidentiality reasons.

The stationary sources included are combustion within ISIC 10-37, except from the branches separately reported in 1.A.2.a-1.A.2.f, stationary combustion within all companies with less than 10 employees regardless of branch, and stationary combustion within the construction sector. The Quarterly fuel statistics (KvBr) is a cut-off survey including enterprises with ten or more employees. The estimation of emissions from enterprises with less than ten employees is based on activity data from the annual energy balances, i.e. a model estimate of aggregate fuel consumption in all small enterprises within the entire manufacturing industry. These emissions are reported in 1A2gviii.

The mobile emission source included in this sector is combustion by off-road vehicles and other machinery (working machinery) used in the construction and manufacturing industry. For 2024, 45% of total GHG emissions from working machinery are reported in CRT 1.A.2.g.vii. In 2024, GHG emissions from working machines in this subsector have increased by over 40% compared to 2024 and by 70% since 1990. The sharp increase is a

result of changes in the GHG-reduction mandate and decreased use of biofuels.

In terms of stationary fuel combustion and emissions, two branches of industry are dominating: manufacturing of wood products (ISIC 20), and mining industry (ISIC 13). In mining industry, the main fuel used is hard coal. In ISIC 20, however, biomass fuels are dominating and hence the emissions of fossil CO₂ from this branch of industry are low. The construction industry also accounts for a significant share of fuel consumption and emissions. The fuel consumption varies between years but are mainly biomass, gaseous fuels, liquid fuels, other fossil fuels and solid fuels. For stationary combustion within 1.A.2.g in total, fuel consumption has decreased slightly since 1990, liquid and biomass fuels account for most of the decrease.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.12.

Table 3.12. Summary of source category description, CRT 1A2g, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.2.g Off-road vehicles and other machinery	CO ₂	X (Liquid fuels)	X (Liquid fuels)		T2	CS	Yes
	CH ₄	-	-		M	CS	Yes
	N ₂ O	-	-		M	CS	Yes
1.A.2.g Other (1.A.2.g i-vi reported as "C" or "IE" in	CO ₂	X (Liquid fuels, Solid fuels)	X (Liquid fuels, Solid fuels, Gaseous fuels)		T2	CS	Yes
1.A.2.g Other)	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. T2 Tier 2. M Model.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.15.2 METHODOLOGICAL ISSUES

All consumption of motor gasoline and diesel oil in manufacturing industries and construction is allocated to mobile combustion, and all other fuels (heating oils, natural gas etc.) to stationary combustion.

3.2.15.2.1 Stationary combustion

For emissions from stationary combustion, the Tier 2 method is used with the following exception: For the construction industry and for companies with less than 10 employees the Tier 1 method is used, since current data does not allow the Tier 2 method to be used.

Emissions from stationary combustion in mining and quarrying and in the manufacturing of various products such as textiles, wearing apparel, leather, wood and wood products, rubber and plastics products, fabricated metal products and manufacturing of different types of machinery, are calculated with activity data from the Energy use in the manufacturing industry (ISEN) for 1990-1996 and 2000-2002, and from the Quarterly fuel statistics (KvBr) for 1997-1999 and 2003 and later. For more details on these surveys, see Annex 2.

Emissions from all companies in ISIC 10-37 with less than 10 employees are estimated and reported under CRT 1.A.2.g. Activity data is provided by the Swedish Energy Agency⁶⁰. Emissions are minor and with current data not possible to separate on different industry sectors.

Emissions from stationary combustion in the construction industry are calculated with activity data from the Swedish Energy Agency⁶¹. The methodology used for this sub-category is the same as for stationary combustion in the Other sector, see section 3.2.21.4.1.

The fuel statistics for the last emission year, based on preliminary Energy Balance is not readily available in time for the emission calculations. As of submission 2022, the activity data is estimated using the previous year's value per fuel type and year at total energy consumption level for ISIC 10-37 with less than 10 employees, construction industry and the Other sector (CRT 1.AA.4)⁶². The estimated energy consumption is then distributed within the sectors according to the same fuel consumption distribution as the previous year. For more detailed information about the extrapolation models and the effects on GHG emissions of deviances from the models see Annex 2. The activity data for the last inventory year will be revised next coming submission, as the Energy Balance will then be published and definitive.

Due to confidentiality reasons:

- Activity data for solid fuels, biomass, and other fossil fuels are reported as C in CRT-tables in the CRT code 1.A.2.g for 2024.
- Emissions of CH₄, CO₂, N₂O for the 1.A.2.g code for solid fuels, biomass fuels, and other fossil fuels are reported as C in the CRT-tables for 2024.

3.2.15.2.2 *Mobile combustion/Working machinery*

Emissions from mobile combustion in CRT 1.A.2.g refer to working machinery used in industry, including for example tractors, dumpers, cranes, excavators, trucks, generators and wheel loaders. A national model is used to estimate emissions from all working machinery used in Sweden and is considered to correspond to Tier 3 for all emissions, except for CO₂ and SO₂ which are estimated according to Tier 2. The model is further described in Annex 2.⁶³

The consumption of gasoline and diesel, estimated by the model for off-road vehicles, is adjusted with regard to low-blended biofuel. The fuel consumption is also modified with a residual of gasoline and diesel. This residual arises as the volume of gasoline and diesel allocated to different sectors through a top-down approach is compared to the total volume of the gasoline and diesel consumed according to a bottom-up estimate. See Annex 2 for more information regarding the allocation of fuels for mobile combustion⁶⁴.

⁶⁰ Swedish Energy Agency: Annual Energy balances. See also Annex 2.

⁶¹ Swedish Energy Agency: Annual Energy balances. See also Annex 2.

⁶² Helbig, T. & Josefsson Ortiz, C. 2021. Uppdateringar av utsläppsberäkningar för småskalig biomassaeldning inom övrigsektorn (CRT/NFR 1A4) 2017-2021. SMED Rapport Nr 19 2021.

⁶³ Annex 2: 1.6 Methodology for off-road vehicles and working machinery

⁶⁴ See Annex 2, section "1.4 Allocation of fuels for mobile combustion" for more information."

Emissions from working machinery are also reported under CRT 1.A.3.eii, 1.A.4.a.ii, 1.A.4.bii and 1.A.4.cii, in line with IPCC Guidelines, see Table 3.13.

Table 3.13. Distribution of emissions from off-road vehicles and other machinery.

Category	CRT	Definition IPCC Guidelines
Industry	1.A.2.g vii	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
Other	1.A.3.e ii	Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1.A.4.c or 1.A.2.g vii.
Commercial/ Institutional	1.A.4.a.ii	Garden machinery, e.g. lawn mowers and clearing saws, not used by private users, also tractors not used in industry ore forestry or agriculture.
Residential	1.A.4.b	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
Agriculture, Forestry	1.A.4.c	Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded.

3.2.15.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group.

As for stationary combustion in CRT 1.A.2 in general, time series consistency despite the changes in activity data source is discussed in Annex 2. As for other categories in CRT 1.A.2, the IEFs vary slightly between years due to variations in the fuel mix. In earlier submissions, the EC (European Commission) has asked for clarification of the drop in wood consumption in 2000 compared to earlier years. This issue has not been prioritized, but since the annual wood consumption 2001-2009 is considerably lower than in the 1990s, there is no reason to believe that the activity data for 2000 is incorrect.

The emissions of CO₂ from diesel (used by off-road vehicles and working machinery) and heating oils (used for stationary combustion) represent the largest sources of uncertainty in regard to GHG emissions within CRT 1.A.2.g. The activity data uncertainty for all heating oils within this sector is as high as 20% on an aggregate level, due to the fact that emissions from the construction sector and small industries are estimated with the Tier 1 method. The activity data uncertainty for diesel combusted in off-road vehicles and working machinery is 5% and for gasoline 3% based on fuel sold.

The amount of low-blended biofuel used by working machinery and road traffic is allocated proportionally to the amount of fossil gasoline and diesel consumed in each subsector. The model estimated consumption of fossil gasoline and diesel by working machinery is decreased by the amount of ethanol respectively FAME/HVO allocated to the subsector in question. In 2004, the consumption of gasoline by working machinery decreased noticeably as a result of an increase in the amount of ethanol allocated to working machinery, due to a large increase in the national deliveries of low-blended

ethanol. The same phenomenon took place between 2017 and 2018 as a result of a sudden increase of the ethanol sold on the Swedish market.

3.2.15.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Generally, the same QA/QC procedures are applied for 1.A.2.g as for other 1.A.2 categories described above. In some earlier submissions, extensive QA/QC and verification efforts have been made for the Other sector including the construction industry. This is described in section 3.2.21.4.1 below.

3.2.15.5 SOURCE-SPECIFIC RECALCULATIONS

3.2.15.5.1 *Stationary combustion*

No recalculation occurred in this sector in submission 2026.

3.2.15.5.2 *Mobile combustion*

This year's development projects⁶⁵ had limited impact on emissions in this category. The project aimed to calibrate the stock of mobile cranes, wheel loaders, and backhoe loaders against the Swedish road traffic register, with respect to age distribution and scrappage rates. The calibration and adjustments regarding scrappage and fleet composition were carried out using conservative estimates, as the register data utilized is not fully comprehensive. The model's previous assumptions were relatively accurate, which also explains the limited effect of the recalculations. Approximately half of the emission changes are connected to error corrections due to a misallocated machine category which affect year 2021-2023.

The effect on CO₂-eq emissions is ranging from -1% to + 0,2% over the time series.

3.2.15.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

The machine stock in the NRMM will be updated for wheel loaders and excavators during the next submission. The updates will be implemented as a result of a study carried out based on the national vehicle register. The changes will mainly affect the older machines in the stock as data shows that the NRMM assumes a slightly incorrect scrapping rate of machines.

Further category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.16 Civil Aviation (CRT 1.A.3.a)

3.2.16.1 SOURCE CATEGORY DESCRIPTION

Activity data is presently provided for a total of 39 airports with regular and/or chartered air traffic in Sweden. The national government administers 10 of these airports, while the remaining 29 are private and/or administered by local governments.⁶⁶ The emissions of greenhouse gases (GHG) from national aviation in 2024 were 269 kt CO₂-eq., which is a decrease by 24 % since last year and a decrease by 61 % compared to 1990.

⁶⁵ Hammerlid, 2025

⁶⁶ Trafikanalys. 2022. Luftfart 2021. <https://www.trafa.se/luftfart/>

The corona pandemic had a large impact on domestic civil aviation during 2020 and 2021. In 2022 and 2023, there was a substantial increase in emissions from civil aviation as a rebound effect after the pandemic. However, in 2024 a decrease has been observed. The emissions from domestic aviation have gradually decreased since 1990 while the emissions from international aviation have increased.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.14.

Table 3.14. Summary of source category description, CRT 1A3a, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.3.a	CO ₂	X (Jet kerosene)	X (Jet kerosene)		T1	D	Yes
	CH ₄	-	-		T2/M	CS	Yes
	N ₂ O	-	-		T2/M	CS	Yes

T1 Tier 1. T2 Tier 2. D Default. M Model

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.16.2 METHODOLOGICAL ISSUES

Sweden uses tier 2 to estimate emissions of CO₂, tier 2 for SO₂ and Tier 3 to estimate the emissions of CH₄, N₂O and the indirect greenhouse gases CO, NO_x and NMVOC. Emissions from aviation in agricultural and forestry activities are included in domestic aviation in line with IPCC Guidelines.

The methodology for calculating national emissions is the same for all years with a few exceptions for earlier years. Data of good quality from the Swedish Transport Agency (STAg), former Swedish Civil Aviation Authority (SCAA) is available from 1995 onwards.

The Swedish Transport Agency (STAg) is responsible for reporting the GHG emissions from aviation, but the fuel consumption and emissions are modeled by the Swedish Defence Research Agency (FOI) on behalf of STAg. The model and the methodology are described in a published report⁶⁷. The STAg provides FOI with input data for the model regarding:

- Airport of departure and arrival
- Type of aircraft
- Number of flights
- Number of passengers
- International or domestic flight

A database with information regarding 200 different types of aircraft, which originates from “ICAO Engine Exhaust Emission Data Bank”, is also used in the emission model. The fuel consumption and the emissions are estimated for both the cruise phase as well as

⁶⁷ Mårtensson, T. & Hasselrot, A., 2013.

for the LTO cycle (landing and take-off), which is defined as aircraft movements below 3000 feet.

Due to the fact that the Swedish airports in general are smaller than airports in other countries; taxi times are much shorter for domestic flights as well as climb-out and take-off times compared to the International Civil Aviation Organization (ICAO) standards which the IPCC guidelines follow⁶⁸. The air traffic at Swedish airports thus consumes less fuel and emits less emissions.

The emissions reported by STAg are aggregated into four groups; emissions from domestic landing and take-off (LTO), domestic cruise, international LTO and international cruise. The modeled fuel consumption and emissions are adjusted to be in line with the total deliveries of aviation fuel in Sweden⁶⁹, which is in line with the IPCC 2006 guidelines.

Emissions of CO₂ from aviation gasoline are based on the fuel consumption and thermal values as well as emission factors from 2006 IPCC Guidelines. Emissions of SO₂ from aviation gasoline are based on country-specific emission factors. CO₂ and SO₂ emissions from aviation kerosene are based on thermal values and emission factors from the Swedish defense research agency (FOI).

Thermal values and emission factors for CO₂ and SO₂ are based data from FOI. The values are identical for all years. The emissions are split into domestic and international aviation based on the mean value for LTO cycles for domestic and international flights in 1995-2000. Emissions of CO for 1990-1994 are based on the ratio between CO and CO₂ in 1995 (the same ratio was assumed for 1990-1994). The emissions of NO_x in 1990-1994 were estimated in a similar way as for CO, whereas the emissions of NMVOC in 1990-1994 were determined by extrapolation.

In 2006, the STAg responded to a governmental call to reduce the response burden for statistical respondents. As a result, private aviation as well as educational training flights are no longer covered in STAg's yearly report on fuel consumption and emissions from aviation as from 2007. However, as the estimated emissions from aviation are adjusted to match the delivered amount of aviation fuels on a national level, the emissions from private aviation as well as from educational training flights are consequently included.

STAg includes the traffic from a number of non-governmental airports in their estimates from 2005 and from all Swedish airports as of 2006. Since 2010, there is no separate reporting on emissions from governmental and private airports, respectively, only totals are reported.

The estimated emissions of HC are split into NMVOC and CH₄, based on the ratio given in EMEP/EEA guidebook 2013⁷⁰. Emissions of N₂O from LTO are estimated by using the number of LTO cycles reported by STAg and default emission factors from EMEP/EEA guidebook 2013. Emissions of N₂O from cruise are based on the fuel

⁶⁸ Gustafsson, 2005.

⁶⁹ Monthly fuel, gas and inventory statistics. Statistic Sweden.

⁷⁰ EMEP/EEA air pollutant emission inventory guidebook 2013. In the 2016 and 2019 edition of the EMEP EEA Guidebook, the methodology has changed. Sweden still uses the methodology described in the 2013 edition.

consumption for the cruise phase and default emission factors from the EMEP/EEA 2013 Guidebook.

Biogenic jet kerosene was introduced on the Swedish market in 2018. However, the government did not establish a mandatory reduction obligation for jet fuel until 2021 and hence there was no mandatory admixture of the biojet before 2021. Currently, the same emission factors are used for biojet as for fossil jet kerosene, since jet kerosene is a highly controlled product with narrow specifications as to its chemical properties.

3.2.16.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

In order to maintain consistency with the time series, the estimation procedures have been developed as described in section 3.2.16.2.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. Time series are checked for consistency and recalculations are verified.

3.2.16.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

3.2.16.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations are performed for domestic aviation in submission 2026.

3.2.16.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.17 Road transport (CRT 1.A.3.b)

3.2.17.1 SOURCE CATEGORY DESCRIPTION

Road transport is a significant source of greenhouse gases (GHG) and contributes 33% of the total emissions of GHG from all sectors (excluding LULUCF) in Sweden. The emissions of GHG from road transportation were about 15 884 kt CO₂-eq. in 2024, which accounts for approximately 78% of the total emissions of GHG from mobile combustion in Sweden. The emissions of GHG from road transportation in 2024 increased by 24% since 2023 and decreased by 12% since 1990. The large increase of GHG emissions in 2024 is due to a large decrease of biofuels in diesel compared to the previous year.

Road transport includes six vehicle categories: A-tractor cars, Passenger cars, Buses, Heavy goods vehicles (HGV), Light commercial vehicles (LCV) and Mopeds & Motorcycles. A-tractor cars were added as a new category in submission 2024. Gasoline was previously the most common fuel used for road transportation, but as from 2011 the amount of diesel used by road traffic surpassed gasoline as can be seen in Figure 3.6 below⁷¹. The increasing consumption of diesel by road traffic is primarily explained by a shift from gasoline to diesel cars, but also by an increased consumption of diesel by HGV and LCV. The total consumption of fossil diesel by HGV and LCV corresponds to 54 % of the total consumption by road traffic in 2024, while passenger cars use around 44 %.

⁷¹ When writing gasoline and diesel; it's implied that it is fossil gasoline and fossil diesel

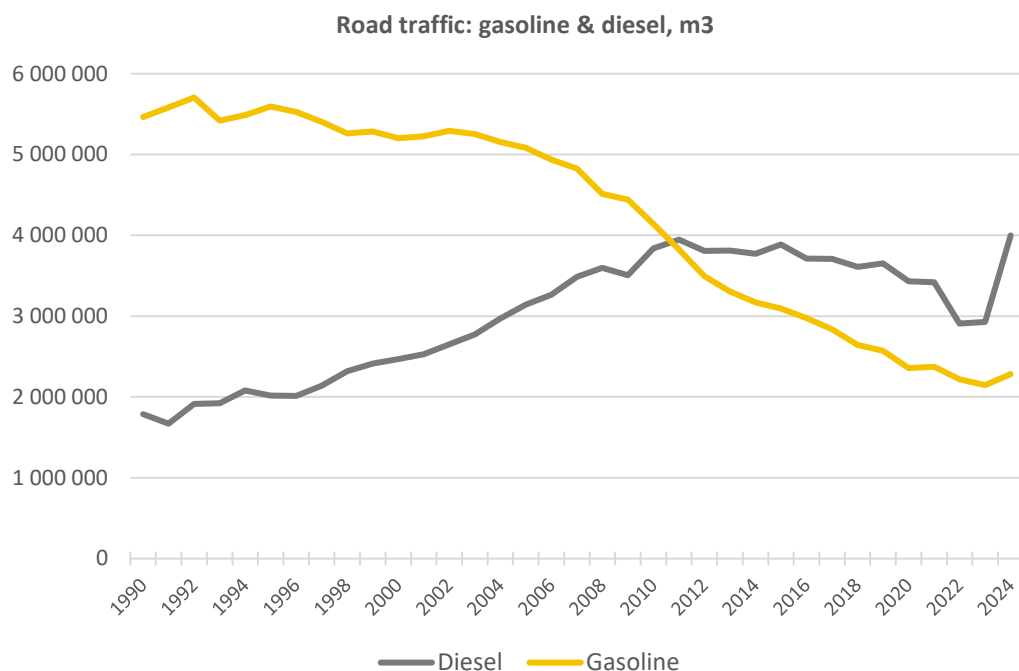


Figure 3.6. Consumption of fossil gasoline & diesel by road traffic 1990-2024 (m³).

The consumption of diesel by LCV has increased by approximately six times since 1990. The consumption of fossil diesel by passenger cars increased between 1996 and 2019, surpassing the consumption by heavy trucks in 2015. During the years 2011-2023 there was a decline in the amount of fossil diesel used despite an increase of the distance driven by diesel vehicles (Figure 3.9) during this period. This decline was possible due to a gradual increase of the percentage of biofuels mixed into diesel. In 2024, the reduction mandate for diesel was lowered from 30.5% in 2023 to 6% (table 3.15) due to a political decision, which led to a sharp increase in the amount of fossil diesel consumed.

Table 3.15. The Swedish reduction mandate for gasoline and diesel 2018-2024.

År	Gasoline	Diesel
2018	2,6 %	19,3 %
2019	2,6 %	20 %
2020	4,2 %	21 %
2021	6,0 %	26 %
2022	7,8 %	30,5 %
2023	7,8%	30,5 %
2024	6.0%	6.0%

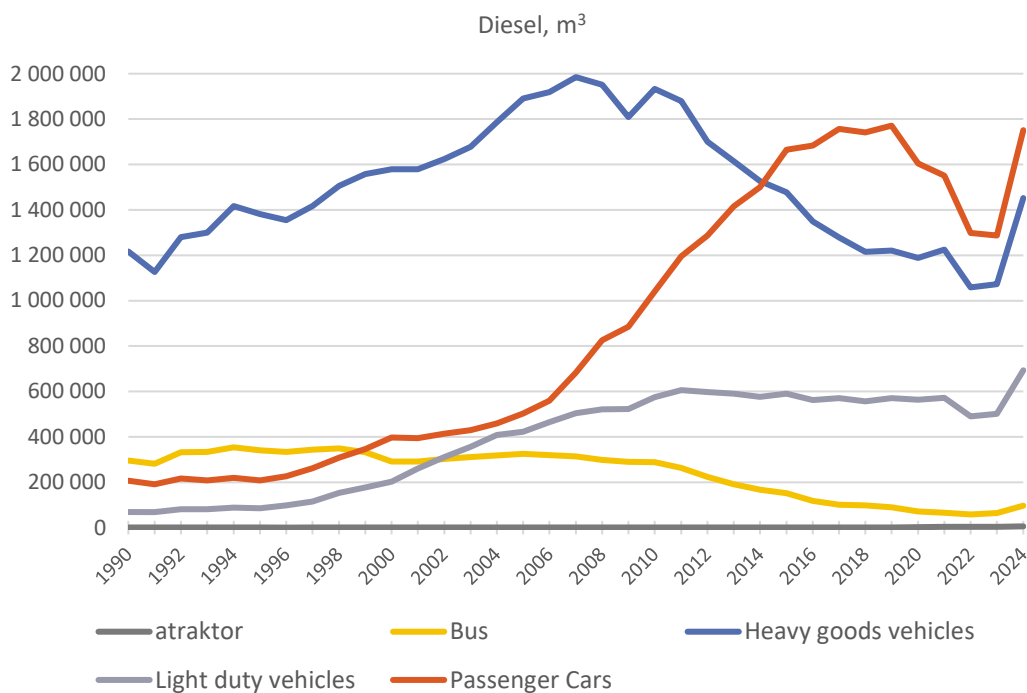


Figure 3.7. Consumption of diesel by vehicle type 1990-2024 (m³).

The gasoline consumption has a decreasing trend for all vehicles, which can be seen in Figure 3.8.

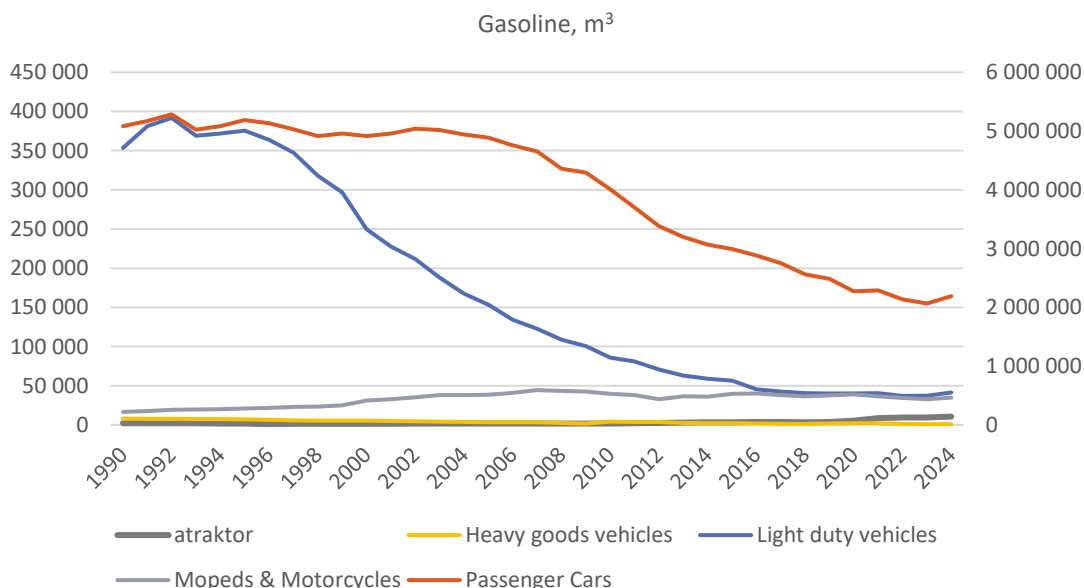


Figure 3.8. Consumption of gasoline by vehicle type 1990-2024 (m³). Passenger car consumption shown on secondary y-axis.

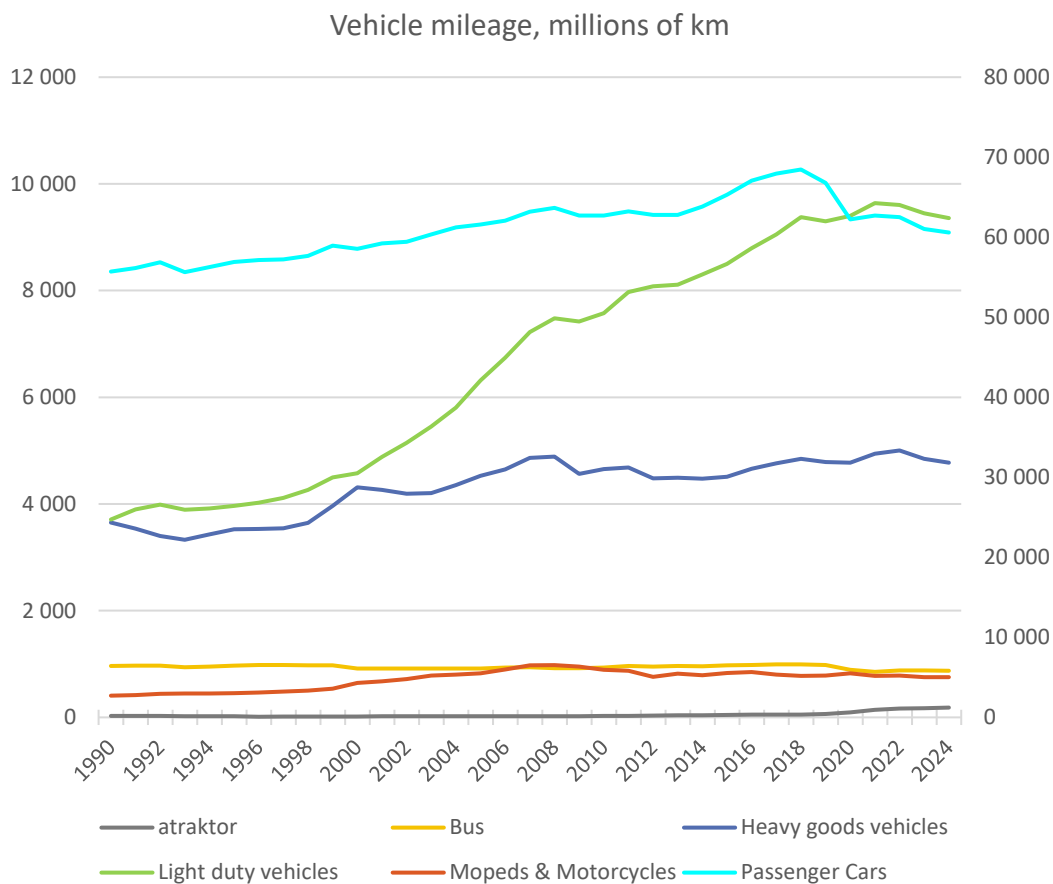


Figure 3.9 Vehicle mileage by vehicle type 1990-2024 (million kilometres). Passenger car mileage shown on secondary y-axis.

The total consumption of liquid biofuels (FAME/HVO⁷² and ethanol/ETBE) had an increasing trend from 2003, when large-scale blending of ethanol in petrol began, until 2023. The increasing production and use of biofuels was initiated by advantageous policy regulations and tax reliefs for biofuels⁷³. The amount of biogas used by road traffic has to a great extent replaced the consumption of natural gas by road traffic and has increased significantly since it was introduced on the market although it was not introduced at the same time for all vehicle types, e.g. HGV and LDV did not start using biogas until 2012 and 2016, respectively (see Figure 3.10 and Figure 3.11).

⁷² FAME=Fatty Acid Methyl Ester; HVO= Hydrogenated Vegetable Oil

⁷³ Swedish Energy Agency, 2013.

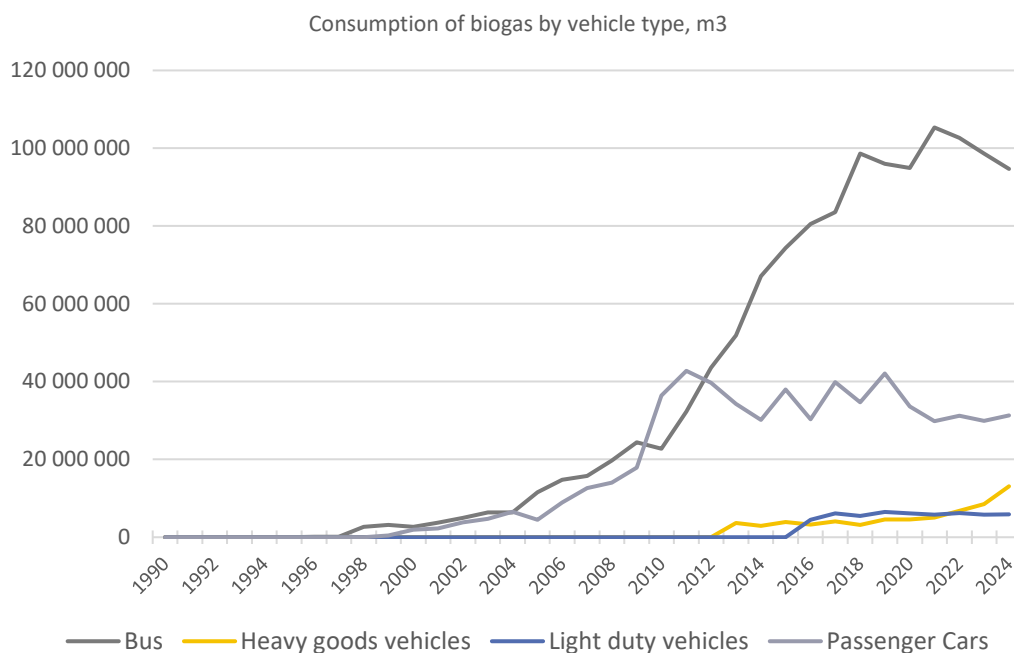


Figure 3.10. Consumption of Biogas by vehicle type in road traffic, 1990-2024 (m³).

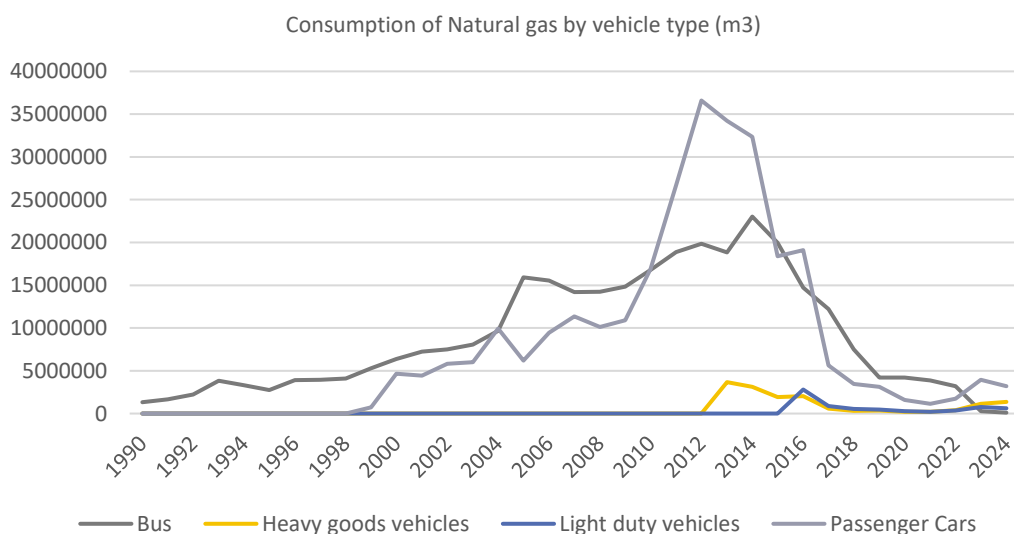


Figure 3.11. Consumption of Natural gas by vehicle type in road traffic, 1990-2024 (m³).

A major part of ethanol used by road transportation in Sweden is used as a blending component for gasoline. Large-scale blending of ethanol in petrol began in 2003. The total amount of ethanol used for road traffic nearly tripled between 2003 and 2011 (see Figure 3.12) but then started to decline because of a shift from gasoline cars to diesel cars. Just about all 95-octane petrol was sold as E5 (5% ethanol) fuel before the 1st of August 2021, when the ethanol level was raised to 10% with the introduction of E10. This measure was taken in order to achieve Sweden's national goal to reduce GHG

emissions from transport by 70% before 2030. An increased admixture of biofuels provides a means to reduce the emissions of fossil CO₂ from existing vehicles without any shift in technology.

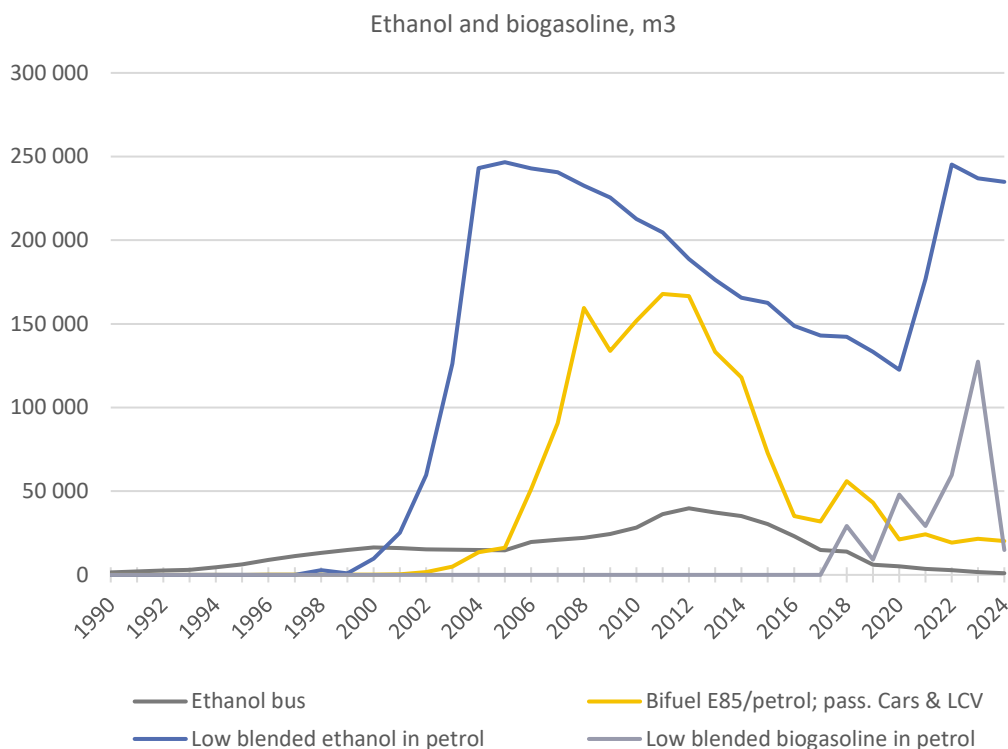


Figure 3.12. Consumption of ethanol and bio gasoline by road traffic 1990-2024 (m³).

Pure and high blended ethanol is used by ethanol buses and by E85 vehicles (flexi fuel vehicles)⁷⁴. The ethanol used by E85 vehicles and buses peaked in 2011 respectively 2012 and then started to decline. A decreasing trend can also be seen for low-blended ethanol from 2005 to 2020 due to the decline of gasoline cars. The use of low blended ethanol in gasoline rose sharply in 2021 and 2022 as a result of the introduction of E10 (Figure 3.12).

Large-scale blending of FAME in diesel began in 2007/2008. The consumption of HVO for road traffic started in 2012, both as a blending component and as 100% renewable fuel. The Swedish reduction obligation was introduced in 2018. In the first year, the obligation stipulated an admixture of at least 19.3% biofuels in diesel. This percentage increased gradually and peaked in 2023 when the admixture was 30.5%. The total use of FAME and HVO by road traffic showed a tenfold increase between 2009-2023, mainly due to a growing trend for diesel cars with a rising fraction of low blended FAME/HVO and an increasing trend for trucks and buses that run on 100% renewable diesel. In 2024, there is a sharp decline of HVO and FAME consumption due to the lowered reduction mandate (see Figure 3.13 and 3.14).

⁷⁴ E85 passenger cars, light duty vehicles and heavy goods vehicles.

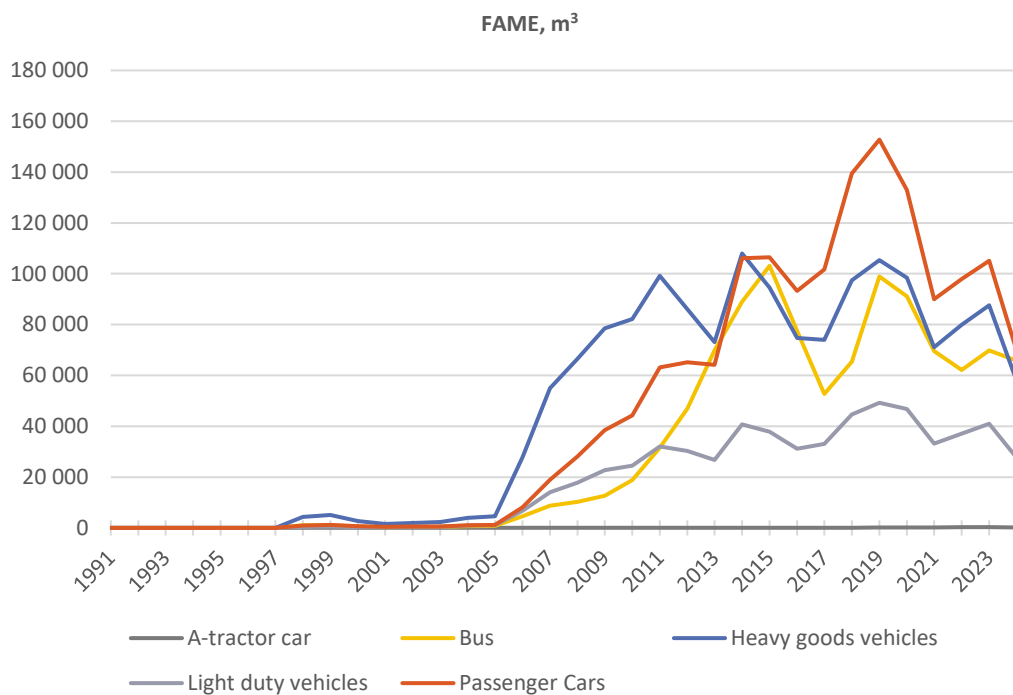


Figure 3.13. Consumption of FAME by vehicle type in road traffic 1990-2024 (m³).

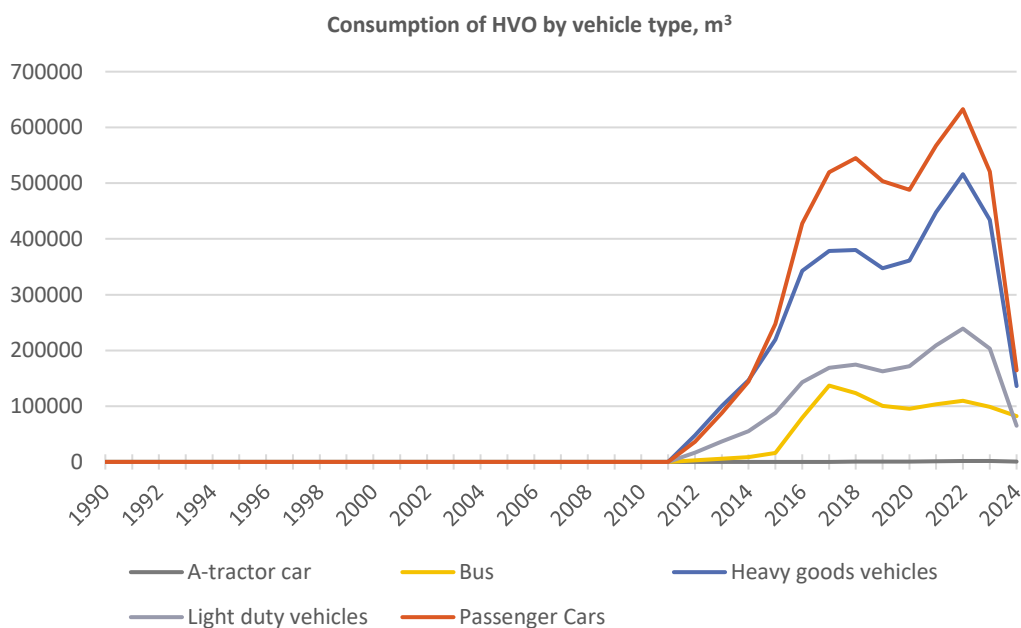


Figure 3.14. Consumption of HVO by vehicle type in road traffic 1990-2024 (m³).

The summary of the latest key category assessment, methods and EF used, as well as information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.16.

Table 3.16. Summary of source category description, CRT 1A3b, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.3.b Cars	CO ₂	X (Diesel, Gasoline)	X (Diesel, Gasoline)		T2	CS	Yes
	CH ₄	-	X (Gasoline)		T1, T2, M	CS, D	Yes
	N ₂ O	-	X (Gasoline)		T1, T2, M	CS, D	Yes
1.A.3.b Light duty trucks	CO ₂	X (Diesel, Gasoline)	X (Diesel, Gasoline)		T2	CS	Yes
	CH ₄	-	-		M, T2	CS, D	Yes
	N ₂ O	-	-		M, T2	CS	Yes
1.A.3.b Heavy duty trucks and buses	CO ₂	X (Diesel)	-		T2	CS	Yes
	CH ₄	-	-		M, T2	CS, D	Yes
	N ₂ O	-	-		M, T1, T2	CS, D	Yes
1.A.3.b Motorcycles	CO ₂	X (Gasoline)	-		T2	CS	Yes
	CH ₄	-	-		M, T2	CS, D	Yes
	N ₂ O	-	-		M, T2	CS	Yes

CS Country Specific, D Default, T1 Tier 1, T2 Tier 2, T3 Tier 3, M Model

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.17.2 METHODOLOGICAL ISSUES

The road emission model HBEFA is used by the Swedish Transport Administration (STA) to estimate the fuel consumption and emissions from road traffic and was updated from version 4.1 to version 4.2 in submission 2023.

The fuel consumption estimated by HBEFA is adjusted to be in line with the national fuel statistics. For 1990-2017, data from the survey “Monthly fuel, gas and inventory statistics” is used for this purpose. A revised version of the survey was introduced in 2018, but uncertainties regarding the quality of the statistics resulted in a change of data source and data collected and reported according to the “Swedish fuel quality act” is used as from 2018.⁷⁵

In the monthly fuel survey, data is collected from oil companies and other sellers who keep stocks of petroleum products and coal as well as liquid biofuels. The survey also collects stock data from companies with a large consumption of oil in the manufacturing industries and energy industries. As the same oil companies are obliged to collect and report fuel data under the “Swedish fuel quality act” which is used as data source for 2018-2022, the time series is still considered consistent. The amount of diesel, gasoline and liquid biofuels⁷⁶ collected and reported by the monthly survey and the “Swedish fuel quality act” has only differed by ~1-2% from the data reported under the “Swedish fuel quality act” for the last years. Therefore, despite the use of another data source for 2018-2022 than for previous years, the activity data used in submission 2024 is considered to be consistent and of good quality.⁷⁷

⁷⁵ <https://www.energimyndigheten.se/en/sustainability/sustainable-fuels/fuel-quality-act/>

⁷⁶ Diesel, gasoline, FAME, HVO, Ethanol and ETBE.

⁷⁷ Eklund, V. et al. 2019. Analys och implementering av data från nya MåBra.

The fuel consumption and emissions for road traffic are allocated by fuel type and the following vehicle categories: A-tractor cars, passenger cars, light commercial vehicles (LCV), heavy goods vehicles (HGV), buses and mopeds & motorcycles. The road traffic emission model HBEFA used by Sweden, is updated yearly with new information regarding emission factors, vehicle fleet, composition of the fuel and the current traffic work.

Emissions of CO₂ from combustion of gasoline, diesel, ethanol and FAME/HVO are based on the fuel consumption, country-specific thermal values and emission factors provided by the Energy Agency and “Drivkraft Sverige” which are shown in Annex 2.^{78,79,80,81}

The emissions of CO₂ from natural gas and biogas are based on thermal values and emission factors from the Danish Energinet⁸² respectively AGA. Emissions of CO₂ from biogas, ethanol and HVO are reported as 100% biomass and not included in the national totals as well as the majority of the FAME and ETBE used. A small part of FAME and ETBE are considered fossil and the emissions of CO₂ from the fossil part of FAME and ETBE are included in the national emissions of CO₂.⁸³ The emission of CO₂ from the fossil share of FAME and ETBE are reported under “Other fossil fuels” in the CRT tables. See section 3.2.17.5.2 for more information.

Emissions of SO₂ are based on the actual sulphur content for the different environmental classes of petrol and diesel fuel. Data on the sulphur content is provided by the Swedish Transport Administration (STA) and based on estimates made by the Swedish National Road and Transport Research Institute (VTI) for the years 1990-2001 and on fuel analysis from “Drivkraft Sverige” for 2001 and the following years⁸⁴.

The emissions of CH₄, N₂O, CO, NMVOC and NO_x from most fuel- and vehicle types are estimated by the road emission model HBEFA. Emissions of CH₄ and N₂O from low blended ethanol in gasoline and FAME/HVO are included in the estimated emissions from gasoline and diesel vehicles in HBEFA. The emissions of N₂O and CH₄ from E85 cars are also estimated by HBEFA, but the model does however not estimate the emissions of N₂O from ethanol buses. These emissions are calculated with default emission factors from 2006 IPCC Guidelines according to Tier 1. Emissions of N₂O from natural gas and biogas from buses are also missing in HBEFA but are estimated using activity data on delivered amounts of natural gas and biogas for road transport and

⁷⁸ <https://drivkraftsverige.se/>

⁷⁹ Paulrud, S., Fridell, E., Stripple, H., Gustafsson, T., 2010.

⁸⁰ [Värmevärden och densiteter \(energimyndigheten.se\)](http://varmevarden.och.densiteter.energimyndigheten.se/)

⁸¹ Helbig, Eklund, Mawdsley m.fl. 2021, Utv. Proj. "SMED memo CO2 emission factor for fossil diesel fuel" (fr.o.m. 1996.)

⁸² <https://ens.dk/ansvarsomraader/co2-kvoter/stationaere-produktionsenheder/co2-rapportering-og-returering>

⁸³ Eklund, V. Gerner, A. SCB. 2019. Fossil inblandning i biobränsle.

⁸⁴ Directive 98/70/EC of the European Parliament and of the Council of 13 October 1998 relating to the quality of petrol and diesel fuels.

country specific emission factors⁸⁵. The activity data for natural gas and biogas is based on the survey “Deliveries of natural gas and biomethane for transport”⁸⁶.

The bottom-up estimated fuel consumption and the CO₂ emissions by HBEFA and the Swedish Transport Administration (STA) differ from those reported to the UNFCCC, which are adjusted to be in line with the national deliveries of fuel. The STA aims to describe what is emitted on Swedish roads, regardless of where the fuel was bought or the nationality of the vehicles. According to IPCC Guidelines, the inventory should account for emissions which derives from fuel purchased in Sweden. The fuel consumption and the CO₂ emissions reported to UNFCCC, are consequently adjusted to be in line with national statistics on supply and deliveries of fuel. An overview of the two different objectives is presented in Table 3.17.

Table 3.17. Emissions from road transport reported by the STA and in the CRT.

Fuel bought in	Traffic on Swedish roads	Traffic in Sweden, not on roads	Traffic to/from other country	Traffic in other countries
Sweden	CRT 1.A.3.b STA	CRT 1.A.3.b	CRT 1.A.3.b * STA to the Swedish border	CRT 1.A.3.b *
Other country	STA	Not reported	STA to the Swedish border	Not reported

* Since the IPCC Guidelines do not consider international bunkers for road transportation, all emissions from road traffic and fuel bought in Sweden are considered to be domestic and thus reported under CRT 1A3b.

Emissions of greenhouse gases from the use of LPG by road traffic was estimated for the first time in submission 2017 and are based on national statistics on supply and delivery of LPG for road traffic. The emissions of CO₂ are estimated using a country-specific thermal value and emission factor, while emission factors from the IPCC 2006 guidebook are used to estimate the emissions of CH₄ and N₂O. The emissions are minor and represent only 0.02-0.03% of emissions of CO₂-eq. from road transportation considering the whole time series. As from 2018, these emissions are included in stationary combustion and reported as “IE”, as data on LPG no longer is separated between stationary and mobile combustion.

In the UNFCCC 2020 review, Sweden was recommended to report emissions from lubricants combusted in two-stroke engines. However, as GHG emissions from lubricants combusted in two-stroke engines are estimated to be below 0.0184% of the Swedish national GHG emissions and hence below the threshold of significance, Sweden does not consider this a prioritized issue.

3.2.17.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Activity data for gasoline, diesel and natural gas is available from 1990, while reliable activity data for biogas exists from 1996, for ethanol from 1998 and for FAME from 1999.

⁸⁵ Paulrud, S., Fridell, E., Stripple, H., Gustafsson, T., 2010.

⁸⁶ <https://www.scb.se/en/finding-statistics/statistics-by-subject-area/energy/energy-supply-and-use/deliveries-of-natural-gas-and-biomethane-for-transport/>

One important basic parameter for the HBEFA model is vehicle-km, which is calculated using another model⁸⁷. This other model is based on the mileage driven by the vehicle noted at time of the annual motor vehicle inspection test of the vehicle (MOT⁸⁸). A passenger car that goes through MOT in the beginning of 2023 has driven the most part during 2022. If the development of traffic is without interruption, this issue is not a problem for the calculations. However, if a sudden event occurs, such as a drop in the economy, there will be a delay in the modelled development of vehicle mileage as opposed to statistics on fuel consumption.

In 2018 a revised version of the survey “monthly fuel, gas and inventory statistics” was introduced, but uncertainties regarding the quality of the statistics were identified and data from the survey has therefore not been used for 2018-2024. Instead, data regarding diesel, gasoline and biofuels which are collected and reported according to the “Swedish fuel quality act” is used for 2018-2024. Despite the change of data source, the activity data used in submission 2026 is considered to be consistent and of good quality. See section 3.2.17.2 for more information.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7. Time series are checked for consistency and recalculations are verified.

3.2.17.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

3.2.17.5 SOURCE-SPECIFIC RECALCULATIONS

For submission 2026, the following changes have been made to the HBEFA road model:

- Calibration of load patterns was made for HDV (*Heavy Duty Vehicles*) for the period 2021-2023. This leads to increases and decreases of fuel consumption for the relevant time series and category 1AA3B (Heavy duty trucks and buses).
- Distribution of traffic work among traffic situations has been updated for 2023.

In addition to the changes made in the road model HBEFA, the following changes have been made:

- In 2023 and 2024, some of the diesel fuel consumption was MK3, and not MK1 as previously assumed. This has been accounted for in this submission, resulting in a higher amount of CO₂ for 2023 (an increase of 0,35%).
- A reallocation of fuel between working machinery and road traffic has resulted in small increase of CO₂-eq emissions in road traffic for the entire time series. This is due to a development project regarding working machinery (see 3.2.20.5).
- Emissions of CH₄ and N₂O from biogas was previously allocated to natural gas. From submission 2026 it is allocated to biogas. This update does not entail any change in total emissions, only a redistribution between natural gas and biogas.

⁸⁷ Vehicle - km statistics are produced by Statistics Sweden on behalf of the ministry of transport analysis (TRAFKA)

⁸⁸ Ministry of Transport test, originally a British abbreviation.

3.2.17.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.18 Railways (CRT 1.A.3.c)

3.2.18.1 SOURCE CATEGORY DESCRIPTION

The majority of all railway traffic in Sweden runs on electricity. Only a small part runs on diesel fuel. Emissions related to the use of electricity for railway is not included in this sector according to IPCC's guidelines. Production of electricity is accounted for in CRT 1.A.1.a, regardless of where it is consumed.

The consumption of diesel for railways has had a decreasing trend since 1990. As a consequence, the emissions of CO₂-eq. have declined by 65% from 1990 (103 kt) to 2024 (36 kt). In 2024, the emissions decreased from 39 kt to 36 kt CO₂-eq compared to 2023.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.18.

Table 3.18. Summary of source category description, CRT 1.A.3.c, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.3.c	CO ₂	-	X (Liquid fuels)		T2	CS	Yes
	CH ₄	-	-		T1	D	Yes
	N ₂ O	-	-		T1	D	Yes

CS: Country Specific. D: Default. T1: Tier 1. T2: Tier 2.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.18.2 METHODOLOGICAL ISSUES

Both Tier 1 and Tier 2 methods are used. The Swedish Transport Administration (STA) estimates the emissions of CO₂, SO₂, NO_x, NMVOC, CH₄, CO, HC and N₂O based on the amount of diesel consumed by the railways⁸⁹ and various emission factors. Country-specific emission factors are used to estimate the emissions of CO₂^{90,91} and SO₂⁹².

Emissions of CH₄ and N₂O are estimated with emission factors from EMEP/EEA Guidebook 2019 for all engines, since they are not regulated by EU directives which regulate an upper limit for emissions. The threshold limits for CO and NO_x are used as emission factors for all emissions from engines that comply with the EU emission standards Stage IIIA and Stage IIIB.⁹³ For engines introduced before the implementation

⁸⁹ The Swedish Energy Agency is responsible for statistics regarding the rail fuel consumption since 2017; previously Transport Analysis (a Swedish government agency for transport policy analysis).

⁹⁰ Utv. Proj. "SMED memo CO2 emission factor for fossil diesel fuel", IVL 2021,

⁹¹ Paulrud, Fridell, Stripple & Gustafsson, 2010. Uppdatering av klimatrelaterade emissionsfaktorer

⁹² Drivkraft Sverige. 2023. <https://drivkraftsverige.se/>

⁹³ <http://www.dieselnet.com/standards/eu/nonroad.php#rail>

of EU emissions standards, the emission factors from EMEP/EEA guidebook 2019 are used to estimate emissions of CO and NO_x.

The conversion of g/kWh to g/litre is based on the fuel consumption factors in Table 3-5 in the EMEP/EEA Guidebook 2019 and a diesel density of 816 g / litre. The same density is used for all years.

3.2.18.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Overall, the emissions for CRT 1.A.3.c are consistent over time and associated with low uncertainties. The estimate of diesel consumption is based on fees paid by the rail operators and is considered to be of very high quality.

The uncertainty analysis tables are presented in Annex 7, and a general description of the uncertainties is presented in section 1.7.

3.2.18.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

3.2.18.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations are performed in submission 2026.

3.2.18.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.19 Navigation (CRT 1.A.3.d)

3.2.19.1 SOURCE CATEGORY DESCRIPTION

In 2024, the emissions of greenhouse gases from domestic navigation decreased by 5 % compared to 2023 (see Figure 3.15). The emissions of greenhouse gases were 658 kt CO₂-eq. in 2024, which is an increase by 43% since 1990. The consumption of LNG by shipping increased during 2024 and as a result, the consumption of marine gasoil decreased.

An amendment to Directive 2012/33/EU introduced a mandatory use of marine fuels with a sulphur content of no more than 0.10% in sulphur control areas from the 1st of January 2015^{94, 95}. But already in 2012, the consumption of fuels with a high sulphur content started to decrease in Sweden. However, with the introduction of hybrid fuels on the market, i.e. heavy fuel oils with a reduced sulphur content, the consumption of residual fuel oils didn't continue to decrease as anticipated. But in 2019, a shift from residual fuel oils to LNG (liquid natural gas) can be noticed (see Figure 3.16).

⁹⁴ DIRECTIVE 2012/33/EU OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL of 21 November 2012 amending Council Directive 1999/32/EC as regards the sulphur content of marine fuels.

⁹⁵ <https://eur-lex.europa.eu/eli/dir/2016/802/>

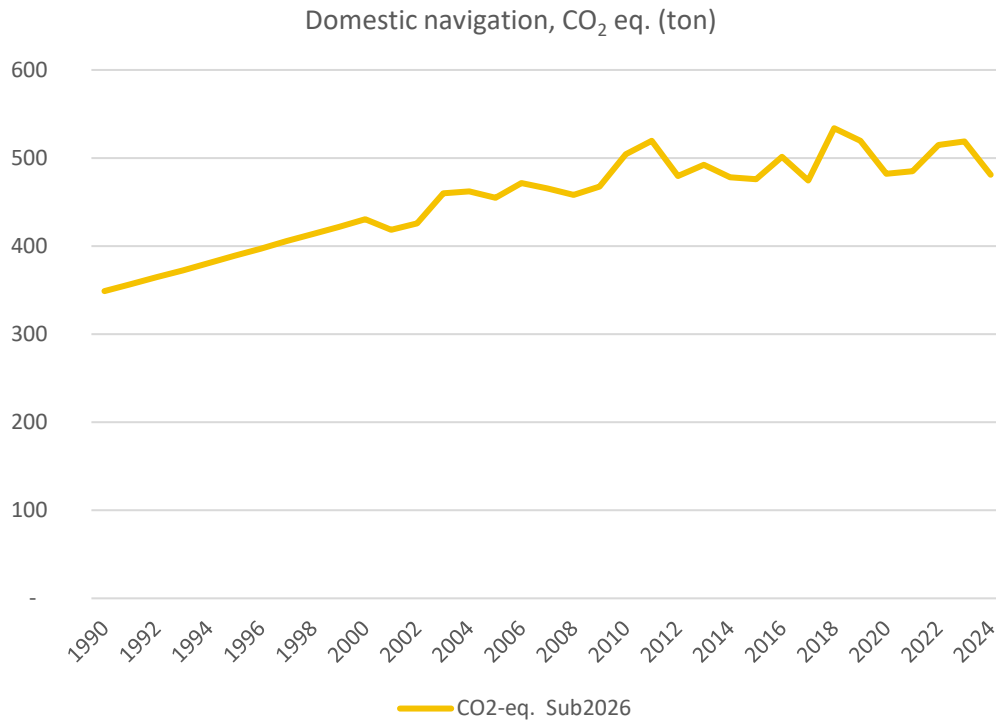


Figure 3.15. Emissions of greenhouse gases in CO₂ eq. by national navigation in submission 2026 (including leisure boats) for 1990-2024.

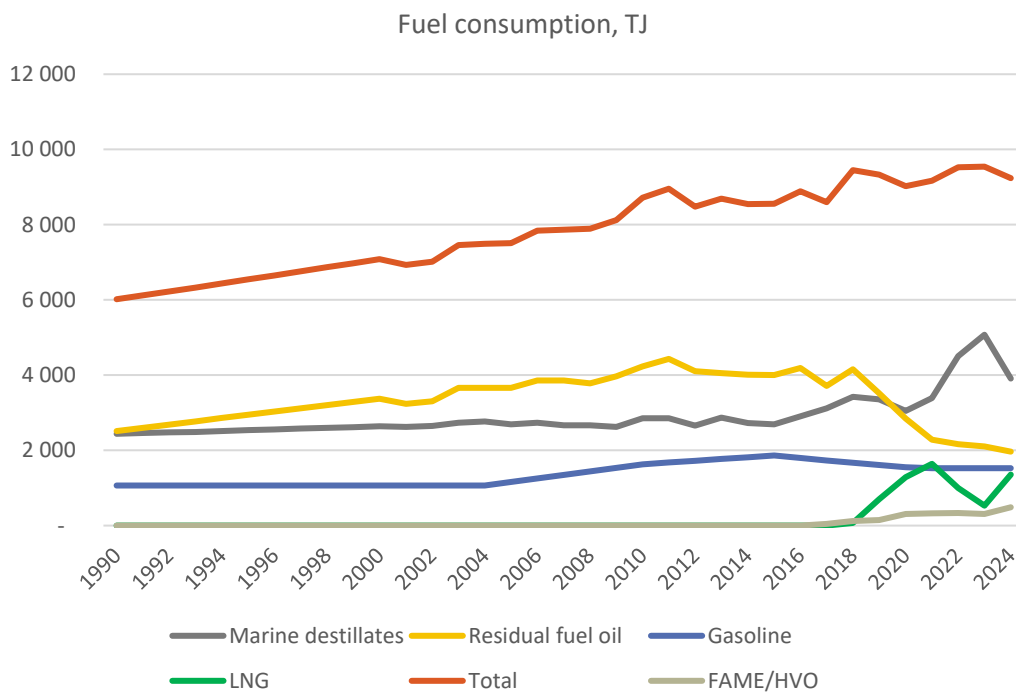


Figure 3.16. Fuel consumption by domestic navigation and fuel type (including leisure boats) 1990-2024 (TJ).

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.19.

Table 3.19. Summary of source category description, CRT 1A3d, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.3.d	CO ₂	X (Gas/Diesel, Residual Oil)	X (Gas/Diesel, LNG)		T2	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T2	CS	Yes

T1 Tier 1. T2 Tier 2. CS Country Specific.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.19.2 METHODOLOGICAL ISSUES

The emissions from domestic navigation are estimated applying Tier 2 methodology. The fuel consumption for domestic navigation⁹⁶ is estimated by a LNG survey and the Shipair model, which is developed by the Swedish meteorological and hydrological institute (SMHI). The Shipair model is based on AIS data (Automatic Identification System), which is used by ships to transmit identity and position information and shows how the ships move between different ports. Information regarding the ships such as size, engine power and type of vessel is also used by the Shipair model to estimate the amount of energy and fuel used by the ships to move between the given positions. In the Shipair model, fuel consumption in port is split equally between the voyage preceding the port call and the following voyage.

Shipair uses the fuel allocation method described in the 4th IMO GHG study⁹⁷ to decide what fuel a ship is using. If data is lacking, Shipair, assumes that ships with a gross tonnage larger than 6000 in the Shipair database run on residual fuel oil. For ships with a tonnage less than 6000, the Shipair data is complemented with fuel statistics from a survey. The survey addresses the largest shipping actors in domestic navigation with the exception of cargo ships⁹⁸ and collects information regarding the fuel consumption by fuel type. The fuel residual between Shipair and the survey is assumed to be marine gasoil used by cargo ships. The survey is used to separate the fuel consumption for ships with a gross tonnage smaller than 6000 into different fuel types.

The use of LNG as a shipping fuel increased rapidly between 2018 and 2021. In 2022 and 2023 however, the use of LNG has declined significantly due to higher gas prices. Despite the decline, it has a significant impact on methane emissions due to methane slip.

⁹⁶ Excluding leisure boats.

⁹⁷

<https://wwwcdn.imo.org/localresources/en/OurWork/Environment/Documents/Fourth%20IMO%20GHG%20Study%202020%20-%20Full%20report%20and%20annexes.pdf>

⁹⁸ EN0118, Transportsektorns energianvändning (inrikes sjöfart). Eklund, V. et al. 2019. Analys och implementering av data från nya MåBra.

See Figure 3.17. A survey to estimate the use of LNG by shipping has been conducted annually between the years 2020 and 2025⁹⁹ and shows the consumption of LNG since 2018. However, in submission 2025 a large proportion of the shipping companies failed to respond to the survey, lowering the credibility of the result. Consequently, survey data was only used for the years 2018-2020 in submission 2025. A new method was implemented to estimate the LNG consumption for 2021-2023. The new method uses the energy consumption by LNG ships calculated by Shipair and assumes the same LNG/MGO ratio as for the dual fuel LNG vessels with the highest LNG consumption in domestic navigation. Shipair cannot calculate the energy consumption for international navigation and therefore LNG in international navigation still relies on the survey. The emission factors LNG are based on a study from 2020¹⁰⁰.

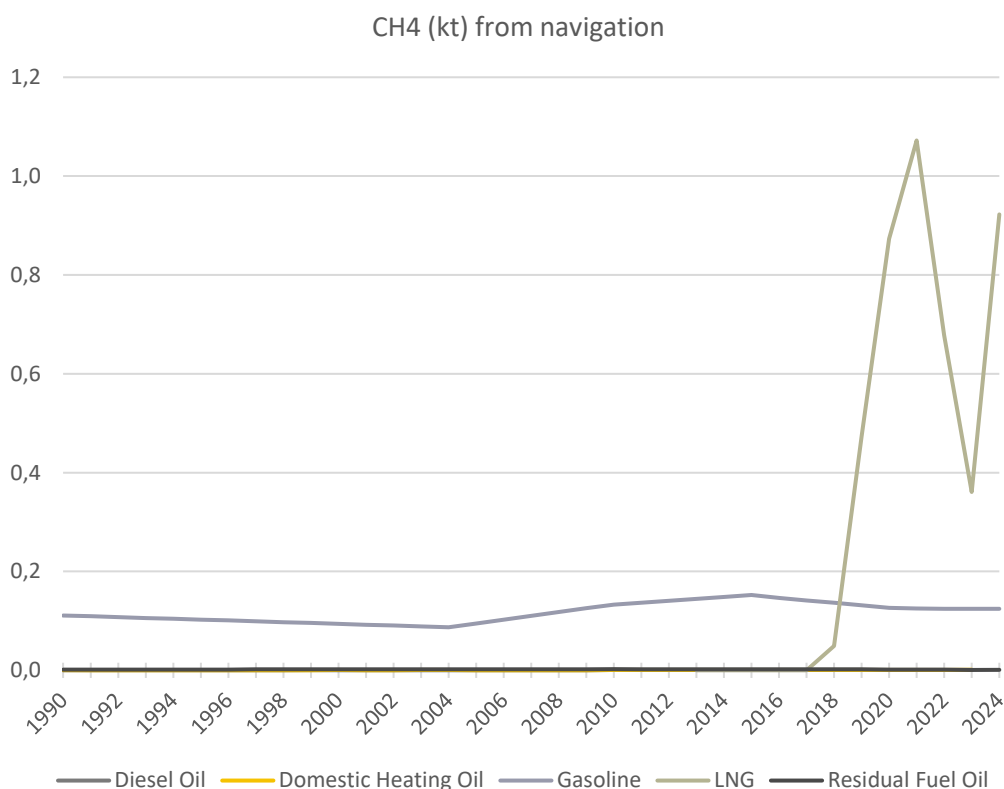


Figure 3.17. Emissions of CH₄ from navigation 1990-2024 (including leisure boats).

3.2.19.2.1 The emission factors for national navigation

The emission factors for CO₂ from diesel and marine gasoil are country-specific and based on two different studies^{101, 102}. The CO₂ emission factor for residual fuel oil is based on a SMED study from 2004¹⁰³. For LNG, the CO₂ emission factor is based on a

⁹⁹ Eklund, V., Kellner, M. Sjöfartens förbrukning av LNG

¹⁰⁰ Hult, C. et al. 2020. Emission factors for methane engines on vehicles and ships

¹⁰¹ Helbig, Tobias. 2018. Uppdatering av emissionsfaktorer för CO₂ från diesel och EO1 för sjöfart

¹⁰² Helbig, Eklund, Mawdsley m.fl. 2021, Utv. Proj. "SMED memo CO₂ emission factor for fossil diesel fuel"

¹⁰³ Cooper and Gustafsson, 2004.

study from 2020¹⁰⁴. All other emissions factors for shipping except CO₂ and SO₂ are based on fuel- and engine type as well as engine age and the abatement equipment used. The engine types are divided into the following categories: slow speed diesel engine, medium speed diesel engine, high speed diesel engine, steam turbine and gas turbine as well as dual fuel engines for LNG.

Emission factors for CH₄, N₂O, CO, NMVOC, NO_x and SO₂ were provided by the Swedish Maritime Administration (SMA) on a yearly basis until 2015 and by the Swedish Transport Agency (STA) as from 2016, in accordance with the Swedish climate legislation.

There have been four surveys of recreational boats since 1990; in 2004, 2010, 2015 and 2020¹⁰⁵. The surveys have been reviewed and the fuel consumption estimated in four different studies^{106,107, 108,109}. The fuel consumption in between the surveys is estimated by interpolation.

Emissions of CO₂ and SO₂ from leisure boats are based on the estimated consumption of gasoline and diesel and the same thermal values and emission factors used by road traffic.

3.2.19.2.2 *The emission factors for leisure boats*

Emissions of CH₄ and N₂O from *gasoline* leisure boats are based on emission factors from EMEP/EEA guidebook 2019, while country specific emissions factors are used for CO¹¹⁰ as well as for NO_x and NMVOC¹¹¹. The emissions from gasoline leisure boats also depend on the ratio between 2- and 4-stroke engines and the ratio used is based on two studies from 2005¹¹² and 2017¹¹³. The studies indicate that the share of 4-stroke engines is increasing over time. Based on information from the periodical publication “Fakta om Båtlivet i Sverige”, the ratio has been determined for the years 2003, 2009, 2015 and 2020 the ratio for 1990 has been estimated. For the years in between, the ratio has been interpolated, assuming that the change towards 4 stroke engines is gradual. The ratio for the years 2021-2025 is assumed to be the same as for 2020. In a review, the UNFCCC has recommended Sweden to report emissions from lubricants combusted in two-stroke engines. However, in 2015 such emissions constituted less than 0.0184% of Sweden’s total GHG emissions and are thus under the threshold of significance. Being insignificant, Sweden does not prioritize this issue.

¹⁰⁴ Hult & Winnes 2020. Emission factors for methane engines on vehicles and ships with a focus on methane emissions. IVL 2020.

¹⁰⁵ <https://www.transportstyrelsen.se/sv/sjofart/Fritidsbatar/Statistik-och-fakta--fritidsbatar/batlivsundersokningen/>

¹⁰⁶ Gustafsson, 2005.

¹⁰⁷ Eklund V. 2014.

¹⁰⁸ Fridell, E., Mawdsley, I., Wisell T. 2017.

¹⁰⁹ Per Dyfvelsten, The Swedish Energy Agency, personal communication, 2021.

¹¹⁰ Fridell, E., Mawdsley, I., Wisell T. 2017.

¹¹¹ Wisell, T. 2022. Uppdaterade emissionsfaktorer för fritidsbåtar i Sverige.

¹¹² Statistics Sweden, 2005a.

¹¹³ Fridell, E., Mawdsley, I., Wisell T. 2017.

Emissions of CH₄ and N₂O from the consumption of diesel by leisure boats are based on emission factors provided by the Swedish Maritime Administration up to 2015 and from the Swedish Transport Agency as from 2016. Country-specific emissions factors are used for CO¹¹⁴ as well as for NO_x and NMVOC¹¹⁵.

3.2.19.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The fuel consumption by domestic navigation was before submission 2020 based on the “Monthly fuel, gas and inventory statistics” survey¹¹⁶ and showed fluctuations for which it was difficult to find natural explanations.¹¹⁷ In submission 2020, the methodology for both national and international navigation was revised. The new methodology is based on the Shipair model and a survey and is explained in section 3.2.19.2.

The first year covered by the Shipair method is 2013. For the years before 2013, data has been extra- or interpolated with different methodologies. The method depends on what data was available for each shipping company and is either constant, interpolation or a moving average.

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7.

3.2.19.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

3.2.19.5 SOURCE-SPECIFIC RECALCULATIONS

Minor adjustments have been made to the amounts of diesel and marine gasoil for the year 2023 due to adjustments in the survey to shipping companies.

3.2.19.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.20 Other transportation (CRT 1.A.3.e)

3.2.20.1 SOURCE CATEGORY DESCRIPTION

Emissions reported under CRT 1.A.3.e refer to emissions from combustion of natural gas for pipeline transport (1.A.3.e.i), off-road vehicles and other machinery (1.A.3.e.ii). Examples of working machinery included in this sector are machinery used in ports and airports as well as snow groomer machines used in ski resorts. Around 11% of total GHG emissions from non-road working machinery are reported in CRT 1.A.3.e.ii. The emissions from working machinery increased with around 10% compared to 2023 mainly due to the significant decrease in the renewable share in diesel. Compared with 1990 the emissions and has decreased by 64% since 1990.

¹¹⁴ Fridell, E., Mawdsley, I., Wisell T. 2017.

¹¹⁵ Wisell, T. 2022.

¹¹⁶ Monthly fuel, gas and inventory statistics. <http://www.scb.se/en/finding-statistics/statistics-by-subject-area/energy/energy-supply-and-use/monthly-fuel-gas-and-inventory-statistics/>. See Annex 2.

¹¹⁷ Statistic Sweden. Monthly fuel, gas and inventory statistics. EN31SM.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.20.

Table 3.20. Summary of source category description, CRT 1A3e, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
1.A.3.e	CO ₂	X	X		T2	CS	Yes
	CH ₄	-	-		M	CS	Yes
	N ₂ O	-	-		M	CS	Yes

M Model, T2 Tier 2, CS Country Specific.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.20.2 METHODOLOGICAL ISSUES

3.2.20.2.1 Pipeline Transport (1.A.3.e.i)

Annual amounts of total natural gas in pipeline transport in Sweden are known for the whole reporting period 1990-2024. Combustion of natural gas for pipeline transport of natural gas in Sweden is only known from 2013, but not for the period 1990-2012. According to a national expert at Swedegas, the annual amount of natural gas used for pipeline transport is proportional to the total natural gas in the pipelines (about 0.12% in 2013). Based on data for 2013, annual amounts of natural gas for combustion at pipeline transport were estimated for 1990-2012. The increase in the emissions in 2010 is a result of an increase in the import of natural gas due to a cold winter.

Annual national calorific values and emission factors are applied to estimate the emissions of CO₂, while tier 1 default emission factors from 2006 IPCC Guidelines are used to estimate the emissions of CH₄ and N₂O. The emissions of CO, NMVOC, NO_x and SO₂ are estimated using the same Tier 2 national emission factors as for stationary combustion of natural gas in sector 1.A.4.a.

3.2.20.2.2 Working machinery (1.A.3.e.ii)

A national model is used to estimate emissions from all working machinery used in Sweden and it is considered to correspond to Tier 3 for all emissions, except for CO₂ and SO₂ which are estimated according to Tier 2. The model is further explained in Annex 2.¹¹⁸

The consumption of gasoline and diesel, estimated by the model for off-road vehicles, is adjusted with regard to low-blended biofuel. The fuel consumption is also modified with a residual of gasoline and diesel. This residual arises as the volume of gasoline and diesel allocated to different sectors through a top-down approach is compared to the total volume of the gasoline and diesel consumed according to a bottom-up estimate. See Annex 2 for more information regarding the allocation of fuels for mobile combustion¹¹⁹.

¹¹⁸ Annex 2: 1.6 Methodology for off-road vehicles and working machinery

¹¹⁹ See Annex 2, section "1.4 Allocation of fuels for mobile combustion" for more information."

Emissions from off-road vehicles and other machinery are also reported under CRT 1.A.2.g vii, 1.A.4.a, 1.A.4.b and 1.A.4.c, in line with IPCC Guidelines, see Table 3.21.

Table 3.21. Distribution of emissions from off-road vehicles and other machinery.

Category	CRT	Definition IPCC Guidelines
Industry	1.A.2.g vii	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
Other	1.A.3.e ii	Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1.A.4.c or 1.A.2.g vii.
Commercial/ Institutional	1.A.4.a.ii	Garden machinery, eg lawn mowers and clearing saws, not used by private users. Also tractors not used in industry ore forestry or agriculture.
Residential	1.A.4.b.ii	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
Agriculture, Forestry	1.A.4.c.ii	Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded.

3.2.20.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The fuel and emission estimates of working machinery are based on a model that takes into consideration emission regulations according to EU legislation in g kWh^{-1} , differences between regulation and value measured at certification, transient use (i.e. difference between static test cycle and real use of the machine), emission deterioration with age and differences between certification fuel and Swedish diesel of type “MK1”. The model does not consider market fluctuations due to for example economic recession.

The amount of low-blended biofuel used by working machinery and road traffic is allocated proportionally to the amount of fossil gasoline and diesel consumed in each subsector. The model estimated consumption of fossil gasoline and diesel by working machinery is decreased by the amount of ethanol and FAME/HVO, respectively, allocated to the subsector in question. In 2004, the consumption of gasoline by working machinery decreased noticeably as a result of an increase in the amount of ethanol allocated to working machinery, due to a large increase in the national deliveries of low-blended ethanol. The same phenomenon took place between 2017 and 2018 as a result of a sudden increase of the ethanol sold on the Swedish market. On the same note there was a drastic decrease in renewable fuel share in 2024. The renewable share of diesel fuels decreased from 30.5% to 6%, and for gasoline the renewable share decreased from 7.8% to 6% (see section 3.2.17.1). The decrease of renewable fuel led to an increase of fossil fuels, and increased emissions of GHG. During 2025 the renewable share is expected to rise to 10% for both diesel and gasoline. In addition, there is some pure biofuels on the Swedish market such as HVO100.

The uncertainty analysis tables are presented in Annex 7, and a general description of the uncertainties is presented in section 1.7.

3.2.20.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The model for working machinery was implemented for the first time in submission 2009. During 2010 the model underwent a second verification. Activity data and emissions factors were reviewed in 2012 and 2013. Time series are checked for consistency and recalculations are verified every year.

3.2.20.5 SOURCE-SPECIFIC RECALCULATIONS

Recent updates in this CRT includes updates on “other machinery” and the old machine population, the aggregated machine group +24-year-old machines. This group of machines mainly includes machinery specifically used in the road infrastructure sector and have for long made up 25-50% of the total machine population. Since EU-regulations forced a change from stage 0 to stage 5 (today) engines, it was concluded that the amount of +24-year-old machines cannot make up a large share of the total amount of active machines as these aren't allowed to be used. Aside from changing the number of +24-year-old machines the operating hours for new machines (machine year 0) was decreased by 50% to better match the fact that the average machine mange half a year of operating hours during the year it was brought to the market.

The recalculation effect is around 1-6% decrease in CO₂ emissions over the time series. The decrease is greater for the latter part of the time series. This is because emissions from the old machine population gradually constituted a larger share of the total emissions as the old population grew.

The activity data for pipeline transport has been reviewed and updated for 2021-2023, the recalculation resulted in a decrease of between 2 and 6 %.

In 2023 and 2024, some of the fossil diesel fuel consumed was MK3, and not MK1 as previously assumed. This has been considered in this submission, resulting in a higher amount of CO₂ for 2023.

3.2.20.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.21 Commercial/institutional (CRT 1.A.4.a)

3.2.21.1 SOURCE CATEGORY DESCRIPTION

This category includes stationary combustion for heating of premises used for commercial and institutional activities and emissions from working machinery used in these activities. GHG emissions in 1.A.4.a have increased by 13,6 % compared to 2023 (mainly due to reduced share of renewables in fuels) and decreased by around 80% since 1990.

Around 8% of total GHG emissions from working machinery are reported in CRT 1.A.4.a.ii. The emissions from working machinery make up 43% of the total emissions in this category. The emissions from working machines increased 3% compared to 2022 but has decreased about 9 % since 1990.

Since 1990, the total consumption of fuels for heating of premises has decreased significantly due to the increased use of district heating. In the early 1990s, the total

annual fuel consumption in this sector was around 35 000 TJ, around year 2000 it had decreased to about 21 000 TJ, and in 2023 it was around 5 723 TJ. Liquid fuels account for most of the decrease. The share of liquid fuels in 1990 was about 94% and the corresponding share in 2023 was about 19%.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.22.

Table 3.22. Summary of source category description, CRT 1A4a, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.4.a	CO ₂	X (Gaseous fuels, Liquid fuels)	X (Gaseous fuels, Liquid fuels)		T2	CS	Yes
	CH ₄	-	-		T2, M	CS	Yes
	N ₂ O	-	-		T2, M	CS	Yes

CS Country Specific. T1 Tier 1, T2 Tier 2. M Model

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.21.2 METHODOLOGICAL ISSUES

3.2.21.2.1 Stationary combustion

For stationary combustion within CRT 1.A.4.a, all activity data and emission factors are on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 2. Since submission 2020, biomass activity data and emission factors are separated into traditional and modern technology for the whole time series¹²⁰. The data source for activity data is the annual energy balance, which for this sector is mainly based on premises statistics that is further described in section 3.2.21.4.1 and in Annex 2. Activity data for the latest emission year is preliminary as the annual energy balances are not published at the time when the emission calculations have to be finalized.

The activity data and emission factors for CH₄, CO and NMVOC from biomass combustion within 1.A.4.a are separated into modern and traditional combustion technology for the whole time series in order to capture the phasing-out of old technology¹²¹. The revision is described more in detail in Annex 2.

The activity data for the last emission year (2024), is the same as for 2023. The reason for estimating the activity data is due to that the preliminary Energy Balance compiled by the Swedish Energy Agency, is delivered too late in the process of compiling the GHG inventory and that the last years activity data is often revised in the definitive Energy Balances. For more detailed information about the extrapolation effects see Annex 2. The

¹²⁰ Helbig, T., Kindbom, K., Jonsson, M. 2019. Uppdatering av nationella emissionsfaktorer för övrig sektor. SMED rapport no 12 2019.

¹²¹ Helbig, T., Kindbom, K., Jonsson, M. 2019. Uppdatering av nationella emissionsfaktorer för övrig sektor. SMED rapport no 12 2019.

activity data for the last inventory year will be revised next coming submission, as the Energy Balance will then be published and definitive.

3.2.21.2.2 Mobile combustion/Working machinery

Emissions from mobile combustion in CRT 1.A.4.a refer mainly to gardening machines for professional use, wheel loaders, excavators and tractors that are not used in industry, farming, or forestry. A national model is used to estimate emissions from all working machinery used in Sweden and it is considered to correspond to Tier 3 for all emissions, except for CO₂ and SO₂ which are estimated according to Tier 2. The model is further explained in Annex 2.¹²²

The consumption of gasoline and diesel, estimated by the model for off-road vehicles, is adjusted with regard to low-blended biofuel. The fuel consumption is also modified with a residual of gasoline and diesel. This residual arises as the volume of gasoline and diesel allocated to different sectors through a top-down approach is compared to the total volume of the gasoline and diesel consumed according to a bottom-up estimate. See Annex 2 for more information regarding the allocation of fuels for mobile combustion¹²³.

Emissions from working machinery are also reported under CRT 1.A.3.e, 1.A.4.A, 1.A.4.b and 1.A.4.c, in line with IPCC Guidelines, see Table 3.23.

Table 3.23. Distribution of emissions from off-road vehicles and other machinery.

Category	CRT	Definition IPCC Guidelines
Industry	1.A.2.g vii	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
Other	1.A.3.e ii	Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1.A.4.c or 1.A.2.g vii.
Commercial/ Institutional	1.A.4.a.ii	Wheel loaders, excavators, garden machinery, eg lawn mowers and clearing saws, not used by private users, Also tractors not used in industry ore forestry or agriculture.
Residential	1.A.4.b.ii	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
Agriculture, Forestry	1.A.4.c.ii	Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded.

3.2.21.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis tables are presented in Annex 7, and a general description of the uncertainties is presented in section 1.7. The uncertainties for stationary combustion are revised in submission 2020 and set on fuel group aggregation level. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group.

¹²² Annex 2: 1.6 Methodology for off-road vehicles and working machinery

¹²³ See Annex 2, section "1.4 Allocation of fuels for mobile combustion" for more information."

Activity data uncertainty is 20% for Liquid Fuels and 10% for all other fuel groups. The large activity data uncertainty is due to the use of data from the annual energy balances. CO₂ emission factor uncertainty is highest for Biomass (30%) and lowest for Liquid Fuels, (1%).

The implied emission factor for CO₂ for liquid fuels in CRT 1.A.4.a fluctuates according to the relative proportions of LPG, domestic heating oil and residual fuel oils (the latter not used in the latest years). The IEF is below 70 kg/GJ in the years 2007-2011 due to extensive use of LPG. In 2012, the share of LPG decreased somewhat, resulting in a CO₂ IEF of 71.9 kg/GJ.

The amount of low-blended biofuel used by working machinery and road traffic is allocated proportionally to the amount of fossil gasoline and diesel consumed in each subsector. The model-estimated consumption of fossil gasoline and diesel by working machinery is decreased by the amount of ethanol and FAME/HVO, respectively, allocated to the subsector in question. In 2004, the consumption of gasoline by working machinery decreased noticeably as a result of an increase in the amount of ethanol allocated to working machinery, due to a large increase in the national deliveries of low-blended ethanol. The same phenomenon took place between 2017 and 2018 as a result of a sudden increase of the ethanol sold on the Swedish market.

3.2.21.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In submission 2005 and earlier, there were large uncertainties in estimation models and allocation methods for fuel in the Other sectors. In 2005, a study was performed by SMED, aiming at identifying and analysing the methods and models applied for each subsector and determine whether they were in line with the IPCC guideline recommendations¹²⁴. In addition, each fuel was traced back to its original source in order to determine whether it had been correctly allocated on stationary and mobile combustion.

The results from the study show good agreement with IPCC guideline recommendations. All fuels but biomass had little or no changes in methodologies, and where changes occurred, no significant inconsistencies in fuel consumption time series were detected. However, for biomass, several significant inconsistencies were identified leading to recalculations of activity data and emissions in CRT 1.A.4.a and 1.A.4.b¹²⁵. Due to these recalculations, there are obvious inconsistencies between the national energy balances and the national emission inventory data for years before 2005. Furthermore, all fuels proved to be correctly allocated to stationary and mobile combustion. All diesel and gasoline reported under Other sectors in the energy balances is allocated to mobile combustion, while all the other fuels are related to stationary combustion.

3.2.21.4.1 Activity data for stationary combustion in other sectors

For stationary combustion within the Other sectors the activity data source is the energy balance.

Since 2002, and in particular since 2004, the consumption of biomass fuels has increased in this sector. This is partly explained by the general shift from liquid to biomass fuels in

¹²⁴ Gustafsson, et al. 2005.

¹²⁵ Paulrud et al. 2005.

recent years. However, a data check performed in 2009 showed that the data for biomass use in the commercial/institutional sector in the energy balances might not be complete. In submission 2010, it was noted that the consumption of biomass, liquid fuels and gaseous fuels within this sector was higher in 2007 than in 2006 and 2008. In submission 2011, the activity data for 2007 and 2008 were revised due to revisions in the energy balances (as described above). The fuel consumption in 2007 is still relatively high. The input data to the energy balances for this sector has not been available for analysis. However, the activity data uncertainty is high in this sector and the time series 1990-2010 shows that inter-annual variations in total fuel consumption can be large. Thus, the fuel consumption in 2007 is considered to be high, maybe as a result of the large uncertainty, but not erroneous as no calculation errors have been found.

3.2.21.5 SOURCE-SPECIFIC RECALCULATIONS

3.2.21.5.1 *Stationary combustion*

In submission 2026 there is a revision of activity data for the year 2023 for the sector as the data was updated to the final energy balance statistics. The effect of the recalculations in 1.A.4.a.i for 2023 was a decrease of 46.4 kt CO₂-eq (15.2%).

The emission factor of natural gas was corrected for 2019 which resulted in an increase of emissions by 1.51 kt CO₂-eq (0.42%).

3.2.21.5.2 *Mobile combustion*

Development project¹²⁶ conducted in 2025 had very limited impact on emissions in this category. The project aimed to calibrate the stock of mobile cranes, wheel loaders, and backhoe loaders against the Swedish road traffic register, with respect to age distribution and scrappage rates. The machines that were impacted by the project have limited presence in this CRT and besides this the model's previous assumptions were relatively accurate, which also explains the limited effect of the recalculations.

The effect on CO₂-eq emissions is ranging from -0.2% to +0.4% over the time series and the accumulated change in calculated CO₂-eq emissions sum up to +2 kt.

3.2.21.1 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Further category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.22 Residential (CRT 1.A.4.b)

3.2.22.1 SOURCE CATEGORY DESCRIPTION

In this category both stationary and mobile combustion occur. Stationary combustion of fuels within residential decreased 70% between 1990 and 2023, mainly due to a continuous increase in district heating use¹²⁷. Most of this change occurred before 2006; however, the use of heating oils is still decreasing while combustion of wood, wood chips and pellets has increased in recent years. In 2009-2010, fuel consumption increased due to the cold winters these years, especially in 2010. Despite this, the consumption of

¹²⁶ Hammerlid, 2025

¹²⁷ Swedish Energy Agency 2020, All numbers are according to data used in the greenhouse gas inventory this submission.

heating oil continued to decrease while consumption of wood fuels and natural gas increased quite considerably. In recent years, the use of heat pumps has also increased significantly¹²⁸. Emissions of CO₂, CH₄ and N₂O from the use of charcoal are included in this source category.

Mobile combustion in 1.A.4.b refers to gardening machines used in households e.g. lawn mowers, hedge cutters, clearing saws and more. Also snow mobiles and all-terrain vehicles not used for professional purposes and tractors are allocated to 1.A.4.b. Around 6% of total GHG emissions from working machinery are reported in CRT 1.A.4.b.ii. GHG emissions in this sector have decreased by 1% compared to 2023 and by 20% compared to 1990.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.24.

Table 3.24. Summary of source category description, CRT 1A4b, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.4.b	CO ₂	X (Liquid fuels)	X (Liquid fuels)		T2	CS	Yes
	CH ₄	-	-		M, T2	CS	Yes
	N ₂ O	-	-		M, T2	CS	Yes

CS Country Specific. T1 Tier 1, T2 Tier 2, M Model.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.22.2 METHODOLOGICAL ISSUES

3.2.22.2.1 Stationary combustion

For stationary combustion, all activity data is on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 2.

The main data source is the annual energy balances. One- and two-dwellings statistics, Holiday cottages statistics and multi-dwellings statistics are used as a complementary data source to get more details on biomass combustion. Biomass fuel consumption for heating residences is surveyed for the three most common combustion technologies: boiler, stoves and open fireplaces. Since 1998, biomass activity data is separated into wood logs, pellets/briquettes and wood chips/saw dust. Historical biomass data has been estimated by inter- and extrapolation. Since submission 2019, biomass activity data and emission factors for boilers and stoves are further separated into traditional and modern technology for the whole time series¹²⁹.

¹²⁸ Swedish Energy Agency 2020, All numbers are according to data used in the greenhouse gas inventory this submission.

¹²⁹ Helbig, T., Gustafsson, T., Kindbom, K. Jonsson, M. 2018. Uppdatering av nationella emissionsfaktorer för övrig sektor (CRT/NFR 1A4). SMED rapport no 13 2018.

Estimation models and allocation methods for fuel in the Other sectors, and use of preliminary data for stationary combustion in other sectors as discussed in section 3.2.21.4.1, also applies to CRT 1.A.4.b.

Emissions arising from the use of charcoal are estimated using national statistics and default 2006 IPCC guidelines EFs.

3.2.22.2.2 *Mobile combustion/Working machinery*

A national model is used to estimate emissions from all working machinery used in Sweden and it is considered to correspond to Tier 3 for all emissions, except for CO₂ and SO₂ which are estimated according to Tier 2. The model is further explained in Annex 2.

¹³⁰

The consumption of gasoline and diesel, estimated by the model for off-road vehicles, is adjusted with regard to low-blended biofuel. The fuel consumption is also modified with a residual of gasoline and diesel. This residual arises as the volume of gasoline and diesel allocated to different sectors through a top-down approach is compared to the total volume of the gasoline and diesel consumed according to a bottom-up estimate. See Annex 2 for more information regarding the allocation of fuels for mobile combustion¹³¹.

Emissions from off-road vehicles and other machinery are also reported under CRT 1.A.2.g vii, 1.A.3.e, 1.A.4.A and 1.A.4.c in line with IPCC Guidelines, see Table 3.25.

Table 3.25. Distribution of emissions from off-road vehicles and other machinery.

Category	CRT	Definition IPCC Guidelines
Industry	1.A.2.g vii	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
Other	1.A.3.e ii	Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1.A.4.c or 1.A.2.g vii.
Commercial/ Institutional	1.A.4.a.ii	Garden machinery, eg lawn mowers and clearing saws, not used by private users, also tractors not used in industry ore forestry or agriculture.
Residential	1.A.4.b.ii	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
Agriculture, Forestry	1.A.4.c.ii	Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded.

3.2.22.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time series for 1.A.4.b is considered to be consistent as there has not been any major changes in methodology or input data to the energy balances that affect this category. The estimates for the last year, however, are somewhat inconsistent due to issues in the activity data in biomass described in section 3.2.21.4.1. The CO₂ IEF for liquid fuels

¹³⁰ Annex 2: 1.6 Methodology for off-road vehicles and working machinery

¹³¹ See Annex 2, section "1.4 Allocation of fuels for mobile combustion" for more information."

shows a decreasing trend because the share of residual fuel oil is decreasing. The CH₄ IEF for biomass is slightly fluctuating between years due to variations in type of biomass and technology.

The uncertainty analysis tables are presented in Annex 7, and a general description of the uncertainties is presented in section 1.7. The uncertainties for stationary combustion were revised in submission 2020 and set on fuel group aggregation level. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group.

Activity data uncertainty is 20% for Liquid Fuels and 10% for other fuels groups. The CO₂ emission factor uncertainty is highest for Biomass, 30%. The other fuel groups vary between 1-5%.

The amount of low-blended biofuel used by working machinery and road traffic is allocated proportionally to the amount of fossil gasoline and diesel consumed in each subsector. The model estimated consumption of fossil gasoline and diesel by working machinery is decreased by the amount of ethanol and FAME/HVO, respectively, allocated to the subsector in question. In 2004, the consumption of gasoline by working machinery decreased noticeably as a result of an increase in the amount of ethanol allocated to working machinery, due to a large increase in the national deliveries of low-blended ethanol. The same phenomenon took place between 2017 and 2018 as a result of a sudden increase of the ethanol sold on the Swedish market.

3.2.22.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

See section 3.2.21.4.

3.2.22.5 SOURCE-SPECIFIC RECALCULATIONS

3.2.22.5.1 *Stationary combustion*

In submission 2026 there was a revision of activity data for the year 2023 for the sector as the data was updated to the final energy balance statistics. The total effect of the recalculations in 1.A.4.b.i for 2023 was a decrease of 25.98 kt CO₂-eq (9.6%).

3.2.22.5.2 *Mobile combustion*

No recalculations other than minor insignificant changes (ranging between -0.05% to 0.03%) were made during submission 2026. The recalculations are a result of minor effects from the revised scrapping rates for machines that have very limited presence in this CRT.

In 2023 and 2024, some of the diesel fuel combustion was MK3, and not MK1 as previously assumed. This has been considered for in this submission, resulting in a higher amount of CO₂ for 2023.

3.2.22.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.23 Agriculture/forestry/fisheries (CRT 1.A.4.c)

3.2.23.1 SOURCE CATEGORY DESCRIPTION

This category includes emissions from stationary combustion for heating purposes and mobile combustion in working machinery within agriculture and forestry, and fishing vessels. The sectors agriculture and forestry each account for approximately 40% of the total emission in this category. Around 15% arise from stationary combustion and 5 % from fishing vessels.

Around 30% of total GHG emissions from working machinery are reported in CRT 1.A.4.c.ii/ciii. In 2024, GHG emissions from working machinery in this category have increased by 35% compared to 2023 and increased by 13% since 1990. The notable increase between 2023 and 2024 is due to a lowered reduction mandate. The structure of the agricultural sector in Sweden is described in section 5.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.26.

Table 3.26. Summary of source category description, CRT 1A4c, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.A.4.c	CO ₂	X (Liquid fuels)	X (Liquid fuels, Solid fuels, Domestic heating oil)		T2	CS	Yes
	CH ₄	-	-		M, T2	CS	Yes
	N ₂ O	-	-		M, T2	CS	Yes

CS Country Specific. T1 Tier 1, T2 Tier 2. M Model

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.2.23.2 METHODOLOGICAL ISSUES

3.2.23.2.1 Stationary combustion

For stationary combustion, all activity data and emission factors are on national level by fuel type and estimated emissions are therefore considered to correspond to Tier 2 for agriculture and forestry (stationary combustion is not occurring for fisheries). Activity data is taken from the annual energy balances, which for this sector are based on models and results from a survey from 1985 and repeated in 2007 (see Other statistics from Statistics Sweden in Annex 2).

Estimation models and allocation methods for fuel in the Other sectors as discussed in section 3.2.21, and use of preliminary data for stationary combustion in other sectors as discussed in section 3.2.21.4.1 also applies to CRT 1.A.4.c. Since submission 2020, biomass activity data and emission factors are separated into traditional and modern combustion technology for the whole time series¹³².

¹³² Helbig, T. Kindbom, K. Jonsson, M. 2019. Uppdatering av nationella emissionsfaktorer för övrig sektor. SMED rapport no 12 2019.

In submission 2022, activity data for other biomass was revised for the time series between 1990 and 2004 according to Josefsson Ortiz & Helbig (2021)¹³³. The energy consumption of other biomass for this sector had an abrupt start in 2002, which was not credible. The revision of other biomass for 1.A.4.c has increased the time series consistency by incorporating an estimated other biomass energy consumption between the years 1990 to 2004. The estimate was made after a thorough investigation of data available at different authorities gathering data for statistic production of fuel consumption from the agricultural sector. Surrogate data according to IPCC GL 2006 was used in reproducing the energy consumption for the early years of the time series. Surrogate data used in the estimates were:

- Yearly cereal harvests
- Variation of fractions of wood fuel for heating greenhouses
- Energy consumption per ton cereal harvest or energy consumption per m² heated greenhouse

3.2.23.2.2 *Mobile combustion*

The estimated fuel consumption for fisheries is based on the following sources:

- The survey “Energianvändning inom fiskesektorn” for the years 2005, 2017 and 2022, which estimates the energy consumption by the fishing industry for each year^{134,135,136}.
- The Swedish fishing fleets’ total installed effect in kW¹³⁷.
- The SMED report “Fiskenäringen – uppdatering av bränsleförbrukning samt emissionsfaktorer” which included an analysis of the fuel type used by the fishing industry¹³⁸.

The estimated fuel consumption for the years before and after 2005 is estimated by adjusting the fuel consumption in 2005, from the survey, based on the development in total installed capacity.

The emission factors used to estimate emissions from the fishing fleet are based on a SMED study from 2005¹³⁹, producing emission factors for NMVOC, CH₄ and N₂O for 1990-2004. These emission factors are used for the whole time series. However, from 2007 and onwards, the emission factors for SO₂ from fisheries are assumed to be the same as for domestic navigation, which are updated every year.

The emission factor for CO₂, is based on a SMED report from 2021¹⁴⁰. The emission factors for SO₂ from fisheries are assumed to be the same as for domestic navigation,

¹³³ Josefsson Ortiz, C. & Helbig, T. 2021. Revidera bränsleförbrukning i övrig sektor 1990-2002. SMED Memorandum 2021.

¹³⁴ Statistics Sweden, 2006. ER 2006:35. Energianvändningen inom fiskesektorn år 2005

¹³⁵ Swedish Energy Agency 2018. EN0115. Energianvändning inom fiskesektorn,

¹³⁶ Swedish Energy Agency 2023. EN0115. Energianvändning inom fiskesektorn.

¹³⁷ Swedish Agency for Marine and Water Management (SwAM). Personal communication.

¹³⁸ Eklund, V. Kellner, M. Parsmo, R. 2021. Fiskenäringen – uppdatering av bränsleförbrukning samt emissionsfaktorer.

¹³⁹ Cooper et al., 2005a.

¹⁴⁰ Helbig, Mawdsley et al. 2018. SMED memo CO₂ emission factor for fossil diesel fuel, 2021.

which are updated annually by the Swedish transport agency. The emission factor for NO_x has been updated for all years in submission 2022 after a SMED study from 2021¹⁴¹.

Emissions from fisheries are derived under the assumption that the fishing fleet operates using medium speed diesel engines running on marine gasoil. The emission abatement technologies used by the fleet (e.g. Selective Catalytic Reduction (SCR) for NO_x reduction) are assumed to be negligible.

Mobile combustion in CRT 1.A.4.c refers also, beside the fishing industry, to working machinery used in agriculture and forestry. A national model is used to estimate emissions from all working machinery used in Sweden and it is considered to correspond to Tier 3 for all emissions, except for CO₂ and SO₂ which are estimated according to Tier 2. The model is further explained in Annex 2.¹⁴²

The consumption of gasoline and diesel, estimated by the model for off-road vehicles, is adjusted with regard to low-blended biofuel. The fuel consumption is also modified with a residual of gasoline and diesel. This residual arises as the volume of gasoline and diesel allocated to different sectors through a top-down approach is compared to the total volume of the gasoline and diesel consumed according to a bottom-up estimate. See Annex 2 for more information regarding the allocation of fuels for mobile combustion¹⁴³.

Emissions from off-road vehicles and other machinery are also reported under CRT 1.A.2.g vii, 1.A.3.e ii, 1.A.4.a.ii and 1.A.4.b.ii, in line with IPCC Guidelines (Table 3.27).

Table 3.27. Distribution of emissions from off-road vehicles and other machinery.

Category	CRT	Definition IPCC Guidelines
Industry	1.A.2.g vii	Mobile machineries in industry that run on petroleum fuels, as for example tractors, dumpers, cranes, excavators, generators, wheel loaders, sorting works, pump units etc.
Other	1.A.3.e ii	Combustion emissions from all remaining transport activities including ground activities in airports and harbours, and off-road activities not otherwise reported under 1.A.4.c or 1.A.2.g vii.
Commercial/ Institutional	1.A.4.a.ii	Garden machinery, e.g. lawn mowers and clearing saws, not used by private users. Also, tractors not used in industry, forestry or agriculture.
Residential	1.A.4.b	All emissions from mobile fuel combustion in households, as for example tractors, lawn movers, snow mobiles, forklifts, trimmers, chainsaws and forklifts
Agriculture, Forestry	1.A.4.c	Emissions from mobile fuel combustion in agriculture and forestry, as for example loader-excavator, tractor, harvester, clearing saw etc. Highway agricultural transportation is excluded.

3.2.23.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The sharp increase in the use of biomass in 2003 is due to a revision in submission 2009, where improved data was used for 2003 and later years. There is no information available

¹⁴¹ Eklund, V. Kellner, M. Parsmo, R. 2021. Fiskenäringen – uppdatering av bränsleförbrukning samt emissionsfaktorer

¹⁴² Annex 2: 1.6 Methodology for off-road vehicles and working machinery

¹⁴³ See Annex 2, section “1.4 Allocation of fuels for mobile combustion” for more information.”

to improve data from 2002 and earlier years. Emissions in 1990 are considered to be of a sufficient quality as they are based on the 1985 survey mentioned above, which was reasonably recent in 1990. The time series for liquid, solid and gaseous fuels are considered to be consistent. Solid fuels have not been used in this sector since 2000. The uncertainty analysis tables are presented in Annex 7, and a general description of the uncertainties is presented in section 1.7. The uncertainties for stationary combustion are revised in submission 2020 and set on fuel group aggregation level. The uncertainty values are assigned by staff at Statistics Sweden and are based on expert judgements made on fuel type that were aggregated to fuel group.

The consumption of gasoline by off-road vehicles and other machinery drops in 2004, as a result of a large increase in the total consumption of low-blended ethanol, which is allocated to road traffic and working machinery. The amount of low-blended biofuel (Ethanol/FAME) allocated to road traffic is given by the road emission model HBEFA in combination with national fuel statistics. A residual of biofuel arises when the biofuel allocated to road traffic is subtracted from the national deliveries of biofuel. *This residual is distributed to off-road vehicles and other machinery.* The model-estimated consumption of gasoline and diesel by working machinery is decreased by the residual of ethanol and FAME, respectively. In 2004 the consumption of gasoline by working machinery decreased noticeably as a result of an unusual large residual of ethanol allocated to working machinery, due to a large increase in the national deliveries of low-blended ethanol. The same phenomenon took place in 2014, but regarding FAME and diesel, e.g. a noticeable decrease in the consumption of diesel between 2013 and 2014 as a consequence of an increased consumption of low-blended FAME.

3.2.23.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.23.5 SOURCE-SPECIFIC RECALCULATIONS

3.2.23.5.1 *Stationary combustion*

In submission 2026 there was a revision of activity data for the year 2023 for the sector as the data was updated to the final energy balance statistics. The effect of the recalculations in 1.A.4.a.i for 2023 was a decrease of 41.499 kt CO₂-eq (28.8%).

3.2.23.5.2 *Mobile combustion*

This year's development projects¹⁴⁴ had very limited impact on emissions in this category. The project aimed to calibrate the stock of mobile cranes, wheel loaders, and backhoe loaders against the Swedish road traffic register, with respect to age distribution and scrappage rates. The calibration and adjustments regarding scrappage and fleet composition were carried out using conservative estimates, as the register data utilized is not fully comprehensive. The model's previous assumptions were relatively accurate, which also explains the limited effect of the recalculations.

The effect on CO₂-eq emissions is ranging from -2kt to +2kt for the affected years.

¹⁴⁴ Hammerlid, 2025

3.2.23.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.2.24 Other stationary (CRT 1.A.5.a)

No emissions are reported in this sector.

3.2.25 Other mobile (CRT 1.A.5.b)

3.2.25.1 SOURCE CATEGORY DESCRIPTION

The emissions from military activities are included elsewhere.

3.3 Fugitive emissions from solid fuels and oil and natural gas (CRT 1.B)

During all stages from extraction of fossil fuels to final use, escape or release of gaseous fuels, volatile components or absorbed gases may occur. These fugitive emissions are intentional or unintentional escapes and releases of gases from extraction point to final oxidation. In particular, they may arise from the production, processing, transmission, storage and use of fuels, and include emissions from combustion only where it does not support a productive activity (e.g. flaring).

Fugitive emissions in Sweden stem from charcoal production, flaring of fuels at refinery plants, flaring of coke oven gas at coke ovens, hydrogen production, transport of crude oil, transmission losses of gasworks gas, storage and handling of oil in refineries, depots and gasoline distribution, venting and flaring in the national natural gas and biogas transmission network (including storage) and leakage from sources such as gas driven vehicles, appliances and more.

Table 3.28 gives an overview of data sources used to calculate fugitive emissions of greenhouse gases reported in CRT 1.B. All emissions from oil refineries are included in CRT 1.A.1.b from submission 2026 onwards, however fugitive emissions from refineries are described in this section.

Table 3.28. Data sources used to calculate fugitive emissions of direct and indirect greenhouse gases reported in CRT 1.B.

CRT	GHG	Activity data	Emission factors	Emissions
1.B.1.b: Charcoal production	CH ₄ , N ₂ O, CO, NO _x	Amounts of produced charcoal in FAO statistics	Default EF in Refinement 2019 to 2006 IPCC Guidelines	Calculated
1.B.1.b: Coke production	SO ₂	—	—	Environmental reports
	CH ₄	Amounts of produced coke in environmental reports	Default EF in Refinement 2019 to 2006 IPCC Guidelines	Calculated
	NO _x , NMVOC	Amounts of produced coke in environmental reports	Default EF in EMEP /EEA Guidebook 2019	—
1.B.1.c: COG flaring	CO ₂ , CH ₄ , N ₂ O, NMVOC, CO, SO ₂ , NO _x	Amounts of flared COG in environmental reports	National emission factor for stationary combustion of COG	Calculated
1.B.2.A.3: Oil transport	CH ₄	Import/export of crude oil	Default EF in Refinement 2019 to 2006 IPCC Guidelines	Calculated
1.B.2.A.4: Oil refining (reported in 1.A.1.b)	CH ₄ , NMVOC	—	—	Adjusted total <i>diffuse emissions</i> in environmental reports
	SO ₂	—	—	Emissions from sulphur recovery

CRT	GHG	Activity data	Emission factors	Emissions
				units (excluding flaring) in environmental reports
	CO ₂	—	—	EU ETS
	CH ₄ , N ₂ O NMVOC, SO ₂ , CO, NO _x	Amounts of burned make-up coke in EU ETS; Amount of feed to the cracking unit	National emission factor for stationary combustion of petroleum coke; for NMVOC –default emission factor for catalyst regeneration in the EMEP/EEA Guidebook 2016	Calculated or, where available, taken from facilities' environmental reports; CO is estimated based on the total emissions and relative input from the cracking unit
1.B.2.A.4: Hydrogen production at refineries (reported in 1.A.1.b)	CO ₂	—	—	EU ETS
	CH ₄ , N ₂ O, NMVOC, CO, SO ₂ , NO _x	Amounts of feedstocks: naphta, LNG, refinery gases	National emission factors for stationary combustion of naphta, LNG and refinery gas; for NO _x , LNG – EF specific for flaring	Calculated or, where available, taken from facilities' environmental reports
1.B.2.A.5: Fuel handling (gasoline, other fuels)	NMVOC	Volumes of fuel	EF Guidebook 2023	Calculations, Environmental reports
1.B.2.B.4*: Gas transmission	CO ₂ , NMVOC	Number of facilities in the Swedish network for gas storage and transmission including LNG terminal	CO ₂ och NMVOC content in leaked natural gas	Calculated
	CH ₄		CH ₄ leakage rates	Calculated, environmental reports
1.B.2.B.5*: Gas distribution	CO ₂ , CH ₄ , NMVOC	Length of distribution networks	CO ₂ , CH ₄ and NMVOC content in leaked natural gas	Calculated
1.B.2.B.6: Post-meter	CO ₂ , CH ₄ , NMVOC	Number of gas vehicles, appliances in commercial and residential sector, Volume of gas consumed at industrial plants/power stations	National EF for industrial leakage, EF from 2019 Refinement for gas vehicles and appliances	Calculated
1.B.2.C.1.2*: Gas venting	CO ₂ , CH ₄ , NMVOC	Amounts of natural gas vented	CO ₂ , CH ₄ and NMVOC content in vented natural gas	Calculated
1.B.2.C.2.1: Flaring at refineries (reported in 1.A.1.b)	CO ₂	—	—	EU ETS
	CH ₄ , N ₂ O, NMVOC, CO, SO ₂ , NO _x	Amounts of flared refinery gas in EU ETS; amounts of flared sulphur-rich gas from environmental reports	National emission factor for stationary combustion (NO _x , CO, SO ₂) and flaring (CH ₄ , N ₂ O) of refinery gas, natural gas/LNG	Calculated or, where available, taken from facilities' environmental reports

CRT	GHG	Activity data	Emission factors	Emissions
			and hydrogen; default emission factors for flaring of refinery gas from EMEP/EEA Guidebook 2019 (NMVOC)	
1.B.2.C.2.2*: Flaring in the natural gas network	CO ₂ , CH ₄ , N ₂ O, NMVOC, CO, SO ₂ , NO _x	Amounts of natural gas flared	National emission factor for stationary combustion of natural gas	Calculated

* Activity data and leakage factors for gas networks are obtained via personal communication with Swedish gas companies.

3.3.1 Fugitive emissions from solid fuels (CRT 1.B.1)

3.3.1.1 SOURCE CATEGORY DESCRIPTION

There are no coal mines in Sweden and hence no fugitive emissions from coal mines occur (hence reported as NO).

Fugitive emissions from solid fuels instead include emissions from quenching and extinction at coke ovens at integrated iron and steel facilities and fugitive emissions from charcoal production (both reported in CRT 1.B.1.b), as well as flaring of coke oven gas from the coke ovens (reported in CRT 1.B.1.c). CRT 1.B.1 is in fact not designed to include flaring, but since CRT 1.B.2 only refers to liquid and gaseous fuels, it is not possible to report flaring of coke oven gas in CRT 1.B.2. Flaring of blast furnace gas in the blast furnace and steel converter are reported in CRT 2.C.1 in accordance with the 2006 IPCC Guidelines.

Reported activity data is amounts of produced coke and charcoal in CRT 1.B.1.b (Mton) and amounts of flared coke oven gas (COG) (Mton) in CRT 1.B.1.c. The amounts of flared COG vary considerably between years, and during some years (2009, 2015) they were unusually high, resulting in increasing emissions in CRT 1.B.1. According to environmental reports¹⁴⁵, COG is flared when the production is temporarily stopped because of urgent needs of reparation of equipment or other maintenance measures.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.29.

¹⁴⁵ SSAB, 2008, 2009, 2015

Table 3.29. Summary of source category description, CRT 1B1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.B.1	CO ₂	-	-		T2	CS	Yes
	CH ₄	-	-		T1, T2	CS, D	Yes
	N ₂ O	-	-		T2	CS	Yes

CS Country Specific. T1 Tier 1. T2 Tier 2. D Default

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.3.1.2 METHODOLOGICAL ISSUES

The estimation of emissions from flaring of coke oven gas is included in the carbon balance calculations and other plant specific calculations made in cooperation with the two integrated iron and steel production facilities.

Data on SO₂ emissions from quenching and extinction at coke ovens are obtained directly from the operators of the two facilities; NO_x and NMVOC emissions from the same processes are calculated with default emission factors specified in the EMEP / EEA Guidebook 2019; CH₄ emissions are estimated with default emission factors specified in the 2019 Refinement to the 2006 IPCC Guidelines.

Emissions of CH₄, N₂O, CO and NO_x from charcoal production have been estimated since submission 2025 using FAO statistics¹⁴⁶ as activity data, and default emission factors specified in the 2019 Refinement to the 2006 IPCC Guidelines.

3.3.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7.

The uncertainty for amounts of flared coke oven gas has been estimated to $\pm 50\%$. The extent of flaring is by nature very variable between years, and the uncertainty in activity data is high compared to other activities. The emission factor uncertainty has been estimated to $\pm 5\%$ for CO₂ and $\pm 20\%$ for CH₄ and N₂O.

The uncertainty for amounts of produced coke has been estimated to $\pm 5\%$. The emission factor uncertainty has been estimated to $\pm 900\%$ for CH₄.

The uncertainty for amounts of produced charcoal has been estimated to $\pm 100\%$ (1990) - 70% (the latest inventory year). The emission factor uncertainty has been estimated to $\pm 60\%$ for CH₄ and $\pm 193\%$ for N₂O.

3.3.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

See section 4.4.1 Iron and steel production (CRT 2.C.1).

3.3.1.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations were made in submission 2026.

¹⁴⁶ FAOSTAT, Forestry Production and Trade, <https://www.fao.org/faostat/en/#data/FO>

3.3.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

3.3.2 Oil and natural gas (CRT 1.B.2)

3.3.2.1 SOURCE CATEGORY DESCRIPTION

In the Swedish inventory, fugitive emissions from a number of different activities related to production and handling of liquid fuels and natural gas are reported in CRT 1.B.2. These activities include crude oil transport (1.B.2.A.3), gasoline handling and distribution (1.B.2.A.5), natural gas and biogas transmission (1.B.2.B.4), distribution of natural gas, biogas and gasworks gas (1.B.2.B.5), Post-meter leakage (1.B.2.B.6) venting of natural gas (1.B.2.C.1.2), and flaring of natural gas and oil (1.B.2.C.2).

Emissions activities in refineries such as catalytic regeneration, desulphurisation, storage and handling of oil and hydrogen production at oil refineries (1.B.2.A.4), as well as flaring at refineries (1.B.2.C.2.1) are also described in this section but reported in CRT 1.A.1.b due to confidentiality reasons.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 3.30.

Table 3.30. Summary of source category description, CRT 1.B.2.a, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level*	Trend**	Qualitative			
1.B.2.a	CH ₄	-	-		T1	D	Yes

D Default. T1 Tier 1.

* Shows key category (level) per fuel type

** Shows key category (trend) per fuel type

3.3.2.2 METHODOLOGICAL ISSUES

All emissions from refineries must be reported in CRT 1A1b for year 2021 onwards due to confidentiality. To keep a consistent time series, emissions from refineries for all years are reported in CRT 1A1b starting from submission 2026. However, emissions for 1990-2020 are presented in Table 3.31 below by categories 1.B.2.A.4, 1.B.2.C.2.1 and 1.A.1.b (reported in 1.A.1.b), Refining/storage (earlier reported in 1.B.2.a.4), and Flaring at refineries (earlier reported in 1.B.2.c.2.1).

Table 3.31. Estimated fugitive emissions of CH₄ (kt), CO₂ (kt) and N₂O (kt) reported in CRT 1.B.2.A.4, 1.B.2.C.2.1 and 1.A.1.b. Due to data confidentiality, some of the emission data for later years cannot be displayed.

Year	1.B.2.A.4			1.B.2.C.2.1			1.A.1.b		
	CH ₄	CO ₂	N ₂ O	CH ₄	CO ₂	N ₂ O	CH ₄	CO ₂	N ₂ O
1990	0.44	255	0.004	0.005	73	0.0004	0.028	1778	0.005
1995	0.39	264	0.004	0.005	64	0.0004	0.030	1891	0.005
2000	0.53	310	0.004	0.004	57	0.0003	0.033	2061	0.005
2005	0.37	296	0.004	0.005	60	0.0004	0.036	2224	0.005
2010	0.45	782	0.005	0.003	37	0.0002	0.037	2130	0.005
2015	C	C	C	0.003	42	0.0002	0.038	2063	0.004
2016	C	C	C	0.003	50	0.0003	0.031	2160	0.004
2017	C	C	C	0.002	39	0.0002	0.028	2066	0.003
2018	C	C	C	0.002	37	0.0002	0.030	2199	0.003
2019	C	C	C	0.004	59	0.0004	0.026	C	0.003
2020	C	C	C	0.003	37	0.0003	C	C	C
2021-	C	C	C	C	C	C	C	C	C

3.3.2.2.1 Transport (CRT 1.B.2.A.3)

Crude oil is transported to and from Sweden by tankers. In response to recommendations from the UNFCCC expert review teams in submission 2010, Sweden estimates emissions of CH₄ from transport of crude oil using the default IPCC method. Imported and exported amounts of crude oil from Reference Approach are used as activity data.

In the 2006 IPCC Refinement from 2019, a default emission factor for CH₄ from crude oil transport by tankers is provided. This emission factor (0.002 t CH₄/1000 m³) is much lower than default emission factor for oil pipelines (745 kg CH₄/PJ) applied in submission 2021 and earlier in the absence of more specific emission factor for tankers. From submission 2022, tanker-specific emission factor is used in calculations. Units of reported activity data are changed from TJ to 1000 m³.

Fugitive emissions of CO₂ from transport of crude oil are not estimated (NE) as no country-specific measurements have been carried out and no default IPCC emission factor for tanker ships is available.

3.3.2.2.2 Refining/Storage (CRT 1.B.2.A.4)

CO₂ emissions are estimated using the IPCC Tier 3 method, and non-CO₂ emissions – using Tier 2 method. The Tier 2 method requires data at plant level and Sweden uses data provided by the refineries in their annual environmental reports. Emissions are reported from combustion of cracker coke (catalyst regeneration) (CO₂, CH₄, N₂O, NMVOC, SO₂), desulphurisation (SO₂), and from the storage and handling of oil (NMVOC, CH₄).

Amounts of crude oil processed at the refineries (Mt) are shown in Table 3.32.

Fugitive emissions of CH₄ from refineries include emissions from the process area as well as emissions from the refinery harbours when loading tankers. The estimate of fugitive CH₄ emissions is for two refineries based on reported data in the facilities' environmental reports. For the remaining three refineries the fugitive CH₄ emissions are estimated as 4-5% of the total fugitive VOC emission. An estimate of 5% has been provided by one refinery that refines about 50% of the crude oil in Sweden, while another

refinery provided an estimate of 4%. The reported emissions of CH₄ are very uncertain due to limited measurements – however, using a value of 0.2-3%, assumed by default emission factors for oil refining in IPCC 2006 Guidelines, seem to result in underestimation of CH₄ emissions.

Table 3.32. Activity data (Mt processed crude oil) at refineries.

Year	AD (Mt)	Year	AD (Mt)	Year	AD (Mt)	Year	AD (Mt)
1990	17.3	1998	20.3	2006	20.1	2014	18.9
1991	16.8	1999	19.5	2007	17.7	2015	19.9
1992	17.9	2000	20.3	2008	20.4	2016	19.6
1993	18.7	2001	19.6	2009	19.4	2017	19.5
1994	18.2	2002	19.7	2010	20.1	2018	20.3
1995	19.4	2003	19.7	2011	18.7	2019	16.9
1996	20.3	2004	20.6	2012	20.7	2020	17.5
1997	20.1	2005	19.9	2013	16.5		

Amount of crude oil throughput is known for almost all years. Implied emission factors have been developed, based on reported emissions and known crude oil throughput. Reported data for years for which either activity data or emission data is missing have been calculated using the implied emission factors thus developed. In Table 3.33, reported emissions of CH₄ and crude oil throughput can be seen.

Table 3.33. Throughput of crude oil in refineries and estimated fugitive emissions of CH₄ (t) reported in CRT 1.A.1.b. Due to data confidentiality, emission data for the years after 2014 cannot be displayed.

Year	Throughput of crude oil (t)	Total emissions of CH ₄ (t)
1990	17 330 000	460
1995	19 430 000	400
2000	20 253 120	577
2005	19 919 968	399
2010	20 068 888	469
2015	19 889 131	—
2016	19 572 799	—
2017	19 501 741	—
2018	20 325 433	—
2019	16 871 125	—
2020	17 496 688	—

The trend of hydrocarbon emission does not follow the fluctuations of the crude oil throughput very well. This is most likely due to the uncertainties in the method used by the refineries to estimate the emissions.

Emissions from combustion of cracker coke in refineries belong to CRT 1.B.2.A.4 according to the IPCC Guidelines (as the combustion is not carried out for energy purposes). This was based on a study performed by SMED¹⁴⁷. The cracking reactions produce some carbonaceous material (referred to as *coke*) that deposits on the catalyst and very quickly reduces the catalyst reactivity. The catalyst is regenerated by burning off the deposited coke. Combustion of cracker coke occurs at three facilities. Activity data as

¹⁴⁷ Skårman, T., Danielsson, H., Kindbom, K., Jernström, M., Nyström, A-K. 2008. Fortsättning av riktad kvalitetskontrollstudie av utsläpp från industrin i Sveriges internationella rapportering. SMED Report 2008

amount of cracker coke and CO₂ emissions are taken from the companies' reports to the EU ETS system. Non-CO₂ emissions are calculated with the plant-specific activity data and either national emission factors (CH₄, N₂O) or default emission factors specified in the EMEP/EEA Guidebook 2016 for the catalyst regeneration stage (NMVOC). NO_x emissions from the large catalytical cracker, which accounts for >95% of make-up coke combustion in Sweden, are taken from the facility's environmental report, while for the other two facilities, default emission factors from the EMEP/EEA Guidebook 2016 are used. CO emissions from the large cracker unit are estimated based on the total facility's CO emissions (as specified in the environmental report) and the relative input of cracker feedstock to the total material input to the refinery processes. Implied emission factors calculated for this process are further used to estimate CO emissions from the other two facilities with coke combustion and catalyst regeneration processes.

Within a development project during 2018-2019¹⁴⁸, performed in close cooperation with the refineries, certain improvements were made in this category. In particular, national emission factor for NMVOC for stationary combustion was replaced with the default emission factor specified in the EMEP/EEA Guidebook 2016 for the catalyst regeneration stage, emissions of NO_x from the large cracker were taken from the environmental report instead of being estimated with the national emission factor for stationary combustion of cracker coke, and consistency in the calculations was improved.

In 2020, combustion of cracker coke was significantly lower than in 2019, which resulted in the decrease of all emissions by ~70% compared to 2019. This is because the large catalytical cracker was out of operation most part of the year. In 2021, the cracker was back to normal operation conditions, and the emission increased.

Emissions from **hydrogen production plants at refineries** belong to CRT 1.B.2.A.4 in line with the *2019 refinement to the 2006 IPCC guidelines for national greenhouse gas inventories*, however as stated above reported in CRT 1.A.1.b due to confidentiality reasons. Since the 1980s, one of the Swedish refineries has had hydrogen production. In 2006, another refinery took a hydrogen plant into operation. Two other refineries launched hydrogen production facilities recently – one started production in 2019, another one in 2020. All four facilities apply steam reforming process to produce hydrogen, using LNG/natural gas as main feedstock (with the exception of one facility using three different feedstocks). Hydrogen production in Sweden also occurs at several facilities within the chemical industry – emissions from that production are reported in CRT 2.B.

CO₂ emissions are estimated using the IPCC Tier 3 method, and non-CO₂ emissions – using Tier 2 method. CO₂ emissions are taken from the company's reports to the EU ETS system from 2005 onwards – the reports contain activity data, CO₂ emissions and emission factors. For the years before 2005, CO₂ emissions are estimated using implied emission factors.

Activity data are amounts of feedstock used for hydrogen production, as reported to the EU ETS for three of four facilities. One of the plants does not report amounts of feedstock - a mixture of butane, off-gas from one of the refinery units, and LNG. Instead,

¹⁴⁸ Yaramenka et al. 2019 Improvements in the reporting of fugitive emissions (CRT and NFR 1B), Phase II. SMED Report No 8 2019

to calculate CO₂ emissions reported to the EU ETS, the facility uses amounts of so called 'PSA (pressure swing adsorption) gas' - energy-poor off-gas from the hydrogen production unit¹⁴⁹. PSA gas is a good proxy for activity data for this particular plant with a complicated feedstock structure; however, it is not a feedstock. For calculation of emissions other than CO₂, the amounts of feedstocks at this facility for the entire time series have been estimated based on the ratio *amount of LNG used as feedstock / corresponding amount of PSA gas* averaged over 2014-2019. Neither the exact amounts of the other two feedstocks nor the relations between the different feedstock amounts are known.

CO₂ implied emission factor for the facility reporting amounts of PSA gas as activity data to the EU ETS is not constant over time. This is due to variations in the relative amounts of LNG, butane and internal off-gas in the complicated feedstock mixture. In particular, the increase of CO₂ emissions by 11% between 2016 and 2017 is explained by a lower share of LNG in the mixture.

Non-CO₂ emissions are calculated with plant-specific activity data and national emission factors. For two facilities, emissions of NO_x are taken from the environmental reports, while for the other two facilities, activity data and national emission factors are used. Due to lack of specific emission factors, "other petroleum fuels" emission factors are used for naphtha (except for CH₄, for which default emission factor, specified in the 2006 IPCC Guidelines for naphtha, is used), and emission factors for refinery gas are used for the mixture that includes three different feedstocks with unknown shares.

Within a development project during 2018-2019¹⁵⁰, efforts were made to investigate whether alternative emission factors can be used instead of currently used national emission factors for stationary combustion. The project work, performed in close cooperation with the refineries, resulted in better accounting of information available in environmental reports (often based on continuous measurements) in the emission inventories. NO_x emission factors for LNG/natural gas as feedstock, and CH₄ emission factor for naphtha as feedstock were revised with respect to available (measurement) data. However, no relevant emission factors specific for hydrogen production were found in the literature.

3.3.2.2.3 Gasoline handling and distribution (CRT 1.B.2.A.5)

NMVOC emissions from Gasoline handling and distribution are reported in CRT 1.B.2.A.5. Calculated fugitive emissions of NMVOC from the storage of oil products have been obtained from the environmental reports of the oil depots. The calculations are based on the amount of product handled in the depots. The calculations are based on methods given by Concawe 85/54¹⁵¹ for the years 1990-2006 and on Concawe 03/07¹⁵² for 2007 and onwards.

¹⁴⁹ Ortiz, C., et al.. Överlappande mellan CRT 1 och 2, SMED memorandum, 2017

¹⁵⁰ Yaramenka et al. 2019. Improvements in the reporting of fugitive emissions (CRT and NFR 1B), Phase II. SMED Report No 8 2019

¹⁵¹ Concawe, 1986, Hydrocarbon emissions from gasoline storage and distribution systems, Report No 85/54.

¹⁵² Concawe Report No. 3/07, Air pollutant emission estimation methods for E-PRTR reporting by refineries

The calculation of fugitive NMVOC emissions from gasoline distribution is based on methods given by Concawe¹⁵³, including annual national gasoline consumption and assumptions on the share of gasoline evaporated at different stages of the handling procedure, as well as effects of applied abatement technology at gasoline stations. Previously not reported emissions from handling of other fuels (diesel, jet fuel) is included in the inventory from submission 2025 onwards. Calculations of these emissions are based on methods and emission factors in 2019 Refinement. Activity data is the annual national diesel and jet fuel (kerosene, jet gasoline) consumption.

The total NMVOC emissions from this segment amounts to about 3 kt NMVOC. The sub-segments “gasoline handling” and “handling at depots” each account for around 45% and 49% of the total emissions from CRT 1.B.2.A.5 while other fuel accounts for the remaining part.

3.3.2.2.4 *Natural gas transmission (CRT 1.B.2.B.4)*

The Swedish natural gas transmission network consists of a 600 km pipeline (extending from southern Sweden up along the west coast) connected to Dragör in Denmark and the European natural gas network. There are two injection sites for biogas injection to the transmission net. The Swedish network for gas storage and transmission includes several different types of facilities: metering and regulation stations (M/R stations), compressor stations, ramification stations, valve stations, pig launcher & receiver stations, and a storage facility. According to Swedegas¹⁵⁴, many of the facilities are combined, e.g. valves located close to M/R stations. In 2013, a national method for estimating the Swedish emissions of natural gas was developed and described in Jerksjö et al.¹⁵⁵. Emission estimates are based on information provided by Swedegas, the operator of the transmission pipeline and storage of natural gas in Sweden. Emission data includes transmission and storage of gas and was for the first time adopted in submission 2014. In submission 2017, the method for estimating the emissions from the gas transmission network was revised since new measurements of methane emissions became available¹⁵⁶. Methane leakage rates per hour have been measured at all major types of facilities. Estimated emission factors (see Table 3.34) have been applied to the number of facilities of each type. Emissions earlier reported as gas leakage have been re-allocated to the sector *CRT 1.B.2.C.1.2 Natural gas venting* since these emissions are controlled and associated with regular network maintenance work rather than with uncontrolled gas leakage. Submission 2025 includes the previously not reported fugitive emissions of methane and CO₂ from LNG-terminals. There are two LNG terminals in Sweden. The emissions from this source are reported from year 2011 when the first LNG-terminal opened. Emission data used is either collected from the environmental reports (measured or calculated by companies) or, when data is lacking, estimated based on previous years' emissions.

¹⁵³ Concawe, 2019, report no. 4/19. Air pollutant emission estimation methods for E-PRTR reporting by refineries

¹⁵⁴ Bjur & Lindsjö, 2016

¹⁵⁵ Jerksjö, M., Gerner, A., Wängberg, I. 2013. Development of method for estimating emissions of methane, NMVOC and carbon dioxide from natural gas, biogas and town networks in Sweden. SMED Report No: 121, 2013.

¹⁵⁶ Jerksjö, M., Salberg, H. 2016. Mätningar av metanläckage längs svenska naturgasnätets stamledning, IVL report C202 (in cooperation with Fluxsense)

Table 3.34. Method for estimation of gas leakage from the gas transmission network.

Facility type	CH ₄ EF g/hour	Number of facilities in 2022	Comment
M/R station	91	43	Number of facilities is known for the whole time series
Storage	200	1	In operation since 2006
M/R + compressor station	222	1	In operation since 2014
Valve station	30	26	For the years 1990-2014, the number of facilities is assumed to be in direct proportion to the network's length (320 km in 1990, 620 km in 2017)
Pig launcher & receiver station	300	9	
Ramification station	30	39	

Parameters used to calculate emissions of carbon dioxide and NMVOC via composition of natural gas are shown in Table 3.35. Information on gas composition was obtained from Swedegas and constitutes average values from the period 2006 to 2012.

Table 3.35. Composition and physical properties of natural gas.

Property	Unit	Value
Methane content in natural gas	% by weight	78.6
Carbon dioxide content in natural gas	% by weight	1.80
NMVOC content in natural gas	% by weight	19.0
Density of natural gas	kg/Nm ³	0.817
Density of methane	kg/Nm ³	0.716

As explained above, emissions of CO₂ and CH₄ are based on the number of the different facility types within the national gas transmission network and the LNG terminals – the numbers for the transmission network are checked with the company owning the network on the annual basis meanwhile the data for the LNG terminals are based on environmental reports. Methane leakage during gas transmission including the LNG terminals based on the recent measurements is shown in Table 3.36 below together with approximated emissions using EF for LNG terminals from 2019 Refinement.

Table 3.36. Estimated fugitive methane emissions from the gas network and LNG terminals.

Year	CH ₄ , kt	IPCC Refinement 2019, CH ₄ , kt
2006	0.072	3.2
2010	0.076	3.2
2015	0.165	3.2
2020	0.123	3.2
2021	0.234	3.2
2022	0.234	3.2
2023	0.247	3.2
2024	0.241	3.2

3.3.2.2.5 Natural gas distribution (CRT 1.B.2.B.5)

There are three types of gas networks for distribution of gas in Sweden:

1. The gas network for distribution of natural gas (since 2016 mixed with biogas)
2. Local biogas distribution network
3. Gasworks gas distribution network.

The gas network for distribution of natural gas is connected to the national transmission pipeline via M/R stations as mentioned above and had a total length of 2620 km in year 2012. This network delivers natural gas to the end users, which are industries or municipalities which in turn use the gas for energy production, to feed their town gas networks, etc. There are about 40 small local distribution networks for biogas in Sweden¹⁵⁷. The total length was 146 km in 2012. The biogas is of similar quality as natural gas and is distributed in similar distribution pipes as natural gas.

Most of the gasworks gas networks use natural gas and their distribution system has been modernised and considered to be of the same standard as the distribution system for natural gas. However, the gasworks gas networks in Stockholm and Gothenburg (the two largest cities in Sweden) are different. These networks consist to a large part of old pipes with considerable high leaking rate. Between 1990 and 2011, a facility in Stockholm produced gasworks gas from cracking light petroleum. In 2011, they started to use a mixture of natural gas and air. The city of Gothenburg produced gasworks gas of a similar quality as that in Stockholm during the period 1990 – 1993. In 1993, the city of Gothenburg shifted to a mixture of natural gas and air. Activity data in terms of leakage of gasworks gas has been obtained from the gasworks gas distributor in Stockholm for the years 2002-2012. For earlier years, only production data is available, and the average relation of leakage to production has been used to estimate leakage for the years 1990-2001. The emissions of CH₄ and CO₂ have been calculated with data on chemical composition of gas from cracking and natural gas/air mixture. The methodology is described in Jerksjö et al¹⁵⁸.

Since no measurement on fugitive methane emissions from distribution of gas has been made in Sweden, emission factors found in the literature were compared and examined. Information on the Swedish gas network was collected by contacting the operators. Based on this information an emission factor obtained from a Dutch investigation (Wikkerlink 2006¹⁵⁹) was chosen. The emission factor is the result of an evaluation of data from measurements of gas leaks at several places in the Netherlands and is equal to 120 Nm³ methane per km distribution line. According to net operators of new or renewed Swedish networks for natural gas, the networks in Sweden are of similar standard and design as those in the Netherlands. The Dutch emission factor is considered to be valid for pipes made from PVC and polyethylene, etc., and can be used as an average value covering different pressure regimes. The emission factor from the Dutch study was adopted for estimating the methane emissions from Swedish gas networks 1. (Natural gas) and 2. (Biogas) and also gas networks in cities with new or renewed distribution systems. The fugitive emissions from distribution of gasworks gas in Stockholm and Gothenburg has

¹⁵⁷ Jerksjö, M., Gerner, A., Wängberg, I. 2013. Development of method for estimating emissions of methane, NMVOC and carbon dioxide from natural gas, biogas and town networks in Sweden. SMED Report No: 121, 2013.

¹⁵⁸ Jerksjö, M., Gerner, A., Wängberg, I. 2013. Development of method for estimating emissions of methane, NMVOC and carbon dioxide from natural gas, biogas and town networks in Sweden. SMED Report No: 121, 2013.

¹⁵⁹ Wikkerlink. 2006.

been estimated based on statistics on production of gasworks gas and natural gas mixed with air and leakage rate obtained from Stockholm Gas¹⁶⁰.

Data on gas mixtures, sources of activity data and emission factors used for emission calculations in CRT 1.B.2.B.5 for each gas distribution network are summarized in Table 3.37.

Table 3.37. Summary of method for calculating emissions from Swedish gas distribution networks.

Gas distribution networks	Natural gas*	Local biogas	Gasworks gas – Stockholm
Gas mixture used	Natural gas	Biogas of similar quality as natural gas	Mixture of natural gas and air. Until 2011 – gasworks gas and mixture of natural gas and air
Source of activity data	Gas distribution companies	Grönmij. 2009	Stockholm gas environmental reports
Type of activity data	km length	km length	Nm ³ gas leakage
Emission factor for CH ₄	120 Nm ³ / km (Wikkerlink, 2006 ¹⁶¹)		No emission factors are used. Emissions are calculated based on the content of CH ₄ , CO ₂ and NMVOC in the gas mixtures considered.
Emission factor for CO ₂	No emission factors are used.		
Emission factor for NMVOC	Emissions are calculated based on estimated methane emissions and the content of CO ₂ and NMVOC in the natural gas.		

* Including a number of city gas distribution networks, for instance Gothenburg gas distribution network since 2011.

Parameters used to calculate the content of methane, carbon dioxide and NMVOC in gasworks gas and natural gas air mixture are shown in Table 3.38 and Table 3.39, respectively. Information on gas composition was obtained from Stockholm Gas and Swedegas.

Table 3.38. Composition and physical properties of gasworks gas.

Property	Unit	Value
H ₂ content	% by volume	54
CH ₄ content	% by volume	30.0
CO ₂ content	% by volume	11.5
NMVOC content	% by volume	2.0
Air content	% by volume	2.5
Amount of CH ₄ per Nm ³ gas	kg/Nm ³	0.21
Amount of CO ₂ per Nm ³ gas	kg/Nm ³	0.23
Amount of NMVOC per Nm ³ gas	kg/Nm ³	0.04

¹⁶⁰ Jerksjö, M., Gerner, A., Wängberg, I. 2013. Development of method for estimating emissions of methane, NMVOC and carbon dioxide from natural gas, biogas and town networks in Sweden. SMED Report No: 121, 2013.

¹⁶¹ Wikkerlink. 2006.

Table 3.39. Composition and physical properties of natural gas air mixture.

Property	Unit	Value
Density of natural gas air mixture	kg/Nm ³	1.054
CH ₄ content	% by weight	30.4
CO ₂ content	% by weight	0.7
NMVOC content	% by weight	7.4
Air content	% by weight	61.5
Amount of CH ₄ per Nm ³ gas	kg/Nm ³	0.32
Amount of CO ₂ per Nm ³ gas	kg/Nm ³	0.0075
Amount of NMVOC per Nm ³ gas	kg/Nm ³	0.08

3.3.2.2.6 Post-meter emissions (CRT 1.B.2.B.6)

This subsegment includes fugitive emissions of methane (CH₄), carbon dioxide (CO₂) and Non methane volatile organic compounds (NMVOC) from leakage in industry. From submission 2025 a complete timeseries is reported for all emission segments. Prior to submission 2025 there were no emissions reported in this CRT.

Leakage sources in the three segments are:

Industry - Leakage from internal piping.

Appliances - Leakage from house piping and natural gas appliances such as furnaces, water heaters, stoves and ovens, and barbecues/grills.

Gas vehicles - Leakage from dead volumes during fuelling, emptying of gas cylinders of high-pressure interim storage units, for execution of pressure tests and relaxation of residual pressure from vehicles' gas tanks, or decommissioning.

Tier 1 emission factors for the segments are presented in 2019 Refinement. The emission factor for industry leakage is not used in the inventory. Instead, a more suitable national emission factor based on a couple of industry measurements are used. Table 3.40.

Table 3.40. Emission factors for the post-meter segment.

Segment	CH ₄	CO ₂	NMVOC	Units of measure
Leakage at industrial plants and power stations.	*[6,1] 1,08	*[6,1*10 ⁻²] 0,108	*0[,19] 0,03	Tonnes/million m ³ gas consumed
Appliances in commercial and residential sector	3,2*10 ⁻³	3,2*10 ⁻⁵	1,0*10 ⁻⁴	Tonnes/appliance
Natural gas-fuelled vehicles	3,0*10 ⁻⁴	3,0*10 ⁻⁶	9,3*10 ⁻⁶	Tonnes/car

*Numbers in brackets are EF from 2019 Refinement

The reported emissions from post-meter leakage in industry, appliances and from gas vehicles, are shown in Table 3.41.

Table 3.41. Estimated total methane emissions from post-meter leakage.

Year	Post-meter methane leakage			Total emissions (kt)
	Industry (kt)	Appliances (kt)	Gas vehicles (kt)	
2006	0.79	0.26	0.00	1.05
2007	0.91	0.24	0.00	1.16
2008	0.86	0.23	0.00	1.09
2009	1.16	0.22	0.01	1.39
2010	1.38	0.21	0.01	1.60
2011	1.09	0.24	0.01	1.34
2012	0.92	0.23	0.01	1.16
2013	0.92	0.23	0.01	1.16
2014	0.71	0.22	0.02	0.95
2015	0.62	0.22	0.02	0.86
2016	0.80	0.22	0.02	1.04
2017	0.62	0.21	0.02	0.85
2018	0.65	0.21	0.02	0.87
2019	0.62	0.20	0.02	0.84
2020	0.54	0.20	0.02	0.75
2021	0.59	0.19	0.02	0.79
2022	0.37	0.16	0.02	0.54
2023	0.33	0.16	0.01	0.50
2024	0.36	0.16	0.01	0.53

3.3.2.2.7 Venting (CRT 1.B.2.C.1)

In preparation of submission 2011, it was investigated whether vented emissions from refineries already were included in reported emissions in other CRT categories. The conclusion from this study was that emissions from venting at refineries most likely are included in other categories of fugitive emissions; mainly in CRT 1.B.2.A.4 but possibly partly in 1.B.2.C.2. Hence, it was concluded that the emissions reported in 1.B.2.C.1 in submission 2010 were double counted, and in submission 2011 onwards, emissions in CRT 1.B.2.C.1.1 and 1.B.2.C.1.3 are reported as IE (included in 1.B.2.A.4 and 1.B.2.C.2.). The fugitive CH₄ emissions from oil refineries reported in CRT 1.B.2.A.4 are based on measurements of total hydrocarbon emissions from the refinery areas. These emissions include leakages but also emissions from venting activities. It is therefore not possible to report fugitive emissions and emissions from venting separately. However, the hydrocarbon emissions from venting activities at refineries are assumed to be very small, since during normal operation conditions, the vented gases enter the gas flare systems.

Venting of natural gas from transmission pipelines and the storage facility, reported under CRT 1.B.2.C.1.2, occurs as a part of maintenance. Swedegas reports estimates of the annual amounts of vented gas. Venting at M/R stations during ordinary maintenance procedures results in ~ 0.3 to 0.5 t methane emissions per year. In addition, similar

amounts of gas are vented as a part of a network inspection conducted by Swedegas usually once in eight years¹⁶² but sometimes more often. Such an inspection requires so called pigging – emptying M/R stations, which means release of certain amounts of natural gas. A larger part of the released gas is flared but some is vented. From the year 2014, estimated amounts of gas vented during the inspections have been obtained from the operator. For the years 2006, 1998 and 1990, estimates were made based on the relation of the amount of vented gas to the number of M/R stations in 2014-2015. Total amounts of vented gas from M/R stations are shown in Figure 3.18.

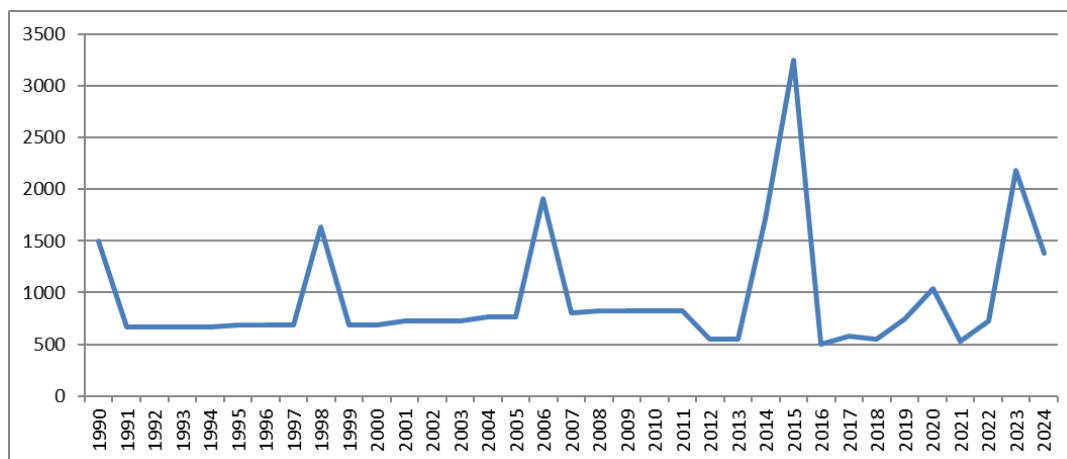


Figure 3.18. Gas venting at M/R stations, Nm³ natural gas.

The reported emissions from the gas storage facility, dominated by venting, are shown in Table 3.42 in comparison with the corresponding values obtained using the 2006 IPCC Guidelines. Emissions reported by Swedegas are comparable to estimations according to the 2006 IPCC Guidelines, if the lower value of the default emission factor is used. The large emission of natural gas from the gas storage in 2013 was due to a compressor failure¹⁶³. In 2019 accidental damage during building activities resulted in an increased emissions (reported under pigging and projects, see Table 3.42). The emissions reported from the operator seem reasonable in comparison to other estimates that can be made using emission factors found in the literature and it was concluded that it constituted the best estimate available at the moment¹⁶⁴.

¹⁶²Hellström 2013-2015

¹⁶³ Hellström 2013-2015

¹⁶⁴ Jerksjö, M., Gerner, A., Wängberg, I. 2013. Development of method for estimating emissions of methane, NMVOC and carbon dioxide from natural gas, biogas and town networks in Sweden. SMED Report No: 121, 2013.

Table 3.42. Estimated total methane emissions from gas storage and maintenance within the Swedish gas transmission network.

Year	Swedish gas transmission network					
	Diffuse emissions ¹ , (kt)	Venting ² , (kt)	Pigging and Projects ² (kt)	Total emissions, (kt)	IPCC (2006) ³ , (kt), lower value	IPCC (2006) ⁴ , (kt), upper value
2006	0.072	0.0288	0.0007	0.101	0.084	0.465
2007	0.074	0.0324	-	0.106	0.087	0.485
2008	0.076	0.0079	-	0.084	0.080	0.444
2009	0.076	0.0026	-	0.079	0.106	0.586
2010	0.076	0.0028	-	0.079	0.142	0.788
2011	0.076	0.0028	-	0.079	0.113	0.626
2012	0.076	0.0219	-	0.098	0.097	0.541
2013	0.076	0.0686	-	0.145	0.094	0.519
2014	0.077	0.0009	0.0007	0.079	0.077	0.426
2015	0.079	0.0023	0.0017	0.083	0.070	0.388
2016	0.079	0.0018	0.0003	0.081	0.079	0.438
2017	0.079	0.0013	0.0002	0.080	0.065	0.360
2018	0.080	0.0007	0.0019	0.082	0.069	0.383
2019	0.080	0.0008	0.0106	0.091	0.069	0.381
2020	0.079	0.0006	0.0084	0.088	0.060	0.335
2021	0.079	0.0004	0.0048	0.084	0.070	0.390
2022	0.079	0.0005	0.0003	0.080	0.051	0.282
2023	0.082	0.001	0.0009	0.084	0.047	0.263
2024	0.079	0.001	0.0007	0.081	0.051	0.283

¹Unintended emissions, leakage

²Intended venting within scheduled maintenance, pigging and projects

³ 2.5×10^{-5} kt per year and 10^6 Nm³ marketable gas for storage; 66×10^{-3} kt per year and 10^6 Nm³ marketable gas for transmission (lower value)

⁴ 2.5×10^{-5} kt per year and 10^6 Nm³ marketable gas for storage; 480×10^{-3} kt per year and 10^6 Nm³ marketable gas for transmission (upper value)

3.3.2.2.8 Flaring (CRT 1.B.2.C.2)

Flaring of liquid fuels was estimated and reported for the first time in the Swedish inventory in submission 2005. Data includes flaring from natural gas transmission. Emissions from flaring of refinery gases at refineries are described in this section but reported in CRT 1.A.1.b due to confidentiality reasons. For refineries reported activity data is amounts of flared gases in TJ. Emissions vary a lot between years due to large variations in the amount of refinery gases that needs to be flared each year. For 1990-2007, quarterly fuel statistics is used as the main data source. From 2008, data has been collected directly from the plant operators, and from environmental reports. For the years 2005 and later, data from the EU ETS has been used when possible. Data from the EU ETS are verified against data from environmental reports and vice versa.

In submission 2010, EU ETS data was analysed in detail. It was concluded that the notation key for flaring of natural gas (NE in earlier submissions) could be changed, since

no such flaring of pure natural gas could be found in the EU ETS data, and all plants that might be flaring are included in the EU ETS. However, certain amounts of natural gas can be used as feedstock in the refinery processes together with liquid fuels. Hence, it cannot be ruled out that the flared gases, which are mostly refinery gas and petrochemical by-products gases, might also contain some natural gas. Because of this, the notation key IE rather than NO is used for flaring of natural gas, referring to emissions from flaring at refiners, reported under CRT 1.A.1.b.

Emissions from another type of flaring of natural gas – flaring in connection with gas transmission pipeline maintenance (pigging), and from specific maintenance projects, are reported for the first time in submission 2016 under CRT 1.B.2.C.2.2. From 2014, estimated annual amounts of flared gas have been obtained from the operator. For the years 2006, 1998 and 1990, estimates were made based on the relation of the amount of flared gas to the number of M/R stations in 2014. The same emission factors and calorific values as for natural gas combustion in industries were used. Occurring greenhouse gas emissions are around 0.001-0.018 kt CO₂ eq. per year.

Within a development project during 2018-2019¹⁶⁵, flaring at refineries was investigated in detail. Efforts were made to find alternative emission factors to be used instead of national emission factors for stationary combustion. The project work, performed in close cooperation with the refineries, resulted in better accounting of facility-specific information available in environmental reports (often based on measurements) in the emission inventories. This data, where available, is prioritized in the inventory over estimates made with national emission factors for stationary combustion. Emission factors for CH₄ and N₂O were revised: new emission factors are adopted from Norwegian studies by Norwegian Oil Association¹⁶⁶; they reflect conditions specific for flaring rather than for stationary combustion (lower oxidation grade, no abatement). The emission factor for NMVOC from stationary combustion (implying 0.01% unburnt hydrocarbons) was replaced with the default emission factor from the EMEP/EEA Guidebook 2023 for refinery gas flaring, implying 0.5% unburnt hydrocarbons. Other improvements include revision of estimates made for the years 1990-2004 and better accounting of facility-specific shares of refinery gas, natural gas, LNG, sulphur-rich gases and hydrogen in the flared gas mixture.

3.3.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty analysis tables are presented in Annex 7 and a general description of the uncertainties is presented in section 1.7.

1.B.2.A.3: The uncertainty for the activity data have been estimated to $\pm 7.5\%$. The emission factor uncertainty for fugitive emissions of CH₄ is $\pm 50\%$.

1.B.2.A.4: Uncertainties for CRT 1.B.2.A.4 are included in the uncertainty estimates for CRT 1.A.1.b where emissions are reported. The contribution from 1.B.2.A.4 to the aggregated uncertainties of 1.A.1.b are discussed here.

¹⁶⁵ Yaramenka et al. 2019 Improvements in the reporting of fugitive emissions (CRT and NFR 1B), Phase II. SMED Report No 8 2019

¹⁶⁶ OLF 1994

The uncertainty for the activity data have been estimated to $\pm 7.5\%$. The emission uncertainty for fugitive emissions of CH₄ has been estimated to $\pm 400\%$. The reason for the high emission factor uncertainty is not the use of inaccurate method but the large uncertainties for the measurements with high inter-annual variation. Uncertainties for emission factors for cracker coke regeneration processes are estimated to $\pm 20\%$ for CH₄, $\pm 5\%$ for CO₂ and $\pm 25\%$ for N₂O.

For hydrogen production at refineries, all hydrogen production plants use the level 2 method to measure activity data for reporting to the EU ETS, which means that the activity data uncertainty is $\pm 2.5\%$ or less. For one of the facilities, where activity data is estimated based on amounts of PSA gas, the activity data uncertainty is set at $\pm 10\%$. The emission factor uncertainties have not been available for the GHG inventory team, and hence the same emission factor uncertainties as for the corresponding fuels in stationary combustion, i.e. $\pm 5\%$ for CO₂ are used. For the CH₄ emission factor, general uncertainty from 2006 IPCC Guidelines for oil refining activities ($\pm 100\%$) was used instead, following the precautionary principle. For 1990, when naphtha was the main feedstock for hydrogen production, the uncertainty is set to 233%, according to the default emission factor interval for naphtha specified in 2006 IPCC Guidelines. For the N₂O emission factor, the uncertainty is set to $\pm 25\%$ in accordance with GPG 2000.

1.B.2.A.5: Based on Guidebook Quality Rating C, the uncertainties of collected emissions of NMVOC are $\pm 75\%$.

1.B.2.B.4: Emissions have been revised in submission 2017 due to new measurement results available. The associated emission uncertainty is $\pm 50\%$ according to expert estimates.

1.B.2.B.5: Fugitive emissions from the distributing network in Stockholm constitute 80 – 90% of the total emissions from gas distribution in Sweden. The emission data from the Stockholm distribution network is based on measurements provided by the operator and the associated uncertainty is estimated to $\pm 50\%$. The total uncertainty concerning distribution of gas in Sweden is largely influenced by the contribution from the gas network in Stockholm, and is thus likewise estimated to $\pm 50\%$.

1.B.2.B.6: The emission factor uncertainty for fugitive emissions of CH₄ is $\pm 60\%$.

1.B.2.C.1.2, 1.B.2.C.2.2: Estimates of emissions from natural gas venting are provided by the operator. The associated uncertainty is $\pm 50\%$ according to expert estimates. For gas flaring, the total emission uncertainties are affected by uncertainties in the emission factors, which are the same as for industrial combustion of natural gas – 10% for CO₂, 30% for CH₄ and N₂O.

1.B.2.C.2.1: Uncertainties for CRT 1.B.2.C.2.1 are included in the uncertainty estimates for CRT 1.A.1.b where emissions are reported. The contribution from 1.B.2.C.2.1 to the aggregated uncertainties of 1.A.1.b are discussed here.

The activity data uncertainties for different fuels and plants are as reported to the EU ETS and are in the range $\pm 7.5\text{--}17.5\%$. The total uncertainty from all fuels is $\pm 17.5\%$. The emission factor uncertainties have not been available for the GHG inventory team, and hence the same emission factor uncertainty as for the corresponding fuels in stationary

combustion is used for CO₂, i.e. ± 5%. For N₂O, the uncertainty in emission factor is estimated to ±80%. For CH₄ emission factor, general uncertainty from the 2006 IPCC Guidelines for oil refining activities (±100%) was used instead, following the precautionary principle.

3.3.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The coherence between environmental reports and EU ETS data is checked when possible, and when differences occur, the facilities are contacted for verification.

Emissions from oil refineries are included in the cross-sectoral control tool that was developed in 2017. The tool is described in detail in section 1.3.5.

3.3.2.5 SOURCE-SPECIFIC RECALCULATIONS

The entire time series for refinery emissions (CRT 1.B.2.A.4 and CRT 1.B.2.C.2.1) have been allocated to CRT 1.A.1.b in submission 2026. Other recalculations specific to emissions belonging to CRT 1.B.2.A.4 and CRT 1.B.2.C.2.1 are included in this section.

1.B.2.A.3: Transport. No recalculations in submission 2026.

1.B.2.A.4 (reported in CRT 1.A.1.b): No recalculations in submission 2026.

1.B.2.A.5: Emissions of fugitive NMVOC from gasoline handling. No recalculations in submission 2026.

1.B.2.B.4: Gas transmission. No recalculations in submission 2026.

1.B.2.B.5: Gas distribution. No recalculations in submission 2026.

1.B.2.B.6: Post Meter leakage. No recalculations in submission 2026.

1.B.2.C.1.2: Gas venting in transmission/distribution networks. No recalculations in submission 2026.

1.B.2.C.2.1 (reported in CRT 1.A.1.b): Flaring at refineries. Minor adjustment due to correction of data year 2023. The recalculation resulted in small decreases (less than 0.06% of sector total) for 2023 for N₂O and CH₄ emissions.

1.B.2.C.2.2: Gas flaring in gas transmission/distribution networks. No recalculations in submission 2026.

3.3.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4 Industrial processes and product use (CRT sector 2)

The most important industries within the Swedish industrial sector have historically been basic materials industries such as mining, iron and steel industry and pulp and paper industry. Other important industries when considering emissions of greenhouse gases from industrial processes include the cement industry, primary aluminium production, consumption of fluorinated greenhouse gases and some processes within the chemical industry.

Greenhouse gas emissions from the industrial processes sector have decreased by 648 kt CO₂ eq. since 1990, from 7,226 kt CO₂ eq. in 1990 to 6,578 kt CO₂ eq. in 2024, which is a decrease of 9% (Figure 4.1). Emissions of N₂O, CH₄, PFCs and SF₆ have decreased since 1990 by 705 kt CO₂ eq., 19 kt CO₂ eq., 487 kt CO₂ eq. and 63 kt CO₂ eq., respectively. Compared to 1990, only HFCs have increased to 2024 (702 kt CO₂ eq.). Figure 4.1.1 shows that CO₂ is by far the largest contributor among the greenhouse gases in this sector in 2024, accounting for 86% of emissions. Emissions of HFCs are the second largest among the greenhouse gases in 2024 accounting for 11% of sector emissions.

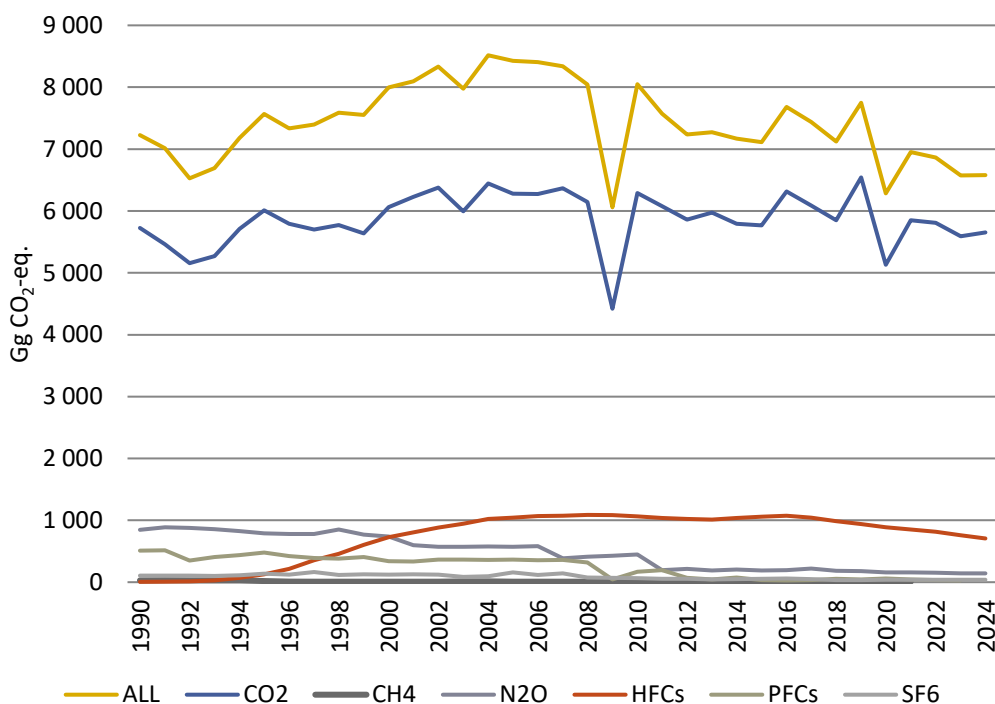


Figure 4.1.1. Total emissions of all greenhouse gases calculated as CO₂ eq. from CRT 2 industrial processes.

Among the industries within this sector, the metal industry (CRT 2.C) is the largest contributor to greenhouse gas emissions in 2024, accounting for 3152 kt CO₂ eq. or 48% (Figure 4.1.2). Emissions in CRT 2.C in 2024 have decreased by 18% (677 kt CO₂ eq.) since 1990.

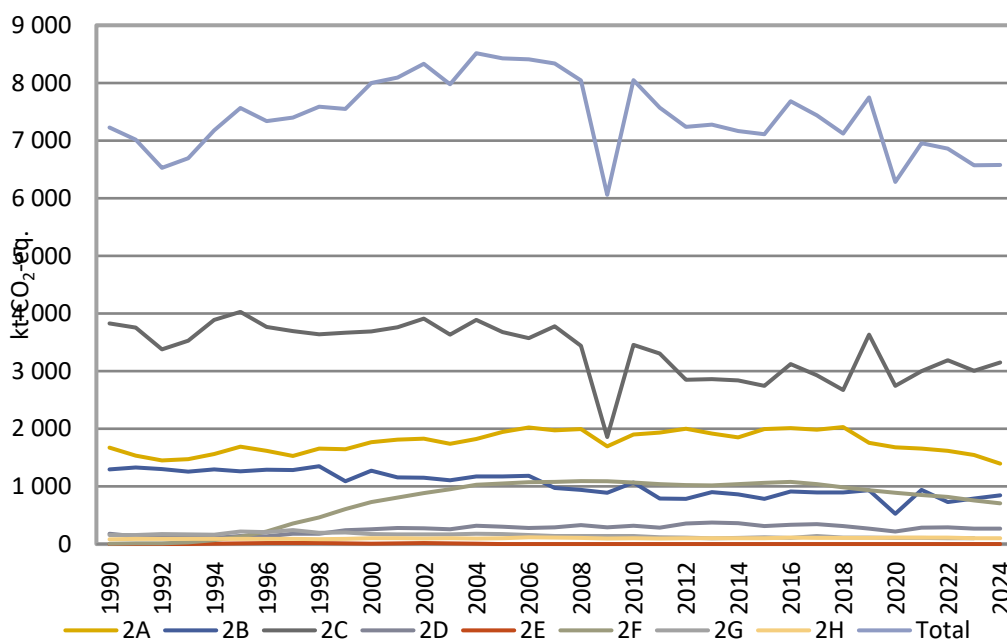


Figure 4.1.2. Total emissions of all greenhouse gases calculated as CO₂ eq. from the different industrial processes sub-sectors. 2A Mineral products. 2B Chemical industry, 2C Metal industry. 2D Non-energy products from fuels and solvent use. 2E Electronics industry, 2F Product uses as substitutes for ODS, 2G Other product manufacture and use, 2H Other.

Figure 4.1.2 shows that there was a sharp decrease in greenhouse gas emissions from the metal industry (CRT 2.C) in 2009. This was mainly due to the economic recession in 2009 which largely affected the production volumes of iron and steel in Sweden and thus the emissions are significantly reduced in 2009. Also concerning the metal industry, Figure 4.1.2 shows a significant increase of CO₂ emissions in 2019. This increase is explained by changes in the raw material mix, as well as replacement of certain part of steel scrap with raw iron having much higher carbon content.

The second largest contributor of greenhouse gas emissions in this sector is the mineral industry (CRT 2.A) with 1395 kt CO₂ eq., or 21% of the sector emissions in 2024. Compared to 1990 there is a decrease in greenhouse gas emissions from the mineral industry (277 kt CO₂ eq.) (Figure 4.1.2).

Greenhouse gas emissions from the chemical industry (CRT 2.B) have decreased 35% since 1990.

Estimated emissions of fluorinated greenhouse gases consist of emissions from the use of these in various applications, as well as PFC emissions from the primary aluminium production process. Emissions of greenhouse gases from product uses as substitutes for ozone-depleting substances (CRT 2.F) have increased substantially, by 701 kt CO₂ eq., since 1990 (Figure 4.1.2). The use of HFCs as refrigerants in refrigerators, freezers and air-conditioning equipment has contributed to the larger share in later years.

Emissions of greenhouse gases from non-energy products from fuels and solvent use (CRT 2.D) accounted for 270 kt CO₂ eq. in 2024, which is an increase of 50% since 1990.

Estimated greenhouse gas emissions from other product manufacture and use (CRT 2.G) consist of fluorinated greenhouse gases from electrical equipment (2.G.1) and sound-proof windows (2.G.2), and N₂O from product use (2.G.3). In 2024, these emissions accounted for 101 kt CO₂ eq., which is a decrease of about 36% since 1990.

Process emissions from production of pulp and paper and mineral wool, reported in other production (CRT 2.H) accounted for 104 kt CO₂ eq. in 2024. The emissions have increased with 26% since 1990.

In CRT 2.E (electronics industry) emissions from production of semiconductors has been reported from 1990 to 2004. In 2004 the production was shut down and greenhouse gas emissions is thus reported as not occurring (NO) from 2005.

4.1 Mineral industry (CRT 2.A)

Reported emissions include estimates for cement production (2.A.1), lime production (2.A.2), glass production (2.A.3) and other process uses of carbonates including ceramics, other uses of soda ash and other uses of limestone, dolomite and sodium bicarbonate (2.A.4). From 2022 onwards emissions and activity data for (2.A.1) Cement production and greenhouse gas emissions from Lime production (2.A.2) are confidential and therefore not shown on a disaggregated level in either text, tables or diagrams.

4.1.1 Cement production (CRT 2.A.1)

4.1.1.1 SOURCE CATEGORY DESCRIPTION

Cement production occurred during 2024 at two facilities in Sweden (owned by one company), with one being dominant. One smaller facility owned by the same company shut down in 2019. Annual production of cement in Sweden is about 2,000-3,000 kt. Emissions from cement production stem both from combustion of fuels and from raw materials used in the processes. Emissions arising from fuel combustion are reported in the energy sector (CRT 1.A.2.g) with the exception of SO₂ which is reported in 2.A.1.

For process-related CO₂ emissions, facility data are obtained from environmental reports, the EU ETS (European Union Emission Trading Scheme) and by direct contacts with the facilities. Process-related CO₂ emissions from cement production arise as a by-product during the production of clinker as limestone is heated to produce lime. CO₂ emissions related to limestone used for flue gas cleaning are also reported in CRT 2.A.1 according to the 2006 IPCC Guidelines, but accounts only for between 0.1 and 0.3% of total CO₂ emissions from the cement industry. Process related CH₄ and N₂O emissions from cement production are assumed to be negligible according to the 2006 IPCC Guidelines and thus reported as not applicable (NA).

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.2.1. An overview of the rationale for data sources used for key categories in the industrial processes sector is presented in Annex 3.5

Table 4.2.1. Summary of source category description, CRT 2.A.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.1	CO ₂	X	X		T3	PS	Yes
	CH ₄	NA	NA		NA	NA	NA
	N ₂ O	NA	NA		NA	NA	NA

PS Plant-specific. T3 Tier 3.

4.1.1.2 METHODOLOGICAL ISSUES

CO₂ emissions from the Swedish cement industry are estimated on a plant-specific basis. Estimates include emissions from by-pass dust and cement kiln dust (CKD), as well as emissions from organic carbon contained in the raw material.

For 1990-2004, information from the company on CO₂ emissions is based on clinker production and default EF from the GHG protocol, CKD correction factor and organic carbon contained in the raw material:

$$\text{CO}_2 = \text{Production of cement clinker (kt)} * 0.525 \text{ (kt CO}_2\text{/ kt clinker, i.e., default value in the GHG-protocol)} * \text{CKD correction factor} + \text{CO}_2 \text{ from organic carbon content of raw meal}$$

The emission estimates were made on initiative by the WRI (World Resources Institute) for the WBCSD (Working Group Cement CO₂ Emissions Inventory Protocol, Version 1.6.), see facts about the GHG protocol below and on their website¹⁶⁷. The protocol tool calculates CO₂ emissions from raw material converted to clinker, by-pass dust and CKD discarded, and has been used for all years except 1991-1994 and 1996, for which insufficient information was provided from the plants. Instead, the cement company has reported production and CO₂ emissions 1991-1994 and 1996 based on mean values from adjacent years.

The GHG protocol

The GHG protocol has been developed to enable companies to uniformly report their emissions of greenhouse gases. Emissions from stationary combustion and from processes are included.

Over 500 experts have developed the protocol and it is used by over 150 companies including industry associations representing pulp and paper, aluminium and cement.

The protocol for CO₂ emissions from the production of cement (WBCSD CSI, version 2.0) can be found on: <http://www.ghgprotocol.org>

As of 2005, the company reports plant-specific data on CO₂ emissions to the EU ETS and from this year onwards, CO₂ estimates as well as produced amount clinker are calculated according to the national guidelines (NFS 2017:6¹⁶⁸) for reporting to the EU ETS¹⁶⁹. For calculation of produced amount clinker, following formula is used:

$$\text{Produced amount clinker} = (\text{delivered amount cement} + \text{stock change of cement}) * \text{ratio of clinker/cement} - \text{imported clinker} + \text{delivered clinker} + \text{stock change of clinker}$$

Within the ratio of clinker/cement, cement deliveries, stock change, input materials to the cement, bypass dust and cement kiln dust are accounted for.

A CO₂ emission factor is calculated on a plant-specific basis according to the national guidelines by using the stoichiometric relationship of CaO and MgO in the product (0.785 for CO₂/CaO and 1.092 for CO₂/MgO). Also, CO₂ emissions from organic carbon contained in the raw material are included in the CO₂ emissions reported to the EU ETS.

¹⁶⁷ <http://www.ghgprotocol.org>. 2005-10-20.

¹⁶⁸ NFS 2017:6 Föreskrifter om handel med utsläppsrätter.

https://www.naturvardsverket.se/lagar-och-regler/foreskrifter-och-allmanna-rad/2012/nfs-20129?_t_hit.id=Boilerplate_Episerver_Features_EpiserverFind_Models_EpiserverFindDocument/14692_sv&_t_q=nfs%202007:5

¹⁶⁹ Lyberg, A., Cementa, Personal communication, September 2011

Table 4.2.2 shows information on clinker production and total CO₂ emissions from clinker production for certain years.

Table 4.2.2. Amount of produced clinker and associated CO₂ from specific sources.

Year	Clinker Production	Total CO ₂ emissions	CO ₂ from Clinker *	CO ₂ from CKD	CKD correction factor	CO ₂ from organic carbon content of raw meal	CO ₂ from limestone used in flue gas cleaning
	(kt)	(kt)	(kt)	(kt)		(kt)	(kt)
1990	2 348	1 272	1 233	13	1.010	27	-
1995	2 405	1 296	1 263	6	1.005	27	-
2000	2 389	1 288	1 254	6	1.005	27	-
2005	2 457	1 315	1 313	IE	NA	IE	2
2010	2 454	1 324	1 322	IE	NA	IE	1
2015	2 826	1 537	1 524	IE	NA	IE	4
2016	2 847	1 554	1 534	IE	NA	IE	4
2017	2 768	1 484	1 467	IE	NA	IE	4
2018	2 958	1 607	1 574	IE	NA	IE	4
2019	2 539	1 357	1 335	IE	NA	IE	4
2020	2 438	1 272	1 257	IE	NA	IE	2
2021	2 405	1 259	1 241	IE	NA	IE	3

* From 2005 includes also CKD and organic carbon content

IE - Included elsewhere (CO₂ from CKD and organic carbon content reported together with CO₂ from clinker). NA - Not applicable.

For the years prior to 2005 the table shows the calculated emissions from CKD and the resulting CKD correction factor as well as CO₂ emissions from organic carbon content of raw meal. From 2005 onwards cement kiln dust emissions are reported together with emissions from clinker production.

From 2022 onwards the production data and CO₂ emissions are classified. During 2018 - 2019, a study was conducted that aimed to estimate the uptake of CO₂ in concrete and cement. The main purpose of the study was to provide input to the national and international greenhouse gas inventories by developing new calculation models for CO₂ in the cement and concrete sector. Due to the regulations for reporting to the UNFCCC, uptake of CO₂ for these sectors at present cannot be reported. The study is described in more detail in NID Annex 8:5.

Total emissions of NO_x by facility are found in the environmental reports or have been obtained directly from the company. Emissions originate mainly from fuel combustion and to a smaller extent from industrial processes. Since the CRT format does not allow for reporting NO_x in CRT 2.A.1, IE is reported for NO_x in CRT 2.A.1 and all emissions are reported in CRT 1.A.2.f.

SO₂ emissions from cement production have been obtained directly from the company or from the environmental reports and are fully allocated to CRT 2.A.1 in order to avoid over- or underestimation of emissions. Reported emissions are decreasing over time since 1990. For 2020 the largest company reported a revised method to estimate SO₂ emissions,

which resulted in considerably higher emissions of SO₂ in 2020 onwards. Thus, for years prior to 2020, SO₂ is estimated using the old method, resulting in that reported data for SO₂ for year 2020 and onwards are not comparable to earlier years.

4.1.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Activity data and CO₂ emissions are reported to the EU ETS and have thus been verified by an accredited verification body. The uncertainty for activity data is judged to be ± 2% and the uncertainty of the emission factor for CO₂ is judged to be ± 5%.

All facilities, three until 2019 and two after 2019, in Sweden are covered in the reported estimates and the time-series are considered complete, accurate and more or less consistent. As described above, for 1990-2004, constant CO₂ EF (0.525 kt CO₂/kt clinker produced) is used together with CKD correction factor and CO₂ emissions from organic carbon of raw meal. Since 2005, CO₂ emissions are retrieved from the EU ETS and are based on the content of CaO and MgO in clinker. This means that different methods are used over time, however there is no indication that either methods lead to over- or underestimations of CO₂ emissions.

For the years 2022 and onwards, activity data and emissions are classified.

4.1.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The implied emission factor for total CO₂ is for most years somewhat higher than the 2006 IPCC Guidelines Tier 1 default value (0.52 kt CO₂/kt produced clinker). The main reason for the higher implied emission factors is that the MgO content in clinker is accounted for in the reported emissions for Sweden. In addition, in line with the 2006 IPCC Guidelines, CO₂ emissions from limestone used for flue gas cleaning are included in CRT 2.A.1, which results in a further increase of the implied emission factor.

Figure 4.2.1 illustrates the CO₂ IEF from clinker production, excluding emissions from the use of limestone in flue gas cleaning. There are larger variations after the introduction of EU ETS data as data source. The reason for the varying CO₂ IEF is varying content of CaO and MgO in clinker; a higher concentration of these compounds in the produced clinker implies that a larger amount of CO₂ has been released per unit produced clinker. Table 4.2.3 lists the content of CaO and MgO for the years 2008-2023 for the largest facility (accounting for an average of 76% of totally produced clinker in the years 2008-2023). For 2024, the content of CaO and MgO could not be obtained (considered confidential).

The correlation between CaO and MgO content and CO₂ IEF for the largest plant is illustrated in Figure 4.2.2. CaO and MgO contents are shown there as a sum, however MgO in clinker has given rise to a slightly larger amount of CO₂ per unit than CaO, explaining the small differences of IEF and CaO and MgO content in the figure. Starting in 2017, the facility used some alternative raw materials for clinker production (for example slag). This is a possible explanation for the weaker correlation between CO₂ IEF and CaO and MgO content in the clinker for latest years.

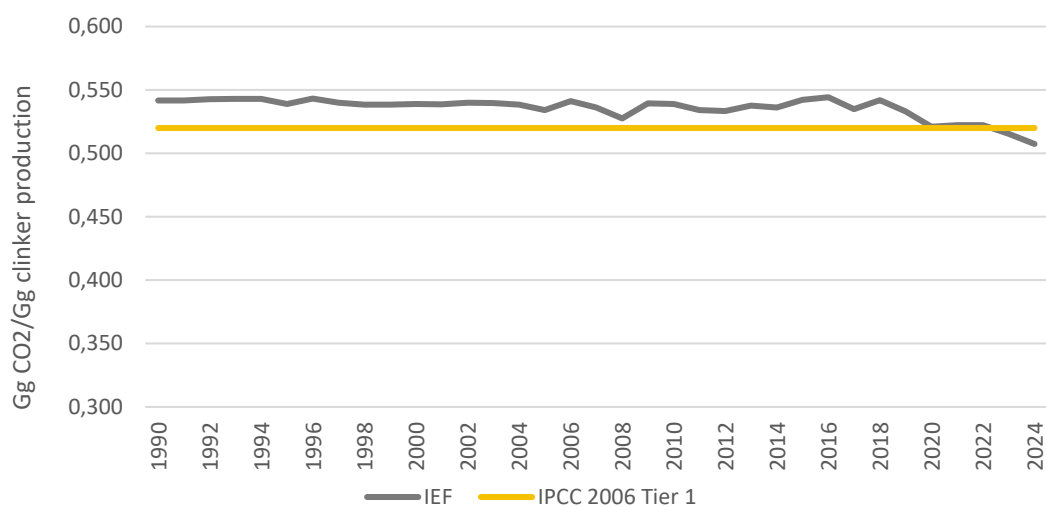


Figure 4.2.1. CO₂ IEF for total emissions from clinker production 1990-2024, excluding emissions from flue gas cleaning.

Table 4.2.3. CaO and MgO content in clinker produced in the years 2008-2023 in the largest facility (accounting for an average of 76% of totally produced clinker in the years 2008-2023). For 2024, data is considered confidential.

Year	CaO content %	MgO content %
2008	63.91	2.74
2009	65.73	2.83
2010	65.43	2.92
2011	65.05	2.58
2012	64.92	2.49
2013	64.76	2.96
2014	64.96	2.87
2015	64.94	2.96
2016	65.27	3.07
2017	65.24	3.13
2018	65.07	3.08
2019	64.88	3.42
2020	64.64	3.49
2021	64.96	3.47
2022	63.89	3.58
2023	63.64	3.66

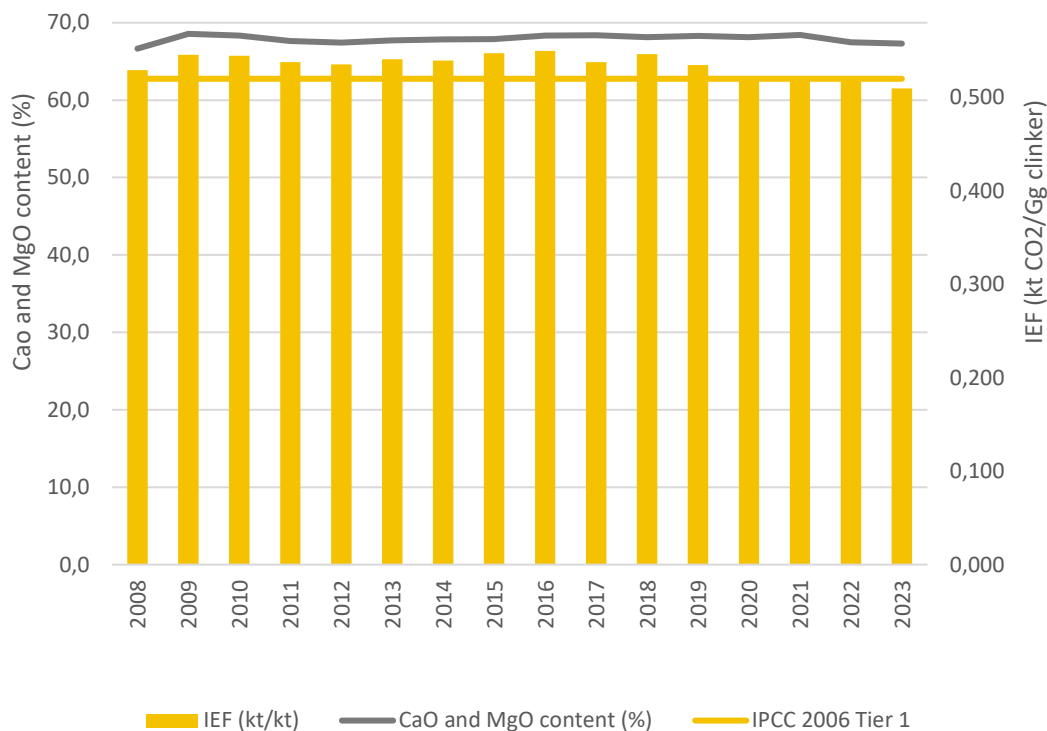


Figure 4.2.2. CO₂ IEF is compared to CaO and MgO content for respective year. Data is taken from the largest facility for the period 2008-2023 and exclude emissions from flue gas cleaning.

In response to previous UNFCCC review recommendations, discussions with the cement producers have led to the conclusion that CO₂ emissions from dust and from carbon content in the raw material are included in the estimations for the whole time series (see methodological issues above). In Table 4.2.2 above, information on clinker production, emissions from production, the calculated emissions from CKD before 2005 and the corresponding CKD correction factors are presented. Compared to the 2006 IPCC default value (1.02) the presented CKD correction factor is generally lower which is in line with the conception that dust emission in Sweden is low or nearly non-existent.

The cement producing facilities are included in the annual quality control procedure using the cross-sectoral control tool described in NID section 1.3.5.1. CO₂ emissions reported in the energy sector (CRT 1.A.2.f) and CRT 2.A.1 are compared to total emissions reported by the facilities to the EU ETS and in the respective environmental reports. This ensures that total emissions from the facilities are neither under- or overestimated to a larger extent.

4.1.1.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations were made in submission 2026.

4.1.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.1.2 Lime production (CRT 2.A.2)

4.1.2.1 SOURCE CATEGORY DESCRIPTION

In Sweden, quicklime, hydraulic lime and dolomitic lime is produced at a number of facilities, owned by a few companies. Produced lime is, for instance, used in blast furnaces, in sugar and carbide production and in the pulp and paper industry to bind impurities and purify the produced material. The production of lime has increased since 1990 (from about 440 kt) and peaked in 2005 (at about 730 kt). In 2009 there was a large decrease in lime production due to the economic recession. In 2017 there was an increase in production compared to the years 2014-2016, with quantities of around 625 kt, but slightly lower compared to years 2010-2013. Lime production from 2018 onwards amounts to around 500 kt.

CO₂ is emitted during lime production through calcination of the calcium carbonate (CaCO₃) in limestone, or through the decomposition of dolomite (CaCO₃·MgCO₃). Emissions are reported for lime produced in lime production plants, the use of make-up limestone in pulp and paper plants, and lime production within the carbide and sugar industry that occurs as part of the process. Out of these sources, emissions from lime production plants are by far the most important.

Process-related CH₄ and N₂O are not emitted during lime production and thus reported as not applicable (NA). Lime contains sulphur which is released as SO₂ during the production process.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.2.4.

Table 4.2.4. Summary of source category description, CRT 2.A.2, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.2	CO ₂	X	X		T3	D	Yes
	CH ₄	NA	NA		NA	NA	NA
	N ₂ O	NA	NA		NA	NA	NA

PS Plant specific. D Default.

4.1.2.2 METHODOLOGICAL ISSUES

4.1.2.2.1 CO₂ (kt)

Activity data and emissions for 2005 onwards (2009 onwards for sugar production) are based on EU ETS data. For 1990 to 2004 (or 2008), statistics are mainly received from the Swedish Lime Association, which is a trade organisation that collects data on lime from various industries. In Mawdsley 2015¹⁷⁰, it was concluded that EU ETS data and data from the Swedish Lime Association were comparable, however EU ETS data is received in time for the UNFCCC reporting, as opposed to data from the Swedish Lime Association. Thus, for later years (since 2005 or 2009), CO₂ emissions from lime

¹⁷⁰ Mawdsley, I. 2015. Change of activity data for lime production

production are based on the individual companies' data reported to the EU ETS, where also emissions from LKD are included. Reported emissions are used directly, and activity data is calculated using emission factors and purity factors according to the 2006 IPCC Guidelines.

Sugar industry

In the production of sugar, lime is used for purification of the juice. Lime is added to raw juice and impurities are precipitated. In the carbonisation step, CO₂ is bubbled through the juice and most of the remaining lime is precipitated as CaCO₃. The precipitated "limestone" is sold and used in the agricultural sector. According to information from the company, around 88% of the used lime was precipitated as CaCO₃ for the years before 2005. For later years this share has increased and is as an average 91%. No dolomitic lime is used.

For 2009 onwards, EU ETS data is used for emission estimates from the sugar industry. For determining activity data and emissions of CO₂ within the sugar industry prior to 2009, the amounts of limestone for the production of quicklime are used. For years prior to 1999, no data on limestone are available. For those years the amounts of limestone used for production of quicklime are estimated using the quantity of coke used for lime production 1990 – 1998, together with the average ratio coke/limestone for the years 1999 to 2002. According to the company, the used limestone consists to 97% of CaCO₃. Between 1999 and 2017, the quantities are obtained directly from the sugar producing company. For 2018, activity data is calculated using emission factors and purities according to the 2006 IPCC Guidelines, since no data is available from the company.

Pulp and paper industry

Make-up lime is an important product in the causticizing process within the pulp and paper industry. Most facilities operate their own kilns and regenerate lime after use.

From 2005 onwards, CO₂ emission data is retrieved from the EU ETS for individual pulp and paper plants. Lime kiln sludge that is put in storage and reburnt in the lime kiln is excluded from the estimations, as resulting CO₂ emissions stem from biogenic carbon from other parts of the production process.

Prior to 2005, data on make-up lime is obtained from the Swedish Lime Association and the Swedish Lime Industry. In response to previous review recommendations, detailed data on quantities of lime used as make-up lime in the pulp and paper industry, and quantities of limestone and dolomite used for production of make-up lime, have been obtained from the trade organisation from 1995 onwards¹⁷¹, unfortunately not always in time for reporting to the UNFCCC.

For the years before 1995, limestone quantities used as make-up lime are estimated using the average ratio between limestone used as make-up lime and produced Kraft pulp for the period 1995 – 2009 and corresponding production data for 1990 – 1994. This gives an average (1995 – 2008) of 2.1 kg limestone per Mg Kraft pulp and is used for estimations of limestone use for the years before 1995. Similarly, CO₂ emissions are estimated for 1990 – 1994 by using the average ratio between emitted CO₂ and used amounts of limestone for the period 1995 – 2008. Based on the 2006 IPCC Guidelines, the purity of

¹⁷¹ Swedish Lime Association and The Swedish Lime Industry, personal communication

the limestone is assumed to be 95%. The corresponding figure for dolomite is 100%. Less than 1% of total make-up lime within the pulp and paper industry is dolomitic lime.

Calcium carbide industry

In order to estimate CO₂ emissions from production of quicklime at Sweden's only calcium carbide production plant, emission data is collected from the EU ETS from 2005 onwards. For 1990-2004, the amount of limestone used for quicklime production is used as activity data together with the default emission factor from 2006 IPCC Guidelines; 0.44 Mg CO₂/Mg limestone used. For these years data has been obtained from the company.

Lime production plants

For all other production of quicklime, hydraulic lime and dolomitic lime, which occurs at lime production plants, EU ETS emission data for the individual lime plants are used from 2005 onwards, and emission factors and purities according to the 2006 IPCC Guidelines are used to calculate activity data.

Detailed data from 1990 to 2004 are obtained from the Swedish Lime Association. To avoid double counting of emissions, activity data for produced quicklime, hydraulic lime and dolomitic lime in the sugar industry and the pulp and paper industry has been deducted. Based on 2006 IPCC Guidelines, the purity of the limestone is assumed to be 95% for the production of lime in conventional lime mills. The corresponding figure for dolomite is 100%. Between 2% and 8% of the total production of lime in conventional lime mills is dolomitic lime. Production data and reported CO₂ emissions for lime plants are shown in Table 4.2.5 together with the implied emission factor. From 2005-2021 however, activity data is calculated based on CO₂ emissions from the EU ETS, and thus the emission factor is constant. From 2022 onwards, CO₂ emissions are confidential.

Table 4.2.5. Produced amounts of quick lime and dolomitic lime, emitted CO₂ and IEF (CO₂ emitted per produced quicklime and dolomitic lime) in conventional lime plants.

Year	Reported Activity Data (quick lime and dolomitic lime, excluding lime in sugar, pulp and carbide industry)	Reported CO ₂ emissions (excluding emissions in sugar, pulp and carbide industry)	IEF (CO ₂ /quicklime + dolomitic lime)
	(kt)	(kt)	(kt/kt)
1990	367	277	0.7555
1995	350	264	0.7550
2000	513	387	0.7544
2005	665	496	0.7458
2010	620	463	0.7458
2011	619	462	0.7459
2012	579	432	0.7460
2013	594	443	0.7459
2014	507	378	0.7459
2015	516	385	0.7459
2016	529	395	0.7458
2017	578	431	0.7458
2018	479	357	0.7458
2019	454	336	0.7458
2020	483	360	0.7459
2021	466	348	0.7459
2022	527	C	C
2023	511	C	C
2024	486	C	C

C - Confidential data

4.1.2.2.2 SO₂ (kt)

Emissions of SO₂ have been estimated for production of quicklime from 1990 onwards. Emissions are calculated using emission factors presented in environmental reports by one of the producers¹⁷². The emission factor provided by the lime producer is substantially higher for 2008 than for earlier years. This resulted in an increase of reported SO₂ emissions for 2008 compared to earlier years. However, in 2009 the reported SO₂ emissions were again on the same level as before 2008 due to less use of lime. For 2009-2023 the emission factor for 2008 has been used for the estimation of emissions of SO₂ due to lack of more recent information in the environmental reports.

Emissions of SO₂ from quicklime production intended for the pulp and paper industry are not included in the estimates reported in CRT 2.A.2 as they are included in CRT 2.H.1.

4.1.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties are estimated based on the 2006 IPCC Guidelines and is estimated to ± 5% for activity data and ± 2% for CO₂ emission factors. Although different sources of activity data are used over the time series, the time series is considered consistent based on comparisons of different data sources (see section 4.2.2.4).

¹⁷² Nordkalk, <http://www.nordkalk.com>

4.1.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Activity data reported in CRT 2.A.2 has been compared with national statistics from Statistics Sweden¹⁷³ and from the Swedish Lime Industry¹⁷⁴, in line with the IPPC Guidelines 2006. In addition, activity data from the EU ETS for year 2017-2021 are included in the comparison. The comparison (Figure 4.2.3) shows that national statistics from Statistics Sweden are more irregular, however for early years the agreement is good. The differences are especially large in 1998, 1999 and from 2004 and onwards. Comparison between reported activity data and activity data from the Swedish Lime Industry shows good agreement with only small differences for a few years. The last years have shown increasing divergence in reported activity data in 2.A.2 compared to activity data from the Swedish Lime Association. Reasons for this divergence might be a combination of the fact that Swedish Lime Association data covers delivered quantities from the members in the association (not produced) and that the emission factor used to calculate activity data reported in 2.A.2 is slightly too high, which results in lower activity data as the data is calculated based on reported CO₂ in the EU ETS. The activity data reported in the EU ETS shows much better correlation to the data from the Lime Association (1-6%) for the years 2017-2021. The emission factors used in the EU ETS are lower than the standard emission factor used in the inventory. Sweden will investigate if it is more suitable to use the activity data reported in EU ETS instead of calculating the activity data based on reported CO₂ and a standard emission factor in future submissions.

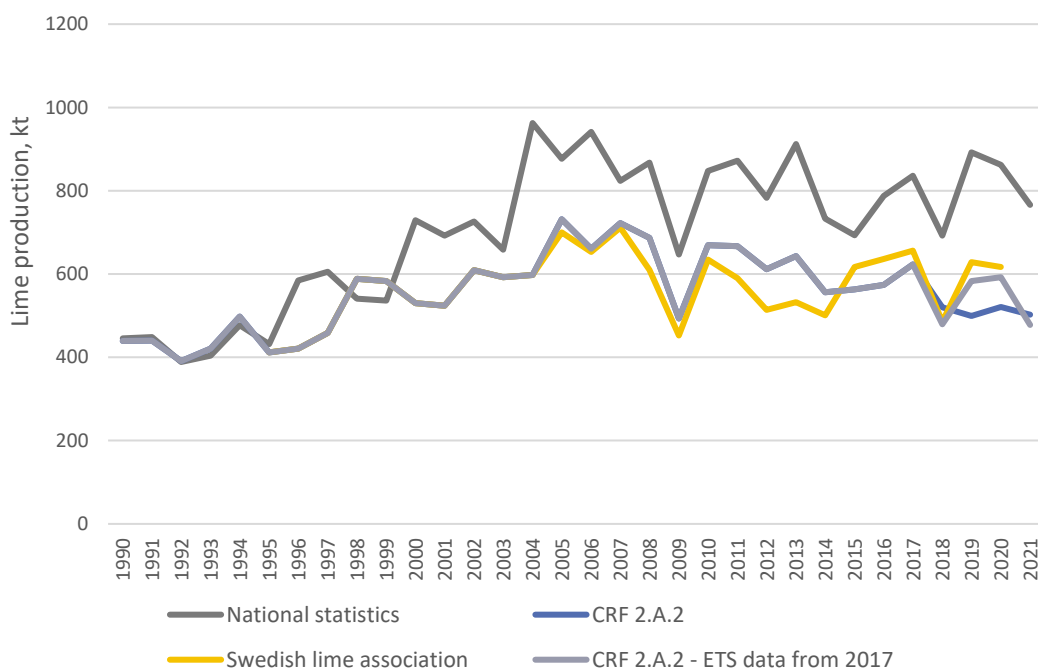


Figure 4.2.3. National total on produced amount of lime according to data from Statistics Sweden, the Swedish Lime Association and reported data in CRT 2.A.2.

¹⁷³ Statistics Sweden. Data from the Industrial production database: www.scb.se

¹⁷⁴ Swedish Lime Association and The Swedish Lime Industry, Svenska Kalkföreningen, personal communication

National statistics are based on national surveys mainly aiming at collecting data for economic statistics. In these surveys not all facilities are included and for those the produced amounts are estimated, which might lead to over- or underestimations of, in this case, produced amounts of lime. This leads to larger fluctuations and higher uncertainties in the national statistics from Statistics Sweden compared to data from the Swedish Lime Association and the Swedish Lime Industry. In a study conducted in 2013¹⁷⁵, Gustafsson and Gerner concluded that national statistics from Statistics Sweden would likely result in overestimated emissions, as imported quantities and calcium hydroxide are likely included in the data. The reported production volumes in the national statistics are significantly higher than both EU ETS data and the Lime Association data. The magnitude of the difference is 30-40% for many years which indicates that the national statistics is comprised by different data than the two other sources. Since the national statistics data cannot be disaggregated the data is unsuitable for comparison with the other two data sources.

In 2015 a review of CRT 2.A.2 was made, where different data sources were compared and where it was determined that the best available data source for this source code is the EU ETS since the data is verified by accredited personnel. It should be noted that the choice of activity data source does not affect the reported CO₂ in CRT 2.A.2.

The lime producing facilities are included in the annual quality control procedure using the cross-sectoral control tool described in NID section 1.3.5.1. CO₂ emissions reported in the respective energy sector and CRT 2.A.2 are compared to total emissions reported by the facilities to the EU ETS and in the respective environmental reports. This ensures that total emissions from the facilities are neither under- or overestimated to a larger extent.

4.1.2.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations were performed in submission 2026.

4.1.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.1.3 Glass production (CRT 2.A.3)

4.1.3.1 SOURCE CATEGORY DESCRIPTION

In Sweden there is one facility for container glass production and several small facilities for manual glass production. The only float glass producer ceased production in 2013. CRT 2.A.3 also includes glass wool production, which occurs at one facility.

From the float glass production, emissions of SO₂ and NO_x from the glass furnace are reported up until 2013 when the only float glass producer ceased production. Since the CRT tables does not allow for SO₂ or NO_x to be reported in 2.A.3 the emissions are included in 2.A.4 until 2013. From the container glass production, SO₂ emissions originating from the raw material and small amounts of NMVOC are reported. All other emissions from the glass production facilities are from combustion for energy purposes and are allocated to the Energy sector (CRT 1).

¹⁷⁵ Gustafsson, T., Gerner A. 2013. Verification of activity data for lime production.

Emissions of CO₂ from the use of limestone, dolomite, soda ash and other carbon containing raw material in glass and glass wool production are reported under glass production. The CO₂ emissions in 2009 are lower than in adjacent years since the demand for glass was low in 2009. In addition, less glass was manufactured from raw material that year – instead, recycled glass was used to a larger extent. In 2013, one plant producing glass using the float glass method was shut down and only very small emissions are reported for 2013 from this facility. Therefore, total CO₂ emissions from CRT 2.A.3 decreased with 65% in 2013 compared to 2012 and, since NO_x emissions are only reported from this facility, the corresponding decrease in NO_x emission is 96%. No NO_x emissions from glass production occur after 2014.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.2.6.

Table 4.2.6. Summary of source category description, CRT 2.A.3, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.3	CO ₂	-	-		T3	CS, D, PS	No, see Annex 5
	CH ₄	NA	NA		NA	NA	NA
	N ₂ O	NA	NA		NA	NA	NA

D Default. CS Country Specific. PS Plant Specific. T3 Tier 3.

4.1.3.2 METHODOLOGICAL ISSUES

Emissions of CO₂ from the use of limestone, dolomite and soda ash in glass production are reported in CRT 2.A.3 together with CO₂ emissions from other carbon containing raw material. Of the reported total CO₂ emissions in 2.A.3, approximately 44% is caused by the use of soda ash and 54% on the use of limestone and dolomite. The remaining CO₂ is emitted as a result of use of other carbon containing raw materials.

Produced amounts of float and container glass has been collected from the annual environmental reports for the two major producers. Information on the quantities of glass wool produced has also been taken from the annual environmental reports. There are also small manual glass-producing facilities for which no activity data are provided. Amounts of produced container glass, flat glass, manual glass and glass wool is reported in the CRT from this submission onwards.

In Table 4.2.7 produced amounts of container glass, flat glass and glass wool, taken from the annual environmental reports, are presented together with estimated amounts of glass produced at small manual glass-producing facilities. For this estimation, default emission factor in 2006 IPCC Guidelines and reported amounts of CO₂ have been used.

Table 4.2.7. Glass production in Sweden, ton.

Year	Float glass	Container glass, large facilities	Manual glass production	Glass wool
1990	223 672	126 257	6 120	94 486
1995	262 171	101 878	6 120	53 400
2000	275 830	109 861	6 120	49 358
2005	273 144	125 477	6 070	54 091
2010	219 837	148 112	5 150	49 218
2011	245 176	160 016	5 120	48 403
2012	200 150	157 423	4 920	45 350
2013	0	155 231	4 770	44 073
2014	0	157 795	4 500	46 721
2015	0	156 206	4 500	44 105
2016	0	139 055	4 500	58 479
2017	0	172 012	4 500	60 697
2018	0	176 333	4 500	51 264
2019	0	175 771	4 500	59 170
2020	0	164 906	4 500	49 461
2021	0	175 263	4 500	57 261
2022	0	185 475	4 500	57 151
2023	0	163 225	4 500	47 536
2024	0	167 331	4 500	45 063

Emissions are mainly collected from the EU ETS or from the facilities' annual environmental reports. For small glass producers, a constant amount of 0.9 kt CO₂ per year, and corresponding amount of limestone, is added. This estimate is based on information from a survey made in the late 1990s by the Swedish EPA on small glass production facilities and represents data from 1997. Two different estimates were made, one based on the consumption of carbonates for the production of glass and crystal, and the other based on the knowledge on the percentage weight loss depending on emitted CO₂, from weight of raw material to produced amount of glass or crystal. Both estimates result in CO₂ emissions of around 0.9 kt annually.

Data on process-related NO_x and SO₂ emissions from glass production (reported in CRT 2.A.4) have been provided directly by the companies or collected from their environmental reports.

CO₂ emissions from the one glass wool producer in Sweden derive from the use of glass wool waste (glass wool production). Glass wool consists almost entirely of glass. A large proportion of the batch mixture, the so-called melt, consists of recovered glass material, e.g. recycled household glass and excess glass from the fiberization process. Also glass wool waste can be recycled and used in the production of glass wool by a method called the "Oxymelt" process. In this process the organic compounds (binders) are burned and the mineral part ("oxymelt glass") of the glass wool waste can be recovered and used as a resource for the production of new glass wool. The burning of the organic binders gives rise to emissions of CO₂. In the EU ETS, CO₂ emissions from the oxymelt process, from use of soda ash and dolomite are reported since 2005 for the glass wool producer. Activity data, emission factors and CO₂ emissions data are based on information from the

EU ETS for the years 2005-2023. The corresponding information for 1990-2004 has been obtained from the company. In 1990, no oxymelt glass was used. The average emission factor, 2005-2023, is 0.138 kt CO₂/kton oxymelt glass.

NMVOC emissions from glass wool production are estimated from data received from the company directly or as reported in environmental reports together with earlier total estimates. Emitted NMVOCs consist of formaldehyde and phenol.

4.1.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties of the direct CO₂ emissions in 2.A.3 are considered to be ± 7% based on expert judgements.

4.1.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The two bigger glass producing facilities and the glass wool producer are included in the annual quality control procedure using the cross-sectoral control tool described in NID section 1.3.5.1. CO₂ emissions reported in energy sector (CRT 1.A.2.f) and CRT 2.A.3 are compared to total emissions reported by the facilities to the EU ETS and in the respective environmental reports. This ensures that total emissions from the facilities are neither under- nor overestimated to a larger extent.

4.1.3.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations were made in submission 2026.

4.1.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.1.4 Other process uses of carbonates (CRT 2.A.4)

4.1.4.1 SOURCE CATEGORY DESCRIPTION

In CRT 2.A.4, Sweden reports emissions from Ceramics (CRT 2.A.4.a), Other uses of soda ash (CRT 2.A.4.b) and Other (CRT 2.A.4.d) which includes the use of limestone, dolomite and sodium bicarbonate for flue gas cleaning. Non-metallurgical magnesium production does not occur in Sweden. NO_x and SO₂ emissions from glass production are included in CRT 2.A.4 for relevant years since these emissions cannot be reported in CRT 2.A.3.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.2.8.

Table 4.2.8. Summary of source category description, CRT 2.A.4, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.A.4	CO ₂	-	-		T3	D	Yes
	CH ₄	NA	NA		NA	NA	NA
	N ₂ O	NA	NA		NA	NA	NA

D Default. T3 Tier 3.

4.1.4.1.1 *Ceramics (CRT 2.A.4.a)*

Sweden reports CO₂ emissions from production of clay-based materials such as LECA, roofing tiles, bricks and ceramics. During the production, CO₂ is emitted from the burning of fuels, reported in CRT 1.A.2.f, but CO₂ originating from the clay, the limestone and from other carbon containing material is also emitted and reported in CRT 2.A.4.a. Reported CO₂ emissions represent emissions from six facilities during the years 1990-2008 and from five facilities from 2009 and onwards, since one facility closed down in 2008. One of the facilities is dominating the total CO₂ emissions. All CO₂ emissions from used raw material are reported in 2.A.4.a. In 2020, the facility accounting for the majority of emissions until 2018 shut down.

4.1.4.1.2 *Other uses of soda ash (CRT 2.A.4.b)*

Due to difficulties in allocating emissions to their respective CRT code, all emissions from soda ash use are reported in CRT 2.A.4.b Other uses of soda ash. Soda ash is used in the production of glass wool, moist snuff and chemicals i.e. detergents, and until 2004 also in flue gas desulphurisation at energy plants. Soda ash is also used in production of glass and glass wool (2.A.3).

4.1.4.1.3 *Other (CRT 2.A.4.d)*

Other process uses of carbonates that occur in Sweden and do not fit into any other category, are the use of limestone, dolomite and sodium bicarbonate for flue gas cleaning purposes in energy industries, whereby CO₂ is emitted. Process-related CH₄ and N₂O are not emitted during the use of these carbonates and thus reported as not applicable (NA).

4.1.4.2 METHODOLOGICAL ISSUES

Specified sub-categories under this heading are “Ceramics”, “Other uses of soda ash”, and “Other”.

4.1.4.2.1 *Ceramics (CRT 2.A.4.a)*

Activity and emissions data for LECA production 1990 - 2004 is retrieved directly from the production plant, divided into emissions from clay and emissions from additives (limestone and other carbon containing material). From 2005 to 2019, the equivalent data is acquired through the EU ETS and the Swedish LECA producer's annual report. The LECA producer shut down its production during 2019.

For roofing tile, brick and ceramics production, activity and emission data from 2005 and onwards is acquired through the EU ETS. In line with the 2006 IPCC Guidelines, CO₂ emissions from limestone and dolomite as well as other carbon containing raw materials are reported in 2.A.4.a. As data prior to 2005 is missing, the reported emissions for 2005 are linearly interpolated for 1990-2004.

Produced amounts of LECA is reported as activity data in 2.A.4.a until 2019, due to lack of activity data for remaining facilities. The implied emission factor may vary somewhat from one year to another because of the specific composition of limestone, clay and additives with different carbon contents. In 2007, the carbon content in one of the additives for LECA production was unusually high, which resulted in comparatively high CO₂ emissions for that year. The use of limestone and other additives in LECA production has declined in favour of clay. From 2008, clay has contributed to between 65-75% of all process-related CO₂ emissions from LECA production, compared to 47-

58% during 1990-2003. The facility producing LECA corresponded to around 70% of yearly reported CO₂ emissions in 2.A.4 for the years the facility was in operation.

4.1.4.2.2 *Other uses of soda ash (CRT 2.A.4.b)*

CO₂ emissions from soda ash use are estimated according to 2006 IPCC Guidelines Tier 3. In 2004, a study was carried out to collect data on soda ash use and calculate CO₂ emissions.¹⁷⁶ Activity data consists of soda ash use from ten plants within several areas:

- production of moist snuff and chemicals and sewage treatment
- until 2004, in flue gas desulphurisation at energy plants

One chemical plant closed detergent production in 2016, which resulted in significant decrease in used amounts of soda ash and related CO₂ emissions in 2017.

Activity data for the use of soda within water treatment and moist snuff production by others than the dominant manufacturer, has been estimated based on information from expert organisations¹⁷⁷ and the dominant snuff manufacturer. The emissions are calculated by applying the emission factor for soda ash and assuming a calcination fraction of 1:

$$\text{CO}_2(\text{kt}) = \frac{44.0098}{105.9884} \times \text{soda ash (kt)}$$

Data on the use of soda ash have been acquired from environmental reports and through direct contacts with the reporting companies.

The data used for national GHG estimations from soda ash use is believed to be more consistent and complete compared to data from national statistics, since the data for the inventory is collected from the environmental reports of the facilities or by direct contact with the plants.

4.1.4.2.3 *Other- Limestone and Dolomite use (CRT 2.A.4.d)*

Process-related CO₂ emissions from the use of limestone and dolomite in the production of cement (2.A.1), lime (2.A.2), glass and glass wool (2.A.3), ceramics (2.A.4.a), carbide (2.B.5), chemicals (2.B.10), iron and steel (2.C.1.a, 2.C.1.b and 2.C.1.c), iron pellets (2.C.1.e), other metals (2.C.7) and mineral wool (2.H.3) are reported in corresponding CRT source categories in accordance with the 2006 IPCC Guidelines. CO₂ emissions from the use of limestone, dolomite and sodium bicarbonate in flue gas desulphurisation at energy plants are reported in 2.A.4.d.

Data on the use of limestone and dolomite in this source category has been acquired from environmental reports, the EU ETS and through direct contacts with the companies. Activity data for sodium bicarbonate has been collected from the EU ETS for the years 2005 onwards. For the period 1990-2004, activity data has been estimated based on the average emissions for the period 2005-2008; equivalent to about 0.54 kt a year. The

¹⁷⁶ Nyström, A-K. 2004. CO₂ from the use of soda ash. SMED report 61 2004.

¹⁷⁷ The Swedish Chemicals Agency (KemI), www.kemi.se

calculations are made by applying the emission factor for respective carbonate according to 2006 IPCC Guidelines Tier 3¹⁷⁸.

Formulas for CO₂ emissions from limestone, dolomite and sodium bicarbonate are as follows:

$$CO_2 (Gg) = \frac{44.0098}{100.0892} \times f \times \text{limestone} (Gg)$$

$$CO_2 (Gg) = \frac{88.02}{184.4} \times f \times \text{dolomite} (Gg)$$

$$CO_2 (Gg) = \frac{44.0098}{84.007} \times f \times \text{sodium bicarbonate} (Gg)$$

where *f* is the purity of the carbonates, set to 97% for limestone and 100% for dolomite and sodium bicarbonate.

4.1.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

In CRT 2.A.4.b (soda ash) and CRT 2.A.4.d (other use), the uncertainty of activity data is ±5% and ±4%, respectively, and the uncertainty of the emission factor for CO₂ is ±5%. In CRT 2.A.4.a (ceramics) the emission uncertainty is ±7%. The time series is consistent and complete.

4.1.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Data from Statistics Sweden on import and export of carbonates has been compared to production data provided by the Geological Survey of Sweden (SGU) and known use included in the national inventory. When calculating carbonate use based on clinker production in CRT 2.A.1 the comparison shows a good coverage of carbonate use included in the inventory. The margin of error is, however, bigger than the amount reported in CRT 2.A.4. which makes this comparison difficult and less reliable.

Facilities reported in CRT 2.A.4 are included in the annual quality control procedure using the cross-sectoral control tool described in NID section 1.3.5.1. CO₂ emissions reported in the respective energy sector and CRT 2.A.4 are compared to total emissions reported by the facilities to the EU ETS and in the respective environmental reports. This ensures that total emissions from the facilities are neither under- nor overestimated to a larger extent.

4.1.4.5 SOURCE-SPECIFIC RECALCULATIONS

4.1.4.5.1 Ceramics (CRT 2.A.4.a)

Minor recalculation (-0.057 kt CO₂-eq) due to previous error were performed in Submission 2026 for emission year 2023.

4.1.4.5.2 Soda ash use (CRT 2.A.4.b)

Minor recalculation (-0.000037 kt CO₂-eq) due to previous error were performed in Submission 2026 for emission year 2022.

¹⁷⁸ IPCC. 2006 Guidelines for National Greenhouse Gas Inventories: Volume 3 section 2.5.

4.1.4.5.3 Other limestone and dolomite use (CRT 2.A.4.d)

No source-specific recalculations were performed in Submission 2026.

4.1.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.2 Chemical industry (CRT 2.B)

Sources covered in the reporting are nitric acid production (2.B.2), carbide production (2.B.5) and other (2.B.10), which include a large variety of processes in the chemical industry. Included in 2.B.10 are also various processes which produce petrochemical products, which according to the 2006 IPCC Guidelines should be reported in 2.B.8. However, due to difficulties in separating these products they are allocated to CRT 2.B.10. No production of ammonia (2.B.1), adipic acid (2.B.3), caprolactam, glyoxal and glyoxylic acid (2.B.4), titanium dioxide (2.B.6), soda ash (2.B.7) or fluorochemicals (2.B.9) occurs in Sweden.

Due to limitations in the ETF GHG Inventory Reporting Tool in calculating correct sector totals when reporting “C” (confidential) at the higher category level (CRT 2.B), all greenhouse gas emissions in CRT 2.B have been reallocated to CRT 2.H.1 for the year 2022 only. This approach was implemented following guidance from the UNFCCC ETF GHG Inventory Tool Technical Support to ensure correct sector totals, but it results in inconsistencies in the time series for both CRT 2.B and CRT 2.H.1.

4.2.1 Ammonia production (CRT 2.B.1)

4.2.1.1 SOURCE CATEGORY DESCRIPTION

There is an annual production of about 5 kt of ammonia in Sweden, according to United Nation statistics¹⁷⁹. This ammonia is not intentionally produced but is a by-product in one chemical industry producing various chelates and chelating agents, such as EDTA, DTPA and NTA¹⁸⁰. Emissions from this industry are included in CRT 2.B.5. Ammonia production, 2.B.1, is thus reported as NO.

4.2.2 Nitric acid production (CRT 2.B.2)

4.2.2.1 SOURCE CATEGORY DESCRIPTION

Production of nitric acid has taken place at three facilities in Sweden during 1990-2000. One of these facilities was shut down at the end of 2000, and a second one was shut down during 2001. Therefore, there is currently only one facility producing nitric acid in Sweden. Beside emissions of N₂O, also emissions of NO_x are reported. The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.3.1. An overview of the rationale for the data sources used for key categories in the industrial processes sector is presented in Annex 3.5.

¹⁷⁹ UN. Commodity Production Statistica Database. Department of Economic and Social Affairs, Statistics Division, as referred in FCCC Synthesis and Assessment report 2002 Part I.

¹⁸⁰ Kindbom, 2004. SMED report: Investigation on the occurrence of ammonia production in Sweden. 2004-05-11.

Table 4.3.1. Summary of source category description, CRT 2.B.2, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources Estimated
		Level	Trend	Qualitative			
2.B.2	CO ₂	NA	NA		NA	NA	NA
	CH ₄	NA	NA		NA	NA	NA
	N ₂ O	-	X		T2	PS	Yes

T2 Tier 2. PS Plant-specific.

4.2.2.2 METHODOLOGICAL ISSUES

Activity data, such as produced amount of nitric acid, have been obtained from the facilities and from official statistics. Emission estimates of N₂O have been reported in the companies' environmental reports or have been provided by the facilities directly. Emission data is not available for all facilities for 1991-1993 and since two plants have shut down, it is no longer possible to acquire this information. Calculations have therefore been made based on production statistics and an assumed emission factor (Table 4.3.2). The assumed emission factor of 7 kg/Mg for 1991 - 1993 is based on calculated emission factors for 1990 and 1994 and is in line with the default factors for nitric acid production presented in Table 4.7 in IPCC Good Practice Guidance.

Table 4.3.2. Activity data, emission factors and emissions of N₂O for nitric acid production.

Year	Production of nitric acid, (kt)	Calculated IEF, kg/t	Emissions of N ₂ O, (kt)
1990	374	7.02	2.63
1995	417	5.48	2.29
2000	430	4.80	2.06
2005	264	5.37	1.42
2010	257	3.92	1.01
2011	263	0.50	0.13
2012	265	0.82	0.22
2013	251	0.64	0.16
2014	262	0.67	0.17
2015	239	0.51	0.12
2016	248	0.70	0.17
2017	267	0.52	0.14
2018	269	0.38	0.10
2019	271	0.34	0.09
2020	280	0.07	0.02
2021	C	C	0.04
2022	C	C	0.02
2023	C	C	0.02
2024	C	C	0.02

C - Confidential data

From 2007, N₂O and NO_x emissions are continuously measured in one of the two production lines at the current facility. New catalytic reduction abatement equipment was installed in 2007 and 2010 which resulted in significant decreases of N₂O. From 2011, the emissions are continuously measured in both production lines. Documentation has been received from the facility concerning production data, production capacity and abatement measures, used emission factors and the method used for estimating emissions as well as

uncertainty in emission estimates and measurements. N₂O measurements are carried out using an EN-14181 certified continuous measuring system.

The facility has in 2012 completed a joint implementation project for catalytic reduction of nitrous oxide emissions from the nitric acid production. The project activity involved installation of a new N₂O abatement technology. The new abatement is a combination of precious metal primary catalyst and secondary catalysts which are installed inside all of the Ammonia Oxidation Reactors, underneath the precious metal primary catalyst gauzes. The N₂O emissions are monitored using an automated system based on EU standards.¹⁸¹,¹⁸²

During the later part of 2019 a new production line was taken into operation. In connection with this, the oldest production line, with higher emissions of N₂O, was shut down. As a result of this, the calculated IEF for N₂O was reduced compared to earlier years. In 2020, only the newly installed production line was in operation which resulted in a considerable decrease in emissions (Table 4.3.2).

4.2.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty for activity data is $\pm 2\%$ and the uncertainty of the N₂O emissions, or emission factors for early years, is $\pm 5\%$. The time-series is consistent. The fluctuations in the calculated total IEF for N₂O 1994 – 2000 (Table 4.3.2) are mainly due to fluctuations in one of the facilities. The IEFs are within the IPCC default interval (2-19 kg N₂O/Mg). Activity data and reported emissions have been acquired from e.g. environmental reports from the facilities, but since two of the facilities have shut down, it is no longer possible to check previously reported estimates.

The lower level of N₂O emissions from 2001 and onward compared to earlier years is a result of one facility being shut down in late 2000 and a second one during 2001. Emissions for all years, except 1991 - 1993, are as reported from the facilities. For the years 1991-1993, the applied emission factor from 1990 have been used together with activity data from the facilities. The higher level of NO_x emissions in year 2004 is a result of a long-lasting leakage of NO_x from one of the production units at the active facility. During 2007, catalytic abatement was installed at one of the production units at the active facility and as a result the emissions of N₂O and NO_x were reduced compared to previous years. The used abatement system is described in the BREF document for large volume inorganic chemicals¹⁸³. During 2009, the production of nitric acid was lower compared to previous years and also lower compared to later years. The higher N₂O implied emission factor in 2009 is due to that the N₂O reduction catalysts were not used during 2009. This was because 2009 was set as base year in a joint implementation project with the aim to reduce N₂O emissions. For some months in 2010, N₂O-reducing catalysts were used again, now in both production units at the facility. In one of the production units the catalyst was used from March and in the other unit from December. The fact that the catalysts were not used during all months of the year is the reason for the higher implied emission factor in 2010 compared to 2007 and 2008. From 2011 and onwards the catalysts in both production units were used the whole year with a significant

¹⁸¹ Joint Implementation Supervisory Committee, 2011. YARA Köping S2 N₂O abatement project in Sweden.pdf

¹⁸² Joint Implementation Supervisory Committee, 2011. YARA Köping S3 N₂O abatement project in Sweden.pdf

¹⁸³ European Commission, 2007

decrease of N₂O emissions compared to earlier years. The time series 2011 – 2018 shows that the N₂O emissions tend to vary as much as ± 25% from one year to another. In 2017, the emissions were lower than in 2016 but higher than the emissions in 2015. Hence, no trend can be discerned. Uncertainty estimates are based on information from the company, which is considered to be the best available information.

4.2.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The company is contacted every year for verification of production capacity and to collect data on purification technology and its effectiveness.

The methodology for estimating N₂O emissions from nitric acid production has been discussed during a joint Nordic workshop in May 2015. A comparison of implied emission factors in Sweden, Finland and Norway (Figure 4.3.1), based on open UNFCCC data¹⁸⁴, shows similar trend in the three countries – a decrease by 85-90% compared to the level in 1990. The drop in N₂O implied emission factor in Finland during 2010 is explained by the implementation of N₂O abatement technology (similar as installed in Sweden) at one of the largest plants in Finland. In all the three countries, nitric acid plants are currently equipped with automatic systems based on EU standards to continuously measure N₂O emissions, according to national experts.^{185,186}

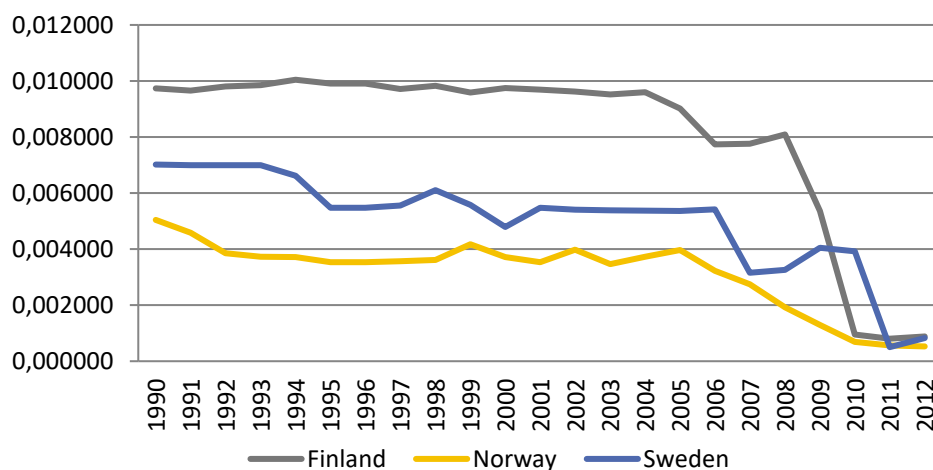


Figure 4.3.1. Implied N₂O emission factors for CRT 2.B.2 Nitric acid production in three Nordic countries, kt N₂O/Gg nitric acid.

4.2.2.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been performed for submission 2026.

4.2.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

¹⁸⁴ GHG data from UNFCCC http://unfccc.int/ghg_data/ghg_data_unfccc/items/4146.php , 2015

¹⁸⁵ Kolshus, H. Norwegian Environmental Agency. Personal communication. 2015

¹⁸⁶ Forsell, P. Statistics Finland. Personal communication. 2015

4.2.3 Adipic acid production (CRT 2.B.3)

4.2.3.1 SOURCE CATEGORY DESCRIPTION

No production of adipic acid occurs in Sweden, and thus NO is reported for CRT 2.B.3.

4.2.4 Caprolactam, glyoxal and glyoxylic acid production (CRT 2.B.4)

4.2.4.1 SOURCE CATEGORY DESCRIPTION

No production of caprolactam, glyoxal or glyoxylic acid occurs in Sweden, and thus NO is reported for CRT 2.B.4.

4.2.5 Carbide production (CRT 2.B.5)

4.2.5.1 SOURCE CATEGORY DESCRIPTION

Silicium carbide production does not occur in Sweden, however calcium carbide is produced at one facility. All process-related CO₂ emissions from the carbide plant, with the exception of emissions from quicklime production, are included in 2.B.5.b. Emissions from quicklime production is included in CRT 2.A.2. The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.3.3.

Table 4.3.3. Summary of source category description, CRT 2.B.5, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.B.5	CO ₂	-	-		T1	D	Yes

D Default. T1 Tier 1.

4.2.5.2 METHODOLOGICAL ISSUES

To cover all sources of CO₂ from the production of calcium carbide, estimates of emissions from reduction of quicklime to calcium carbide and emissions from the use of calcium carbide (comprising emissions from production and use of acetylene) have been made. However, CO₂ emissions from production of quicklime at the carbide plant are reported in CRT 2.A.2 in accordance with the 2006 IPCC Guidelines.

4.2.5.2.1 CO₂ emissions from calcium carbide production.

Calcium carbide is produced in an electric arc furnace at high temperature, 2000 – 3000 °C. Quicklime, CaO, is reduced with coke and forms CaC₂. In this process an energy rich carbide furnace gas, consisting mostly of CO, is produced as a by-product. Carbide furnace gas is further used as fuel within the facility and at the closely located steam power station; a part of the gas is also flared.

According to the 2006 IPCC Guidelines, CO₂ emissions from combusting carbide furnace gas generated in the process of calcium carbide production should be accounted in the IPPU sector and should not be included in the energy sector. All CO₂ emissions from carbide furnace gas combustion and flaring are therefore reported in CRT 2.B.5.b. Activity data and associated CO₂ emissions from carbide production are presented in Table 4.3.4. From 2022 onwards, activity data and CO₂ emissions are confidential.

Table 4.3.4. Activity data and associated CO₂ emissions from carbide production to be reported in CRT 2.B.5.b.

Year	Activity data as produced calcium carbide, (kt)	CO ₂ from the reduction of CaO to CaC ₂ , (kt)
1990.	54.9	59.8
1995	46.1	50.2
2000	38.1	41.5
2005	42.0	45.8
2010	34.9	38.0
2011	33.4	36.4
2012	34.6	37.7
2013	37.6	41.0
2014	37.5	40.9
2015	34.3	37.4
2016	35.9	39.1
2017	33.7	36.7
2018	35.0	38.2
2019	35.8	39.1
2020	30.0	32.7
2021	34.1	37.2
2022-	C	C

C – Confidential data

4.2.5.2.2 CO₂ emissions from use of calcium carbide

In the 2006 IPCC Guidelines it is stated that in addition to reporting CO₂ emissions from calcium carbide production, CO₂ originating from the use of calcium carbide for acetylene production and acetylene use in welding applications has to be reported. CO₂ emissions mainly occur at the stage of acetylene use, as follows from the equation summarizing acetylene production and use in welding applications:



Information from the calcium carbide producer in Sweden indicates that one third of the produced calcium carbide is used for acetylene production. Assuming that imported and exported amounts of calcium carbide have the same utilisation, it is possible to estimate the CO₂ emissions originating from calcium carbide use for acetylene production, including emissions from subsequent acetylene use. Annual statistics on imported and exported amounts from 1998 and onwards are available from Statistics Sweden¹⁸⁷. Amounts used for acetylene production for earlier years are estimated.

The default emission factor presented in the 2006 IPCC Guidelines¹⁸⁸, 1.1 t CO₂/Mg calcium carbide used for acetylene production, has been used for the estimations. This emission factor implies that all carbon containing in calcium carbide is emitted as CO₂ when acetylene is used in e.g. welding applications. It is furthermore assumed that all

¹⁸⁷ www.scb.se

¹⁸⁸ 2006 IPCC Guidelines, Volume 3: Industrial Processes and Product Use, Chapter 3: Chemical Industry Emissions, Section 3.6.2.2: Choice of Emission Factors

produced acetylene is used within the country (no “exported” emissions). Thus, CO₂ emissions calculated for carbide use for acetylene production comprise emissions from acetylene use.

Amounts of calcium carbide used for acetylene production and associated CO₂ emissions from acetylene production and acetylene use are presented in Table 4.3.5. From 2022 onwards, this data is confidential.

Table 4.3.5. Used amounts of calcium carbide and associated CO₂ emissions from acetylene production and acetylene use, reported in CRT 2.B.5.b.

Year	Amount of calcium carbide for acetylene production, (kt)	CO ₂ from acetylene production and acetylene use, (kt)
1990	7.4	8.1
1995	6.2	6.8
2000	6.0	6.5
2005	9.0	9.9
2006	7.7	8.5
2007	8.1	8.9
2008	8.5	9.4
2009	4.4	4.9
2010	5.5	6.0
2011	5.4	6.0
2012	4.0	4.4
2013	5.8	6.4
2014	6.2	6.8
2015	5.8	6.4
2016	7.5	8.2
2017	6.0	6.7
2018	6.8	7.4
2019	7.4	8.1
2020	5.7	6.3
2021	6.5	7.1
2022-	C	C

C - Confidential data

4.2.5.2.3 Time series reported in CRT 2.B.5.b

In Figure 4.3.2, total CO₂ emissions for the years between 1990 and 2021 are presented. For 2022 onwards, activity data and CO₂ emissions are classified.

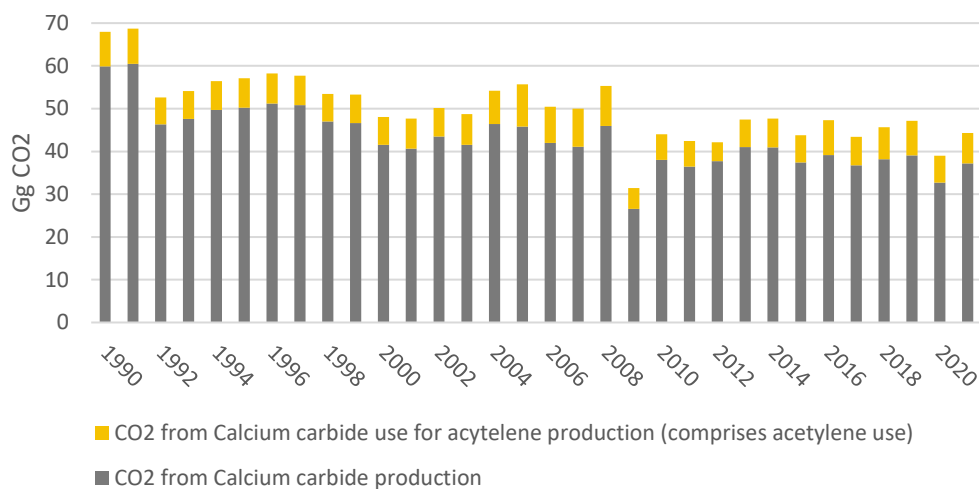


Figure 4.3.2. CO₂ emissions from production of calcium carbide, calcium carbide use for acetylene production and acetylene use.

4.2.5.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Based on expert judgements and recommendations in the 2006 IPCC Guidelines, the uncertainty of collected activity data is $\pm 10\%$. Uncertainties in the default CO₂ emission factors for calcium carbide production and acetylene production and use are both $\pm 5\%$.

In submission 2021, the estimation method for CO₂ emissions from combustion of carbide furnace gas was revised¹⁸⁹. After the recalculations, all CO₂ emissions from carbide furnace gas combustion and flaring are reported in IPPU sector (2.B.5.b.). The recalculated CO₂ emissions have been increased unevenly during different years as noticed by the ERT during the latest UNFCCC review. This is due to emissions reported in submission 2020 (total emissions from carbide gas combustion and flaring) being calculated in direct proportion to carbide production while the corresponding emissions in submission 2021 are not. In submission 2020, emissions reported in CRT 2.B.5 were estimated for carbide gas flaring only, using the ratio “flaring time/total production time”, which had no direct connection to the carbide production volumes. Another part of the emissions currently included in CRT 2.B.5 – emissions from carbide gas combustion – was in submission 2020 reported in CRT 1.A.2.c. These emissions were calculated based on amounts of combusted carbide gas reported by the facilities to the quarterly fuel statistics. This reporting was not directly linked to carbide production numbers either, and moreover, most probably was incomplete and missing for several years. This is why replacing each of these emission parts (carbide gas combustion (CRT 1.A.2.c), carbide gas flaring (CRT2.B.5.)) with total emissions (CRT 2.B.5) directly linked to carbide production numbers, resulted in uneven change in emissions.

4.2.5.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The plant producing calcium carbide is included in the annual QC procedure where the cross-sectoral control tool is applied (see section 1.3.5.1 for further explanation).

¹⁸⁹ Yaramenka et al. 2020. Improvements in reporting of emissions from carbide production. SMED report No 16 2020

4.2.5.5 SOURCE-SPECIFIC RECALCULATIONS

Recalculations have been performed for year 2021 and 2022 due to updated activity data in submission 2026, which led to CO₂ emissions increasing by 0.36 kt and 0.21 kt, respectively.

4.2.5.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.2.6 Titanium dioxide production (CRT 2.B.6)

4.2.6.1 SOURCE CATEGORY DESCRIPTION

No production of titanium dioxide occurs in Sweden, and thus NO is reported for CRT 2.B.6.

4.2.7 Soda ash production (CRT 2.B.7)

4.2.7.1 SOURCE CATEGORY DESCRIPTION

In 2004 a study was carried out to collect data on soda ash use and calculate CO₂ emission¹⁹⁰. From this study it became clear that no production of soda ash occurs in Sweden and is hence reported as NO in the CRT.

4.2.8 Petrochemical and carbon black production (CRT 2.B.8)

4.2.8.1 SOURCE CATEGORY DESCRIPTION

Petrochemicals and carbon black are produced in Sweden. However, emissions from these sources are reported in CRT 2.B.10 Other, since it is difficult to separate these emissions from emissions from other sources within the chemical industry. Moreover, part of the emissions originating from internal make-up fuels is reported in the CRT 1A since these emissions are very difficult to separate from other emissions from fuel use, which are to be reported in the energy sector. Thus, IE is reported for CRT 2.B.8.

4.2.9 Fluorochemical production (CRT 2.B.9)

4.2.9.1 SOURCE CATEGORY DESCRIPTION

No production of fluorochemicals occurs in Sweden, and thus NO is reported for CRT 2.B.9.

4.2.10 Other (CRT 2.B.10)

4.2.10.1 SOURCE CATEGORY DESCRIPTION

This sub-category includes various chemical industries, such as sulphuric acid production, the pharmaceutical industry, production of base chemicals for plastic industry, various organic and inorganic chemical productions, and other non-specified chemical production, which are not covered elsewhere. Production of petrochemical products (ethylene, ethylene dichloride and vinyl chloride monomer and ethylene oxide) as well as carbon black, which are described in IPCC 2006 Guidelines under CRT 2.B.8,

¹⁹⁰ Nyström, A-K. 2004. CO₂ from the use of soda ash. SMED report 61 2004.

are included in 2.B.10 due to difficulties in separating these emissions. Approximately 70 larger industrial facilities are included in the emission estimates. Emissions of CO₂, CH₄, N₂O, NO_x, CO, NMVOC and SO₂ are reported in this sub-category. Some NMVOC emissions are possibly to be reported in CRT 2.D.3, solvent use. However, since it is difficult to distinguish between process emissions and emissions from solvent use, all NMVOC from these facilities have been included in CRT 2.B.10.

Emission time-series for GHG are relatively stable. There is a slight drop in emissions of GHG in 2009 compared to 2008 e.g., due to lower production of carbon black. In addition, CH₄ emissions decreased in 1999 due to a much lower production at one facility and N₂O emissions increased in 1999, 2004 and in 2014 due to the fact that one facility within the sub-category "Pharmaceutical industry" reported higher emissions these years. In 2017, the production process at the only facility causing emissions of N₂O within the "Pharmaceutical industry" was shut down. Since no emissions of CH₄ or CO₂ are reported from any facilities in this category, no greenhouse gas emissions are reported for this subcategory from 2018 onwards.

The total greenhouse gas emissions from the chemical industry decreased significantly in 2020. This is due to the cracker plant, which accounts for up to 80% of total emissions reported in CRT 2.B.10 in previous years, being out of operation for the larger part of 2020 due to a fire at the facility.

The SO₂ emissions reported in 2.B.10 decreased dramatically in 2004 in comparison to earlier years. This is because in December 2004, one facility producing viscose staple fibre was shut down. The annual SO₂ emissions from this facility represented between 8 and 20% of the total reported SO₂ emission in CRT 2 – Industrial Processes for the years 1990 - 2003.

CO emission from "Other inorganic chemical production" increased from below 200 tonnes in 2005 to 500 tonnes in 2006. This increase is due to unusually high CO emissions in 2006 from one facility producing PVC. In 2007, the CO emissions were very low from one facility producing PVC. The increase of CO emissions in 2014 is due to rather high CO emission from one facility within organic chemical production.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.3.6.

Table 4.3.6. Summary of source category description, CRT 2B10, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.B.10	CO ₂	X	X		T3	PS	Yes
	CH ₄	-	-		T1, T2, T3	PS, D, CS	No, see Annex 5
	N ₂ O	-	-		T2, T3	PS, CS	No, see Annex 5

D Default. CS Country Specific. PS Plant-specific. T1 Tier 1. T2 Tier 2. T3 Tier 3.

4.2.10.2 METHODOLOGICAL ISSUES

A total of approximately 70 facilities are included in the Swedish chemical industry. In the 2006 IPCC Guidelines, methods for estimating CH₄ emissions from the production of

several chemical products are presented and consequently the CRT Reporter is divided on those products. Since several plants in Sweden each produce several chemical products, but report emissions aggregated by plant, it is not possible to report emissions in accordance with the suggested split in the CRT Reporter. In Sweden, since submission 2006 the emissions are thus allocated to six separate branch categories: sulphuric acid production, pharmaceutical industry, production of base chemicals for plastic industry, organic chemical production, inorganic chemical production and other non-specified chemical production.

The primary information on emissions of CO₂, CH₄, N₂O, NO_x, CO, NMVOC and SO₂ is as reported by the companies in their environmental reports. For facilities reporting to the EU ETS, CO₂ emissions from the EU Register are compared to those provided in the environmental reports. Process-related CO₂ emissions in the chemical industries origin mainly from hydrogen production within chemical plants and combustion of internal gases. CO₂ emissions from the use of limestone and soda ash in the process are included for one plant as well. Limestone and soda ash activity data are collected from the plant's environmental reports and the 2006 IPCC Guidelines emission factors are used together with an assumed limestone purity of 97%.

According to the 2006 IPCC Guidelines, emissions from the combustion of fuels produced within the facility (internal make-up gases) as well as from fuels obtained from the feedstocks should be allocated to the source category in the IPPU Sector except when the fuels are used in another source category e.g. district heating. Sweden has made extensive efforts to follow the recommendations as far as possible; however, exceptions have been made for some plants, due to the fact that CO₂ emissions from these plants are very difficult to separate from other emissions from fuel use, which are to be reported in the energy sector. In those cases, all emissions are reported in the energy sector in CRT 1.A.2.C. The allocation of emissions from these plants to the energy sector affects the comparability only to a small extent, since the larger emission sources have been correctly divided between process-related and energy emissions. To what extent comparability is affected cannot be exactly quantified since plant-specific data cannot be disclosed due to confidentiality.

For some facilities, there is a certain share of emissions (derived mainly from environmental reports) allocated to CRT 2.B.10.a while the remaining emissions are reported in the energy sector. In these cases, this allocation on a plant level is done for the entire time series based on a few recent years that have been studied in detail. Emissions from the production of secondary fuels obtained from feedstocks and also from the combustion of process off-gases are reported in CRT 2.B.10 since these emissions are associated with (petro-)chemical processes and these fuels and off-gases are combusted within the same chemical processes and not combusted for e.g., district heating purposes. Secondary fuels and off-gases from the plants within the biggest petrochemical complex in Sweden located in Stenungsund are not transported to heating plants outside the complex but rather between these plants to be used as feedstocks or fuels in chemical processes. Fuels and off-gases derived from chemical processes that are combusted for energy purposes only, e.g., within district heating are registered in the quarterly fuel statistics which is used for emission calculations in CRT 1.A.2, meaning that those fuels and off-gases are accounted for in the emission inventory by default.

Irrespective of the chosen method, comparisons have been made by applying a cross-sectoral control tool to ensure that all emissions are covered in either sector and that no double-reporting occurs. The tools and procedures used for this comparison and verification are described in more detail in the sections 1.3.5.1 and 4.2.10.4.

The 2006 IPCC Guidelines include methods on reporting of methane emissions from production of ethylene oxide. Such production does occur in Sweden (one company). The company's own emission estimate is around 4 tons/year, based on measurements, however a complete time series is not available. Applying the default emission factor, given in the 2006 IPCC Guidelines, results in emissions of about ten times the amount estimated by the company, due to the fact that the plant uses catalytic oxidation, reducing methane emissions by about 90% according to measurements. Thus, the default method is judged not to be representative and methane emissions from this company is reported NE, since they are less than 0.05% of the national emissions, and the effort to collect sufficient data is disproportionate to the significance of the emissions.

Production volumes in the chemical industry are related to different processes with different emission factors, meaning that summarizing them in one set of activity data would not be relevant. Activity data for CRT 2.B.10 is therefore reported as not applicable, NA.

4.2.10.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Based on expert judgements, the uncertainties of collected emissions of CO₂ from inorganic and organic chemical products as well as from base chemicals for plastic industry are $\pm 5\%$ for CO₂. The uncertainty of collected emissions of CH₄ is estimated to be $\pm 100\%$ for all chemical industries reported in CRT 2.B.10. Collected emissions of N₂O are associated with an uncertainty of $\pm 125\%$ according to experts with the exception of N₂O emissions from other organic chemical products where the uncertainty is estimated to be $\pm 80\%$.

The time-series for GHG have been reviewed and are considered to be consistent.

4.2.10.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Emissions reported in the plant-specific environmental reports are carefully studied annually to retrieve the most appropriate data for the GHG inventory.

Verification of sector emissions and allocation between CRT 1 and CRT 2

Emissions in this sub-category were reviewed as part of a quality control SMED project, financed by the Swedish EPA, during 2010. The project aimed at increasing the quality and reducing the uncertainties in the most important air emissions substances from chemicals industries in Sweden¹⁹¹. Emissions reported in the environmental reports were compared to plant-specific data in the GHG inventory, significant discrepancies were investigated, and recommendations were provided on feasible improvements for submission 2011 as well as recommendations on further investigations¹⁹². Overall, the

¹⁹¹ Gustafsson, T., Nyström, A-K., Gerner, A. Riktad kvalitetskontrollstudie av utsläpp från kemiindustrin i Sveriges internationella rapportering. SMED report 2010.

¹⁹² Most recommendations on further investigations refer to the energy sector

QC-project showed that total reported GHG emissions from the chemical industries in the Swedish inventory are in coherence with the plant emission data.

Prior to submission 2018, a development project¹⁹³ was carried out with the specific purpose to improve emission allocation between the energy sector and IPPU and to establish a procedure for annual cross-sectoral control of reported emissions. Within this project, a new quality control tool has been developed to ensure that comparisons of emissions in the energy sector and in CRT 2.B.10 are done on a more regular basis, for the same range of facilities, and using a unified procedure. In the tool, for each of the relevant facilities, emissions reported in the energy sector (CRT 1A) are summed up with the emissions reported in the CRT 2.B.10, and the sum is compared to both EU ETS data (if available) and environmental reporting provided by facilities. Quality control is therefore being conducted on a facility level. In case of discrepancies, they are easily identified and further investigated regarding potential gaps or double counting.

In 2017 and 2018, allocation issues between mainly the energy sector and IPPU have been further investigated for the chemical industry¹⁹⁴. An allocation strategy for the chemical sector has been developed which aims at achieving a correct allocation between the sectors according to the 2006 IPCC Guidelines where possible, however making sure that total reported emissions are in accordance with plant-specific data as the main priority. In submission 2022, all CO₂ emissions from the large cracking plant and a polyethylene producing plant were reported in CRT 2.B.10.a due to difficulties in separating the amounts of fuel used for stationary combustion from fuels used in the chemical processes. In submission 2023, a development project was carried out to reallocate CO₂ emissions for these two plants between CRT 1.A.2.c and CRT 2.B.10.a, resulting in less CO₂ emissions being reported in CRT 2.B.10.a.

A comparison between CO₂ emissions reported in environmental reports or to the EU ETS and emissions reported in submission 2019 shows that inventory data exceeds these two sources for the years 2013-2016 (Table 4.3.7). The comparison was only made for these years since EU ETS data covers fewer chemical plants for earlier years. The reason for the inventory estimate being larger is that all plants and sources are not included in the EU ETS or do not report emissions in environmental reports.

Table 4.3.7. Comparison between CO₂ emissions from environmental reports/EU ETS and reported inventory data, submission 2019.

Source	2013	2014	2015	2016
Environmental reports / EU ETS, kt	1202	1158	1115	1211
Inventory, kt	1364	1259	1203	1423
Difference, kt	162	101	88	212
Inventory data compared to plant data	113%	109%	108%	118%

Verification of activity data and emissions for some chemical products

Some of the main chemical production processes included in the emission inventory were compared with national production data from Statistics Sweden in order to ensure that all

¹⁹³ Ortiz, C., Jonsson, M., Yaramenka, K., Helbig, T., Danielsson, H. Överlappande mellan CRT 1 och 2, SMED memorandum, 2017

¹⁹⁴ Mawdsley, I., Ortiz, C. Allocation of emissions from the chemical sector between CRT/NFR 1 and CRT/NFR 2, SMED memorandum, 2018

production of these chemical products is accounted for. The results showed that all production of ethylene, VCM, ethylene oxide and carbon black are accounted for in the emission inventory. In addition, comparing implied emission factors calculated from emissions and activity data showed good agreement with emission factors from 2006 IPCC Guidelines.¹⁹⁵

4.2.10.5 SOURCE-SPECIFIC RECALCULATIONS

Minor corrections of AD leading to +0,0007 kt CO₂-eq for 2023 were made during submission 2026.

4.2.10.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

¹⁹⁵ Mawdsley, I., Ortiz, C. Allocation of emissions from the chemical sector between CRT/NFR 1 and CRT/NFR 2, SMED memorandum, 2018

4.3 Metal industry (CRT 2.C)

The sub-categories which are covered in the estimates include iron and steel production (2.C.1), ferroalloy production (2.C.2), aluminium production (2.C.3), SF₆ and HFC used in magnesium foundries (2.C.4) and other metal production (2.C.7). Other (2.C.7) consists of estimates from one large non-ferrous smelter plant and one metal recycling plant. Other (2.7.C) also include emissions from lead production (2.C.5), zinc production (2.C.6), and emissions from copper production and nickel production since these emissions cannot be separated.

4.3.1 Iron and steel production (CRT 2.C.1)

4.3.1.1 SOURCE CATEGORY DESCRIPTION

An overview of iron and steel industry in Sweden is presented in Figure 4.4.1. There are two primary iron and steel facilities equipped with blast furnaces, producing iron and steel products from virgin materials. Ten secondary steel plants equipped with electric arc furnaces, producing iron and steel products from scrap and one facility producing direct reduced iron are also included. Included are also emissions from one facility using a shaft furnace process to produce stainless steel from recovered flue gas dust and other waste products, and one foundry using a cupola furnace for melting cast iron. In total, there are 18 different facilities included in the estimates. Processes occurring besides the primary processes, production of secondary steel and direct reduced iron, are rolling mills, pickling and other refinement processes and one iron and steel foundry. Emissions from three major iron ore mines and three facilities producing pellets in Sweden are reported in 2.C.1.e. Emissions from one sinter producing facility are reported in 2.C.1.d until 1995, when the production closed down.

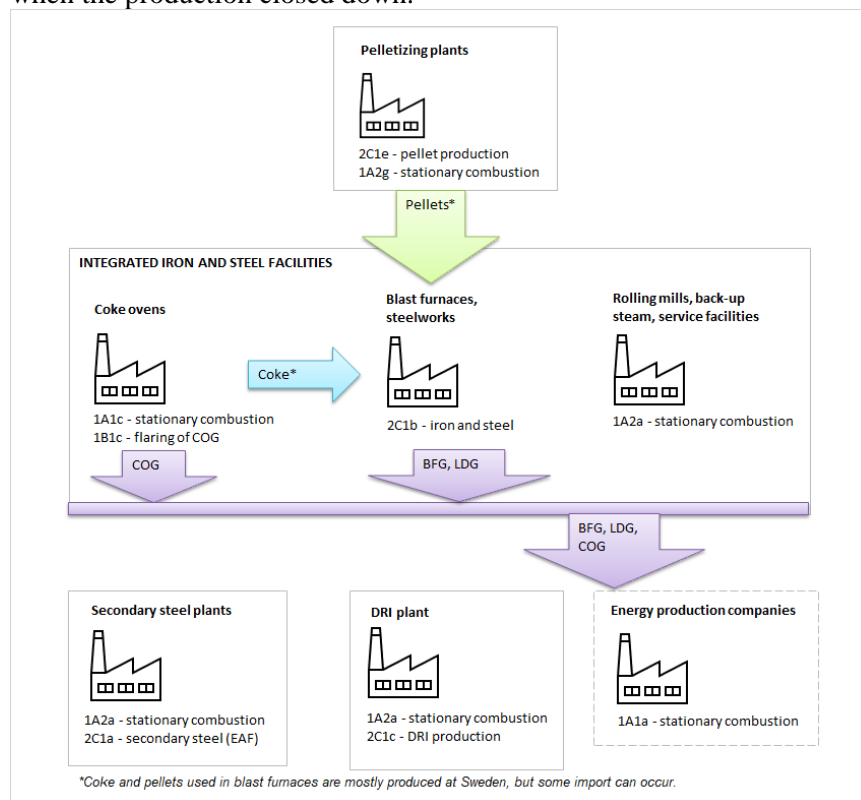


Figure 4.4.1. Carbon flow chart of integrated primary iron and steel plants in Sweden.

Process emissions arising from reducing agents in the primary steel works and secondary iron and steel works are reported in CRT 2.C.1. As the plants also generate emissions from fuel combustion (CRT 1.A.1.c and CRT 1.A.2.a) and fugitive emissions (CRT 1.B.1.c), the text in this section is closely connected to the text in the corresponding section in the energy section. Emissions of N₂O do occur to a small extent according to the 2006 IPCC Guidelines¹⁹⁶, however, CRT tables are not designed for reporting N₂O emissions from primary steel production.

In the Swedish inventory, emissions from primary iron and steel production and secondary steel production are reported separately and fed into CRT Reporter under 2.C.1.b Pig iron and 2.C.1.a Steel, respectively. This enables process emissions from the two integrated iron and steel production plants in Sweden to be reported together (2.C.1.b Pig iron), and thus not introducing further sources of uncertainty due to additional data handling. One facility is producing direct reduced iron and its emissions are reported in 2.C.1.c Direct reduced iron.

Production increased in the 1990s and remained at a stable high level until 2008, which is also reflected in the reported emissions. However, the economic recession in 2009 had a great effect on the production volumes of iron and steel in Sweden and thus the emissions 2009 are significantly reduced. In later years emissions are back at about the same level as prior to 2009.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.4.1. An overview of the rationale for data sources used for key categories in the industrial processes sector is presented in Annex 3.5.

Table 4.4.1. Summary of source category description, CRT 2.C.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.1	CO ₂	X	-		T3	PS	Yes
	CH ₄	-	-		T1, T2	CS	No, see Annex 5
	N ₂ O	NA	NA		NA, NE	NA, NE	No, see Annex 5

CS Country Specific. PS Plant-specific. T1 Tier 1. T2 Tier 2. T3 Tier 3.

4.3.1.1.1 Secondary steel production (CRT 2.C.1.a)

Reported CO₂ emissions include emissions from reducing agents such as coke, coal and electrodes in electric arc furnaces, emissions from the use of limestone and dolomite, and emissions from flaring of gasoil (pilot fuel) occurring in secondary steel industry as a part of annual maintenance procedure.

The reported CO₂ emissions in CRT 2.C.1.a include data from eleven plants in 1990-1991, twelve plants in 1992-2003 and eleven plants from 2004 onwards. Also, another five plants with process related NO_x, SO₂ and/or NMVOC emissions are included in this sector. These plants do not produce steel and hence do not emit CO₂.

¹⁹⁶ IPCC 2006 Guidelines. http://www.ipcc-nggip.iges.or.jp/public/2006gl/pdf/3_Volume3/V3_4_Ch4_Metal_Industry.pdf

Emissions from flaring pilot gas (included in submission 2020 as a result of a development project investigating fugitive emissions and emissions from flaring¹⁹⁷), are calculated based on estimated constant fuel amounts, periodically checked with the facilities. This affects emissions from 1990 of CO₂, NO_x, NMVOC and CO. This also adds small amounts of CH₄ emissions for the entire time series.

4.3.1.1.2 *Primary iron and steel production (CRT 2.C.1.b)*

There are two plants in Sweden that produce pig iron and steel as part of their integrated coke ovens, blast furnaces and steel converters. The primary purpose of the use of coal and coke in the blast furnace is to ensure oxidation and to act as reducing agents. The associated emissions are thus to be reported as industrial processes from iron and steel production in CRT 2.C.1, according to the IPCC Guidelines.

4.3.1.1.3 *Direct reduced iron (CRT 2.C.1.c)*

There is one plant in Sweden which produces iron sponge and iron powder using direct reduction of iron ore fines in a unique process where solid coal is mixed with iron ore fines.

4.3.1.1.4 *Sinter (CRT 2.C.1.d)*

During 1990-1995, a sinter plant was in operation at one of the integrated primary iron and steel plants. Operation of sinter plants produce CO₂ emissions from oxidation of the coke breeze and other inputs. When carbon-containing materials are heated in the furnace for sinter production or iron production, volatiles, including CH₄, are emitted¹³⁰. SO₂ from the sulphur content in the ore is also considered to be emitted from the facility.

4.3.1.1.5 *Pellet (CRT 2.C.1.e)*

CO₂ emissions arise mainly from the use of limestone and dolomite, and to a smaller extent from bentonite, organic binder, olivine and quartzite. SO₂ emissions, which stem from the sulphur content in the ore and NO_x emitted as a result of the use of explosives, are also reported from pellets production. The use of mining explosives also causes emissions of carbon monoxide, CO¹⁹⁸, which however are not reported. Estimated emissions from combustion of fuels are included in the Energy sector (CRT 1.A.2.g). In 2014 the SO₂ emissions were lower than previous years due to implementation of stage one of a new abatement technology at one facility. Stage two was completed by the end of 2015. The new abatement technology has led to a reduction of the SO₂ emissions by more than 95%.

4.3.1.1.6 *Other (CRT 2.C.1.f)*

No emissions of CO₂ reported in this source category but small amounts of NMVOC from eight facilities are included.

4.3.1.2 METHODOLOGICAL ISSUES

4.3.1.2.1 *Secondary steel production (CRT 2.C.1.a)*

In most cases, data from the Swedish enquiry for the Swedish national allocation plan (NAP) for the EU ETS could be used for the years 1998-2002. Data for 1990-1997 and 2003-2004 has been collected directly from the plants. From 2005, the equivalent data are

¹⁹⁷ Yaramenka, K., Kindbom, K., Helbig, T. 2019.

¹⁹⁸ Wieland, M.S. 2004.

acquired from the EU ETS, from the facilities' environmental reports and through contacts with the companies.

Data in the EU ETS includes information concerning carbon bound in products, slag, etc., but also other sources, for process-related CO₂ emissions. Prior to submission 2010, these other emissions were not included for all facilities. Estimates of these missing CO₂ emissions were performed using EU ETS data for 2005 – 2008 and production data for years prior to 2005. All CO₂ emissions presented for the facilities in the EU ETS 2005 – 2024 are included in 2.C.1.a.

Reported CO₂ emissions until year 2008 are for all facilities, except the one which closed down in 2004, based on data in the EU ETS. Reported CO₂ emissions can therefore be classified to follow the 2006 IPCC Guidelines Tier 3, since according to the Guidelines, reported emissions shall be based on all carbon input to and carbon output from the process. From 2009 to 2012, background data needed for estimation of process-related CO₂ emissions for one facility is collected from the facility's environmental report, since all data needed could not be retrieved from the EU ETS for these years.

For non-CO₂ emissions, the companies' environmental reports are the main information source. NO_x, NMVOC and SO₂ emissions emitted from electric arc furnaces are reported in 2.C.1.a. NO_x emissions may also arise from pickling and NMVOC emissions from rolling mills. These sources are also included in the estimates.

4.3.1.2.2 Primary iron and steel production (CRT 2.C.1.b)

Sweden uses the recommended Tier 3 method according to the 2006 IPCC Guidelines and the calculations of CO₂ emissions are based on carbon mass-balances in order to reduce the risk of double counting or omitting CO₂ emissions. Calculations of CO₂ emissions and simplified mass-balances are made by the facilities as a part of their reporting to the EU ETS. Emissions are also specified in the facilities' environmental reports that are used as a primary information source for estimation of emissions from CRT 2.C.1.b and other CRT sub-sectors relevant for primary iron and steel production. Total CO₂ emissions as specified in the facilities' environmental reports are further verified by more detailed mass-balances developed by emission inventory experts and based on EU ETS reporting, complemented with data from facilities' environmental reports. While environmental reports are used to distribute total reported CO₂ emissions to relevant CRT codes, reporting to the EU ETS provides data on carbon contents in all in-coming materials and products. The total CO₂ emissions in both sources are exactly the same.

Production processes and plant stations – an overview

Figure 4.4.2 gives an overview of the input and output materials, the carbon flows between the different processes (plant stations), and the CO₂ emitting sources.

In the coke ovens (battery), coking coal is turned into coke through dry distillation. During the process, coke oven gas (COG) and by-products are formed. The coke oven gas is purified through several procedures and used as fuel in all other plant stations, but smaller amounts are also flared.

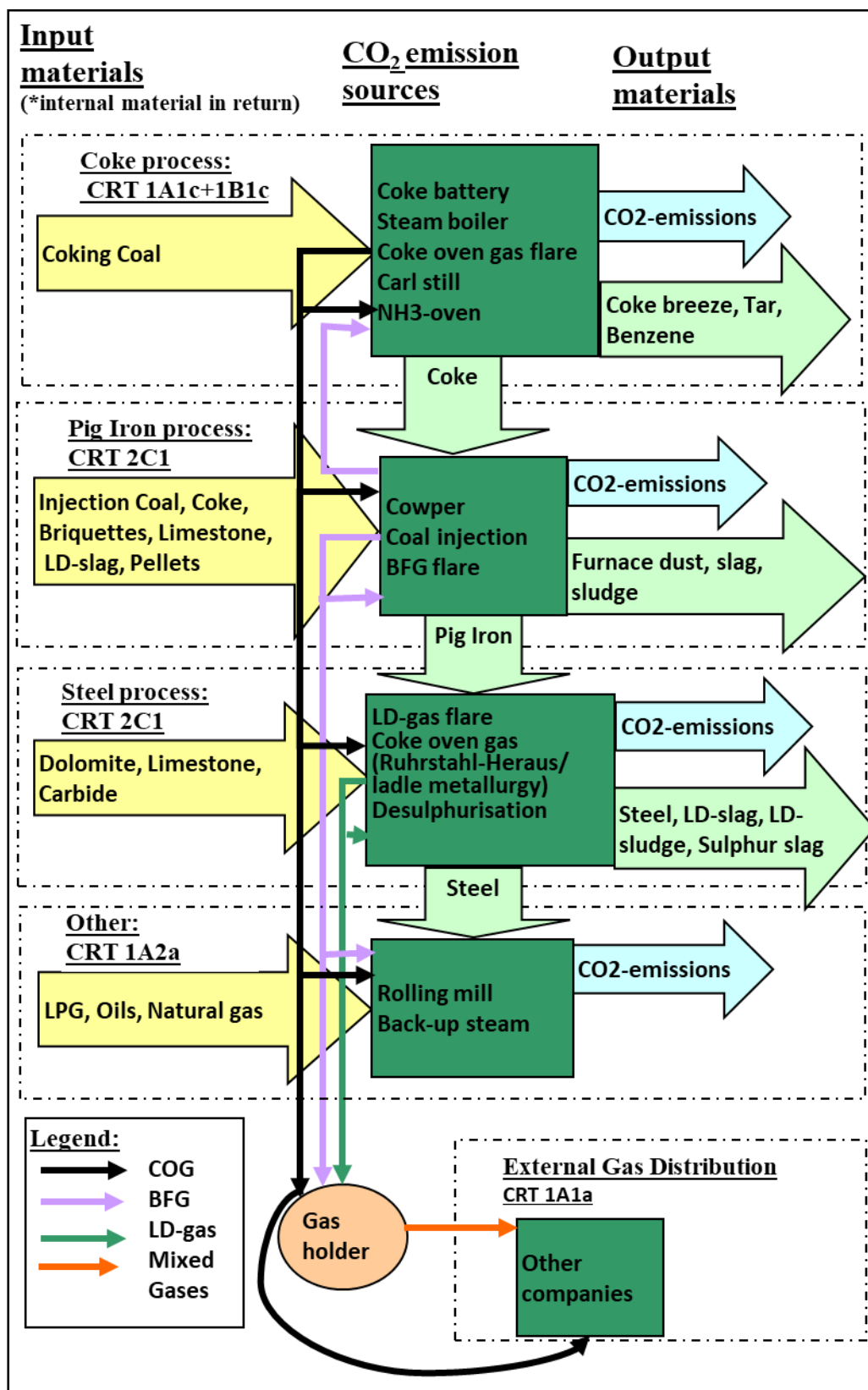


Figure 4.4.2. Carbon flow chart of integrated primary iron and steel plants in Sweden.

Produced amounts of coke are fed into the blast furnace together with injection coal to act as reduction agent when pig iron is produced from iron ore pellets. Limestone is added to extract slag and other by-products from the pig iron. Besides pig iron and by-products, blast furnace gas (BFG) is produced in the process. The main use for the blast furnace gas is to heat up the cowpers (and in one plant used in the coke oven), but some excess gas is released through flaring.

In the steelworks, pig iron is transformed into various qualities of steel depending on the demand. In addition to pig iron, dolomite, carbide, etc., are added depending on the different metallurgic processes. LD-gas is produced in the steel converter and used as fuel on-site or flared.

Some steel is treated in the rolling mills where COG, BFG, LPG, oils, and natural gas are used as fuel.

Considerable amounts of energy gases (COG, BFG, and LD-gas) from the different processes are collected in a gas holder and sold to external consumers (mainly in CRT 1.A.1.a. Electricity and heat production). These amounts of gases and their associated emissions are allocated to the source category where they are consumed and thus not accounted for in the iron and steel production. This is in accordance with the 2006 IPCC Guidelines¹⁹⁹ where allocation of emissions from delivered gases is described.

Distribution of total CO₂ emissions for national reporting

During the whole process from raw material to final product, emissions of CO₂ are released. The **allocation of total CO₂ emissions and energy consumption (TJ)** on plant stations and consequently CRT sub-sectors is based on measured fuel consumption and associated CO₂ emissions (see Tables 4.4.2 and 4.4.3 and the describing text below). Note that energy consumption (TJ) cannot be reported in CRT-reporter for 2.C.1.b.

Table 4.4.2. Allocation of CO₂ emissions in integrated primary iron and steel production.

Year	CO ₂ emissions, kt					Total
	1.A.1.a	1.A.1.c	1.A.2.a*	1.B.1.c	2.C.1.b	
1990	1 373	300	836	5	2 094	4 606
1995	1 537	341	948	6	2 383	5 212
2000	1 582	335	1 052	6	2 270	5 241
2005	2 303	344	1 120	5	2 206	5 968
2010	2 004	313	880	5	2 317	5 519
2015	1 559	458	821	24	1 690	4 556
2020	1 879	360	558	7	1 708	4 512
2021	1 873	327	590	9	1 911	4 711
2022	1 591	372	617	12	2 126	4 722
2023	1 589	373	563	6	2 026	4 557
2024	1 144	354	387	14	2 235	4 572

*Excluding external fuels – gasoil, diesel, natural gas and oils, only combustion of internal gases included

¹⁹⁹ See 2006 IPCC Guidelines: Volume 3: Industrial Processes and Product Use, Box 1.1 (page 1.8)

Table 4.4.3. Allocation of energy consumption in integrated primary iron and steel production.

Year	Consumed energy, TJ					Products and losses	Total
	1.A.1.a	1.A.1.c	1.A.2.a*	1.B.1.c	2.C.1.b		
1990	5 278	4 424	3 886	115	9 208	29 524	52 435
1995	5 683	5 038	4 404	132	10 479	31 324	57 060
2000	7 990	4 636	4 890	120	9 910	29 406	56 953
2005	8 879	4 834	5 224	115	10 624	38 969	68 644
2010	7 384	4 069	4 237	109	8 529	40 307	64 634
2015	6 271	4 601	3 902	510	7 383	34 153	56 820
2020	7 272	4 256	2 925	140	7 483	31 795	53 871
2021	7 063	3 679	3 062	177	7 708	31 716	53 405
2022	6 278	4 312	3 047	202	8 212	31 670	53 721
2023	6 565	4 163	2 877	111	8 290	31 368	53 374
2024	5 051	4 237	2 356	284	9 027	30 643	51 598

*Excluding external fuels – gasoil, diesel, natural gas and oils, only combustion of internal gases included.

Main data sources used for allocation of emissions and energy flows in 2003-2024 are environmental reports and personal communication. Amounts of derived solid fuels (COG, BFG, LD-gas) – combusted/ flared at different plant stations as well as sold outside – are available in the environmental reports. CO₂ emissions by station are obtained directly from one of the plants, and for the other plant all emissions are derived from environmental reports. Emissions from coke oven at this plant cover both COG combustion in coke ovens (CRT 1.A.1.c) and flaring (CRT 1.B.1.c) – emissions from flaring are calculated with national CO₂ emission factors, and the remaining emissions are allocated to CRT 1.A.1.c. Emissions from sold energy gases CRT 1.A.1.a) are calculated based on amounts specified in environmental reports, and national emission factors.

For 1990-2002, CO₂ emissions for one of the plants were obtained directly from the plant. For the other plant, CO₂ emissions 1990-2002 are calculated using its pig iron production 1990-2002 and an average CO₂ IEF 2003-2007. Allocation of CO₂ emissions on different sub-categories (CRT 1.A.1.c, 1.A.2.a, 1.B.1.c and 2.C.1.b) in 1990-2002 are based on the plant specific average distributions 2003-2007. Consumed amounts of different energy gases and other fuels 1990-2002 are derived by applying the 2006 IPCC Guidelines surrogate method using the average values 2003-2007 and the CO₂ emissions as the surrogate parameter. Activity data reported in CRT Reporter in CRT 2.C.1.b is produced amount of primary pig iron. Amounts of pig iron produced 1990-2002 were obtained directly from both plants. Energy allocated to products and losses (primary and secondary products, distribution losses and transformation losses) is estimated as total energy in input materials and stock change subtracted by the measured energy in fuels used, and consequently emissions are not applicable. Data on main input materials and their calorific values are summarized based on environmental reporting and personal communication with the facilities^{200, 201}. Examples of material inputs for certain years, as well as their calorific values, are given in Tables 4.4.4 and 4.4.5, respectively.

²⁰⁰ Gustafsson et al. 2011. Emissions from integrated iron and steel industry in Sweden: Model for estimation and allocation of energy consumption and CO₂ emissions for reporting to the UNFCCC, SMED report 97/2011

²⁰¹ Yaramenka, K, Jönsson, M, 2018, Förbättringar av inventeringar av utsläpp från SSAB, SMED PM

Table 4.4.4. Material input in the Swedish iron and steel production processes, ton.

Plant	Year	Coking coal	External coke	Injection coal	Source
1	1990	937 000	60 000	100 000	Personal communication
1	1995	920 000	70 400	102 000	Personal communication
1	2000	920 700	56 300	146 700	Personal communication
1	2005	946 100	39 300	314 000	Environmental report
1	2010	895 800	117 900	286 500	Environmental report
1	2015	892 000	0	182 700	Environmental report
1	2020	851 000	47 000	244 000	Environmental report
2	2005	623 972	136 901	170 217	Environmental report
2	2010	583 274	127 310	94 754	Environmental report
2	2015	543 590	60 434	116 390	Environmental report
2	2020	436 005	32 691	85 990	Environmental report

Table 4.4.5. Calorific values by input material in the Swedish iron and steel production processes, GJ/ton.

Plant	Coking coal	External coke	Injection coal	Source
1	32.23	29.67	30.6	Personal communication
2	32.23	27.5	30.6	Personal communication

Verification with data reported to ETS: CO₂ emissions and detailed carbon mass-balances

Detailed mass-balances, simplified energy balances and carbon and energy flow charts according to the EU ETS have been compiled for the two plants included in the reporting for several recent years. Due to data confidentiality, they cannot be displayed here but can be provided for reviewers upon request.

The carbon contents of external input materials such as coking coal, coke, injection coal, limestone, etc., are balanced against final output materials; coke and pig iron²⁰², steel, tar, sludge, slag, etc. The remaining carbon contents are accounted for as CO₂ emissions:

$$CO_2 \text{ emissions}_{Total\ CRF\ 1\ and\ 2} = \left[\sum_i (MI_i * C_i) - \sum_p (MO_p * C_p) \right] * 44 / 12$$

Where

MI_i = External carbon material input *i* fed into any part of the integrated processes (t).

MO_p = Final carbon material output *p* (t).

C_x = Carbon content of material input or output *x* (t C/t material *x*).

The mass balances indicate that among all input materials, coking coal makes the largest contribution to the carbon inputs. Carbon content of the coking coal was summarized and the relevant time-series for both facilities were compiled within a development project

²⁰² If put in stock or sold externally

during the fall of 2018²⁰³. Due to data confidentiality, these time series cannot be displayed here but can be provided for reviewers upon request.

It is important to note that carbon mass balances are not used directly in the calculations of CO₂ emissions from integrated iron and steel facilities but mainly as a verification tool, for the following purposes:

- To assure that data on CO₂ emissions and energy flows at the facilities, available in their environmental reports, are consistent with the EU ETS reporting;
- To estimate non-emissive energy use (losses and product-bound materials);
- To verify energy use and emissions in the CRT 1.A.1.a attributable to combustion of solid fuels sold by the integrated iron and steel facility to the power sector.

Activity data (amount of pig iron produced) on integrated pig iron and steel production along with CO₂ emissions and consumed amounts of energy gases (coke oven gas, blast furnace gas and LD-gas) and other fuels, are reported by the plants in the environmental reports since 2003. Mass-carbon balances and associated CO₂ emissions are also reported to the EU ETS since 2005. For some years, CO₂ emissions to the EU ETS did not include all plant stations (rolling mills), and additional information from the plants was obtained in order to ensure that no omissions occurred. Since 2008, annual CO₂ emissions reported by the plants in their environmental reports are equal to those reported to the EU ETS. For 2003 onwards, information on activity data and emissions for all plants (CRT 1.A.1.c, 1.A.2.a, 1.B.1.c and 2.C.1.b) are taken from the environmental reports.

Emissions of CH₄, NMVOC and CO are not reported in the plants' environmental reports. In the Swedish inventory these emissions are instead estimated from consumed amounts (including flared amounts) of energy gases multiplied by country-specific emission factors (see Annex 2). Emissions of CH₄, NMVOC and CO from coke oven gas, blast furnace gas and LD-gas in the blast furnace and steel converter are allocated to CRT 2.C.1.b. Emissions of NO_x and SO₂ are based on detailed plant information from the environmental reports.

4.3.1.2.3 *Direct reduced iron (CRT 2.C.1.c)*

Emissions of CO₂ are calculated using the 2006 IPCC Guidelines Tier 3 method. Plant-specific data on emissions from carbon-containing input materials such as coke and anthracite and also specific carbon-contents of output iron and by-products are used for all years. From 2005 onwards, EU ETS data is used, and for 1990-2004, information has been acquired from the plant. The emissions are verified using national statistics from Statistics Sweden on amounts of coke, anthracite and output material. CO₂ emissions from natural gas used for production of reduction gas used in the process are considered to be process related and thus reported in CRT 2.C.1.c. The remaining amounts of natural gas used by the facility are considered to be energy related and the corresponding emissions are reported in the energy sector (CRT 1.A.2.a). Limestone used in the production is included in the emissions from the production of iron powder in CRT 2.C.1.c. Reported activity data is produced amount of direct reduced iron (iron sponge). The carbon output from iron products includes slag and tunnel kiln lime produced as byproduct and waste, and flue gas dust with a certain carbon content that is deposited. Slag and tunnel kiln lime are contributing the most to the carbon output.

²⁰³ Yaramenka, K, Jönsson, M, 2018, Förbättringar av inventeringar av utsläpp från SSAB, SMED PM

In submission 2024, CH₄ emissions from direct reduced iron is reported for the first time. In the calculations, default Tier 1 emission factors from the 2006 IPCC Guidelines together with activity data was used (natural gas used for production of reduction gas).

4.3.1.2.4 Sinter (CRT 2.C.1.d)

No plant-specific or national emission factors are available. Thus, in accordance with the 2019 Refinement, emissions are estimated using production data and default emissions factors (0.21 t CO₂/t sinter produced and 0.07 kg CH₄/ t sinter produced). Production data has been collected from “Statistics of the Swedish Mining Industry”²⁰⁴ produced by the Geological Survey of Sweden (SGU).

4.3.1.2.5 Pellet (CRT 2.C.1.e)

Production data (iron pellets) are collected from the facilities’ annual environmental reports from 2006 onwards. For earlier years, national production statistics from Statistics Sweden are used. SO₂ emissions have been supplied by the facilities for the entire time series. Amounts of bentonite, organic binder olivine and quartzite used for the production of iron ore pellets and the corresponding CO₂ emissions are for later years collected from the EU ETS. For earlier years the amounts of bentonite and organic binder were provided by the company and EFs for bentonite and organic binder from the EU ETS were used for the calculations. Also, information on limestone and dolomite used in the pellets production is collected from the EU ETS. In the EU ETS, information of the amounts of carbon bound in products are available. For earlier years the average of these figures are used to estimate how much of the carbon that is not emitted but bound in product. Emissions of CO₂ from the use of limestone and dolomite are from 2005 and onwards collected from the EU ETS. Before 2005, the 2006 IPCC Guidelines emission factor for limestone and dolomite use is used to calculate CO₂ emissions and a purity of 97% and 100% are used for respective carbonate. Emission factor intervals for carbon containing raw materials and carbon content bound in pellets are presented in Table 4.4.6.

Table 4.4.6. Emission factor intervals for carbon containing raw materials (ton CO₂/ton) and carbon content bound in pellets (kg CO₂/ton).

	Average	Minimum	Maximum
Limestone, ton CO ₂ /ton	0.42	0.41	0.43
Dolomite, ton CO ₂ /ton	0.45	0.43	0.46
Bentonite, ton CO ₂ /ton	0.040	0.020	0.075
Organic binder, ton CO ₂ /ton	1.4	0.5	2.1
Olivin, ton CO ₂ /ton	0.0014	0.0010	0.0022
Quartzite, ton CO ₂ /ton	0.004	0.002	0.005
Pellets, kg CO ₂ /ton	0.49	0.13	1.67

Apart from raw materials that give rise to process related CO₂ emissions, reported in CRT 2.C.1.e, fuels are also used that give rise to CO₂ emissions and which, in accordance with the 2006 IPCC Guidelines, are to be reported as energy related emissions and reported in CRT 1. These fuels are light and heavy fuel oil and hard coal, and the emissions are reported in CRT 1.A.2.g. In addition to these fuels, bio-oil is also used. The raw material, the iron ore, mainly consists of magnetite. Magnetite requires less external energy input during enrichment and pellet production.

²⁰⁴ Geological Survey of Sweden. <http://www.sgu.se>.

No data concerning the CO emissions is available and the time series is thus reported NE.

Emission factor for CO₂ in 2006 IPCC Guidelines

The CO₂ emission factor for iron ore pellet production, 0.03 ton CO₂/ton pellets produced, refers to Best Available Techniques Reference Document for Iron and Steel Production. As the Swedish iron ore pellet producer is the main contributor to data for the BREF, the implied emission factor should be consistent with the 2006 IPCC Guidelines. The information in the Best Available Techniques Reference Document for Iron and Steel Production (Remus et al., 2013) indicates that the CO₂ emissions are between 17 and 193 kg/t of pellets produced. With CO₂ data from the EU ETS as a basis and produced quantities of pellets from the company's environmental reports, an IEF of between 26 and 31 kg/t is obtained for the Swedish producer (including energy as well as process related emissions), which is within the interval of the information in the BAT document and on level with the IPCC default value. In CRT 2.C.1.e, only process-related CO₂ is reported, while energy-related emissions are reported in CRT 1.A.2.g (NID section 3.2.15). The emission factor indicates, as mentioned above, that the CO₂ emissions (both energy and process related) are between 17 and 193 kg/t of pellets produced.

As described in 2006 IPCC Guidelines the default emission factor should be used if the inventory compiler does not know anything about the fuels or raw materials used.

Pellet production process – overview

The iron ore is mainly extracted in underground mines, but there is also one open pit. The processing of the ore takes place in the vicinity of the mines and consists of sorting and fine-crushing plants, concentrators and pelletizing plants.

Sorting and crushing: The ore is roughly sorted and residual waste rock removed. After that, the iron ore is crushed into smaller fractions. This increases the iron concentration from approximately 45 to more than 60 percent.

Concentration: The ore is then finely ground and further purified to remove silicon, sodium, potassium, phosphorus, apatite etc. Additives like olivine, quartzite, limestone and dolomite are then mixed into the resulting slurry (a mix of ground iron ore and water).

Pelletisation: In the pelletising plants, binders are added, and the slurry is rolled in large rotating drums, into small balls called pellets. The iron ore pellets are then dried and preheated before finally being heated at 1 250°C to a point where the iron ore particles partially fuse together. Before delivery, the pellets are cooled down.

There are currently six pelletising plants producing iron ore pellets in Sweden. Four of the pellet plants are of the Grate-Kiln type, while the other two are of the Straight-grate (or traveling grate) type.

The pelletisation process requires high temperatures and coal, oil (including bio-oil) and electrical energy are used as energy carriers.

The emissions of CO₂ originating from coal and fossil oil are allocated to CRT 1.A.2.g, while CO₂ originating from raw materials, additives and binders are allocated to CRT 2.C.1.e.

4.3.1.2.6 Other (CRT 2.C.1.f)

The data on emitted amounts of NMVOCs have been taken from the facilities' annual environmental reports. For the years where data is missing for individual facilities, extrapolation has been used to make the time series complete.

4.3.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Activity data and CO₂ emission trends

During 2015, the blast furnace at one of the facilities was closed for renovation. The blast furnace was stopped for several month, and after it came into operation again, pig iron production required substantially lower input of injection coal and coke than usually, according to the facility. This is why in 2015, CO₂ emissions were relatively low and did not follow the trend for pig iron production.

Between 2016 and 2017, the CO₂ emissions in CRT 2.C.1.b dropped while the total production of pig iron increased. This is explained by the fact that while the total emissions from the two facilities increased, more carbon-containing internal gases were flared and combusted at other units than blast furnaces and steel works – these emissions are reported in the energy sector (CRT 1A).

In 2019, the CO₂ emissions in CRT 2.C.1.b increased significantly more than production. This increase is explained by disturbances in the production process at one of the facilities, which hindered possibilities to sell energy-rich process gases to external consumers for heat and power generation. Emissions from sold gases are included in the reporting within the energy sector (CRT 1.A.1.a). In 2019 however, a major part of surplus gases was flared at the iron-and-steel facility instead, which resulted in increased CO₂ emissions from the category CRT 2.C.1.b. In 2020, no such process disturbances occurred, so CO₂ emissions decreased. In 2021, CO₂ emissions were at roughly the same level as in 2020, and in 2022 they increased, largely due to more energy-rich gases flared and combusted on-site and less gases sold to the energy-producing facilities. Similar situation was observed in 2024: emissions reported in CRT 2.C.1.b increased compared to 2023, but this increase is explained by the fact that internal gases were consumed at the facility and thus reported in CRT 2.C.1.b, not in CRT 1.A.1.a. Another factor contributing to higher emissions in 2024 was larger amount of coking coal consumed in 2024 than in 2023.

CO₂ implied emission factor

Figure 4.4.3 shows the default 2006 IPCC CO₂ EF for pig iron production and the CO₂ IEF for primary pig iron production in Sweden for submission 2026. The Swedish CO₂ IEF (0.53-0.84 kt CO₂/t pig iron) is significantly lower than the default IPCC value (1.35 kt CO₂/t pig iron). The main reason for the large difference is due to the allocation model used in the Swedish inventory, where large amounts of derived gases (and associated CO₂ emissions) produced in the processes (blast furnace and LD-steel converters) are used in the coke plant and for power and heat production purposes.

As the different process gases are allocated to different source categories according to an allocation model, the implied emission factor for CRT 2.C.1.b can show an annual variation, which is not in correlation with the total emissions from the industry.

Decrease in CO₂ IEFs from 0.77 kt CO₂/kt pig iron in 1990 to 0.54 kt CO₂/kt pig iron in 2009 is explained by several energy efficiency measures undertaken under this period,

e.g., increased temperature in the blast furnaces and increased recycling of energy gases and by-products²⁰⁵.

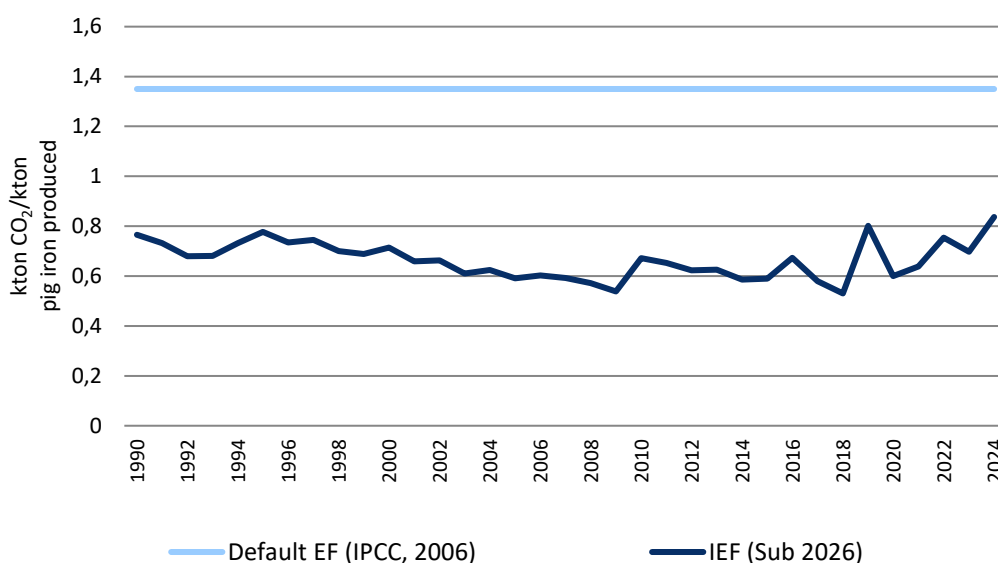


Figure 4.4.3 Default 2006 IPCC CO₂ EF for pig iron production and the CO₂ IEF for primary pig iron production in Sweden for submission 2026.

In 2010, reparation work was performed at the LD gas holder at one of the plants, and during 2011 the LD gas holder was out of operation during a large part of the year because of problems with leakage after repairing the unit in 2010. During 2010-2012 there were disruptions or constraints in the production at the blast furnaces at the second plant and the start-ups of the blast furnaces after disruptions require extra fuel. Still in 2014, only one out of two blast furnaces were in use, due to the overall weak economy. These activities or events may have contributed to the higher CO₂ IEF for 2010-2016.

One of the integrated facilities sells significant amounts of internal gases (LD-gas, BFG, COG) to a local power plant. Emissions from sold gases are subtracted from the category CRT 2C1b and reported under the category CRT 1A1a. Inter-annual variations of amounts of sold gases and redistribution of total CO₂ emissions between the power plant and the iron-and-steel facility have large impact on IEFs in the category CRT 2C1b. Amounts of sold gases are determined by energy demand of the local power plant and by production conditions at the iron-and-steel facility, e.g. production stops causing extra flaring on-site. In 2019, a major part of surplus gases was flared at the iron-and-steel facility instead, which resulted in increased CO₂ emissions from the category CRT 2.C.1.b and increased IEF. In 2020, no such process disturbances occurred, so both CO₂ emissions and the IEF decreased. In 2021, IEF was roughly at the same level as in 2020.

Increased CO₂ IEFs in 2022 and in 2024 were largely due to more carbon-containing internal gases combusted and flared on-site than sold to energy-producing facilities. Specifically, amount of internal gases sold in 2024 was minimal for the entire period 1990-2024, which resulted in larger amounts of gases flared and combusted on-site and

²⁰⁵ ENET-Steel, 2007.

consequently increased IEF. Another factor contributing to high IEF in 2024 was larger amount of coking coal consumed in 2024 than in 2023, while production decreased.

Uncertainties

The largest implication on the national total uncertainties from this category stems from uncertainties in CO₂ emissions in primary iron and steel production (CRT 2.C.1.b); based on judgement by SMED expertise the estimated uncertainty is $\pm 5\%$. It should be noted, however, that total emissions of CO₂ from iron and steel production, including energy related emissions, are likely to deem lower uncertainty estimates.

4.3.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All plants in this category report their emissions in environmental reports. For plants included in the EU ETS, the reported data is scrutinized and compared to EU ETS data. EU ETS data is applied wherever it is judged to be appropriate in line with the 2006 IPCC Guidelines. Detailed carbon mass balances according to the EU ETS are compiled for both integrated iron and steel plants included in the reporting. This information is used for verification but cannot be displayed due to data confidentiality. More information on QC activities related to EU ETS is included in Annex 8.1.

Emissions from this source are included in the cross-sectoral control tool that was developed in 2017, described in detail in section 1.3.5.

Due to the fact that one of the operators of the integrated iron and steel plants did not take into account any intermediate stock change of produced coke in the carbon mass balance used when calculating the CO₂ emissions (see section 4.4.1.3), there will be discrepancies in the annual CO₂ emissions used in the reporting to the UNFCCC and the plant-specific data already reported to the EU ETS for 2005 – 2012. It should be noted that 2011 is the year with the largest discrepancy in reported CO₂ emissions between the two sources.

For primary iron and steel production, activity data from facilities is compared to production statistics from the Swedish Steel Producers' Association and only minor differences are detected for the time-series.

For the company producing iron sponge by direct reduction of iron, the CO₂ IEF seems to have increased during the time period 1990-2014 (see Figure 4.4.4). However, this is because the production of iron powder has increased with about 140% over the time period, whereas the production of iron sponge has been relatively stable. The reduction of iron to iron sponge gives rise to most of the process-related CO₂, although some CO₂ is released by the production of iron powder. Almost all of the produced iron sponge is further processed to iron powder. Iron powder is however also produced from other raw materials, such as scrap materials, adding to the CO₂ emissions. This production has increased substantially over the time series; in 1990 approximately 80% of the iron powder produced at the plant originated from the plant's production of iron sponge, and in 2014 that figure decreased to around 30%, indicating that other materials now stand for the majority of the iron powder production. This is the reason why the implied emission factor for CO₂ seems to be increasing when using sponge production as activity data. However, if calculated from total iron powder production it is decreasing.

Since the main part of process-related CO₂ emissions stem from iron sponge production, this has been chosen as reported activity data. Figure 4.4.4 illustrates the different IEFs as well as the trend of the production ratio of iron sponge to iron powder production.

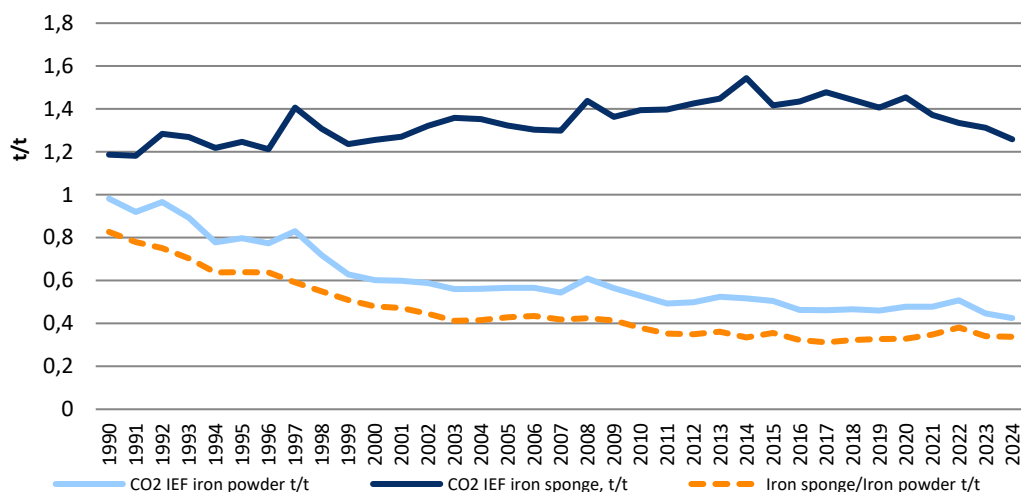


Figure 4.4.4. CO₂ implied emission factors in relation to iron sponge production and total iron powder production, as well as the production ratio of iron sponge to iron powder.

The emission factor given for pellet production in 2006 IPCC Guidelines (0.03 ton CO₂/ton pellet) refers to Best Available Techniques Reference, Document on the Production of Iron and Steel, from December 2001 (15.6 – 31.8 kg CO₂/ton pellet). This emission factor represents emissions of CO₂ both from raw material, additives, binders and coal and fossil oil and can not be used to calculate the process related CO₂ emissions reported in CRT 2.C.1.e. In 2006 IPCC Guidelines, this text can be found: “If the inventory compiler knows the inputs used, CO₂ emissions should be calculated using the Tier 2 method, accounting for the fuel consumption, heating value and carbon content of the fuel.” The EU ETS data is accredited and verified by an approved controller and considered to be of high quality.

With CO₂ data from the EU ETS (both process and energy related) as a basis and produced quantities of pellets from the company’s environmental reports, an IEF of between 26 and 31 kg/t is obtained for the Swedish producer, which is at the same level as the information in the BAT document. Only the process related CO₂ emissions (CRT 2.C.1.e) have EU ETS as data source, while the energy related emissions (CRT 1.A.2.g) are based on fuel statistics.

4.3.1.5 SOURCE-SPECIFIC RECALCULATIONS

2.C.1.a: For one of the facilities, CO₂ emissions were corrected for 2013-2023 based on data in the environmental reports, which resulted in annual emission increase up to 5 kt CO₂, compared to submission 2025.

2.C.1.b: Incorrect EU ETS reporting for 2023 by one of the facilities was corrected in submission 2026, resulting in 10 kt CO₂ emission increase, compared to submission 2025.

2.C.1.c: No source-specific recalculations have been performed in submission 2026.

2.C.1.d: No source-specific recalculations have been performed in submission 2026.

2.C.1.e: Update of activity data and emissions for CO₂ resulted in a decrease in 0.58 kt CO₂ compared to submission 2025.

2.C.1.f: No source-specific recalculations have been performed in submission 2026.

4.3.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.3.2 Ferroalloy production (CRT 2.C.2)

4.3.2.1 SOURCE CATEGORY DESCRIPTION

Due to data confidentiality, data for 2015-2020 cannot be displayed for this category. Ferroalloy production is reported for only one facility in Sweden. There is also ferroalloy production at one more plant, but since the main production at this facility is iron and steel, the emissions are reported in CRT 2.C.1. The production of ferrosilicon has decreased sharply since 2005, and between 2008 and 2011 and again from 2014 there has not been any ferrosilicon production at all. As CH₄ emissions within CRT 2.C.2 stem only from ferrosilicon production, this led to zero emissions of CH₄ during these years. In addition, production of ferrosilicon leads to larger emissions of SO₂ compared to production of ferrochromium, which is why the reduced or non-existent ferrosilicon production since 2005 resulted in a distinct decrease in SO₂ emissions. From 2008 are the SO₂ emissions at a fairly stable level with a few exceptions. The economic recession in 2009 had a great effect on production volumes of ferroalloys in Sweden and thus the emissions 2009 are significantly reduced compared to adjacent years. Higher sulfur concentrations in the raw materials used have resulted in increased emissions of SO₂ in 2012, 2018 and 2020.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.4.7.

Table 4.4.7. Summary of source category description, CRT 2.C.2, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.2	CO ₂	X	X		T3	PS	Yes
	CH ₄	NA	NA		NA	NA	NA
	N ₂ O	NA	NA		NA	NA	NA

T3 Tier 3. PS Plant-specific.

4.3.2.2 METHODOLOGICAL ISSUES

The estimation of CO₂ emissions due to the production of ferroalloys are plant specific (in line with Tier 3). CO₂ emissions reported by the plant are calculated based on consumed amounts of reducing agents, i.e. electrodes and coke (and in 2003 coal), chrome ore and other input agents, together with their specific carbon contents, and the amount of carbon bound in produced ferroalloys, slag and in dust. The general carbon balance, calculated as averages for 2013 – 2020, is:

$$\frac{\text{Coke}}{94\%} + \frac{\text{Electrodes}}{5\%} + \frac{\text{Chrome ore}}{< 1\%} + \frac{\text{Other agents}}{< 1\%} \rightarrow \frac{\text{Ferroalloys}}{13\%} + \frac{\text{Emissions}}{86\%} + \frac{\text{Particles/slag}}{1\%}$$

To verify the emissions reported by the plant, emissions are also calculated based on activity data on coal, coke, electrodes and the amount of carbon in produced ferroalloys together with:

- Emission factors and thermal values used for stationary combustion for coke and coal and information from the company that the electrodes contain around 90% carbon.
- IPCC default factors for coal, coke and electrodes²⁰⁶.

The following formula is used:

$$\text{CO}_2 \text{ (t)} = \text{Coke (t)} \times \text{EF} \times \text{Thermal value} + \text{Coal (t)} \times \text{EF} \times \text{Thermal value} \\ + \text{Electrode (t)} \times \text{C-content} \times \frac{44}{12} - \text{CO}_2 \text{ in produced ferroalloys (t, plant data)}$$

where 44/12 is the molecular weight ratio of CO₂ and carbon. As can be seen in Table 4.20, there are differences in the plant specific data, emissions based on Swedish default EF and emissions estimated with IPCC Guidelines default values. The differences are due to the fact that – according to the company – the carbon content of coke may vary from one year to another.

Since 2013 the CO₂ emission is entirely calculated based on plant-specific data on raw material consumption and its carbon content as well as the carbon content of products produced and the carbon content in slag and dust as reported to EU ETS.

The following formula is used:

$$[(\text{AD}_{\text{coke}} \times \text{CC}_{\text{coke}} + \text{AD}_{\text{coal}} \times \text{CC}_{\text{coal}} + \text{AD}_{\text{graphite electrodes}} \times \text{CC}_{\text{graphite electrodes}} + \text{AD}_{\text{chrome ore}} \times \text{CC}_{\text{chrome ore}} + \text{AD}_{\text{added material}} \times \text{CC}_{\text{added material}}) - (\text{AD}_{\text{slag}} \times \text{CC}_{\text{slag}} + \text{AD}_{\text{produced metal}} \times \text{CC}_{\text{produced metal}} + \text{AD}_{\text{dust}} \times \text{CC}_{\text{dust}})] \times 44/12.$$

Where AD and CC denotes the Activity Data of each component and its Carbon Content, respectively. The ratio 44/12 is the molecular weight of carbon dioxide divided by the atomic weight of carbon.

The total amounts of carbon in the produced ferroalloys are presented in Table 4.4.8 and are calculated based on the carbon content in coke, coal, electrodes and dust. The amount of carbon in the produced ferroalloys varies between 0.1% and 7%. This carbon is stored in the product and is reported under CRT 1.AD.10 (Non-energy use of fuels and feedstocks) - coke and coal.

²⁰⁶ IPCC. Revised 1996 Guidelines for National Greenhouse Gas Inventories: Reference Manual, Table 2.12.

Table 4.4.8. Total emissions of CO₂ based on plant specific data (reported in the CRT), data based on Swedish EF and thermal values and based on 1996 IPCC Guidelines default values. Due to data confidentiality, data for the years 2015-2020 cannot be displayed.

Year	Plant specific data, (kt CO ₂)	Swedish values, (kt CO ₂)	IPCC default values, (kt CO ₂)
1990	243	244	263
1995	265	274	295
2000	240	266	287
2005	225	215	232
2010	107	96	104
2011	117	121	130
2012	101	99	107
2013	88	75	81
2014	110	100	107
2021	163	140	151
2022	197	173	187
2023	141	123	133
2024	135	116	125

As activity data, the carbon content of coke, electrodes and slag binder is used. The reason for this is that the company produces both ferrochrome and ferrosilicon, which bind carbon to different extents. The relative production of each product varies greatly between years (Table 4.4.9), affecting CO₂ emissions to a large extent. To report total production volumes as activity data would therefore not give any good indication on the relation between production and CO₂ emissions.

Table 4.4.9. Total amount of carbon bound in produced ferroalloys and production data. Due to data confidentiality, data for the years 2015-2020 cannot be displayed.

Year	Carbon in ferroalloys, (kt)	Ferrosilicon, (kt)	High Carbon Ferrochrome, (kt)	Charge chrome, (kt)
1990	8.4	20.6	NE	NE
1995	8.7	23.4	NE	NE
2000	9.5	20.2	34.2	98.7
2005	8.0	10.5	41.5	78.4
2010	4.0	0	1.6	59.5
2011	4.7	0	80.1	0
2012	2.2	9.8	39.0	0
2013	2.7	0.9	49.0	0
2014	4.1	0	66.0	0
2021	7.2	0	110	0
2022	7.8	0	129	0
2023	5.9	0	95	0
2024	5.9	0	93	0

CH₄ emissions from production of ferrosilicon alloys are reported from submission 2010 and calculated based on ferrosilicon alloy production (Tier 2²⁰⁷). Data on non- CO₂

²⁰⁷ 2006 IPCC Guidelines for National Greenhouse Gas Inventories, Table 4.8

emissions has been obtained directly from the company for the whole time series. The reported emissions include NO_x and SO₂ from the process.

4.3.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties in this category have little impact on the estimated national total emission uncertainty. Emission uncertainties of CO₂ are judged by SMED expertise to be low at ± 5% as plant-specific values and Swedish default values give similar results.

The time series is considered to be consistent.

4.3.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

As presented in Table 4.4.8 above, verification of CO₂ emissions reported by the plant is obtained as calculated Swedish default values give similar results.

4.3.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed during submission 2026.

4.3.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.3.3 Aluminium production (CRT 2.C.3)

4.3.3.1 SOURCE CATEGORY DESCRIPTION

There is one facility that produces primary aluminium in Sweden. The facility consists of two plants. One of the potlines (plant 1) includes 56 closed Prebake cells (CWPB), each of 150 kA. The other plant (plant 2) consisted of 262 cells and, until the beginning of 2008, operated three closed Prebake cells and 259 open cells with Söderberg anodes (VSS). The Söderberg anodes were produced in an electrode pulp factory at the facility. From 2008, when all Söderberg cells were shut down, these potlines have gradually been replaced by closed Prebake cells. In 2012, 56 closed Prebake cells in plant 1 and 242 closed Prebake cells in plant 2 (all CWPB) were in operation. During the conversion from Söderberg technology to Prebake technology there were start-up problems that caused increased emissions of PFC, especially in 2010 and 2011.

The time series of emissions compiled for primary aluminium production include emissions of CO₂, PFCs, NO_x, CO, NMVOC and SO₂. Use of SF₆ as a cover gas is not occurring in Swedish aluminium foundries, thus reported as NO.

Process related emissions from one producer of secondary aluminum are also included in CRT 2.C.3. The time series of emissions compiled for secondary aluminum production includes emissions of CO, NO_x and SO₂. Also, small amounts of NMVOC from one aluminum foundry are included in CRT 2.C.3.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.4.10. An overview of the rationale for data sources used for key categories in the industrial processes sector is presented in Annex 3.5.

Table 4.4.10. Summary of source category description, CRT 2.C.3, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.3	CO ₂	X	-		T3	PS	Yes
	CH ₄	NA	NA		NA	NA	NA
	PFCs	-	X		T2	D	Yes

D Default. PS Plant-specific. T2 Tier 2. T3 Tier 3.

4.3.3.2 METHODOLOGICAL ISSUES

4.3.3.2.1 Primary aluminium production

Reported production statistics and emissions data are based on information in the environmental reports or received directly from the company.

Emission data for CO₂ from the production of primary aluminium 2001 - 2022 are derived through measurements and reported directly by the plants, whereas the emissions for 1990-2000 are calculated based on the mass of coal elements (anodes) such as electrodes, coke etc. and the amount of carbon that is bound in soot and rest anodes. The formula used for CO₂ (t) for 1990-2000 is:

$$\text{Mass anodes (100\% C)} \times \frac{44}{12} \times (1 - 0.259^*)$$

* Average mass CO₂ bound in soot and rest anodes 2001-2008

The value for carbon bound in soot and rest anodes (0.259) is based on average of reported values for 2001-2008. For subsequent years the amounts bound in soot and rest anodes vary between 0.171 and 0.297.

For the years 2001 and onwards, the emissions reported by the plant have been verified by collecting data on the amount of coal elements used and by calculating the emissions based on the equation above. Both methods show similar results.

The carbon bound in soot and in rest anodes is not emitted to the atmosphere as CO₂, and it is therefore excluded in the reported CO₂ emissions in 2.C.3. Therefore, the IEF values in the Swedish inventory are lower than the IPCC Guidelines Tier 1 default emission factors for Prebake and Söderberg technologies (1.6 and 1.7 kt CO₂/kt produced Al) (Table 4.4.11). For 2023 onwards, the quantity of production as well as the IEF are classified.

The two different processes for aluminium production, Prebake (CWPB) and Söderberg (VSS), have substantially different emission factors for PFCs. Estimates of emissions are based on the number of ovens and the number and duration of anode effects. This activity data is considered to be of good quality.

Table 4.4.11. Implied emission factor for CO₂ for the production of primary aluminium. Production quantity and IEF are confidential for 2023-2024.

Year	Aluminium production	Emissions of CO ₂	IEF
	(kt)	(kt)	kt CO ₂ /kt Al
1990	96	133	1.4
1995	94	129	1.4
2000	101	145	1.4
2005	103	144	1.4
2010	96	135	1.4
2015	119	180	1.5
2016	124	190	1.5
2017	126	206	1.6
2018	125	188	1.5
2019	117	177	1.5
2020	115	172	1.5
2021	116	174	1.5
2022	117	175	1.5
2023	C	171	C
2024	C	163	C

Activity data used for the PFC emission calculations, anode effects in min/oven day and production statistics, were provided by the company, and specified for the Prebake and Söderberg technologies. The reported emissions and calculated Implied Emission Factors are presented in Table 4.4.12.

Table 4.4.12. Activity data, emissions of C₂F₆, CF₄ and calculated IEF for primary aluminium production. Production quantity and IEF are confidential from 2023 onwards.

Year	Al production, CWPB, kt	Al production, VSS, kt	Total emissions, C ₂ F ₆ t	Total emissions, CF ₄ t	Calculated IEF			
					CWPB kg C ₂ F ₆ /t	VSS kg C ₂ F ₆ /t	CWPB kg CF ₄ /t	VSS kg CF ₄ /t
1990	23.4	72.9	4.27	69.92	0.0426	0.0449	0.3518	0.8463
1995	22.8	71.2	3.56	64.65	0.0102	0.0467	0.0845	0.8808
2000	23.0	78.1	2.46	45.08	0.0057	0.0299	0.0470	0.5635
2005	23.6	78.9	2.67	49.84	0.0021	0.0332	0.0175	0.6262
2010	96.1	-	2.52	20.80	0.0262	-	0.2164	-
2015	119.4	-	0.47	3.86	0.0039	-	0.0323	-
2016	124.1	-	0.42	3.43	0.0033	-	0.0277	-
2017	125.8	-	0.49	4.07	0.0039	-	0.0323	-
2018	124.8	-	0.84	6.94	0.0067	-	0.0557	-
2019	116.8	-	0.67	5.56	0.0058	-	0.0476	-
2020	114.9	-	0.89	7.36	0.0077	-	0.0640	-
2021	115.9	-	0.68	5.61	0.0059	-	0.0484	-
2022	116.6	-	0.52	4.32	0.0045	-	0.0370	-
2023	C	-	0.48	3.93	C	-	C	-
2024	C	-	0.37	3.03	C	-	C	-

Reported emissions of NO_x are calculated from production statistics using emission factors defined by Swedish EPA²⁰⁸. NMVOC emissions are calculated from reported emissions of tar, assuming that 70% of the tar is emitted as NMVOC²⁰⁹. Closing down the Söderberg ovens also eliminated the need for anode production in late 2008.

The shutdown of the anode production ended the tar emissions which meant that the NMVOC emissions also fell sharply. From 2009 and onwards, emissions of NMVOC are reported NE since no emission factor is specified in the EMEP/EEA Guidebook.

CO emissions were for the first time reported in submission 2008 and are for 2002 - 2021 as reported in the company's environmental reports. For the period 1990 to 2001, the CO emissions are calculated based on production statistics and emission factors provided by the company. The same method is used for SO₂ emissions during 1990 to 2005. For later years SO₂ emissions data are based on environmental reports published by the company.

The elevated SO₂ emission in 2012 is primarily due to high sulphur content in delivered anodes. The desulfurization of flue gases in the flue gas treatment facilities was not sufficiently efficient. In 2014 the SO₂ emissions were lower than previous year due to improved abatement technology. The improved abatement technology is also shown in low SO₂ emissions in 2015 - 2021. Also, the CO emissions were higher for 2012 compared to previous years. The reason for this is, according to the company, that a new calculation method has been used from 2012 onwards.

4.3.3.2.2 *Secondary aluminium production and aluminium foundries*

Reported emissions data are based on information in the facilities' environmental reports. For the years where data is missing for individual facilities, extrapolation has been used to make the time series complete.

4.3.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

4.3.3.3.1 *Primary aluminium production*

The uncertainty for activity data is estimated to $\pm 2\%$. The uncertainty for CO₂ emission factor is estimated to $\pm 5\%$. Uncertainty for SO₂, NO_x and NMVOC are $\pm 30\%$, $\pm 50\%$, $\pm 75\%$, respectively. Uncertainty for PFCs is $\pm 30\%$ for 1990 and $\pm 5\%$ for the latest year.

As can be seen in Table 4.4.11 the IEFs show a downward trend from 1990, especially so for CF₄. This reflects the company's on-going work aiming to reduce the time and frequency of the anode minutes. Between 2008 and 2011 the Söderberg potlines were gradually replaced by closed Prebake cells.

By the end of December 2009, 120 of a total of 262 cells in plant 2 had been converted to the Prebake technology and in the beginning of December 2010 242 Prebake cells in plant 2 were in operation. At the end of December 2010, a power outage led to major disturbances in plant 2 leading to both increased emissions and major production problems. On January 7, 2011, 120 Prebake cells were shut down as a direct result of the power outage. At the end of June 2011 all Prebake cells in plant 2 were restarted and in operation.

²⁰⁸ Ahmadzai, H. Swedish EPA. Personal communication. 2000.

²⁰⁹ Ahmadzai, H. Swedish EPA. Personal communication. 2000.

The shutdown of Söderberg ovens explains the very large decline in PFC emissions in 2009 (-89% compared to 2008) (Figure 4.4.5). Also, the reported CO₂ has declined in 2009 relative to previous years. The cold winter in 2010 resulted in high power input to the anodes, thus leading to high emissions of PFCs. There were also problems with power outages which affected the production and led to increased number of AE minutes. During the start-up period in 2011, emissions to air increased but later in 2011 the emissions decreased to expected levels. During the first few months in 2012 there was however problems with disturbances in the oxide distribution, leading to elevated emissions of PFCs. In all, the PFC emissions in 2012 were considerably lower in comparison to 2010 and 2011. In 2013 the PFC emissions continued to decrease due to the fact that the production process was stable with less anode effects in min/oven day. In 2014 the PFC emissions were higher than 2013 year due to a transformer failure that caused disturbances in the production. In August 2015 a new transformer was installed and operating which led to lower emissions of PFCs in 2015 - 2017. In 2018 emissions of PFC increased compared to recent years. This is due to the sanctions introduced from the US aimed at Russian oligarchs, of which one controlled the mother company that owns the Swedish facility. The sanctions resulted in cancelled deliveries of necessary raw-materials and spare parts from other companies trying to avoid effects of the sanctions. After the sanctions were introduced, the production process at the facility was instable due to lack of raw materials and spare parts for maintenance. The sanctions were removed on January 27, 2019, after changes in the company- and owner structure. During 2019, after the removal of the sanctions, the production has become more stable again, but some activities were delayed due to the sanctions in 2018. The company reports that they were catching up on these activities in 2019. In 2020, there have been a number of power outages which was disturbing the process, resulting in a higher frequency of anode minutes and higher emissions of PFCs.

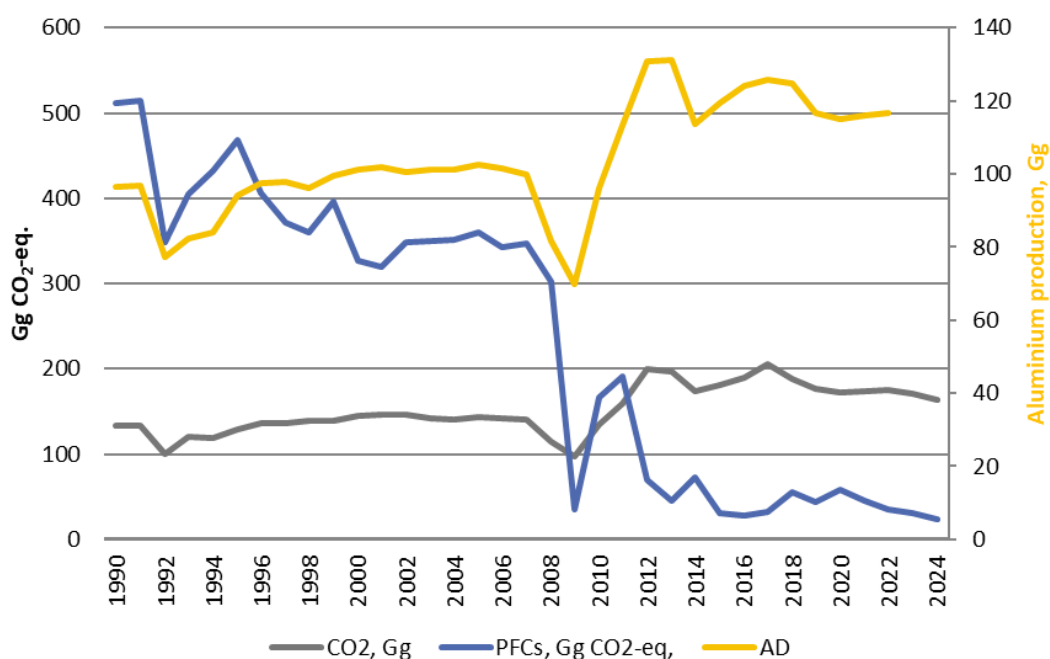


Figure 4.4.5. Time series for CO₂ and PCF emissions and produced amounts of primary aluminium in CRT 2.C.3. AD from 2023 onwards is confidential.

The reported time series are considered to be consistent.

4.3.3.3.2 Secondary aluminium production and aluminium foundries

Uncertainties for CO, SO₂, NO_x and NMVOC are ± 100%, ± 30%, ± 50%, and ± 100%, respectively.

4.3.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The implied emission factors for CO₂ and PFCs are analysed annually. Explanations for unexpected variation between years are obtained by direct contact with the company or from information in their legal environmental reports.

4.3.3.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed during submission 2026.

4.3.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.3.4 Magnesium production (CRT 2.C.4)

4.3.4.1 SOURCE CATEGORY DESCRIPTION

There is no production of magnesium in Sweden, thus emissions of CO₂, NO_x, CO, NMVOC and SO₂ are reported as NO (Not occurring) in the CRT tables. However, there are four magnesium foundries in Sweden that have used SF₆ as a cover gas. In 2012 – 2013 and 2017 - 2022, small amounts of HFC-134a were also used as a cover gas.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.4.13.

Table 4.4.13. Summary of source category description, CRT 2.C.4, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.4	SF ₆	NA	NA		NA	NA	Yes
2.C.4	HFC-134a	-	-		T2	D	Yes

D Default. T2 Tier 2

4.3.4.2 METHODOLOGICAL ISSUES

The total amounts of SF₆ and HFC-134a used annually in the magnesium foundries (CRT 2.C.4) are reported as emissions, according to the 2006 IPCC Guidelines. Data is obtained from companies using SF₆ and HFC-134a as a cover gas. From 1 January 2018, the use of SF₆ as a cover gas is prohibited and this gas has primarily been replaced by SO₂.

4.3.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

For the three sites where the data is obtained directly from the companies, an uncertainty of 5% is applied, according to data in the 2006 IPCC Guidelines. For the "unknown" plant a much higher uncertainty (~ ± 200%) is applied. The total uncertainty has thus been estimated for CRT 2.C.4 to ± 20%. Time series are considered to be consistent.

4.3.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In response to questions raised during the 2011 submission UNFCCC review, data for 2009 has been checked with information from the Swedish Chemicals Agency's Products Register and the data was found to be consistent.

During the review of the 2017 submission, the Expert Review Team recommended Sweden to report both amounts of magnesium casted and emissions of SF₆ in CRT 2.C.4. Despite efforts, Sweden has not been able to find national data on amount of magnesium casted. Sweden will therefore continue to report "NE" for amounts of magnesium casted.

In Figure 4.4.6, below, implied emission factors (ton SF₆/kton magnesium casted) for the largest of the magnesium foundries are presented, from 2009 to 2017. Between 2009 and 2011, the implied emission factor decreases much while it remained at about the same level after 2011.

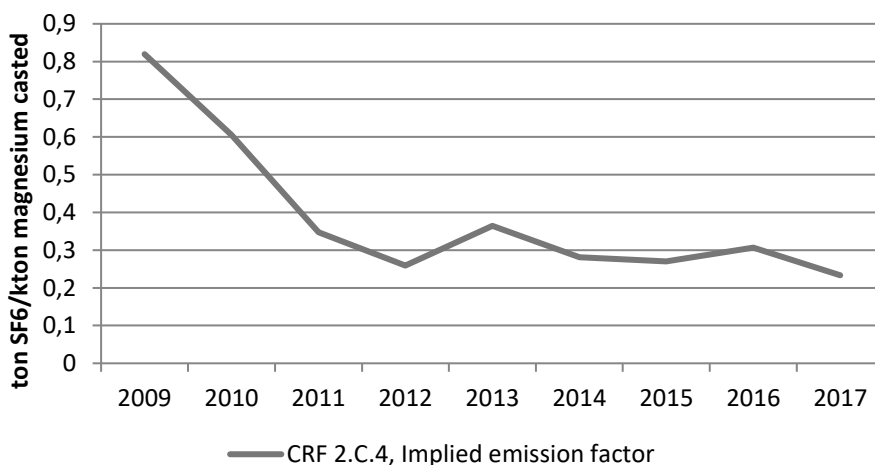


Figure 4.4.6. SF₆ implied emission factors for the largest Swedish magnesium foundry, 2009 – 2017.

4.3.4.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations in submission 2026.

4.3.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.3.5 Lead production (CRT 2.C.5)

4.3.5.1 SOURCE CATEGORY DESCRIPTION

Lead production does occur in Sweden. However, since Swedish non-ferrous metal smelters produce several metals in the same process, emissions cannot be separated and are all included in CRT 2.C.7.c Other metal production. Thus, IE is reported in CRT 2.C.5.

4.3.6 Zinc production (CRT 2.C.6)

4.3.6.1 SOURCE CATEGORY DESCRIPTION

Zinc production does occur in Sweden. However, as Swedish non-ferrous metal smelters produce several metals in the same process, emissions cannot be separated and are all included in CRT 2.C.7.c Other metal production. Thus, IE is reported in CRT 2.C.6.

4.3.7 Other metal production (CRT 2.C.7)

4.3.7.1 SOURCE CATEGORY DESCRIPTION

Due to data confidentiality, CO₂ emissions for 2015 -2020 cannot be displayed for this category. This sub-category includes CO₂, NO_x and SO₂ emissions from one large smelter producing various non-ferrous metals: copper, lead, zinc etc., and from one metal recycling company mainly producing lead. The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.4.14.

Table 4.4.14. Summary of source category description, CRT 2.C.7, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.C.7	CO ₂	X	-		T3	PS	Yes
	CH ₄	NA	NA		NA	NA	No, see Annex 5

T3 Tier 3. PS Plant-Specific.

4.3.7.2 METHODOLOGICAL ISSUES

Emissions of CO₂ originate from one plant producing copper, lead and zinc, and one metal recycling plant mainly producing lead by melting used batteries and recover the lead.

CO₂ emissions from the smelter are calculated based on plant-specific data on raw material consumption and respective CO₂ emission factors as reported to EU ETS (available for 2013 and onwards). Data on raw material consumption for 1990-2012 has been obtained directly from the facility and from its environmental reports. In cases where exact numbers on material use are unavailable, approximation, interpolation, and relations to production volumes have been applied (Yaramenka & Mawdsley²¹⁰). In particular, the following assumptions have been made:

- The amount of electronic scrap increases linearly during 1990-2005 whereas the amount of metal ashes at the same time decreases linearly;
- The amount of metal dust for 1990-1992 is the same as for the year 1993;
- The amount of lead cable correlates with lead production;
- The amount of electrode mass correlates with copper production.

It is assumed that all emission factors are constant over the period 1990-2013 and are the same as reported to EU ETS for 2013, see Table 4.4.15.

²¹⁰ Yaramenka, K., Mawdsley, I. 2015

Table 4.4.15. Emission factors applied for estimating CO₂ emissions from the non-ferrous metal smelter plant in 1990-2013.

Raw material	Emission factor, Gg CO ₂ / Gg material
Lead cable	0.18
Limestone	0.44
Coke	2.89
Metal ashes	0.14
Concentrate	0.01
Electronic scrap	0.90
Electrode mass	3.00
Less valuable electronic scrap	2.24
Metal dust from steel	0.03
Coal	2.85

The metal recycling plant emits CO₂ from the melting of lead batteries composed of carbon containing plastics (polypropylene). The total CO₂ emissions from the plant are reported by the company for all years from 1990. For the years 1990 to 2003, the reported total CO₂ emissions by the company also include energy related emissions, which are subsequently subtracted from the energy sector. From 2005 onwards, the amount of plastics, their carbon content, as well as the CO₂ emissions from plastics are known from the EU ETS. This information for 2005 is used for estimating the process related CO₂ part of the total CO₂ emissions from the plant for the years 1990 until 2003. Also, CO₂ originating from the limestone used is included. For the years 1990 – 2003 the yearly amounts of limestone used are estimated using activity data for 2004.

The reported emissions of SO₂ originate from the sulphur content in the raw materials used.

The reported activity data comprises amounts of copper, lead and zinc produced at the two above mentioned facilities. As shown in Figure 4.4.7 below, metal production does not show the same trend as CO₂ emissions. The metal production does however correlate with the total raw material consumption at the smelter that dominates production (material consumption at the recycling plant is not available for the entire time series and has not been included in this comparison). The main reason for the different CO₂ emission trends is variations in the combination of raw materials at the smelting facility. Ratio of materials with high and low carbon content is a crucial factor determining implied emission factors for non-ferrous metal production. The sharp decline in metal production (copper) in year 2023 is due to a major fire in an electrolysis plant. However, the decline in copper production did not affect the total yearly CO₂ emission since the process in the electrolysis plant is driven by electrical energy.

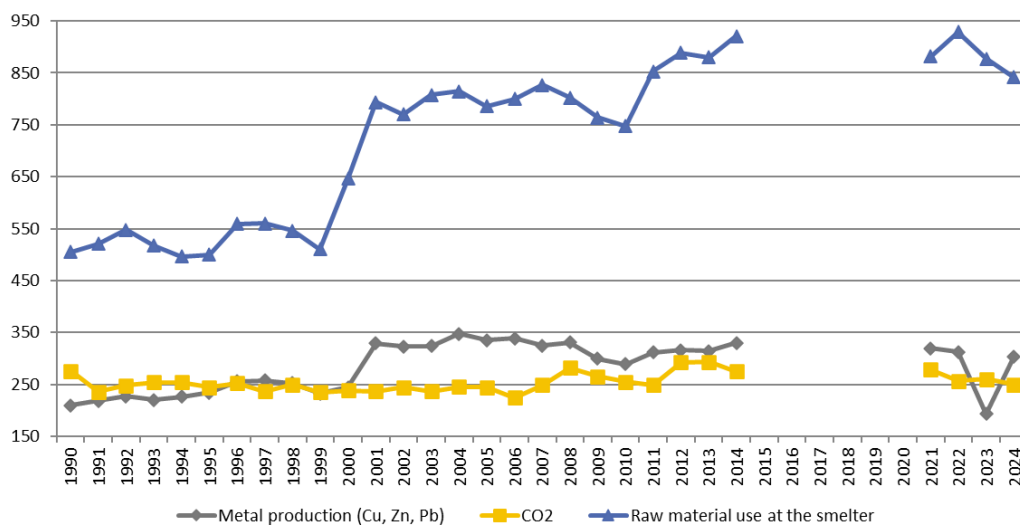


Figure 4.4.7. CO₂ emissions and activity data trends in CRT 2.C.7.c, kt. Due to data confidentiality, data for the years 2015-2020 cannot be displayed.

Figure 4.4.8 illustrates relative consumption of raw materials with different carbon contents at the smelter.

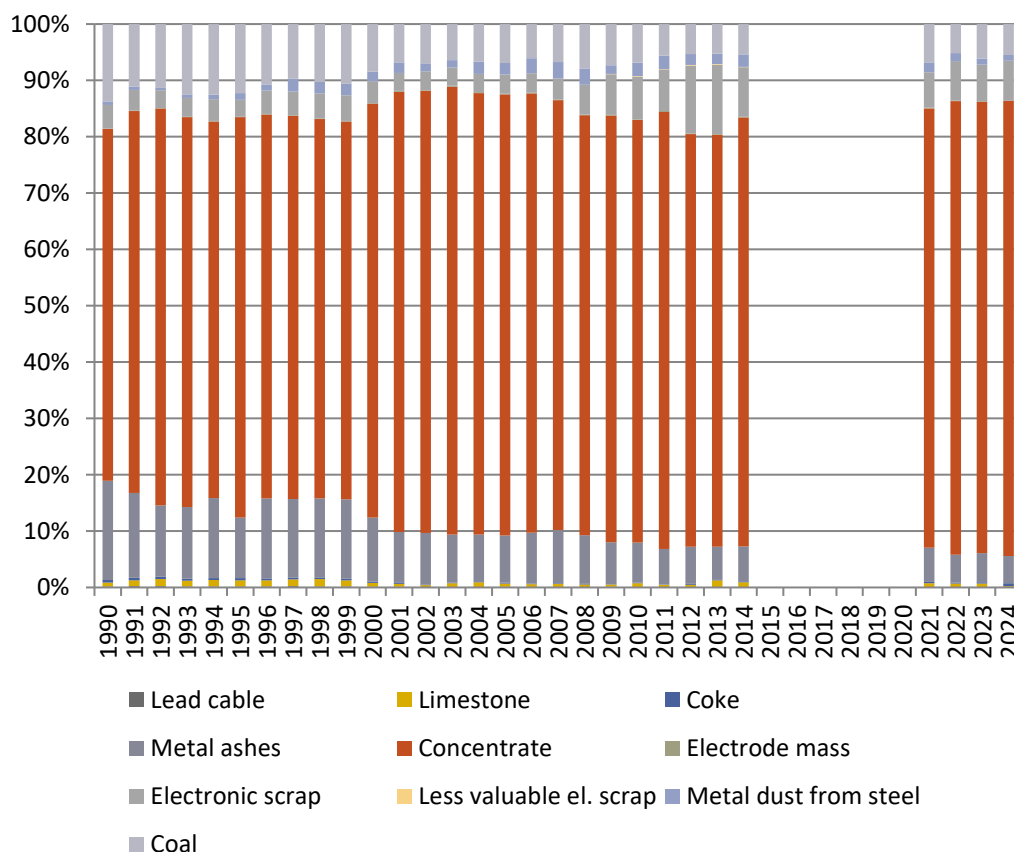


Figure 4.4.8. Consumption of raw materials at the smelter. Due to data confidentiality, data for the years 2015-2020 cannot be displayed.

The share of coal in the total raw material consumption at the smelter is estimated as 10-14% during 1990-1998 and only 7% in 2001. A substantial increase in the produced copper from 133 kt in 2000 to 216 kt in 2001 is not followed by a similar increase in CO₂ emissions, because it has been reached due to higher consumption of copper concentrate with a low emission factor, while the use of other materials, in particular coal, has not increased. Similar relations between emissions and metal production, characterized by rather low implied emission factor, continues until 2008 (see figure 4.4.7 above), when higher amounts of electronic scrap and much more modest increase in copper production cause a notable raise in CO₂ emissions. In 2012, the company installed a new E-kaldo oven for smelting electronic scrap. This resulted in further increase in CO₂ emissions during 2012-2013 compared to previous years. In 2014 the amount of processed electronic scrap was rather low, which is seen in the emission decrease.

4.3.7.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainty for activity data is estimated to $\pm 4\%$. The uncertainty for CO₂ emission factor is estimated to $\pm 5\%$. Time-series are considered to be consistent.

4.3.7.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

In submission 2016, the method for calculating emissions from the smelter has been updated since the previously applied method resulted in substantial underestimations. The new method is described in detail in Yaramenka & Mawdsley²¹¹. The differentiation of raw materials is much wider in Submission 2016 than previously – category “plastic and other raw materials” is substituted with sub-categories “lead cable”, “metal ashes”, “concentrate”, “electrode mass”, “electronic scrap”, “less valuable electronic scrap” and “metal dust from steel production”, each with its own emission factor.

Both plants in this category report emissions in annual environmental reports. The reported activity data and emissions are analysed and compared to EU ETS data. More information on QC activities related to the EU ETS is included in Annex 8.1.

In addition, emissions from the large smelter and the metal recycling plant are included in the cross-sectoral control tool as part of a QC procedure that was developed in 2017 and is further described in section 1.3.5.1. This tool was used again in submission 2026 and suggests that summed emissions reported in CRT 1 and CRT 2 match total emissions reported in the respective environmental reports or to the EU ETS in a sufficient manner.

4.3.7.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed in submission 2026.

4.3.7.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

²¹¹ Yaramenka, K., Mawdsley, I. 2015

4.4 Non-energy products from fuels and solvent use (CRT 2.D)

4.4.1 Lubricant use (CRT 2.D.1)

4.4.1.1 SOURCE CATEGORY DESCRIPTION

In CRT 2.D.1, CO₂ emissions from lubricants during use are reported.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any significant sources are not estimated (NE), is presented in Table 4.5.1.

Table 4.5.1. Summary of source category description, CRT 2.D.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.D.1	CO ₂	X	-		T1	D	Yes

D Default. T1 Tier 1.

4.4.1.2 METHODOLOGICAL ISSUES

Amounts of lubricants per year are obtained from the Swedish Energy Agency and Statistics Sweden. Due to the delay of the data delivered by the Swedish Energy Agency, data for the latest reporting year is set equal to the previous year. Since no obvious trend can be discerned and no data is available for the current year, this is considered to be the best available method. Data for 2024 is thus preliminary and will be updated in submission 2027.

Emissions of CO₂ from oxidation of lubricants during use is calculated according to the following formula:

$$Emissions = \left[\frac{(SM_{TJ} \times CC_{SM} \times ODU_{SM} \times \frac{44}{12})}{1000} \right] - CO_{2D3}$$

Emissions = CO₂ emissions from oxidation of lubricants.

SM_{TJ} = Lubricants, TJ

CC_{SM} = Carbon content in lubricants, t C/TJ

ODU_{SM} = ODU factor (proportion oxidized during use) for lubricants, %

44/12 = mass ratio CO₂/C

/1000 = conversion from t to kt

CO_{2D3} = CO₂ emissions included in CRT 2.D.3_Other_Solvent_use

Factors used for CO₂ estimates are presented in Table 4.5.2.

Table 4.5.2. Parameters used when calculating emission from oxidation of lubricants.

Parameter	Factor	Unit	References
CC _{SM}	20	Ton C/TJ	IPCC 2006, page 5.9
ODU _{SM}	20	%	IPCC 2006, page 5.9

The time series for CO₂ emissions and used amounts of lubricants in CRT 2.D.1 for 1990-2019 is presented in Figure 4.5.1. The amount of lubricant consumed varies relatively large between different years. During 2016-2020, the CO₂-emissions and the used amounts of lubricants were declining. Unfortunately, no specific explanation for this decline has been found by the Swedish Energy Agency and Statistics Sweden. Data for 2021-2024 showed an increase of the CO₂-emissions and the used amounts of lubricants to the average value slightly below the levels of 2002-2016, which means that the declining trend is broken. Amount of lubricants used in 2020 was the lowest in the time series. However, data for 2020 – 2024 cannot be shown due to confidentiality reasons.

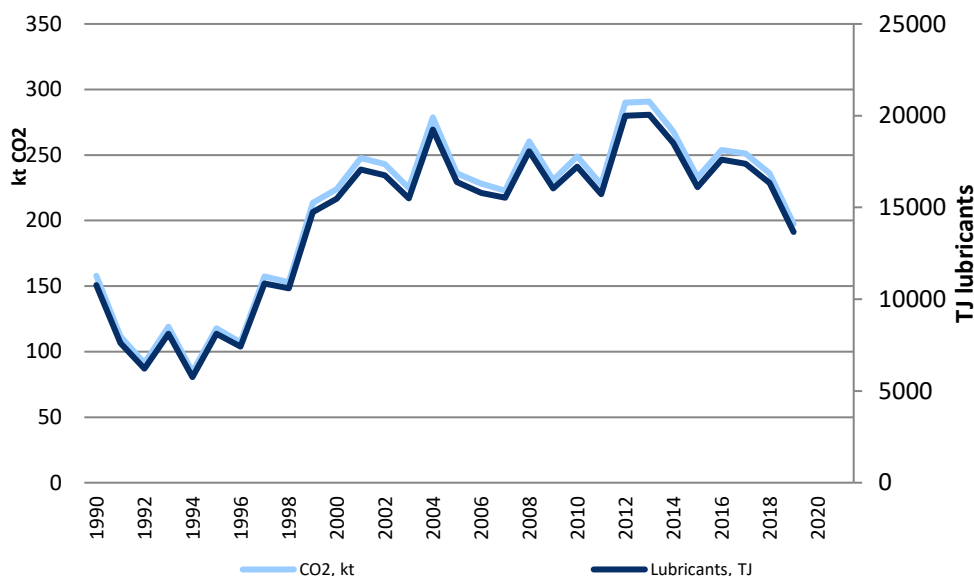


Figure 4.5.1. Time series for CO₂ (kt) and used amounts of lubricants (TJ) in CRT 2.D.1. Data for 2020-2024 are confidential.

4.4.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The applied methodology has been the same during all the years and is therefore considered to be consistent. The activity data is based on information from the Swedish Energy Agency (2005 – 2023) and from Statistics Sweden (1990 – 2004). Data for 2024 is preliminary and will be updated in submission 2027.

Uncertainties for CRT 2.D.1 Lubricants are in accordance with 2006 IPCC Guidelines for National Greenhouse Gas Inventories. The total uncertainty of the EF used is set to $\pm 50\%$, and the uncertainty of activity data is set to $\pm 5\%$.

4.4.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

4.4.1.5 SOURCE-SPECIFIC RECALCULATIONS

As data from the Swedish Energy Agency was not available in time in submission 2026, input data for 2024 was estimated based on data for 2023. In Submission 2026, activity data for 2023 has been retrieved from the Swedish Energy Agency and were updated accordingly in the calculations.

Some lubricants have a vapour pressure of 0.01 kPa or more at 293.15 K, meaning that CO₂ emissions from these lubricants were previously included in CRT 2.D.3 Other Solvent use and subtracted from the amounts reported in CRT 2.D.1 Lubricants. Since submission 2025, no CO₂ emissions are reported in CRT 2.D.3 Other Solvent use. In submission 2026, subtraction of the respective emissions from CRT 2.D.1 Lubricants was removed, which resulted in 1-2% increase of emissions in the entire time series.

The resulting changes in emissions cannot be displayed due to confidentiality reasons.

4.4.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.4.2 Paraffin wax use (CRT 2.D.2)

4.4.2.1 SOURCE CATEGORY DESCRIPTION

Paraffin waxes are produced from crude oil and used in a number of different applications such as candles, corrugated boxes, paper coating and many others. Incineration of such products results in emissions of fossil CO₂. In CRT 2.D.2, CO₂ emissions from the use (incineration) of paraffin candles are reported, while emissions from incineration of e.g., corrugated boxes and coated paper are reported in the energy sector (CRT 1).

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.5.3.

Table 4.5.3. Summary of source category description, CRT 2.D.2, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.D.2	CO ₂	-	-		T1	D	Yes

D Default. T1 Tier 1.

4.4.2.2 METHODOLOGICAL ISSUES

Quantities of imported and exported candles (stearin and paraffin candles, tapers) are taken from Statistic Sweden's statistical database. Import and export data for the years 1990-2001 are considered to be uncertain, thus for these years the values for 2002 are applied. For the assumption of the fraction of paraffin candles of the total imported and exported candles, information from Norway's reporting to UNFCCC has been used (66%), since domestic data is missing.

Amounts of imported paraffin waxes are obtained from the Product Register at the Swedish Chemicals Agency (KemI). Information on the amount of carbon in these paraffin waxes has been received from KemI. Data for 1990 - 1994 is missing in the Product Register, and for these years the value for 1995 is applied. Based on this data, CO₂ emissions are calculated using emission factors and other information presented in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories.

Due to the delay of the data delivered by the Swedish Chemicals Agency, data for the latest reporting year is set equal to the previous year. Since no obvious trend can be

discerned and no data is available for the current year, this is considered to be the best available method. Data for 2024 is thus preliminary and will be updated in submission 2027.

The CO₂ emission estimates are performed in two ways depending on the data source:

1. Imported and exported amounts of candles
2. Imported amounts of paraffin waxes

$$Emission = \left[\frac{(TL_t \times PF_{\%} \times VV_{Wax} \times CC_L \times \frac{44}{12})}{1000} \right] \quad (1)$$

$$Emission = \left[\frac{(TP_{Wax} \times ODU_{Wax} \times \frac{44}{12})}{1000} \right] \quad (2)$$

Emission = CO₂ emissions from incineration of paraffin candles, kt

TL_t = total import of candles – total export of candles, t

PF_% = Proportion of paraffin candles, %

VV_{Wax} = Heating value for paraffin wax, TJ/t

CC_L = carbon content in paraffin candles, t C/TJ

TP_{Wax} = carbon content in paraffin wax, t

ODU_{Wax} = ODU factor for paraffin (proportion oxidized during use = share of paraffin wax used for paraffin candle production), %

44/12 = mass ratio CO₂/C

/1000 = conversion from t to kt

Factors used for the CO₂ estimates are presented in Table 4.5.4.

Table 4.5.4. Parameters used when calculating emissions.

Parameter	Factor	Unit	References
PF _%	66	%	National Inventory Report, Norway ²¹²
VV _{Wax}	0.0402	TJ/t	Statistics Sweden
CC _L	20	Ton C/TJ	IPCC 2006, page 5.12
ODU _{Wax}	20	%	IPCC 2006, page 5,12

The time series for CO₂ emissions in CRT 2.D.2 is presented in Figure 4.5.2. The IEF is the same for the whole time series, 0.073 kt/TJ. Data for 2020-2024 cannot be shown due to confidentially reasons.

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http://unfccc.int/national_reports/annex_i_ghg_inventories/national_inventories_submissions/items/8108.php

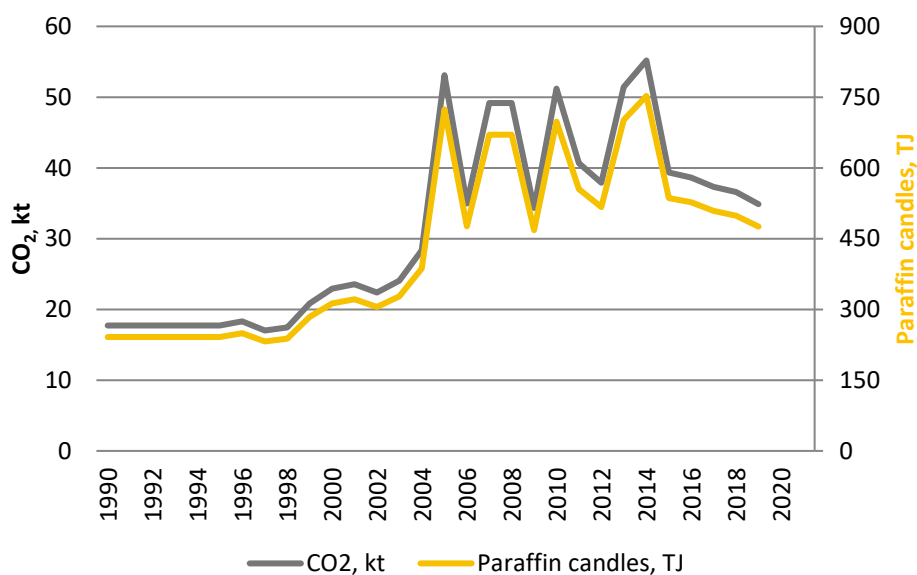


Figure 4.5.2. Time series for CO₂ (kt) and used amounts of paraffin candles (TJ) in CRT 2.D.2. Data for 2020-2024 are confidential.

4.4.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The applied methodology is the same for all years and is therefore considered to be consistent. The amount of paraffin waxes for 2024 is preliminary and may be updated in submission 2027.

Uncertainties for CRT 2.D.2 Paraffin wax use is, as far as possible, in accordance with information in Chapter 3 of the 2006 IPCC Guidelines. Most of the CO₂ emissions reported in CRT 2.D.2 Paraffin wax use derives from the data on imported and exported amounts of candles. These statistics are judged to be of high quality with relatively low uncertainty. The share of reported CO₂ based on the carbon content of imported paraffin constitutes only 5-10% of the total CO₂. The high uncertainty for ODU factor according to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories should thus not be of great importance for the overall uncertainty.

The total uncertainty of the EF used is set to $\pm 50\%$, and the uncertainty of activity data is set to $\pm 10\%$.

4.4.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

4.4.2.5 SOURCE-SPECIFIC RECALCULATIONS

As data from the Swedish Chemicals Agency was not available in time in submission 2026, input data for 2024 was estimated based on data for 2023. In Submission 2026, activity data for 2023 has been retrieved obtained and used in the calculations. The resulting changes in emissions cannot be displayed due to confidentiality reasons.

4.4.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.4.3 Other (CRT 2.D.3)

4.4.3.1 SOURCE CATEGORY DESCRIPTION

In this source category urea used as a catalyst are included.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.5.5.

Table 4.5.5. Summary of source category description, CRT 2.D.3, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.D.3	CO ₂	-	-		T1, T3*	CS, D*	Yes

D Default. CS Country Specific. T1 Tier 1. T3 Tier 3.

* Urea used as a catalyst

Urea is used as a reducing agent in some types of NO_x reducing catalysts. These kinds of catalysts are used in the transport sector, e.g., in trucks, passenger cars and ships, but also in stationary combustion plants. The increased use until 2017 are mainly a consequence of increased use in heavy duty road vehicles since catalysts have been more or less necessary in order to comply with the latest emission standards (Euro V and later). When reacting with the nitrogen oxides and oxygen at the catalyst surface, the carbon in the urea molecule will result in CO₂ emissions.

4.4.3.2 METHODOLOGICAL ISSUES

There is no production of urea in Sweden, meaning that all used urea is imported. For estimation of CO₂ emissions from urea used in catalysts, the net imports are used as activity data. Data is taken from the Product Register at the Swedish Chemicals Agency, where 100% pure urea for use in catalysts is specified as a category. The emissions are calculated with equation 3.2.2 presented in section 3.2.1.1 of the mobile combustion Chapter in the Energy sector in 2006 IPCC Guidelines, based on the assumption of purity of 100%. No data is available prior to 1995 and therefore, the CO₂ emissions for 1990-1994 is estimated from the average CO₂ emission from 1995-1999.

Due to the delay of the data delivered by the Swedish Chemicals Agency, data for the latest reporting year is set equal to the previous year. Since no obvious trend can be discerned and no data is available for the current year, this is considered to be the best available method. Data for 2024 is thus preliminary and will be updated in submission 2027.

CO₂ from the urea use is calculated in accordance with 2006 IPCC Guidelines. See Table 4.5.6 for activity data and calculated emissions.

Table 4.5.6. Activity data and emissions of CO₂ from urea used in NO_x reducing catalysts.

Year	Net imports of urea, kt	CO ₂ emissions, kt
1990	6.5	4.7
1995	7.1	5.2
2000	6.3	4.6
2005	14.3	10.5
2010	20.6	15.1
2015	51.6	37.9
2020	50.1	36.7
2021	50.1	36.7
2022	49.2	36.1
2023	52.6	38.6
2024	48.9	35.9

4.4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The total uncertainty of the EF used is set to $\pm 5\%$, and the uncertainty of activity data is set to $\pm 40\%$.

4.4.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Activity data from the Product Register as net imports of urea used in catalyst has been compared with estimated national sales of urea solutions during 2010-2013 done by one of Sweden's importers of urea solutions for catalysts. The sources agree well 2010 and 2011 but in 2012 the Product Register data is significant higher. Since data from the importer were estimates and not official data, we have chosen to go with the official data from the Product Register. CO₂ emissions from urea use in road vehicles have beside the already described method also been calculated using the default method from IPCC 2006 Guidelines, as a quality check. The 2006 IPCC guidelines method only includes urea used in road vehicles and not in ships or stationary combustion plants. The importer estimates that of total used urea in 2010 (as pure urea and not urea water-based solution) 25% were used in ships, 35% in road vehicles and 40% in stationary combustion plants. The estimated urea use from road vehicles according to Guidelines is about 45% of Sweden's estimates of total used urea in 2010.

Since 2010, the share of urea used in road vehicles has increased due to more road vehicles using urea-based catalysts.

4.4.3.4.1 SOURCE-SPECIFIC RECALCULATIONS

For 2022, correction of exported values was made, resulting in 0.7 kt CO₂ emission decrease.

As data from the Swedish Chemicals Agency was not available in time in submission 2026, input data for 2024 was estimated based on data for 2023. In Submission 2026, activity data for 2023 has been retrieved obtained and used in the calculations. This resulted in 1.8 kt CO₂ emission increase.

4.4.3.5 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.5 Electronics industry (CRT 2.E)

4.5.1 Integrated circuit or semiconductor (CRT 2.E.1)

4.5.1.1 SOURCE CATEGORY DESCRIPTION

HFC, PFC and SF₆ are used in the semiconductor manufacturing process. Semiconductor manufacture has in earlier years occurred on a commercial scale at only one facility in Sweden. Previously, one more facility was located in Sweden, but production was moved abroad. During 2004, the production in the only facility left was also closed down.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.6.1.

Table 4.6.1. Summary of source category description, CRT 2.E.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.E.1	HFCs	NA	NA		T1*	D*	Yes
	PFCs	NA	NA		T1*	D*	Yes
	SF ₆	NA	NA		T1*	D*	Yes

D Default. T1 Tier 1.

* From 2005 NO

4.5.1.2 METHODOLOGICAL ISSUES

Information concerning the annually used amounts of various fluorinated substances has been provided by the company, and as far as possible been compared to information from the Products Register at the Swedish Chemicals Agency. Emissions are calculated using the 2006 IPCC Guidelines Tier 1 method using an average expected lifetime of one year.

4.5.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Emission estimates are judged to be of good quality. The quality of activity data is usually better for the later years than for the earlier years of the inventory. The uncertainty for activity data is judged to be $\pm 2\%$ and the uncertainty of the emission factor for HFCs, PFCs and SF₆ are judged to be $\pm 20\%$.

The time series are calculated using the same methodology for all years and are thus consistent.

4.5.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Cross-references with the Products Register at the Swedish Chemicals Agency could not be made for the entire reported time series, since the level of detail in the Products Register was insufficient.

4.5.1.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed.

4.5.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.5.2 TFT Flat panel display (CRT 2.E.2)

4.5.2.1 SOURCE CATEGORY DESCRIPTION

No production of TFT flat panel displays is currently known to occur in Sweden, thus NO is reported for CRT 2.E.2.

4.5.3 Photovoltaics (CRT 2.E.3)

4.5.3.1 SOURCE CATEGORY DESCRIPTION

No production of photovoltaics occurs in Sweden; thus, NO is reported for CRT 2.E.3.

4.5.4 Heat transfer liquid (CRT 2.E.4)

4.5.4.1 SOURCE CATEGORY DESCRIPTION

There are no electronic industries using FCs in Sweden; thus, NO is reported for CRT 2.E.4

4.5.5 Other (CRT 2.E.5)

4.5.5.1 SOURCE CATEGORY DESCRIPTION

NO is reported for CRT 2.E.5.

4.6 Product uses as substitutes for ODS (CRT 2.F)

Use and emissions of halocarbons have increased since 1990, especially in refrigeration and air-conditioning equipment (CRT 2.F.1), which is the main source of halocarbon emissions in Sweden.

The largest emission source in 2023 is refrigeration and air conditioning (2.F.1) and the second largest is aerosols (2.F.4), followed by foam blowing (2.F.2, XPS-foam). The remaining source, fire protection (2.F.3), is a comparatively small emitter of fluorinated greenhouse gases.

All sub-categories are covered in the estimates except solvents (2.F.5). According to available information, solvents containing HFCs or PFCs are not used in Sweden. An overview of reported emissions in CRT 2.F are shown in Table 4.7.1. The decreasing emission trend in the last few years is mainly due to the use of more efficient equipment and the transition towards lower GWP refrigerants (e.g., HFO (R1234yf) in vehicle air-conditioning, propane (R290) in heat pumps and CO₂ (R744) in supermarket refrigeration).

Due to issues with CRT Reporter, notation keys are missing for many F-gases. The notation key for HFC-23, HFC-245fa, HFC-365, HFC 43-10mee, HFC-134 and NF3 is IE while that of other HFCs and PFCs is NO.

Table 4.7.1. Overview of submitted emission data in CRT 2.F, kt CO₂ eq.

Year	2.F.1 Refrigeration and air-conditioning	2.F.2 Foam blowing agents	2.F.3 Fire protection	2.F.4 Aerosols	2.F.5 Solvents	2.F.6 Other use of ODS substitutes
1990	4.6	NO	NO	1.3	NO	NO
1995	122	NO	NO	6.7	NO	NO
2000	592	111	5.5	22	NO	NO
2005	929	87	6.0	29	NO	NO
2010	1005	32	5.1	25	NO	NO
2011	982	36	2.1	21	NO	NO
2012	970	35	1.9	18	NO	NO
2013	959	37	1.2	18	NO	NO
2014	984	35	1.0	20	NO	NO
2015	1005	34	0.8	20	NO	NO
2016	1023	33	0.8	20	NO	NO
2017	985	32	3.4	21	NO	NO
2018	932	31	1.5	21	NO	NO
2019	891	27	1.3	16	NO	NO
2020	849	26	0.6	13	NO	NO
2021	820	16	0.2	14	NO	NO
2022	790	10	0.2	15	NO	NO
2023	732	9	0.0	15	NO	NO
2024	683	8	0.0	16	NO	NO

The Swedish F-gas model

A national model corresponding to the IPCC Tier 2 approach has been used to estimate emissions in all subcategories, as far as possible. The basis for the emission estimates is the annual bulk import and export statistics of fluorinated greenhouse gases recorded in the Swedish Chemicals Agency's Products Register. However, the register does not cover all chemicals already filled in products imported to or exported from Sweden (e.g., air-air heat pumps, metered dose inhalers, refrigerated trucks and lorries, passenger cars, light and heavy-duty vehicles and busses). In order to make a complete reporting of fluorinated greenhouse gas emissions and, as far as possible, to facilitate allocation of emissions into the IPCC source categories, additional information from various trade associations and companies are collected annually. The Swedish model, a combination of top-down and bottom-up, is schematically illustrated in Figure 4.7.1 below. In submission 2022, 2023, 2024 and 2025 data from the SPIN database (Substances in Preparations in the Nordic Countries²¹³) has also been used.

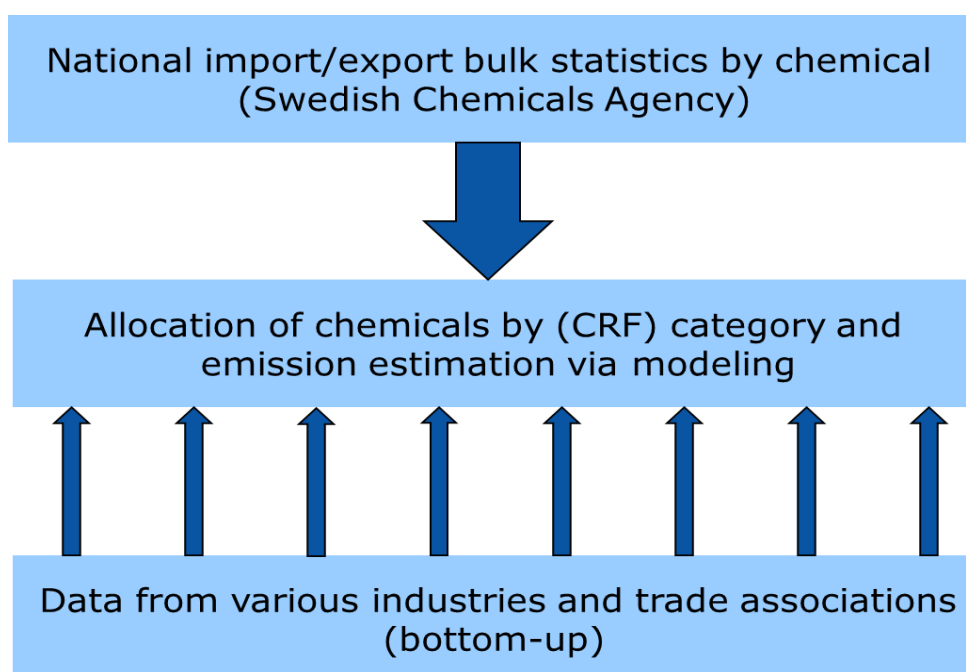


Figure 4.7.1. Schematic illustration of the Swedish national model used for estimation of emissions of fluorinated greenhouse gases.

As of submission 2015, the reporting is in accordance with the 2006 IPCC Guidelines. This means, for example, that the reporting includes the new F-gases HFC-152, HFC-161, HFC-236cb, HCF-236ea, HFC-245fa, HFC-365mfc, C₁₀F₁₈, c-C₃F₆ and NF₃. HFC-23, HFC-245fa, HFC-365, HFC-43-10mee, HFC-236fa and HFC-134 are used in small amounts in Sweden. Consumption data is classified as confidential. After correction of the amounts using the GWP values of the substances, HFC-134, HFC-245fa and HFC-43-10mee have been summed up with HFC-134a, HFC-365 with HFC-32 and HFC-23 and HFC-236fa with HFC-143a.

The model is described in more detail in Annex 3:1.

²¹³ <http://spin2000.net/>

4.6.1 Refrigeration and air conditioning (CRT 2.F.1)

4.6.1.1 SOURCE CATEGORY DESCRIPTION

Emissions of HFCs and PFCs from heat pumps, stationary air-conditioning, mobile air-conditioning, refrigeration, and freezing equipment are included in this category. Emissions of SF₆ from refrigeration and air conditioning equipment are not occurring (NO) in Sweden.

Emissions from HFCs and PFCs in 2.F.1. have increased largely between 1990 (5 kt CO₂ eq.) to 2016 (1023 kt CO₂ eq.). From 2017 onwards, however, the trend has reversed, and emissions have continuously declined (682 kt CO₂ eq., 2024). From 2005 to 2017, the most important source of greenhouse gases in this category has been the F-gas emissions from air-conditioning in mobile air-conditioning (MAC, CRT 2.F.1.e). As of 2017, emissions from MAC have decreased while emissions from commercial refrigeration (CRT 2.F.1.a) and industrial refrigeration (2.F.1.c) have become dominant (Figure 4.7.2).

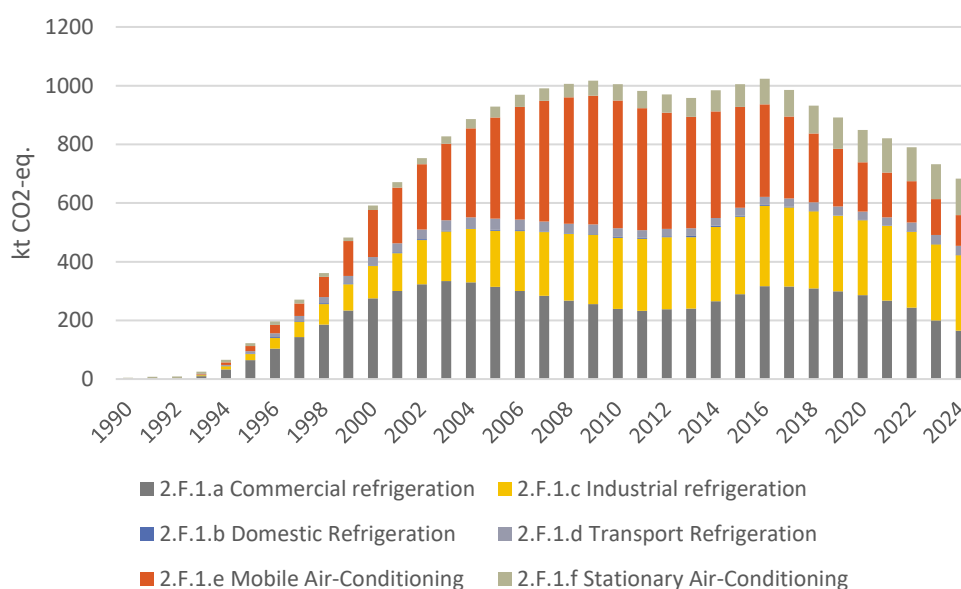


Figure 4.7.2. Overview of submitted emission data in CRT 2.F, separated in subsectors, kt CO₂ eq.

Due to the EU F-Gas Regulation (EU 517/2014), the use of high GWP HFCs as refrigerants is gradually being phased out in several areas, such as air-conditioning in vehicles, heat pumps, as well as supermarket fridges and freezers. Efforts are ongoing to replace these with other alternatives. Examples of alternative refrigerants include HFOs, propane, NH₃ and CO₂, as well as other HFCs with lower GWP.

The decreasing emissions from MAC are also a result of steadily improving equipment in vehicles, leading to declining leakages. Thus, the introduction of HFO-1234yf as a substitute for HFC-134a in passenger cars and light-duty vehicles, has also contributed to the decline in emissions. Similarly, the overall decreasing trend in CRT 2.F.1 over the last few years is a result of the more efficient equipment, and the transition to lower GWP refrigerants.

Starting as early as in the 1980s Sweden has had strict regulation regarding F-gases through legislation, (SNFS 1988:3, later amended by SNFS 1992:16). The Swedish Refrigeration Code of Best Practice (Svensk Kylnorm) include directives concerning annual supervision of refrigeration and heat pump equipment, which includes leakage control, but also requirements for preventive measures. In addition, starting in the late 1980s, companies operating with installations, service, maintenance or execution of the mandatory supervision, have professional permits from the Swedish Environmental Protection Agency, later transferred to requirements for accreditation with SWEDAC (Sweden's national accreditation body). The early national regulation and directive have, in many cases, lead to comparatively low leakage rates in Sweden.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.7.2.

Table 4.7.2. Summary of source category description, CRT 2.F.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.1	HFCs	X	X		T2a	CS, D	Yes
	PFCs	-	-		T2	CS	Yes
	SF ₆	NA	NA		NO	NO	NO

CS Country Specific. D Default. T2a Tier 2a.

4.6.1.2 METHODOLOGICAL ISSUES

Input data for the calculation of emissions consists of information from various sources: the Swedish Chemicals Agency, the SPIN database, equipment producers and importers. Table 4.7.3 summarizes the values for chemical charge, lifetime and emission factors for the applications used in the Swedish inventory. They are based on information from the equipment producers, from IPCC default values and, for working machinery and off-road vehicles, from the national model used to estimate other emissions than HFCs (number of working machinery/off-road vehicles and lifetime)²¹⁴ and from the Finnish inventory²¹⁵.

Regarding data collection on recovered F-gases, the Swedish F-gas model incorporates assumptions regarding the reuse of recovered refrigerants, primarily within the same equipment. Most reused refrigerants are recycled locally rather than through centralized processes. Centralized recycling of F-gases does occur at several facilities in Sweden, and the model assumes that these recycled quantities are subsequently returned and refilled into installed equipment. However, the model does not explicitly quantify the amount of reuse or recycling, as such data are not systematically reported to Swedish authorities. As of now the lack of data collection isn't of concern as per-capita comparisons with other Nordic countries, doesn't show any evidence of significant systematic over- or underestimation of emissions.

Given intervals indicate changes between 1990 and the last inventory year used in the calculations.

²¹⁴ Described in Annex 2

²¹⁵ Tommi Forsberg, SYKE, Finland, personal communication 2018-08-29

Table 4.7.3. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of HFCs or PFCs used in calculations of emissions in Sweden. Given intervals indicate changes between 1990 and the last inventory year used in the calculations.

Application	Fluorinated substances	Lifetime**	Amount installed /unit, kg	Initial emissions, %	Lifetime emissions, %	Remained in product at disposal, %	Emissions at disposal, %
Stand-alone commercial applications (2.F.1.a)	HFCs	10	*	0.5	1	90	5
Medium and large commercial applications (2.F.1.a)	HFCs, PFC-218	7	*	0.5	10	90	5
Domestic refrigeration (2.F.1.b)	HFCs	20	0.1	2	1	90	5
Industrial refrigeration (2.F.1.c)	HFCs	15	*	0.5	7	90	5
Transport refrigeration (2.F.1.d)	HFCs	10	10 - 6	4.5	30 - 7	90	15
Mobile air-conditioning, heavy duty vehicles (2.F.1.e)	HFCs	6	1.2	1 – 0.5	15 - 10	90	15
Mobile air-conditioning, light duty vehicles (2.F.1.e)	HFCs	11	0.8 - 0.7	1 – 0.5	15 - 5	90	15
Mobile air-conditioning, passenger cars (2.F.1.e)	HFCs	11	0.8 - 0.7	1 – 0.5	15 - 5	90	15
Mobile air-conditioning, buses (2.F.1.e)	HFCs	12	7	1 – 0.5	10	90	15
Mobile air-conditioning, A-tractor cars (modified passenger cars registered as tractors) (2.F.1.e)	HFCs	11	0.8 - 0.7	1 – 0.5	15 - 5	90	15
Mobile air-conditioning, working machinery/off road vehicles - tractors (2.F.1.e)	HFCs	7	1	5	30	90	15
Mobile air-conditioning, working machinery/off road vehicles - other (2.F.1.e)	HFCs	8-20***	1.5	5	30	90	15
Heat pumps (2.F.1.f)	HFCs	20-15	5 - 1	1	10 - 1	90	5
Other stationary AC (2.F.1.f)	HFCs	10	*	1	1	90	5

* Top-down calculations

** Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.

*** Depending of type of machinery

2.F.1.a, 2.F.1.c, 2.F.1.f

The information on refrigerant-related imported amounts of fluorinated gases from the Swedish Chemicals Agency's Products Register is compared to calculations made in the model, based on assumptions and information from other sources. Since not all sources are possible to trace separately in the inventory, the amounts imported to the country according to the products register is larger than calculated from the individual sources covered in the model. In order to account for the total volumes of refrigerant-related fluorinated substances, the amount of imported chemicals to Sweden, derived from the Products Register, is assumed to be the correct data. From these data, the amounts of chemicals already accounted for in other applications, treated separately in the calculations, are subtracted. The resulting remainder of all refrigerant related HFCs and PFCs from the Products Register is allocated as input data in the sub-sources Commercial

applications (2.F.1.a), Industrial refrigeration (2.F.1.c) and Stationary AC (2.F.1.f). The chemicals concerned are HFC-23, HFC-32, HFC-125, HFC-134, HFC-134a, HFC-143a, HFC-152a, HFC-245fa and PFC-218 (C₃F₈). Information from the Swedish Refrigeration & Heat Pump Association gives that 100% of all air-to-air heat pumps, 5% of all liquid water heat pumps and about 30% of all air water heat pumps are imported pre-filled with refrigerants. The amounts of F-gases in imported heat pumps are thus not included in the bulk import statistics from the Swedish Chemicals Agency. All exhaust air-to-air heat pumps are manufactured in Sweden.

In submissions prior to 2018, emissions from commercial, industrial, and stationary applications were reported together in commercial refrigeration, 2.F.1.a. As there currently are no national statistics that can be used for allocation between 2.F.1.a, 2.F.1.c and 2.F.1.f, an alternative reallocation model has been used. This model is based on information from Germany's reporting of installed amounts of F-gases in 2.F.1.a, 2.F.1.c and 2.F.1.f from submission 2016. The gases reported by Germany in these codes are also included in the Swedish reporting for 2.F.1.a, 2.F.1.c and 2.F.1.f. Most of the gases show similar trends in quantities used in Germany as used in Sweden in the period 1990 - 2014. Exception is HFC-143a where there is an increase in use in Sweden up to emission year 2016 while it is decreasing in Germany. After 2016, the use of HFC-143a has decreased in Sweden.

According to Germany's NID, the calculations for these three CRT categories are based mostly on models. The input for 2.F.1.a is the sales area of supermarkets, or the number of stores (for low-cost markets) and the quantity and type of refrigeration and freezing systems used per m² and per store (emission factor). The emission factor for 2.F.1.a is based on information from literature or by so-called "expert judgement". For 2.F.1.c, inputs to the calculations are the amount of food and beverages produced and estimation from the literature of the cooling effect required for the production of these foods and beverages. The calculations of emissions in 2.F.1.f are based on data on the number of produced and the number of installed heat pumps and emission factors.

The distribution of the F-gases between 2.F.1.a, 2.F.1.c and 2.F.1.f has been developed for the period 1990 - 2014 and applied to corresponding amounts in the Swedish model. For 2015 – 2021 the same distribution as for 2014 has been used. As before, it is the amount of HFCs and PFCs not allocated to other codes within 2.F that are allocated to 2.F.1.a, 2.F.1.c and 2.F.1.f.

In the UNFCCC review in September 2017, the ERT pointed out that the Swedish national leakage factors appear to be too low for emissions from installed volumes. The ERT also pointed out that the leakage factors for emissions from manufacturing were in many cases considerably higher in the Swedish F-gas model compared to other countries and to IPCC default factors. Therefore, it was important, if possible, to find new leakage factors relevant to Sweden. As mentioned previously, there are currently no national statistics that can be used to find new national emission factors in CRT 2.F.1.a, 2.F.1.c and 2.F.1.f. Therefore, IPCC default factors (lowest value in range) have been used in the Swedish F-gas model for submission 2018 – 2025, both for emissions from manufacturing and for emissions from installed amounts for 2.F.1.a, 2.F.1.c and 2.F.1.f. Calculations of emissions from heat pumps, reported in 2.F.1.f, are however calculated using national emission factors. In the 2006 IPCC Guidelines emission factors given for Stand-alone Commercial Applications and for Medium & Large Commercial

Refrigeration differ significantly. In order to be able to allocate quantities of F-gases within 2.F.1.a to these two types of applications, statistics from Finland has been used (data for 2000-2015). For 1990-1999, the distribution for 2000 has been applied and for 2016-2023, the distribution for 2015.

The model has been updated due to the shift from commonly used high GWP HFCs to alternative refrigerants, and from 2021 onwards, a new refrigerant, R290 (propane), was introduced for heat pumps in Sweden.

As the assumed lifetime of the applications has a significant impact on emissions from installed volumes and also on emissions from decommissioning, the IPCC default values (lowest value in range) have been used for lifetime in 2.F.1.a, 2.F.1.c and 2.F.1.f (but national lifetimes for heat pumps).

2.F.1.b

Activity data for household refrigerators for the 1990s have been obtained from EHL (Elektrisk Household appliances) which is a trade association that has aggregated information on the sale of refrigerators and freezers. For the years after 1999, a constant number has been assumed (450,000 units/year). 75% of the total number is assumed to have been manufactured in Sweden and 25% is imported (Kindbom et al., 2001).

Between 1990 and 1993, CFCs were used as refrigerants in household refrigerators and freezers, for 1991 and 1992 together with HFC-134a. From 1994 onwards, propane has gradually replaced HFC-134a and had completely replaced HFC-134a by 2008²¹⁶.

2.F.1.d

Data on the number of refrigerated trucks and trailers has been retrieved from the Traffic Register at the Swedish Road Administration and from Transport Analysis.

Until 1992, CFCs and HCFCs were used as refrigerants. From 1993 and 1994, it was assumed that 30% of new registered refrigerated trucks and trailers used R404a (44% HFC-125, 4% HFC-134a, 52% HFC-143a) as refrigerant. From 1995 onwards only R404a has been used. However, as of the year 2018, a new refrigerant, R452A, has been introduced onto the market.

As the model assumes that the lifetime for refrigerated trucks and trailers is ten years, disposal in CRT 2.F.1.d is reported for the first time in 2003. Notation key NO (Not occurring) is reported for emissions from manufacturing and from stock for the years 1990, 1991 and 1992 and for disposal for the years 1990-2002.

Used emission factors have been developed through contact with the industry²¹⁷.

2.F.1.e

During the period from 1990 onwards, the product life factor (leakage from installed quantities) has decreased from 15% in the 1990s to 5% from 2011 onwards. 15% in the 1990s corresponds to the mid-range of the default emission factors in 2006 IPCC

²¹⁶ Kindbom et al., 2001

²¹⁷ Kindbom et al., 2001

Guidelines. In the early 2000s, a study was conducted²¹⁸, in which contact was made with the industry to investigate, among other things, whether the leakage factors used in the Swedish F-gas model were relevant. The industry then announced that they had improved and reduced the operational leakage. Therefore, a leakage factor of 10% has been applied between 2001 and 2009. In 2006 IPCC Guidelines, Schwarz and Harnisch (2003)²¹⁹ estimates operation emission factor to be between 5.3% to 10.6% for second generation mobile air conditioners installed in European models in 1996 and beyond. This corresponds well with the Swedish emission factor for leakage from installed amounts. The leakage factor for the year 2000 is interpolated between 1999 and 2001.

In 2011, another survey was published in which, among other things, leakage factors for MAC were studied²²⁰. In the study, Volvo Cars, the largest passenger car producer in Sweden, was contacted. According to Volvo Cars, the range for annual leakage is approximately 7-20 g. This corresponds to an annual leakage of approximately 1-3%. Based on the information from Volvo Cars it was suggested that the yearly operation emission factor in Sweden to be lowered to 7.5% in 2010 and to 5% in 2011 and beyond. The leakage factor is higher than the information from Volvo Cars indicates, to avoid an underestimation of the emissions leakage because of accidents and increased wear due to age.

The model assumes that the leakage factors used can be applied to all manufacturers' passenger cars in Sweden.

As of 2021 onwards, a shift in refrigerants, from R134a to R1234yf, is introduced for vehicles produced in Sweden.

The amount of HFC filled into new manufactured products is based on data on the number of vehicles built in Sweden. Installed quantities in operating systems are based on the annual number of newly registered vehicles, regardless of whether the vehicles are produced in Sweden or imported.

Factors used in 2.F.1

All factors used for emission estimates in 2.F.1.a, 2.F.1.b, 2.F.1.c, 2.F.1.d and 2.F.1.f are presented in detail in Table 4.7.4.

²¹⁸ Kindbom et al., 2001

²¹⁹ Schwarz and Harnisch, 2003

²²⁰ Gustafsson, 2011

Table 4.7.4. Emission factors used for emission estimates in CRT 2.F.1.

CRT	Year	Lifetime, years	Charge, kg	EF Initial Emission, %	EF Operation Emission, %/year	Emissions at disposal, %	Initial Charge Remaining, %
2.F.1.a Stand alone	1990-2024	10		0.5	1	5	90
2.F.1.a Medium & Large	1990-2024	7		0.5	10	5	90
2.F.1.b	1990-2024	20	0.1	2	1	5	90
2.F.1.c	1990-2024	15		0.5	7	5	90
2.F.1.d	1990	NO	NO	NO	NO	NO	NO
	1991	NO	NO	NO	NO	NO	NO
	1992	NO	NO	NO	NO	NO	NO
	1993	10	8.5	4.5	20	NO	NO
	1994	10	8	4.5	20	NO	NO
	1995	10	8	4.5	15	NO	NO
	1996	10	7.5	4.5	14	NO	NO
	1997	10	7	4.5	13	NO	NO
	1998	10	6.5	4.5	11.5	NO	NO
	1999	10	6	4.5	10	NO	NO
	2000	10	6	4.5	10	NO	NO
	2001	10	6	4.5	10	NO	NO
	2002	10	6	4.5	9	NO	NO
	2003	10	6	4.5	9	15	90
	2004	10	6	4.5	8	15	90
2005-2024	10	6	4.5	7	15	90	
2.F.1.f Heat pumps	1990	20	5	1	10	5	90
	1991	20	5	1	9	5	90
	1992	20	4.5	1	8	5	90
	1993	20	4.5	1	7	5	90
	1994	20	4	1	6	5	90
	1995	20	4	1	5	5	90
	1996	20	4	1	4	5	90
	1997	20	3	1	3	5	90
	1998	20	3	1	2	5	90
	1999	20	2	1	1	5	90
	2000	20	1	1	1	5	90
	2001	20	1	1	1	5	90
	2002	20	1	1	1	5	90
	2003	20	1	1	1	5	90
	2004-2024	15	1	1	1	5	90
2.F.1.f other stationary air-conditioning	1990-2024	10		0.2	1	5	90

4.6.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The largest contribution to the total national emission uncertainty from this category stem from HFCs from mobile air conditioning, commercial and industrial refrigeration and from stationary air-conditioning. All uncertainties are documented and are based on expert judgement made in collaboration between inventory experts and experts at the Swedish Chemicals Agency. Prior to each submission, the uncertainties are reviewed.

AD and EF uncertainty are $\pm 10\%$ and $\pm 40\%$ for mobile air conditioning (2.F.1.e), $\pm 25\%$ and $\pm 50\%$ for domestic refrigeration (2.F.1.b) and $\pm 20\%$ and $\pm 40\%$ for transport refrigeration (2.F.1.d). Uncertainty for AD and EF for 2.F.1.a, 2.F.1.c and 2.F.1.f when reported together were set to $\pm 25\%$ and $\pm 50\%$, respectively. This corresponds to an AD

uncertainty of $\pm 40\%$ and an EF uncertainty of $\pm 80\%$ for each of the codes 2.F.1.a, 2.F.1.c and 2.F.1.f.

The uncertainty of emission factors in 2.F.1 has been compared with emission factor uncertainties for other countries. The comparison shows that the Swedish emission factor uncertainties for CRT 2.F.1.a, 2.F.1.c and 2.F.1.f are higher compared to Finland's emission factor uncertainty ($\pm 40\%$). For CRT 2.F.1.d and 2.F.1.e the uncertainties are at the same level ($\pm 40\%$), For CRT 2.F.1.b Sweden's emissions factor uncertainty is slightly higher compared to Finland's ($\pm 50\%$ for Sweden and $\pm 40\%$ for Finland).

Data in the category is of varying quality, but generally considered, by expert judgment, to be of medium quality and is usually better for the later years than for the earlier years of the inventory. The time-series are calculated using the same methodology for all years and are thus considered to be consistent.

4.6.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

When data from equipment producers has been used it has been compared against IPCC default data and been judged as reasonable. Estimates have been checked with the trade association "Svenska Kyl & Värmepumpföreningen" (SKVP)²²¹, with experts at the Swedish EPA²²² and with the Swedish Car Recyclers Association²²³. The information on refrigerant-related imported amounts of fluorinated gases from the Products Register is compared to calculations made in the model, based on assumptions and information from other sources.

In the SMED study²²⁴, based on contacts with the Swedish road vehicles manufacturers, several factors were modified for MAC in road vehicles for 2010 onwards to be more in line with the present status of the Swedish road vehicle fleet. The emission factors used for emission estimates for MAC in road vehicles are presented in Table 4.7.5.

Sweden, together with the other Nordic countries, has in recent years compared the similarities and differences between the countries' F-gas inventories. In the study, we have compared, for example, which data sources and which emission factors are used for the emission calculations. In 2020, 2021 and 2022, the focus has been on the end-of-life factors, with focus on heat pumps in 2022.

²²¹ Per Jonasson, Managing Director, Swedish Refrigeration & Heat Pump Association. Personal communication

²²² Swedish EPA . Ujfalusi, Bernekorn, and Björsell. Personal communication.

²²³ Michael Abraham, Managing Director, Swedish Car Recyclers Association. Personal communication

²²⁴ Gustafsson, T. 2011. Fluorinated Greenhouse Gases in Sweden. Review of Methodology and Estimated Emissions Reported to the UNFCCC and the EU monitoring Mechanism. SMED report 2011.

Table 4.7.5. Emission factors used (1990 – 2024) for emission estimates for MAC in heavy and light duty vehicles, passenger cars and buses.

Year	Mobile air-conditioning, heavy duty vehicles						Mobile air-conditioning, light duty vehicles						Mobile air-conditioning, passenger cars						Mobile air-conditioning, buses					
	Lifetime, year	Charge, kg	EF Initial Emission, %	EF Operation Emission, %/year	Emissions at disposal, %	Initial Charge Remaining, %	Lifetime, year	Charge, kg	EF Initial Emission, %	EF Operation Emission, %/year	Emissions at disposal, %	Initial Charge Remaining, %	Lifetime, year	Charge, kg	EF Initial Emission, %	EF Operation Emission, %/year	Emissions at disposal, %	Initial Charge Remaining, %	Lifetime, year	Charge, kg	EF Initial Emission, %	EF Operation Emission, %/year	Emissions at disposal, %	Initial Charge Remaining, %
1990-1999	6	1	1	15	15	90	11	1	1	15	15	90	11	1	1	15	15	90	12	7	1	10	15	90
2000	6	1	1	12	15	90	11	1	1	12	15	90	11	1	1	12	15	90	12	7	1	10	15	90
2001-2009	6	1	1	10	15	90	11	1	1	10	15	90	11	1	1	10	15	90	12	7	1	10	15	90
2010	6	1	0.5	10	15	90	11	1	0.5	7.5	15	90	11	1	0.5	7.5	15	90	12	7	0.5	10	15	90
2011-2024	6	1	0.5	10	15	90	11	1	0.5	5	15	90	11	1	0.5	5	15	90	12	7	0.5	10	15	90

As HFCs from mobile air-conditioning in passenger cars is one of the most influential sub-sources in the category, its underlying factors are compared to IPCC default values and differences are analysed (Table 4.7.6). The emission factors for lifetime, charge, annual leakage, production, remaining at decommissioning and share recovered for car air conditioning are attained from the Swedish car manufacture Volvo, in cooperation with experts at the Swedish EPA and from the Swedish Car Recyclers Association.

Table 4.7.6. Comparison of IPCC default factors and Swedish factors for MAC in cars.

Parameter	2006 IPCC	Swedish factors	Comment
Lifetime (y)	9 - 16	11	OK
Charge (kg)	0.5 - 1.5	0.8 - 0.7	OK
EF Operation Emission (%/year)	10 - 20	15 - 5	OK
EF Initial Emission (%)	0.2 - 0.5	1 - 0.5	OK
Initial Charge Remaining (%)	0 - 50	90	High; We assume that there is continuous maintenance and refilling of the equipment
Recovery Efficiency (%)	0 - 50	85	OK according to experts at Swedish EPA and the Swedish Car Recyclers Association

During the review of the 2015 and 2016 annual submissions the ERT requested documentation supporting the Swedish country specific emission factors used for estimates of emissions from disposal in CRT 2.F.1. The documents “Letter to Swe

Environmental Protection Agency regarding leakage at decommissioning_Swedish Refrigeration & Heat Pump Association.pdf” and “Swedish Car Recyclers Association.pdf” (Annex 3:5) support the use of the existing national factors in the Swedish GHG inventory, in line with the requirements of the 2006 IPCC Guidelines. The national factors are based on information from the Swedish Refrigerants Code of Best Practices (“Svensk Kylnorm”) and national expert judgments from the relevant business associations (the Swedish Refrigeration & Heat Pump Association and the Swedish Car Recyclers Association). The documents are signed by the Managing Director of the Swedish Refrigeration & Heat Pump Association and the Managing Director of the Swedish Car Recyclers Association.

4.6.1.5 SOURCE-SPECIFIC RECALCULATIONS

General: Due to the recurring one-year lag from data from the Products Register, preliminary data for 2023 used in submission 2025 has been updated for HFC-32, HFC-125, HFC-134a and HFC-140a. Beside this a few changes of emission estimates have been performed for submission 2026, where recalculations stem from updated activity data. Recalculations and their effect on the reported emissions are presented in Table 4.7.7 below.

Table 4.7.7. Recalculations in CRT 2.F.1, submission 2026.

CRT	Reason for recalculation	Year	Recalculation*,
			kton CO ₂ eq.
2.F.1.e	Emissions influenced by updated activity data for heavy machinery, passenger cars, buses and light- as well as heavy duty trucks	2007–2023	2007 – 2023: -0.0084 – +0.2665
2.F.1.f	Decreased emissions influenced by updated activity data	2019-2023	2019: -0.46 2020: -0.85 2021: -1.14 2022: -1.11 2023: -1.11

4.6.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.6.2 Foam blowing agents (CRT 2.F.2)

4.6.2.1 SOURCE CATEGORY DESCRIPTION

This category consists of HFCs emissions from production and use of XPS foam in Sweden. Emissions of PFCs and SF₆ from foam blowing are reported as not occurring (NO). Emissions of HFCs peaked in year 2008 and have since then decreased due to reduced leakage during manufacturing, according to data from the only Swedish manufacturer.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.7.8.

Table 4.7.8. Summary of source category description, CRT 2.F.2, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.2	HFCs	-	-		T2a	PS	Yes
	PFCs	NA	NA		NO	NO	NO
	SF ₆	NA	NA		NO	NO	NO

PS Plant Specific. T2a Tier 2a.

4.6.2.2 METHODOLOGICAL ISSUES

The use of HFCs in this application started in 1996. The company has also provided algorithms to calculate leakage of HFC-134a and HFC-152a during the product lifetime (Table 4.7.9). According to the information provided by the manufacturing company the HFC-134a remains in products for a very long time, while all HFC-152a is emitted during the first 12 years.

Table 4.7.9. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of HFCs used in calculations of emissions in Sweden. Given intervals indicate changes between 1996 and the last inventory year used in the calculations.

Application	Foam blowing (XPS)
Fluorinated substances	HFCs
Lifetime**	> 12
Amount installed /unit, kg	*
Emissions at manufacturing,%	46 - 35
Emissions per year during use	Declining
Remained in product at disposal	\$
Emissions at disposal,%	<76***

* Top-down calculations

** Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.

*** Based on remaining HFC in products at disposal after 12 years. 2008 is the first year for emissions at disposal in Sweden.

\$ Calculated according to a declining curve, different for HFC-134a and HFC-152a.

Since 2008, no HFC-134a is used during manufacturing of XPS foam in Sweden. Thus, the reported emissions of HFC-134a from 2008 represent only emissions from stocks and disposal and from 2020 only from stocks.

In the model, it is assumed that 20% of the XPS products have a lifetime of 12 years. The remaining 80% have a significantly longer lifetime, over 50 years. So, for 80% of the XPS produced using HFC-134a there is still leakage from stock and will be so for a long time.

There is no specific regulation and legislation concerning the HFCs from XPS at disposal, but XPS containing HFCs is classified as hazardous waste, and the management of such waste is covered by the waste regulation. This includes requirements that hazardous waste must be sorted out and handled separately from other waste. Since 2015, there is a

requirement for foam to be labelled as containing F-gas, according to Article 12(5) of EU 517/2014.

Data on the used amount of HFC-134a and HFC-152a, emissions at production as well as the exported amount of chemicals in products each year, has been obtained from the producer, 1996 - 2017. For the years 2018 – 2021, the corresponding information has not been received from the company. There is a clearly declining trend for used and emitted amounts of HFC-152a between 2013 and 2017. This trend is used to estimate used and emitted amounts of HFC-152a for 2018. The result of estimated quantity for this year has been verified with the data in The Swedish Chemicals Agency's Product Register and show good agreement. However, the information on HFC-152a in the Product Register is confidential and can therefore not be used for the emission calculations. In submission 2022 and 2023, data on the quantities of HFC-152a used in 2019 and 2020 has been retrieved from the SPIN database. For 2021, data from The Swedish Chemicals Agency's Product Register has been used, as this data is not confidential for the year. A sharp reduction in the amounts of HFC-152a used can be seen between 2020 and 2021. Information in the environmental report for 2021 states that the company has worked to reduce the use of HFC-152a and that already in 2020 it began testing the use of propellant gases without HFC-152a. New tests were carried out in production in 2021, and in June 2021 the last amount of HFC-152a was consumed. After 2021, no HFCs have been used as blowing agents.

Data that could be used to calculate emissions from imported quantities of foam is not available. An increasing proportion of produced quantities of XPS currently use blowing agents other than HFCs, such as CO₂ and HFO. When compared to other comparable countries, in kg CO₂ eq per capita, Sweden's emissions are in the same order of magnitude as in, for example, Norway. They report in their NID (submission 2020) that emissions of HFC-134a per capita are between 0-1.9 kg CO₂ eq (AR4 GWP) for the years before 2008 and 2.0-3.9 kg of CO₂ eq (AR4 GWP) for 2008-2012, while emissions of HFC-152a are 0-1.74 kg of CO₂ eq (AR4 GWP) for the years 1990-2012. A corresponding calculation for Sweden shows emissions of HFC-134a between 0.65 and 7.2 kg of CO₂ eq (AR4 GWP) per capita for the years prior to 2008 and between 1 and 11 kg of CO₂ eq (AR4 GWP) for the period 2008-2012. Emissions of HFC-152a calculated per capita in Sweden are between 0.7 and 3.5 kg CO₂ eq (AR4 GWP) 1990-2012. The comparison with the Norwegian figures indicates that any underestimation of the emissions would be small and below the threshold of significance. Sweden therefore considers that it is not Good Practice to make large efforts to find out if there are ways to collect data on imported quantities of foam, including which blowing agents has been used in the production.

The basis for the calculation is the amount of HFC-134a and HFC-152a that is introduced into products used in Sweden and subsequently leaked from the products. Beside annual losses from products over time, the reported Swedish emissions in the CRT tables contain emissions from manufacturing.

The ratio of HFC-134a to HFC-152a in products in Sweden has not been constant over the years. This means that since expected leakage rates are very different for the two chemicals, the resulting annual emissions from products vary according to chemical composition and product age in the national method.

4.6.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The quality of activity data, such as amount of chemical used in applications, is usually better for the later years than for the earlier years of the inventory. Data from the manufacturers is considered to be complete and cover all sources of HFC emissions in Sweden. The uncertainty for activity data is judged to be $\pm 2\%$ and the uncertainty of the emission factor for HFCs is judged to be $\pm 20\%$.

The time series are calculated using the same methodology for all years and are thus consistent.

4.6.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The current calculation method provided by the company, used for reporting of emissions, has been compared to the Tier 2a method given in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (see Table 4.7.10).

Table 4.7.10. Leakage factor used for the first 15 years in the national method compared to 2006 IPCC Guidelines Table 7.6.

Year	National method		2006 IPCC Guidelines, Table 7.6	
	Leakage factor, HFC-134a	Leakage factor, HFC-152a	Leakage factor, HFC-134a	Leakage factor, HFC-152a
1	9.5%	66%	25%	50%
2	3.9%	20%	0.56%	13%
3	3.0%	8.3%	0.56%	9.4%
4	2.5%	3.5%	0.55%	7.0%
5	2.2%	1.5%	0.55%	5.3%
6	2.0%	0.62%	0.55%	4.0%
7	1.9%	0.26%	0.54%	3.0%
8	1.7%	0.11%	0.54%	2.2%
9	1.6%	0.050%	0.53%	1.7%
10	1.5%	0.020%	0.53%	1.3%
11	1.5%	0%	0.53%	0.94%
12	1.4%	0%	0.52%	0.70%
13	1.3%	0%	0.52%	0.53%
14	1.3%	0%	0.51%	0.40%
15	1.2%	0%	0.51%	0.30%

The calculated emissions according to the national method and to the method described in the 2006 IPCC Guidelines are presented in Table 4.7.11. The product lifetime of XPS-foam is very long, several decades, and the total amounts of emitted chemical are in the long run comparable.

Table 4.7.11. Emissions of HFC-134a and HFC-152a from the national method compared to calculated emissions using leakage factors in 2006 IPCC Guidelines.

Year	Emissions of HFC-134a and HFC-152a according to the national method (kt CO ₂ eq.)	Emissions of HFC-134a and HFC-152a according to 2006 IPCC Guidelines (kt CO ₂ eq.)
1996	12	12
1997	77	83
1998	83	92
1999	99	110
2000	111	116
2001	109	113
2002	104	106
2003	97	96
2004	106	103
2005	87	83
2006	74	66
2007	54	44
2008	51	39
2009	39	30
2010	32	25
2011	36	28
2012	35	27
2013	37	29
2014	35	28
2015	34	27
2016	33	27
2017	32	27
2018	31	27
2019	27	23
2020	26	23
2021	16	14
2022	10	9
2023	9	8
2024	9	8
SUM 1996 - 2024	1496	1416

4.6.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed in submission 2026.

4.6.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.6.3 Fire protection (CRT 2.F.3)

4.6.3.1 SOURCE CATEGORY DESCRIPTION

HFC may be used as extinguishing medium in fixed fire extinguishing systems. In Sweden, emissions of HFCs from fire extinguishers are reported since 1997. Emissions of PFCs and SF₆ for the category are not occurring (NO).

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.7.12.

Table 4.7.12. Summary of source category description, CRT 2.F.3, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.3	HFCs	-	-		T1a	CS	Yes
	PFCs	NA	NA		NO	NO	NO
	SF ₆	NA	NA		NO	NO	NO

CS Country Specific. T1a Tier 1a

4.6.3.2 METHODOLOGICAL ISSUES

All imports of HFCs to be installed in fire extinguishers are registered at the Swedish Chemicals Agency. In 2001, the use of HFC-227ea in fire extinguishers was introduced in Sweden. Data has been obtained from the companies supplying such systems (Table 4.7.13).

Table 4.7.13. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of HFCs used in calculations of emissions in Sweden.

Application	Fire extinguishing
Fluorinated substances	HFCs
Lifetime*	10
Amount installed /unit, kg	**
Emissions at manufacturing, %	0.5
Emissions per year during use, %	2 / 0.1***
Remained in product at disposal, %	95
Emissions at disposal, %	5

* Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.

** Top-down calculations

*** HFC-227ea 0.1%, other HFCs 2%.

For 2017 and 2018, one of the companies reported unusual high emissions of HFC-227ea from stock (1.8 and 0.34 kton CO₂ eq, respectively).

4.6.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainties are mainly associated with the exported amounts, which are relatively large. The uncertainty for activity data is judged to be $\pm 5\%$ and the uncertainty of the emission factor for HFCs is judged to be $\pm 20\%$. The time series are calculated using the same methodology for all years and are thus consistent.

4.6.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

HFCs in fire protection equipment have been used in Sweden since 1997. In submissions prior to submission 2015, a "Lifetime" factor of 30 years was used. After contact with the industry it became evident that this factor was too high²²⁵. The information from the industry revealed that there are regulated controls of the cylinders in fire protection systems in Sweden. The cylinders have to be controlled by accredited personnel every

²²⁵ Danielsson, H., Mawdsley, I and Gustafsson, T. 2014. Fluorinated greenhouse gases – is there a risk of underestimation of reported Swedish emissions from disposal of products and equipment? SMED report.

10th year. Because of this new information, the factor for "Lifetime" has been changed from 30 to 10 years. The industry also suggested a change of the "Emissions at disposal" factor from 1% to 5%.

4.6.3.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed in submission 2026.

4.6.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.6.4 Aerosols (CRT 2.F.4)

4.6.4.1 SOURCE CATEGORY DESCRIPTION

HFC may be used as propellant gas in aerosols, but also as a component in the actual product e.g. in cleaning sprays. In asthma medication inhalers, HFC-134a (norflurane) and HFC-227ea (apaflurane) are sometimes used as propellant gases. Emissions of PFCs and SF₆ for the category are not occurring (NO).

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.7.14.

Table 4.7.14. Summary of source category description, CRT 2.F.4, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.F.4	HFCs	-	-		T2a	D	Yes
	PFCs	NA	NA		NO	NO	NO
	SF ₆	NA	NA		NO	NO	NO

D Default. T2a Tier 2a.

4.6.4.2 METHODOLOGICAL ISSUES

Emission estimates cover technical aerosols as well as metered dose inhalers. The estimates consist of emissions from the use of imported technical aerosols and metered dose inhalers containing HFCs. The contribution from metered dose inhalers was relatively small in the beginning of the time series but has increased over time. For 2020, 2021 and 2022, the contribution from metered dose inhalers was over 97% of totally reported emissions in CRT 2.F.4.

The technical aerosol importer provided information on the imported and exported amounts of HFC-134a in products. Table 4.7.15 presents the assumptions on product lifetime, emissions at manufacturing and disposal as well as remaining HFC in product at disposal. Due to technical issues in CRT reporter, annual emissions from disposal are reported together with emissions from the use of aerosols. The HFC-134a emissions from technical aerosols decreased strongly from 2018 to 2019. The reason to this is that in 2019, no technical aerosols with HFC-134a were imported, therefore the emissions reported in 2019 only represent emissions from disposal of amounts imported in 2018. From 2020 no emissions of HFC-134a occur in CRT 2.F.4.b, only minor emissions of HFC-152a.

Table 4.7.15. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of HFCs used in calculations of emissions in Sweden.

Application	Aerosols/ MDI
Fluorinated substances	HFCs
Lifetime*	2
Amount installed /unit, kg	**
Emissions at manufacturing, %	NO
Emissions per year X during use, %	50
Emissions per year X+1 during use, %	50

* Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.

** Top-down calculations

For metered dose inhalers, statistics on the numbers of sold inhalers were, for the years 1990 until 2008, received from the Swedish retailer for medical products, Apoteket. From 2009 - 2013 the corresponding information has been received from the company Pharmacy Service AB and from 2014 onwards, the data are received from Swedish eHealth Agency. Information concerning the content of HFC in the inhalers is provided by the Swedish Medical Products Agency.

4.6.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The largest uncertainty in this source concerns the amount of HFC-134a imported in technical aerosols for which there are no statistics available. In 2000, a survey was sent to approximately 10 importers of technical aerosol products. Most of the importers responded to the survey and provided estimates on the amount of HFC imported each year in technical aerosols. In 2004 an update on estimated import was made for the whole time series, in cooperation with the Swedish Aerosol Association (Svenska Aerosolföreningen). The information from this survey was used to update the time series up to year 2003 at that time.

The quality of activity data, such as figures of estimated emissions or amount of fluid used in different applications is usually better for the later years than for the earlier years of the inventory. The uncertainty for activity data is judged to be $\pm 5\%$ and the uncertainty of the emission factor for HFCs is judged to be $\pm 20\%$ for CRT 2.F.4.a. The corresponding figures for CRT 2.F.4.b are $\pm 50\%$ and $\pm 20\%$, respectively. The time series are calculated using the same methodology for all years and are thus consistent.

4.6.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

The emissions reported in CRT 2.F.4 are from products imported to Sweden. Data and information from the Products Register, hosted by the Swedish Chemicals Agency, could not be used for validation or reporting purposes since the information in the Product Register only contains information on imports in bulk.

4.6.4.5 SOURCE-SPECIFIC RECALCULATIONS

Minor improvements on calculation formulas and method resulting in update on the years 2013-2023. Changes ranging from -0,005 to +0,16 kt CO₂-eq.

4.6.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.6.5 Solvents (CRT 2.F.5)

Efforts have been made to find national information concerning this sub-category. For instance, potential users of solvents containing HFCs or PFCs were contacted. No information indicating that these kinds of solvents are used in Sweden was found. Emissions from solvents are consequently reported as NO, not occurring.

4.6.6 Other applications (CRT 2.F.6)

No other applications are covered in the Swedish inventory.

4.7 Other product manufacture and use (CRT 2.G)

4.7.1 Electrical equipment (CRT 2.G.1)

4.7.1.1 SOURCE CATEGORY DESCRIPTION

In Sweden, emissions of SF₆ from electrical equipment consist of two different parts, emissions from the production of gas-insulated switchgear (GIS), and emissions from SF₆ installed in distribution systems. Emissions of HFCs and PFCs are not occurring (NO) for this category.

The use of SF₆ for insulation purposes in operating power systems started to occur in Sweden in the middle of the 1970s²²⁶. The end-of-life factor of 35 years indicates that SF₆ containing equipment started to be replaced in 2010. Therefore, the Swedish reporting of SF₆ from Electrical Equipment (2.G.1) also include emissions from disposal.

Swedenergy has estimated the SF₆ content in the operating Swedish power system from 1975 until 1990. Based on this information, estimates of SF₆ emissions from disposal are made²²⁷.

In submission 2017, amounts of gases recovered at decommissioning are reported for the first time in the CRT tables for CRT 2.G. Recovered amounts are calculated as amount in products at decommissioning minus emissions from disposal.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.8.1.

Table 4.8.1. Summary of source category description, CRT 2.G.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.G.1	HFCs	NA	NA		NO	NO	NO
	PFCs	NA	NA		NO	NO	NO
	SF ₆	-	-		T2, T3	CS, PS	Yes

CS Country Specific. PS Plant-specific. T2 Tier 2. T3 Tier 3

* Distribution

** Production

4.7.1.2 METHODOLOGICAL ISSUES

The larger part of annual SF₆ emissions in earlier years originated from the manufacture of GIS (Table 4.8.2), where emissions in 1995 and 1997 peak due to a leaking valve in 1995 and to rebuilding and accidental leakages in 1997. The SF₆ emissions from production have decreased in later years due to measures taken at the production facility.

²²⁶ Matz Tapper, Swedenergy. Personal communication.

²²⁷ Danielsson, H., Mawdsley, I and Gustafsson, T. 2014. Fluorinated greenhouse gases – is there a risk of underestimation of reported Swedish emissions from disposal of products and equipment? SMED report.

These estimates, obtained from the industry, are of medium to high quality, with better quality in later years.

Table 4.8.2. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of SF₆, used in calculations of emissions in Sweden.

Application	Electrical insulation and GIS manufacture
Fluorinated substances	SF ₆
Lifetime**	35
Amount installed /unit, kg	*
Emissions at manufacturing, %	12 - 0.5
Emissions per year during use, %	0.6 - 0.5
Remained in product at disposal, %	98%
Emissions at disposal, %	2%

* Top-down calculations

** Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.

For the early 1990s, assumptions on the emitted amounts of SF₆ from GIS manufacture were made in cooperation with the industry. The industry has also provided information concerning the used amount of SF₆ for GIS manufacture (Table 4.8.3), as well as the share of products that are exported from the country, which often exceeds 90% of the production.

In Table 4.8.3 the calculated emissions and accumulated stock of SF₆ for electrical equipment is presented. For 2023 the emissions are classified and reported together with emissions from 2.G.2 in the CRT tables.

Table 4.8.3. Calculated emissions and accumulated stock of SF₆ for electrical equipment

Year	Accumulated stock, t	Annual losses SF ₆ , t	Emissions from GIS manufacture SF ₆ , t	Emissions from disposal SF ₆ , t	Total emissions SF ₆ , t
1990	60	0.36	3.00	NO	3.4
1995	70	0.42	3.50	NO	3.9
2000	101	0.61	0.68	NO	1.3
2005	136	0.68	0.47	NO	1.1
2010	184	0.92	0.30	0.086	1.3
2015	229	1.1	0.30	0.086	1.5
2016	236	1.2	0.34	0.086	1.6
2017	237	1.2	0.13	0.086	1.4
2018	241	1.2	0.11	0.086	1.4
2019	250	1.2	0.13	0.086	1.5
2020	253	1.3	0.05	0.086	1.4
2021	248	1.2	0.10	0.118	1.5
2022	250	1.2	0.09	0.118	1.5
2023	C	C	C	C	C
2024	257	1.3	0.19	0.12	1.5

In accordance with the methodology described for deriving amounts of refrigerant chemicals not accounted for, the same procedure was adopted for SF₆. When comparing the amounts of SF₆ accounted for in various applications with data from the Products Register, a rather large annual volume of SF₆ remains unallocated for most years (between 9 and 34%). Sources of SF₆ emissions that are covered in the calculations are the use in semi-conductor manufacture, in production of sound-proof windows, in magnesium foundries, in the production of gas-insulated switchgear and as insulation in electrical equipment. Information from the Products Register did not indicate that any areas of use are not covered and are missing from the calculations.

For all sources, except as insulation in electrical equipment, the levels of annual SF₆ consumption is comparatively easy to estimate with some confidence since there are few end-users. It was thus concluded that the amounts of SF₆ not already accounted for elsewhere, most reasonably should be allocated to the electrical equipment source. However, even though information concerning SF₆ in electrical equipment is more difficult to judge concerning completeness, indications from end-users are that the difference between imported amounts according to the Products Register or the SPIN database and those already accounted for in the calculations seem too large to annually be consumed for electrical insulation. One explanation to the difference could be that there is an underreporting of exported SF₆ from the Products Register, where no export at all of SF₆ is registered.

As the question of the remaining amount of SF₆ could not be unambiguously solved, the unaccounted SF₆ from the Products Register was allocated to be used as electrical insulation (accumulated stock).

4.7.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The quality of activity data is usually better for the later years than for the earlier years of the inventory. The uncertainty for activity data is judged to be $\pm 10\%$ and the uncertainty of the emission factor for SF₆ is judged to be $\pm 20\%$.

The time series are calculated using the same methodology for all years and are thus consistent.

4.7.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

4.7.1.5 SOURCE-SPECIFIC RECALCULATIONS

Recalculations have been performed for 2018-2023 due to minor updates to activity data and error corrections in submission 2026, resulting in decreased emissions by 0.01-0.9 kt CO₂-eq.

4.7.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.7.2 SF₆ and PFCs from other product use (CRT 2.G.2)

4.7.2.1 SOURCE CATEGORY DESCRIPTION

The estimated emissions from the use of SF₆ and PFC-218 in running shoes and SF₆ in sound-proof windows are reported in CRT 2.G.2. No production of SF₆ or PFC containing shoes has ever occurred in Sweden; hence reported emissions only represent emissions from disposal. Since 2008, SF₆ has not been used in production of sound-proof windows.

Sweden has no specific information on military applications/systems using SF₆ or heat transfer fluids in high-powered electronic applications using PFCs. The national military aircraft manufacture company has been contacted, but as of yet, no answer has been received regarding the use of SF₆. Sweden has also searched for information on the Internet and in the environmental reports of aircraft manufacturers and manufacturers of associated equipment, but no data was found to be available. Neither has Sweden data on the total number and types of accelerators in the country. But data from the largest accelerator in Sweden, MAX IV, indicate that the emission of SF₆ is very small, less than one kg per year. This source could thus be considered insignificant.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.8.4.

Table 4.8.4. Summary of source category description, CRT 2.G.2, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.G.2	HFCs	NA	NA		NO	NO	NO
	PFCs	-	-		T1*	D*	Yes
	SF ₆	-	-		T1*	D*	Yes
					T2**	PS**	
				T2***	CS***		

D Default. CS Country Specific. PS Plant specific. T1 Tier 1. T2 Tier 2.

* Running shoes

** Sound-proof windows, manufacturing

*** Sound-proof windows, stock

4.7.2.2 METHODOLOGICAL ISSUES

For running shoes, a more or less rough estimate has been made. It has not been possible to obtain any national data, so a Norwegian estimate was scaled to the Swedish population.²²⁸ According to the results from a study performed in early 2004²²⁹ a phasing out of SF₆ and replacement with PFC-218 was started in 2003. The lifetime for shoes is, in accordance with 2006 IPCC Guidelines, set to 3 years in the national model (Table 4.64).

Manufacturers of windows have provided data on the amount of SF₆ used in the manufacture of barrier gas windows. The manufacturers have also provided estimates of

²²⁸ Weholt, Ø. 1999. Materialstrømsanalyse av SF₆. Beregning av potensielt og faktisk utslipp over tid

²²⁹ Kindbom, K. and Skårman, T. 2004. Nya scenarier för fluorerade växthusgaser. U952, Swedish EPA.

the share of SF₆ emitted in production (Table 4.58). These estimates vary considerably between manufacturers, from 5-50%. The reason for the increase in emissions in later years is the lifetime and the associated time lag for emissions originating from disposal. Calculating a weighted average of the emission factor at production results in a national figure in the order of 30%, which is in line with the point estimate of 33% given in the 2006 IPCC Guidelines.

In Table 4.8.5, given intervals indicate changes between 1990 and the last inventory year used in the calculations. With an assumed lifetime of 30 years for barrier gas windows, emissions of SF₆ from disposal have to be estimated from emission year 2020. The emissions of SF₆ for 2019 were less than 1 kton CO₂ eq. and has by 2020 increased to over 5 kton CO₂ eq. due to the fact that emissions from disposal is reported for 2020. Also, in 2021 the total SF₆ emissions were just over 5 kton CO₂ eq. In 2022 the total SF₆ emissions were just below 4.5 kton CO₂ eq. For 2023 the total SF₆ emissions are classified. The emissions are reported together with 2.G.1 in the CRT tables.

Table 4.8.5. Typical values on equipment lifetimes, amounts of chemical per unit and emission factors for different applications of PFCs or SF₆, used in calculations of emissions in Sweden.

Application	Sound proof windows	Jogging shoes
Fluorinated substances	SF ₆	SF ₆ , PFC-218
Lifetime*	30	3
Amount installed / unit, kg	**	**
Emissions at manufacturing, %	5-50##	NO
Emissions per year during usage, %	1	NO
Remained in product at disposal, %	74	100
Emissions at disposal, %	100	100

* Lifetime means the average expected lifetime of a product, not the designed technical lifetime from its first commissioning.

** Top-down calculations

Different emissions at different production units.

4.7.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The quality of activity data is usually better for the later years than for the earlier years of the inventory. The uncertainty for activity data is judged to be ± 50% for jogging shoes and ± 5% for barrier gas windows. Uncertainty of the emission factor for PFCs and SF₆ are judged to be ± 50%. The time series are calculated using the same methodology for all years and are thus consistent.

4.7.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

4.7.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed in submission 2026.

4.7.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.7.3 N₂O from product use (CRT 2.G.3)

4.7.3.1 SOURCE CATEGORY DESCRIPTION

In CRT 2.G.3, sold amounts and use of N₂O from product use are reported. Due to confidentiality, data for 2.G.3.a – Use of N₂O for Medical Applications and 2.G.3.b – N₂O from Propellant for Pressure and Aerosol Products cannot be reported separately. All emissions are therefore reported in 2.G.3.b. N₂O for use in fire extinguishers does not occur in Sweden and thus reported as not occurring (NO). N₂O for use as a propellant in aerosol products, primarily in food industry, is included.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), are presented in Table 4.8.6.

Table 4.8.6. Summary of source category description, CRT 2.G.3, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.G.3	N ₂ O	-	-		T1	CS	Yes

CS Country Specific. T1 Tier 1

4.7.3.2 METHODOLOGICAL ISSUES

There are two companies in Sweden selling N₂O in gas cylinders. Information on sold amounts was obtained from one of the companies (1990 - 1991) and from the Products Register at the Swedish Chemicals Agency (1992 – 2018). The time series for use of N₂O in Sweden is reported in CRT 2.G.3.b Other (since data for use of N₂O for Anaesthesia and use of N₂O in Aerosol cans cannot be reported separately due to confidentiality).

Activity data in the Products Register at the Swedish Chemicals Agency show a large change between 2018 and 2019. It must be investigated what the reason is for this major change, and in submission 2025, instead, the trend from 2003 to 2018 has been used to estimate used amounts of N₂O for 2019 onwards.

4.7.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Reported time series are considered to be consistent, except for the last four years (2019-2022) where the trend from 2003 to 2018 has been used to estimate used amounts of N₂O. Uncertainties for CRT 2.G.3 is based on expert judgement. The uncertainty for the N₂O emission is set to ± 10%, and the uncertainty of activity data is set to ± 10%.

4.7.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

4.7.3.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed in submission 2026.

4.7.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.7.4 Tobacco smoking and use of fireworks (CRT 2.G.4)

No greenhouse gas emissions are reported from tobacco smoking and use of fireworks.

4.8 Other product manufacture and use (CRT 2.H)

Other production covers emissions from the pulp and paper industry (2.H.1), the food and beverages industry (2.H.2) and other (2.H.3). CRT 2.H.3 includes battery production, mineral wool production and quarrying and mining of minerals other than coal.

Sweden reports emissions of CO₂, CH₄ and N₂O from pulp and paper industry, CO₂ from use of solid coke in the sugar industry and CO₂ from mineral wool production. These emissions were previously allocated to the energy sector.

4.8.1 Pulp and paper (CRT 2.H.1)

4.8.1.1 SOURCE CATEGORY DESCRIPTION

The pulp and paper industry in Sweden is an important source of industrial process emissions. Emissions from 44 individual pulp and paper facilities are included in the inventory. Of those, six facilities only have energy related emissions, which are reported in CRT 1.A.2.D. Of the facilities with process-related emissions reported in CRT 2.H.1, one shut down in 2004, two in 2008 and one in 2012. For 2023, emissions from 33 individual pulp and paper facilities are included in reported emissions in CRT 2.H.1. The Kraft process (sulphate) dominates in Sweden, but the source category also includes emissions from sulphite facilities and facilities that are mainly CTMP (Chemo Thermo Mechanical Pulp) or TMP (Thermo Mechanical Pulp) facilities.

Due to limitations in the ETF GHG Inventory Reporting Tool in calculating correct sector totals when reporting “C” (confidential) at the higher category level (CRT 2.B, 2.C etc.), all greenhouse gas emissions in CRT 2.B have been reallocated to CRT 2.H.1 for the year 2022 only. This approach was implemented following guidance from the UNFCCC ETF GHG Inventory Tool Technical Support to ensure correct sector totals, but it results in inconsistencies in the time series for both CRT 2.B and CRT 2.H.1.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.9.1.

Table 4.9.1. Summary of source category description, CRT 2.H.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.H.1	CO ₂	-	-		T1	CS	Yes
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	X	-		T2	CS	Yes

CS Country Specific. T1 Tier 1, Tier 2 Tier 2

4.8.1.2 METHODOLOGICAL ISSUES

Reported emissions from the pulp and paper industry are primarily based on information on production and emissions in the companies' environmental reports. The industrial organisation within this sector has, for several years, cooperated closely with its members in developing sector-specific methods of measuring and calculating emissions, which have resulted in high-quality emissions data. The following emissions are reported from the pulp and paper industry: CH₄, CO, CO₂, N₂O, NMVOC, NO_x and SO₂.

The Swedish definition of process emissions includes the combustion of spent cooking liquor (black liquor) which gives rise to emissions of N₂O and CH₄ (and biogenic CO₂ emissions). The black liquor contains organic compounds and chemicals and is combusted to recover sodium (Na) and sulphur (S), but also to utilise the energy in the black liquor. The recovered Na and S (as Na₂CO₃ and Na₂S) are recycled and used in the process again. The amount of combusted black liquor and related CO₂ emissions are reported in CRT 1.A.2.d in order to account for the biogenic CO₂ emissions in the memo item "CO₂ emissions from biomass".

The estimated CO₂ process emissions that arise as a result of the use of limestone as make-up lime are allocated in CRT 2.A.2. Minor emissions of fossil CO₂ from use of soda ash and from use of limestone for flue gas cleaning were reported for the first time in CRT 2.H.1 in submission 2019.

The reported emissions of NMVOC do not include terpenes.

Activity data is presented in Figure 4.9.1 below. The various kinds of pulp produced in Sweden are categorized into sulphate, sulphite and mechanical pulp with production of sulphate pulp dominating throughout the years.

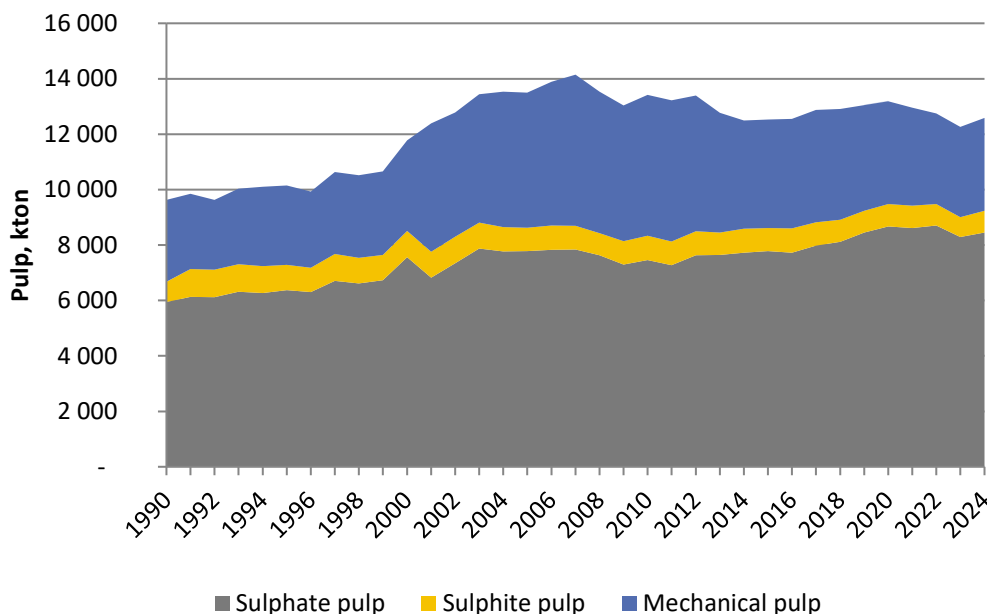


Figure 4.9.1. Production of pulp in Sweden 1990-2024.

4.8.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Uncertainty in activity data is $\pm 7\%$ and uncertainty in emission factors are:

$\text{CH}_4 \pm 21\%$, $\text{N}_2\text{O} \pm 22\%$, $\text{CO} \pm 54\%$, $\text{CO}_2 \pm 5\%$, $\text{NMVOC} \pm 116\%$, $\text{NO}_x \pm 11\%$ and $\text{SO}_2 \pm 24\%$

4.8.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

4.8.1.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations were made during submission 2026.

4.8.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

4.8.2 Food and drink (CRT 2.H.2)

4.8.2.1 SOURCE CATEGORY DESCRIPTION

The food and drink industry is a moderate source of NMVOC and CO_2 emissions in Sweden. The industry consists of beer, wine and liquor producers, bread, sugar, yeast and margarine and solid cooking fat producers, coffee roasters and animal feed producers. In addition, CO_2 emissions from the use of coke for process purposes in one sugar refinery is reported.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 4.9.2.

Table 4.9.2. Summary of source category description, CRT 2.H.2, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.H.2	CO_2	-	-		T3	PS	Yes
	CH_4	NA	NA		NA	NA	NA
	N_2O	NA	NA		NA	NA	NA

4.8.2.2 METHODOLOGICAL ISSUES

Estimates of NMVOC emissions are based on activity data from different official statistics. For wine, the estimation of NMVOC emissions is based on data on sold amount²³⁰ together with figures on import and export²³¹. NMVOC emissions from beer production are based on the Swedish annual total production of beer²³². NMVOC emissions originating from the production of liquors, bread, sugar, yeast, margarine and solid cooking fat, coffee roasters and animal feeds are all based on statistics from Statistics Sweden. For the NMVOC emission estimates, emission factors presented in

²³⁰ Systembolaget. Försäljningsstatistik. <http://www.systembolaget.se/>

²³¹ Statistics Sweden. <http://www.scb.se/>

²³² Bryggeriföreningen. <http://sverigesbryggerier.se>

Table 4.9.3 are used. Emission factors used in 2.H.2 are mainly from the EMEP/EEA Emission Inventory Guidebook 2023. Sweden assumes that abatement equipment reduces the emissions by 90%.

Table 4.9.3. NMVOC emission factors for the reported production activities in CRT 2.H.2 - Food and drink. Sweden assumes that abatement equipment reduces the emissions by 90%.

Production activity	Emission factor	Unit	Reference EF (see footnotes)
Liquors	0.6	kg/1000 litres	233
Wine	0.08	kg/1000 litres	EMEP/EEA Guidebook 2019
Beer	0.035	kg/1000 litres	EMEP/EEA Guidebook 2019
Bread (typical Europe)	0.45	kg/Mg	EMEP/EEA Guidebook 2019
Cakes	0.1	kg/Mg	EMEP/EEA Guidebook 2019
Biscuits	0.1	kg/Mg	EMEP/EEA Guidebook 2019
Breakfast cereals	0.1	kg/Mg	EMEP/EEA Guidebook 2019
Sugar	1	kg/Mg	EMEP/EEA Guidebook 2019
Yeast	1.8	kg/Mg	234
Margarine and solid cooking fats	1	kg/Mg	EMEP/EEA Guidebook 2019
Coffee roasting	0.055	kg/Mg	EMEP/EEA Guidebook 2019
Animal feed	0.1	kg/Mg	EMEP/EEA Guidebook 2019

In submission 2025, CO₂ emissions from the use of coke for process purposes at one sugar producer are reported for the first time in 2.H.2. These emissions were previously reported in 1.A.2.e. Emissions are based on data reported to the EU ETS and the quarterly fuel statistics.

In submission 2026, SO₂- and NO_x emissions from the use of coke for process purposes at one sugar producer are added to the reported emissions for the first time in 2.H.2. These emissions were previously reported in 1.A.2.e. Emissions are based on data reported to the EU ETS and the quarterly fuel statistics.

4.8.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time series is consistent. The uncertainties are calculated according to Guidebook 2023. The uncertainty for NMVOC is $\pm 200\%$.

4.8.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

4.8.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed in submission 2026.

4.8.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

²³³ Based on information from one producer, 2001

²³⁴ Based on information from Finland

4.8.3 Other (CRT 2.H.3)

4.8.3.1 SOURCE CATEGORY DESCRIPTION

In CRT 2.H.3 CO₂ emissions from mineral wool production are reported.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 4.9.4.

Table 4.9.4. Summary of source category description, CRT 2.H.3, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
2.H.3	CO ₂	-	-	-	T2	D	No, see Annex 5
	CH ₄	NA	NA	NA	NA	NA	NA
	N ₂ O	NA	NA	NA	NA	NA	NA

D Default. T2 Tier 2.

Mineral wool production occurs at two facilities run by two companies. Before 2004 there were three facilities, but one closed down during 2003.

4.8.3.2 METHODOLOGICAL ISSUES

CO₂ emissions from mineral wool producers in Sweden derive mainly from the use of limestone and dolomite in the process. Blast furnace slag was used in the process between (1990-1995 and 1998-1999), causing a smaller amount of CO₂ emissions. Activity data on limestone and dolomite are obtained from the EU ETS and the 2006 IPCC emission factor for respective carbonate is used. Limestone is assumed to have a purity of 97% and dolomite a purity of 100%. Data on slag consumption has been obtained from the mineral wool producers. The emission factor is 0.04 kt CO₂ /kt slag based on the fact that slag contains 1% carbon and the CO₂ emissions are calculated by using the formula:

$$\text{Emissions of CO}_2 \text{ (Mg) from use of slag} = \text{Slag (Mg)} * 0.01 * (\text{C content}) * 44/12$$

Within mineral wool production, limestone and dolomite used also cause process emissions of CO₂ which are estimated based on activity data for each type of carbonate and corresponding emission factor:

$$\text{Emissions of CO}_2 \text{ (Mg) from use of limestone and dolomite} = \text{Limestone (Mg)} * 0.97 * 44.0098 / 100.0892 + \text{Dolomite (Mg)} * 88.02 / 184.4$$

The time series of NMVOC emissions is based on data received from the companies directly or as reported in environmental reports together with earlier total estimates. The emissions of NMVOC consist of formaldehyde and phenol.

4.8.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The uncertainties for emissions in 2.H.3 are based on expert judgement (CO₂). The uncertainty of direct CO₂ emissions in 2.H.3 is set to ± 6% and the time series is consistent.

4.8.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

4.8.3.5 SOURCE-SPECIFIC RECALCULATIONS

2.H.3 Quarrying and mining of minerals other than coal:

No source-specific recalculations have been performed in submission 2026.

2.H.3 Batteries Manufacturing:

No source-specific recalculations have been performed in submission 2026.

4.8.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

5 Agriculture (CRT sector 3)

5.1 Overview of sector

In the agricultural sector, emissions of nitrous oxide (N₂O), methane (CH₄) and carbon dioxide (CO₂) are reported. Carbon dioxide from working vehicles and other energy use is reported in the energy sector and carbon dioxide from agricultural soils (excluding liming) is reported in the LULUCF sector. Sweden's inventory includes emissions from enteric fermentation, manure management, agricultural soils, liming and urea application. Rice cultivation, burning of savannahs, burning of agricultural residues and emissions from other carbon-containing fertilisers do not occur in Sweden. The agriculture in Sweden has undergone radical structural changes and rationalisations since the 1940s. During the first half of the twentieth century over 3.7 million hectares was used as cropland in Sweden. In 2024 the cropland had decreased by 30%. Structural changes have also occurred regarding farm holdings. In 1927 Sweden had over 400 000 and in 2024 only 55 400 holdings. The number of animals has not as affected as the number of holdings which means that the closures have mainly affected small holdings, and the remaining holdings are growing larger²³⁵. Livestock farmers predominately engage in milk production and the main crops grown in Sweden are grain and fodder crops²³⁶. The decrease of agricultural land area has continued since Sweden joined the European Union in 1995 but the acreages of land for hay and silage have had an increasing trend. The share of agricultural land used in organic farming has increased until 2020 and has thereafter decreased²³⁷.

Total greenhouse gas (GHG) emissions from the agricultural sector have decreased by 14 % since 1990, from 7 293 kt CO₂-eq to 6 263 kt CO₂-eq. (Figure 5.1). The most significant sub-sectors in Sweden are enteric fermentation (3.A) and agricultural soils (3.D), see Figure 5.2.

²³⁵ Swedish Board of Agriculture, [Långa tidsserier – Basstatistik om jordbruket åren 1866–2024 - Jordbruksverket.se](#)

²³⁶ Swedish Board of Agriculture, [www, Statistik - välj tabell](#)

²³⁷ Swedish Board of Agriculture, [www.jordbruksverket.se](#)

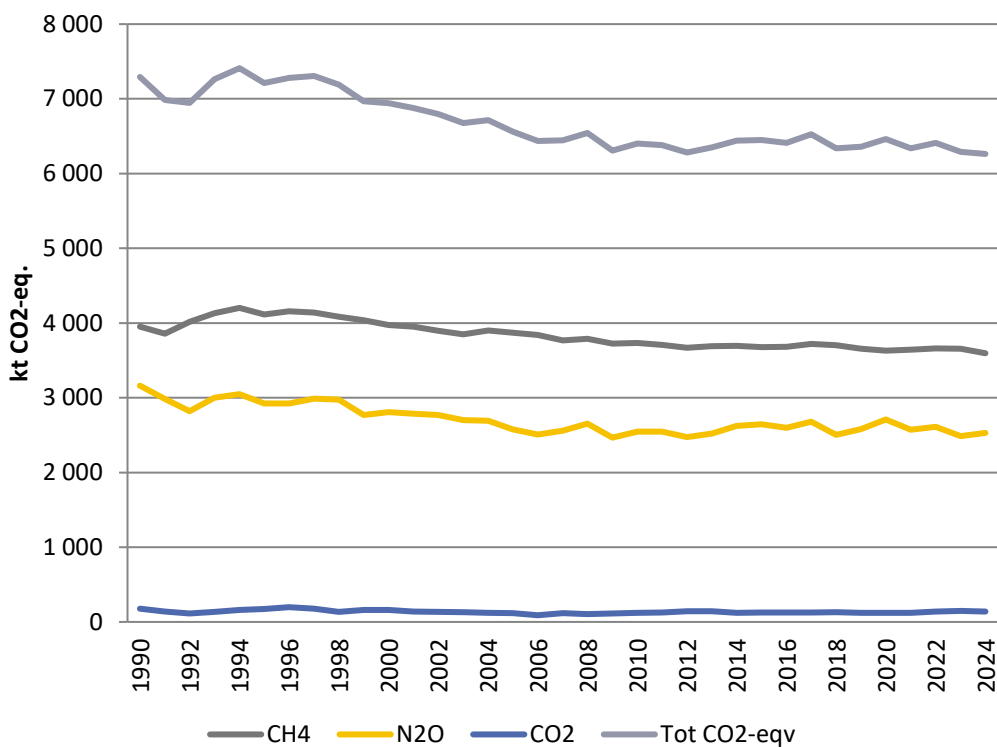


Figure 5.1. Total emissions of all greenhouse gases 1990-2024 calculated as CO₂-eq. from CRT 3, agriculture.

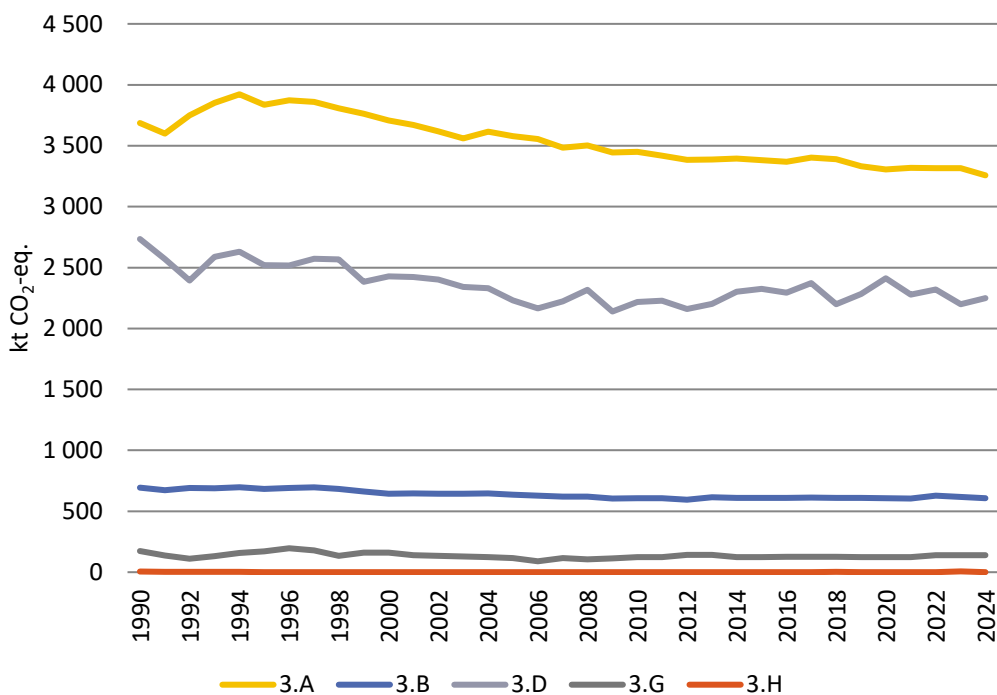


Figure 5.2. Total emissions of all greenhouse gases 1990-2024 calculated as CO₂-eq. from the different agricultural sub-sectors. There are no emissions from 3.C, 3.E-F and 3.I-J.

Emissions from livestock are the main source of greenhouse gas from agriculture. In Table 5.1, all the livestock subgroups used in the calculations are presented. The Farm Register is the main source for agricultural statistics in Sweden. This register is administered by the Swedish Board of Agriculture together with Statistics Sweden and provides annual information on the total number of animals of different categories on Swedish farms²³⁸. The information on livestock refers to the situation prevailing in June of that year and is considered equivalent to a one-year average. Most of the information on livestock numbers comes from the Farm Register, but for the distribution of calves (older or younger than 6 months) 60% are assumed younger than 6 months and the rest are assumed older than 6 months. Swine living shorter than one year, piglets and fattening pigs, are estimated from slaughter statistics. For horses, the Farm Register underestimates the number of horses because only horses on farms are included (i.e. not horses for private leisure activities). However, three separate surveys²³⁹ estimate the total number of horses in Sweden in 2004, 2010, and 2016. These estimates are used in the inventory. The number of slaughter chickens and turkeys (i.e. average number of chickens or turkeys kept during the year) is estimated from the number of slaughtered animals by taking into account the timespan between production cycles.

Table 5.1. Livestock subgroups used in the calculations.

Categories according to IPCC Guidelines	Sub-categories Enteric Fermentation	Sub-categories Manure management	Sub-categories Grazing animals
Dairy Cattle ¹	Dairy cows	Dairy cows	Dairy cows
Non-Dairy Cattle ¹	Suckler cows	Suckler cows	Suckler cows
	Heifers	Heifers	Heifers
	Bulls and steers	Bulls and steers	Bulls and steers
	Calves	Calves < 6 months ³ Calves > 6 months ³	Calves
Swine ¹	Swine	Sows	NO
		Boars	
		Pigs for meat production ²	
		Piglets ²	
Sheep ¹	Sheep	Sheep	Sheep
Goats ¹	Goats	Goats	Goats
Horses ¹	Horses	Horses	Horses
Poultry ¹	NE	Laying hens	NO
		Chickens	
		Slaughter Chickens ²	
		Turkeys ²	
Fur-bearing animals	NE	Minks ⁴	NO
		Foxes ⁵	
Other	Reindeer ⁶	NO	Reindeer

(1) Swedish board of agriculture. (2) Estimated from slaughter statistics. (3) The assumed age distribution of calves. (4) Svensk mink (The trade organization Swedish mink). (5) Statistics Sweden (foxes exists only before 2001). (6) Sametinget (The Sami Parliament of Sweden).

²³⁸ Swedish Board of Agriculture, JO 20-series.

²³⁹ Swedish Board of Agriculture, JO 24-series.

5.2 Enteric Fermentation (CRT 3.A)

5.2.1 Source category description

Enteric fermentation from cattle is the major source of methane emissions in CRT 3.A. The total number of livestock in Sweden is presented in Table 5.5. A summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 5.2.

Table 5.2. Summary of source category description, CRT 3.A, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qual.			
3.A.1.a Dairy cattle	CH ₄	X	X		CS	CS	Yes
3.A.1.b Non-dairy cattle	CH ₄	X	X		CS	CS	Yes
3.A.2 Sheep	CH ₄	X	-		T1	D	Yes
3.A.3 Swine	CH ₄	-	-		T1	D	Yes
3.A.4.d Goats	CH ₄	-	-		T1	D	Yes
3.A.4.e Horses	CH ₄	X	-		T1	D	Yes
3.A.4.h.ii Reindeer	CH ₄	X	-		T1	D	Yes

CS - Country Specific. T1 - tier 1. D - Default.

5.2.2 Methodological issues

5.2.2.1 EMISSION FACTORS, METHANE

The livestock population (table 5.5) for each category is multiplied by an emission factor and the total emission is calculated as:

$$emissions = \sum_i population_i \times EF_i$$

All emission factors (EF_i) for cattle are national. The IPCC guidelines recommends that the methane conversion rate should be zero for calves feeding only milk. Personal communication with Swedish experts resulted in that this period is assumed two months for calves of dairy breeds and three months for other breeds. Since no default emission factor exists for reindeer, the emission factor is estimated based on the live weight ratio between deer and reindeer according to the suggested formula in the guidelines. To estimate the average weight of reindeer in Sweden we have used statistics from the Sami parliament of Sweden (Sametinget) on slaughter weight and on the distribution of different types (i.e. cows, calves, bulls and oxen) of reindeer in the heard²⁴⁰. With the assumption (also from the Sami parliament) that the slaughter weight represents half the live weight, the average reindeer weight was estimated to 64 kg. To estimate the emissions from swine, sheep, goats and horses the IPCC default values are used. The vast majority of the CH₄ from enteric fermentation originates from dairy and non-dairy cattle. Emissions from sheep constitute a few percent in the sector.

The country-specific emissions factors for cattle have been developed at the department of animal nutrition and management at the Swedish university of agricultural sciences

²⁴⁰ Statistik rennärning - Sametinget

(SLU)²⁴¹. The methods and the activity data used are to a large extent developed within the NorFor²⁴² organization. The NorFor organization consist of experts in animal nutrition and information technology from the Nordic countries. One of their main activities is to develop and maintain a feed evaluation system called the NorFor Model. The system is currently in use in Denmark, Sweden, Norway and Iceland on approximately 9,000 dairy farms with some 1,000,000 head of cattle. A distinction between this system and the previous feed evaluation systems is that NorFor is based on net energy (NE) and the previous system used metabolizable energy (ME). Data on how animals actually is fed on farms are not available to the same extent today as 10 years ago. Today, most farmers produce the forage for cattle feeding themselves but concentrates are often bought from feed companies. To estimate actual feed, standard diets from the web-based advisory package AgriWise²⁴³ together with other surveys concerning feeding of cattle. The equations used by the NorFor to estimate methane emissions are based on Nordic feed trials carried out during the recent years on research stations in all participating countries.

5.2.2.1.1 Dairy cattle

One of the variables needed for the dairy cattle calculations is milk yield per cow. This is estimated from total milk delivered to Swedish dairies²⁴⁴, complementing with the on-farm consumption (including milk that does not meet the dairies quality demands) which is estimated to 5.6% of amount delivered. The live weight of dairy cows is assumed to be 650 kg. This is based on experiences from SLU's research herds as well as for research herds where both Holstein and red cows have this weight. The different equations used for the development of the emission factor are:

$$ECM = MilkYield \times ((383 \times Fat + 242 \times Protein + 783.2) / 3140)$$

ECM is the amount of energy corrected milk (kg/year), MilkYield = total milk delivered to Swedish dairies (kg/year), Fat = fat content (%) of the milk, Protein = protein content (%) of the milk.

$$ECM/cow/day = ECM \times 1.056 / Population / 365$$

Amount of milk produced per cow and day, including on farm consumption.

$$ME = (0.507 \times 650^{0.75}) + ECM/day \times 5 + (1/12 \times (8.5+13+19.5))$$

ME = metabolisable energy required per cow and day including maintenance, lactation and pregnancy. 0.507 = maintenance energy (MJ/kg live weight), 650 = average weight (kg), 5 = energy requirements to produce one kg of ECM (MJ). The energy additional requirement for pregnancy is estimated to be 8.5, 13 and 19.5 MJ per day in months 7, 8 and 9, respectively.

$$ME_Corr = 1.11 \times ME - 13.6$$

Metabolisable energy corrected for actual feeding levels.

$$ME_Feed = Frac_{Conc} \times Conc + (1 - Frac_{Conc}) \times Silage$$

²⁴¹ Bertilsson, 2016.

²⁴² <http://www.norfor.info>

²⁴³ <http://www.agriwise.org>

²⁴⁴ Data from The Swedish Board of Agriculture (jordbruksverket.se) Mejeriproduktion efter Variabel och År. PxWeb (siv.se)

Metabolisable energy content in the feed (MJ/kg). $Frac_{Conc}$ = fraction of concentrates in the feed, $Conc$ = energy content in concentrates (13.4 MJ/kg DM), $Silage$ = energy content in silage (see table 5.6).

$$FA = Frac_{Conc} \times Conc_F + (1 - Frac_{Conc}) \times Silage_F$$

Fatty acids content in the feed. $Conc_F$ = fatty acids content in concentrates (43 g/kg DM), $Silage_F$ = fatty acids content in silage (12 g/kg DM).

$$DMI = ME_Corr / ME_Feed$$

DMI is the total dry matter intake per animal and day (kg DM/animal/day).

$$CH_4_MJ = 1.39 \times DMI - 0.091 \times FA$$

CH_4_MJ is the total energy content in the methane emitted (MJ/cow/day). The equation is based on Nordic feed trials carried out during the last few years on research stations within NorFor. This equation was found to be the one that most accurately predicted the emissions for dairy cows²⁴⁵.

$$EF_Dairy = (CH_4_MJ / 55.65) \times 365$$

And finally, EF_Dairy is the total methane emissions from enteric fermentation (kg/animal/year) where 55.65 MJ/kg CH_4 is the energy content of methane (see table 5.6).

$$GE = DMI \times GE_Feed$$

Gross Energy intake (GE) is calculated by multiplying DMI with the gross energy content of silage and concentrate, 20.0 and 18.4 MJ/kg ts respectively²⁴⁶ (GE_Feed). Sweden does not use GE activity data in the model for calculating EF_Dairy , but it is being calculated afterwards to be reported in the CRT tables.

$$Ym = CH_4_MJ / GE$$

The average methane conversion rate (Y_m) for dairy cattle is calculated by dividing the energy content in the emitted methane with the gross energy intake.

5.2.2.1.2 Suckler cows

The same equations as for the dairy cattle are used for suckler cows, but with some modification of activity data. (i) The average amount of milk produced is estimated to 5.5 kg ECM per animal and day. Milk yields are assumed to be 14, 12, 12, 10, 10, 8 kg ECM/cow/day during lactation months 1 to 6, respectively. (ii) The live weight is estimated to be 750 kg. (iii) The additional energy requirement for pregnancy is estimated to be 10, 16 and 29 MJ per day in months 7, 8 and 9, respectively. (iv). Due to slightly lower quality of feed compared to dairy cows, the energy content in silage is estimated to be 9.5 MJ/kg DM for the complete time series. (v) $Frac_{Conc}$ is zero, i.e. only silage feeding is assumed.

5.2.2.1.3 Calves, Heifers, bulls and steers

The estimation of the emission factors for calves, heifers and bulls and steers differ slightly from the method used for dairy cattle and suckler cows. Especially a reduced

²⁴⁵ Nielsen et al. 2013

²⁴⁶ McDonald et al. 2011

amount of activity data is needed for the calculations. In Table 5.3 the activity data used are presented, and in Table 5.4 the intermediate calculation steps to estimate the different emission factors are given.

Table 5.3. Activity data used to estimate the emissions factors for enteric fermentation²⁴⁷.

	Heifers			Bulls and steers		
	<1 year	1-2 years	>2 years	<1 year	1-2 years	>2 years
Live weight	200	385	580	250	500	625
Energy requirements (MJ)	45.5	70.5	93.5	67.5	101.2	102.1
Metabolisable energy in feed (MJ/kg DM)	11.5	10.1	10.1	12.3	11.7	10.4
Frac _{Conc}	0.50	0.15	0.15	0.7	0.5	0.1
Gross energy in feed (MJ/kg DM)	19.2	19.8	19.8	18.9	19.2	19.8

Table 5.4. Intermediate steps to calculate the emissions factors for enteric fermentation.

	Heifers			Bulls and steers		
	<1 year	1-2 years	>2 years	<1 year	1-2 years	>2 years
DMI (kg DM/head/day)	4.0	7.0	9.3	5.5	8.7	9.8
Gross energy intake (MJ/head/day)	76.3	138.1	183.2	103.8	166.7	194.6
CH ₄ MJ (fraction of GE)	0.048	0.064	0.064	0.039	0.048	0.067
EF (kg CH ₄ /head/year)	24	58	77	27	53	85

The first step in Table 5.4 is to estimate the dry matter intakes (DMI). This is done by dividing the energy requirements with the metabolisable energy in feed. Then the gross energy intake per animal and day is calculated by multiplying the DMI by the gross energy content in the feed. In the subsequent step the fraction of the gross energy that is lost as CH₄ is estimated from the equation,

$$CH_4 \text{ MJ (fraction of GE)} = -0.046 \times \text{Frac}_{\text{Conc}} + 0.071379$$

Where *Frac_{Conc}* is the fraction of concentrates in the feed. This equation is used in the NorFor and is based on Danish trials²⁴⁸. Then the average annual energy lost as CH₄ is calculated by multiplying this fraction with the gross energy intake. Finally, the emissions factors are estimated by dividing the result with the energy content of methane (55.65 MJ/kg CH₄) and multiplying it with 365 to get the annual emissions.

For the heifers and bulls and steers categories, the emission factors in table 5.7 are aggregated to take into account different age groups. Calves are defined as cattle younger than one year, and the calf category is assumed to consist of 50% heifer calves and 50% bull calves. The heifer category is assumed to consist of 70 % individuals between one and two years and 30 % above two years. The corresponding numbers in the bulls and steers category is assumed to be 85 % between one and two years and 15 % above two years.

²⁴⁷ Bertilsson 2016 och Spörndly 2003

²⁴⁸ Nielsen 2013

Table 5.5. Population size of different animal groups (1000s heads).

Year	Dairy cows	Non-Dairy Cattle				Swine				Sheep	
		Suckler cows	Heifers	Bulls and steers	Calves	Sow	Pig for meat production	Piglet	Boar	Sheep	Lamb
1990	576	75	337	206	524	221	1 286	844	8.6	162	244
1995	482	157	370	226	542	237	1 310	855	7.6	195	266
2000	428	167	365	224	500	202	1 155	630	4.2	198	234
2005	393	177	327	200	508	185	1 093	599	2.7	222	249
2010	348	197	322	191	479	154	977	487	2.3	273	292
2015	340	184	311	178	467	140	852	425	1.5	289	306
2020	303	207	301	179	462	130	867	433	1.4	263	238
2022	297	213	302	180	458	126	880	439	1.6	264	245
2023	296	210	300	180	459	111	848	423	1.6	264	222
2024	289	200	298	179	444	116	851	425	1.6	241	214

Table 5.5 (continued).

Year	Horses	Goats		Other		Poultry			
	Horse	Goat	Kid	Reindeer	Fur-bearing animals	Laying hen	Chicken	Slaughter Chicken	Turkey
1990	316	3.4	3.4	271	297	6 400	2 200	4 476	122
1995	316	3.4	3.4	253	254	6 100	1 800	7 055	122
2000	316	3.4	3.4	221	276	5 700	1 700	7 896	122
2005	323	4.3	4.3	261	290	5 100	1 700	8 453	122
2010	363	5.9	5.9	250	180	6 061	1 647	9 159	130
2015	363	7.4	7.4	250	210	7 571	1 842	11 044	156
2020	356	9.5	9.5	240	200	8 403	2 420	12 696	130
2022	356	9.6	9.6	236	135	7 919	1 722	12 986	133
2023	356	9.5	9.5	227	100	7 717	2 700	12 586	131
2024	356	9.2	9.2	227	20	8 044	2 557	12 826	119

Table 5.6. Activity data used for estimating the emissions from enteric fermentation for dairy cattle.

Year	Total milk delivered* (kt)	Average fat content (%)	Average protein content (%)	Yield per cow, kg ECM/yr	Energy in silage (MJ ME/kg TS)	Frac _{Conc}	CH ₄ EF for Dairy Cattle (kg CH ₄ /head/year)
1990	3 432	4.31	3.36	6 503	9.5	0.5	112.2
1995	3 243	4.33	3.34	7 352	9.6	0.5	121.9
2000	3 297	4.18	3.28	8 240	9.8	0.51	130.6
2005	3 163	4.25	3.38	8 734	9.9	0.52	135.2
2010	2 862	4.23	3.41	8 928	10	0.54	135.7
2015	2 933	4.25	3.42	9 401	10.1	0.55	140.0
2020	2 773	4.23	3.51	9 997	10.1	0.55	146.9
2022	2 765	4.25	3.5	10 216	10.1	0.55	149.4
2023	2 819	4.26	3.53	10 485	10.1	0.55	152.6
2024	2 800	4.26	3.52	10 627	10.1	0.55	154.2

* Including on-farm consumption.

Table 5.7. Methane from animals, emission factors used.

Livestock subgroups	kg CH ₄ /head/year	Method
Dairy cows	See table 5.6	1
Suckler cows	91.5	1
Heifers	63.7	1
Bulls and steers	57.8	1
Calves	25.5	1
Swine	1.5	2
Sheep	9	2
Goats	9	2
Horses	18	2
Poultry	No fermentation assumed	
Reindeer	12.5	3

(1) Bertilsson, 2016. (2) 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories table 10.10. (3) Estimated from the value for deer.

5.2.3 Uncertainties and time-series consistency

Between 1995 and 1996, there was an increase in the number of sows by 13%. The reason for the increase is that as from this year also uncovered gilts was included in this group. Concerning horses, no estimate on the number of horses exists before 2004 or after 2016. Thus, the value for 2004 is used for all preceding years and the value for 2016 is used for all subsequent years.

5.2.4 Source-specific QA/QC and verification

The time series for the different populations and milk production is checked for consistency. Annual increase or decrease is verified for the whole time series for all sub-sources to determine whether all annual changes are reasonable. We compare the time series for the emission with the time series for the activity data to confirm that they are in agreement. We regularly conduct crosschecks of country-specific factors against the

IPCC default factors. We annually utilize experts from the Swedish board of agriculture to conduct expert peer review of the methods used and we have regular meetings with authorities that provide activity data to the inventory to ensure that the quality of the data are of satisfactory quality and that they in turn use appropriate QC methods.

5.2.5 Source-specific recalculations

Recalculations made in submission 2026:

- Updated number of goats and reindeer

The total effect of the recalculations in 3.A for the two most recent recalculated years entailed a decrease in the emissions corresponding to -0,02% and -0.11% for the year 2022 and 2023.

5.2.6 Source-specific planned improvements

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

5.3 Manure Management (CRT 3.B)

5.3.1 Source category description

This category includes emissions of methane and nitrous oxide from manure management. It also includes indirect emission of N₂O through volatilisation of nitrogen during storage. A summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), are presented in Table 5.8.

Table 5.8. Summary of source category description, CRT 3.B, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
3.B.1.a Dairy cattle	CH ₄	-	-		T2	CS, D	Yes
	N ₂ O	-	X		T2	D	Yes
3.B.1.b Non-dairy cattle	CH ₄	X	X		T2	CS, D	Yes
	N ₂ O	X	-		T2	D	Yes
3.B.2 Sheep	CH ₄	-	-		T1	D	Yes
	N ₂ O	-	-		T2	D	Yes
3.B.3 Swine	CH ₄	-	-		T2	CS, D	Yes
	N ₂ O	-	-		T2	D	Yes
3.B.4.d Goats	CH ₄	-	-		T1	D	Yes
	N ₂ O	-	-		T2	D	Yes
3.B.4.e Horses	CH ₄	-	-		T1	D	Yes
	N ₂ O	-	-		T2	D	Yes
3.B.4.g Poultry	CH ₄	-	-		T2	CS, D	Yes
	N ₂ O	-	-		T2	D	Yes
3.B.4.h.ii Reindeer	CH ₄	-	-		T1	D	Yes
	N ₂ O	-	-		T2	D	Yes
3.B.4.h.iv Fur-bearing animals	CH ₄	-	-		T1	D	Yes
	N ₂ O	-	-		T2	D	Yes
3.B.5 Indirect	N ₂ O	-	-		T2	CS	Yes

CS - Country Specific. T1 - tier 1. T2 - tier 2. D - Default.

5.3.2 Methodological issues

Statistics on manure management and the use of manure and fertilisers in agriculture have since 1988 been collected every second or third year by Statistics Sweden²⁴⁹. Data on stable periods (Table 5.9) and the manure management systems, liquid (Table 5.10), solid (Table 5.11) and deep bedding (Table 5.12) originate from this survey. Data on manure treated in on-farm anaerobic digesters (Table 5.13) are derived from the report series "Production and use of biogas and digestate", produced by the Swedish Gas Association for the Swedish Energy Agency²⁵⁰. This report series has been produced since 2005. Between 1997 (when the first pilot plants started to produce small amounts of biogas) and 2005, we assume a linear increase in amount of manure used as substrate. Emissions from on-farm digesters are accounted for in the agricultural sector, while emissions during

²⁴⁹ Statistics Sweden, MI 30-series.

²⁵⁰ Swedish Energy Agency. Produktion och användning av biogas och rötresten.

manure management from co-digesters (Table 5.14) are accounted for in the waste sector. The reason we include emissions from on-farm digesters in the agricultural sector is that; (i) these biogas plants use almost exclusively manure as substrate, (ii) The manure is stored on the premises, both before and after digestion, and (iii) the digestate is generally used as fertiliser. Data on composting (Table 5.13) originate from the report “Horse keeping in Sweden 2016”²⁵¹. Only manure from horses is systematically composted in significant amounts in Sweden. National estimates of stable periods have been available since 1997. Before this, the data is extrapolated to 1990. Since dairy cows often are stabled at night and spend time in the stables during milking, the data on stable periods for this animal category is combined with the assumption that 38% of its manure is excreted in the stable during the grazing period.

Data on manure and nitrogen excretion are compiled by the Swedish board of agriculture and based on nutrient balance calculations. The underlying data are based on a variety of sources. The data for the most significant animal groups (i.e. cattle and swine) are from public reports produced by the Swedish Board of Agriculture. Annual average population for swine categories with shorter life span than one year, piglets and fattening pigs, is calculated from slaughter statistics. For other swine categories, the farm registry is used. Some of the data for the less significant animal groups are based on expert opinions. See “Compilation of data on manure and nitrogen excretion” in the reference list for a complete list of the sources. For dairy cows the nitrogen and manure excretion are calculated based on milk production (see Table 5.15). Because average milk production has increased during the reporting period, the manure and nitrogen excretion has also increased. For the other animal groups, the data on manure and nitrogen excretion are given in Table 5.16 and Table 5.17. The data are estimated values per head and year. That is, for animals who is in an animal category shorter than one year, for example pigs for meat production, the excretion if one hypothetical animal of a specific animal category would excrete during one year. Total annual excretion per animal category is then estimated by multiplying these values with the estimated annual average population. Naturally, the number of animals in the different categories/age classes will vary somewhat during a year. I.e. piglets will grow and enter the next growth class. However, we use the statistics from the Swedish Board of Agriculture as an approximation of the annual average. Due to a more intense swine production, the yearly excretion for sows and pigs for meat production were updated in 2001. The Nex value for reindeer is calculated using the method and data from the 2006 IPCC Refinement from 2019, Chapter 10, table 19 and equation 10.30 with the assumption (from the Sami parliament) that the slaughter weight represents half the live weight, the average reindeer weight was estimated to 64 kg. All emission factors used in the calculations are presented in Table 5.18.

²⁵¹ Swedish Board of Agriculture. Hästhållning i Sverige 2016.

Table 5.9. Livestock stable periods (months)

Year	Dairy cows	Suckler cows	Heifers	Bulls and steers	Calves	Sheep, horses, goats	Reindeer	Poultry, Swine and Fur-bearing animals
1990	7.2	6.2	6.5	7.6	7.8	6	0	12
1995	7.2	6.2	6.5	7.6	7.8	6	0	12
2000	7.2	5.8	6.1	7.6	7.6	6	0	12
2005	6.9	4.9	5.6	8.4	7.6	6	0	12
2010	7.2	5.5	5.8	8.8	8.2	6	0	12
2015	7.3	5.8	6.0	9.8	8.2	6	0	12
2020	7.1	5.1	5.7	9.1	7.7	6	0	12
2022	7.2	5.2	5.8	9.0	7.9	6	0	12
2023	7.2	5.2	5.8	9.0	7.9	6	0	12
2024	7.2	5.2	5.8	9.0	7.9	6	0	12

Table 5.10. Percentage of manure from different animal categories handled in liquid storage systems

Year	Dairy cattle	Suckler cows	Heifers	Bulls and steers	Calves	Pigs for meat production	Other swine	Sheep, goats, horses, reindeer and fur-bearing animals	Laying Hens, Chickens	Slaughter Chickens, Turkeys
1990	22.6	15.5	16.3	19.0	19.5	44.0	44.0	0.0	25.0	0.0
1995	30.6	21.0	22.0	25.8	26.5	63.0	63.0	0.0	25.0	0.0
2000	39.0	12.5	13.2	16.4	16.4	80.5	25.8	0.0	25.0	0.0
2005	50.8	5.9	19.6	22.5	18.9	91.3	31.8	0.0	20.8	0.0
2010	57.0	11.2	22.3	28.6	16.8	91.3	60.4	0.0	12.0	0.0
2015	60.3	10.0	24.9	31.4	16.1	81.4	49.7	0.0	30.1	0.0
2020	63.8	9.8	24.0	36.6	16.9	78.3	45.6	0.0	5.6	3.2
2022	64.2	9.8	23.4	35.8	18.3	75.3	49.4	0.0	9.9	0.0
2023	63.6	9.7	23.2	35.5	18.1	72.3	47.4	0.0	9.9	0.0
2024	62.1	9.5	22.6	34.6	17.7	66.9	43.9	0.0	9.9	0.0

Table 5.11. Percentage of manure from different animals handled in solid storage systems

Year	Dairy cattle	Suckler cows	Heifers	Bulls and steers	Calves	Pigs for meat production	Other swine	Sheep, goats	Reindeer	Fur-bearing animals	Horses	Laying Hens, Chickens	Slaughter Chickens, Turkeys
1990	51.9	28.9	30.3	35.5	36.4	54.0	45.0	50.0	0.0	100.0	33.0	55.0	87.3
1995	43.8	23.4	24.5	28.7	29.4	35.0	26.0	50.0	0.0	100.0	33.0	55.0	87.3
2000	35.3	28.0	29.5	36.7	36.7	18.0	67.0	50.0	0.0	100.0	33.0	55.0	87.3
2005	22.4	19.0	16.7	27.2	22.8	6.2	45.6	50.0	0.0	100.0	33.0	72.6	87.3
2010	16.4	20.1	15.2	25.8	22.0	5.2	30.4	50.0	0.0	100.0	33.0	88.0	87.3
2015	10.8	19.9	11.9	25.3	16.1	3.4	36.0	50.0	0.0	100.0	33.0	64.6	87.3
2020	5.1	10.3	7.9	10.6	11.9	2.3	23.8	50.0	0.0	100.0	33.0	90.9	69.6
2022	4.7	11.0	7.7	11.8	10.6	3.0	13.5	50.0	0.0	100.0	33.0	86.0	61.0
2023	4.7	11.0	7.7	11.7	10.6	3.0	13.5	50.0	0.0	100.0	33.0	86.0	61.0
2024	4.6	11.0	7.7	11.7	10.6	3.0	13.5	50.0	0.0	100.0	33.0	86.0	61.0

Table 5.12. Percentage of manure from different animals handled as deep bedding

Year	Dairy cattle	Suckler cows	Heifers	Bulls and steers	Calves	Pigs for meat production	Other swine	Sheep, goats, reindeer, Fur-bearing animals	Horses	Laying Hens, Chickens	Slaughter Chickens, Turkeys
1990	0.8	7.2	7.6	8.9	9.1	2.0	11.0	0.0	2.0	20.0	13
1995	0.8	7.2	7.6	8.9	9.1	2.0	11.0	0.0	2.0	20.0	13
2000	0.8	7.7	8.1	10.1	10.1	1.0	7.0	0.0	2.0	20.0	13
2005	0.4	16.0	9.8	19.9	21.6	1.3	22.1	0.0	2.0	6.6	13
2010	0.7	14.5	10.5	18.8	29.5	0.9	7.4	0.0	2.0	0.0	13
2015	0.9	17.1	11.9	22.4	34.5	1.5	6.0	0.0	2.0	5.3	13
2020	1.0	21.3	13.3	25.6	33.5	1.0	19.8	0.0	2.0	3.6	27
2022	0.9	21.1	14.7	24.0	34.6	1.9	24.1	0.0	2.0	4.1	39
2023	0.9	21.1	14.7	23.9	34.5	1.9	24.1	0.0	2.0	4.1	39
2024	0.9	20.9	14.6	23.7	34.3	1.9	24.1	0.0	2.0	4.1	39

Table 5.13. Percentage of manure from different animals handled in on-farm anaerobic digestion treatment and composting systems. Affects only cattle, swine and horses. MCF for the entire digester process is given for different years

Year	Anaerobic digestion in on-farm digesters										Composting
	Dairy cattle	Suckler cows	Heifers	Bulls and steers	Calves	Non-Dairy cattle	Pigs for meat production	Other swine	Swine	MCF for digesters	Horses
1990	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	15.0
1995	NO	NO	NO	NO	NO	NO	NO	NO	NO	NO	15.0
2000	0.0	0.0	0.0	0.0	0.0	0.0	0.2	0.1	0.1	5.7	15.0
2005	0.1	0.0	0.0	0.1	0.1	0.0	0.4	0.1	0.3	5.6	15.0
2010	0.2	0.1	0.1	0.1	0.1	0.1	0.8	0.6	0.8	5.5	15.0
2015	1.1	0.3	0.6	0.8	0.5	0.5	4.7	2.9	4.2	5.7	15.0
2020	1.7	0.5	0.8	1.2	0.7	0.7	6.6	3.8	5.9	5.7	15.0
2022	2.7	0.7	1.2	1.8	1.2	1.1	9.9	6.5	9.1	5.6	15.0
2023	3.0	0.8	1.3	2.1	1.4	1.3	11.9	7.8	10.9	5.6	15.0
2024	4.8	1.3	2.1	3.2	2.2	2.0	18.0	11.8	16.5	5.6	15.0

Table 5.14. Manure handled in anaerobic digestion treatment in co-digesters, percentage for different animals. These fractions of the manure are during manure management accounted for in the waste sector

Year	Anaerobic digestion in co-digesters								
	Dairy cattle	Suckler cows	Heifers	Bulls and steers	Calves	Non-Dairy cattle	Pigs for meat production	Other swine	Swine
1990	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
1995	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0
2000	0.1	0.0	0.0	0.1	0.1	0.0	0.4	0.1	0.3
2005	0.2	0.1	0.1	0.1	0.1	0.1	0.9	0.3	0.7
2010	0.5	0.1	0.2	0.3	0.2	0.2	1.8	1.2	1.6
2015	2.2	0.6	1.1	1.5	1.0	1.0	8.9	5.5	8.0
2020	3.0	0.8	1.4	2.1	1.3	1.3	11.9	6.9	10.6
2022	2.6	0.7	1.2	1.8	1.2	1.1	9.8	6.4	9.0
2023	2.8	0.8	1.2	1.9	1.3	1.2	10.9	7.2	10.0
2024	2.7	0.7	1.2	1.8	1.2	1.1	10.1	6.6	9.3

Table 5.15. Manure and nitrogen excretion from dairy cows

Year	Manure production (kg VS DM/day/head)	Nitrogen excretion (kg/year/head)
1990	5.07	102.0
1995	5.19	110.5
2000	5.29	119.4
2005	5.32	124.3
2010	5.33	126.3
2015	5.35	131.0
2020	5.39	137.0
2022	5.40	139.2
2023	5.41	141.9
2024	5.42	143.3

Table 5.16. Manure excretion from non-dairy cattle and swine

Animal group	Manure production (kg VS DM/day)
Suckler cows	2.30 (in stables) 3.17 (during grazing)
Heifers	2.26
Bulls and steers	2.26
Calves < 6 months	0.60
Calves > 6 months	0.97
Sows	0.64 (1990-2001) 0.69 (as from 2002)
Boars	0.45
Pigs for meat production	0.37
Piglets	0.044

Data from the Swedish Board of Agriculture

Table 5.17. Nitrogen excretion from other animal groups

Animal group	Nitrogen kg/year/ head	Comment
Suckler cows	63	
Heifers	47	
Bulls and steers	47	
Calves	28	
Sows	22.5	Before 2002: 18.5 (kg/ year/ head)
Boars	13	
Pigs for meat production	10.8 (3 prod. cycles / year)	Before 2002: 9.5 (kg/ year/ head) (2.5 prod. cycles/ year)
Piglets	1.2	
Sheep	14	Ewes incl. 1.8 lambs
Lambs	0	
Goats	13	Does incl. 1.8 kids
Kids	0	
Horses	48	
Laying hens	0.60	0.8 prod. cycles/ year
Turkeys	0.69	2.3 prod. cycles/ year
Chickens	0.22	2.2 prod. cycles/ year
Slaughter Chickens	0.29	8.5 prod. cycles/ year
Fur-bearing animals	4.59	
Reindeer	5.4	2019 refinement, typical animal mass 64 kg

Data from the Swedish Board of Agriculture except the value for reindeer.

5.3.2.1 EMISSIONS OF METHANE (INCLUDING EXCRETION FROM GRAZING ANIMALS) (CRT 3.B(A))

The IPCC tier 2 methodology is used for estimating methane from manure management for all animal groups, including excretions from grazing animals. The formula to calculate the emission factors for each livestock group, *i*, according to IPCC guideline's tier 2 methodology is:

$$EF_i = VS_i \times 365 \times B_{0i} \times 0.67 \times \sum_j MCF_j \times MS_{ij}$$

Where VS_i is the volatile substance excreted, B_{0i} is the maximum methane producing capacity for manure produced by an animal within the livestock group, MCF_j is the conversion factor for methane production, given a specific manure management system *j* (where grazing animals are considered as one of the systems). MS_{ij} is the fraction of animal manure handled using manure system *j*.

For cattle and swine country specific values of VS are used whereas default values from 2019 Refinement are used for all other animal groups. The B_{0i} and MCF factors used are the default values from the 2006 IPCC guidelines table 10A-4 to 10A-9 and table 10.17

respectively, except for B_0 for swine and for the country-specific MCF for liquid manure and digesters. For swine the B_0 value 0.268 from the substrate handbook²⁵² is used.

For liquid manure the MCF value 3.5% is used. This value is developed by Rodhe et al. (2009) and is showed to be more appropriate for Sweden's cool conditions. This study measured GHG emissions for one year in three pilot-scale plants with similar conditions to full-scale storage regarding slurry temperature, climate and filling/emptying routines. The study concluded that 3.5% is an appropriate MCF value for the storage of liquid manure in Sweden, which has an average temperature clearly below the definition of "Cool" in the 2019 Refinement of the 2006 IPCC guidelines.

For digesters the MCF:s (Table 5.13) are estimated based on formula 1 in table 10.17 in the 2006 guidelines. The parameters used to estimate the MCF:s for the entire digester process from storage of substrate to storage of digestate, are from a studies relevant to Swedish conditions. Rodhe et al. (2015)²⁵³ investigated the greenhouse gas emissions from storage of digested and non-digested cattle slurry. From this study the $MCF_{\text{storage,digestate}}$ of 25% was obtained. The B_0 for digestate is 30% out of B_0 for untreated manure and the estimation that 35% of the total VS is consumed during the digestion process²⁵⁴. From Lantz & Björnsson²⁵⁵ the following parameters are obtained; the average B_0 in the manure before treatment is estimated assuming 37% of the manure used as substrate in the digesters is from swine, and the remaining from cattle; the methane leaked during digestion averages 0.05% of the produced methane and the dry weight of the substrate is 8.6% of the wet weight. In addition to these a specific methane potential of 200 m³ CH₄/tonne VS is used²⁵⁶ and the flare efficiency for the methane flared is estimated to be 90%.

The reported emissions in the CRT tables are sometimes aggregated. Hence, the implied emission factor for, e.g. "non-dairy cattle" will depend not only on different manure management systems and stable periods over the years, but also on the relative composition of the subgroup. The implied emission factor will therefore vary between years.

When studying the trends for the implied emission factor (IEF) there is a distinctly increasing trend for both non-dairy and dairy cattle. This is caused by a decreased use of solid manure storage systems. This is to some extent counteracted by an increased use of deep litter systems for non-dairy cattle, and by an increased use of liquid systems for dairy cattle.

²⁵² Carlsson M & Uldal M. 2009

²⁵³ Rodhe et al. (2015)

²⁵⁴ Berglund, M. & Mjöfors, K. 2024.

²⁵⁵ Lantz, M. & Björnsson, L. 2016

²⁵⁶ Ahlberg-Eliasson et al. 2017

Table 5.18. Emission factors for manure management.

Manure Management System		MCF (% of B ₀)		Note
Solid manure		2		1
Liquid manure		3.5		2
Deep litter		21		1
Digesters		See table 5.13		4
Composting		1		1
Pasture/Range/Paddock		0.47		1
B ₀ Pasture/Range/Paddock		0.19 m ³ CH ₄ /kg VS		1
Animal category	TAM (kg)	VS	B ₀ (m ³ CH ₄ / kg VS)	
Dairy Cattle	-	87% of manure production (DM)	0.24	3, 1
Non-Dairy Cattle		87% of manure production (DM)	0.18	3, 1
Swine		87% of manure production (DM)	0.268	3, 5
Horse	377	5.65 kg VS / 1000 kg animal mass and day	0.30	1
Goat	40	9 kg VS / 1000 kg animal mass and day	0.18	1
Sheep	40	8.2 kg VS / 1000 kg animal mass and day	0.19	1
Turkeys	6.8	10.3 kg VS / 1000 kg animal mass and day	0.36	1
Laying hens	1.9	8.6 kg VS / 1000 kg animal mass and day	0.39	1
Chickens	1.4	5.3 kg VS / 1000 kg animal mass and day	0.36	1
Slaughter Chickens	1.2	16.1 kg VS / 1000 kg animal mass and day	0.36	1
Reindeer	64	0.39 kg VS / day	0.19	4, 1, 1
Fur-bearing animals	-	0.14 kg VS / day	0.25	1
Manure Management System		Emission factors for N ₂ O (% N ₂ O-N of total N)		
Liquid manure		0.5%		1
Solid manure		1.0%		1
Solid manure, horses		0.5%		1
Solid manure, poultry		0.1%		1
Deep litter		1%		1
Deep litter, poultry		0.1%		1
Digesters		0.06%		1
Composting		0.5%		1
Pasture/Range/Paddock (Cattle) (Aggregated)		0.4%		1
Pasture/Range/Paddock (Sheep & other animals)		0.3%		1

MCF=Methane Conversion Factor. B₀=maximum methane producing capacity for manure. TAM=Total Animal Mass. VS= Volatile Substance. (1) 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. (2) Rodhe et al. 2009. (3) Dustan 2002. (4) National. (5) Carlsson M & Uldal M. 2009.

5.3.2.2 DIRECT EMISSIONS OF NITROUS OXIDE FROM MANURE MANAGEMENT (EXCLUDING EXCRETION FROM GRAZING ANIMALS) (CRT 3.B(B))

N₂O from manure management is estimated with the 2019 Refinement to the IPCC Guidelines, tier 2 methodology. Default emission factors from the 2019 Refinement to the 2006 IPCC Guidelines which are based on more recent literature are used in combination with national activity data. The emission of N₂O from manure management is calculated as:

$$N_2O = \sum_S \left(\sum_T N_T \times Nex_T \times MS_{(T,S)} \times EF_{(T,S)} \right) \times 44/28$$

where N_T is the number of heads of livestock in category T in the country, Nex_T is the annual average excretion of N per head of category T in the country, MS_(T,S) is the fraction of total annual excretion for each livestock category T managed in manure management system S in the country (excluding pasture, range and paddock manure that is reported under 3.D). Even though dairy cattle generally spends the summer on pasture, part of the manure is still produced in the stable during milking and if spending the nights in the stables. This manure is excluded from the pasture, range and paddock manure and instead allocated to the appropriate manure management system. Stable periods and manure management systems are the same as used in the methane calculations (table 5.9 - table 5.13). The emission factors are described in table 5.18. In the CRT tables, where some animal subgroups are aggregated, the implied emission factors for nitrogen excretion rate changes over the years, depending on the relative size of the respective subgroups aggregated.

5.3.2.3 INDIRECT EMISSIONS OF NITROUS OXIDE FROM MANURE MANAGEMENT

The indirect emissions of nitrous oxide due to volatilisation of nitrogen from manure are reported under two different categories, 3.B and 3.D.b. The indirect emissions from manure management are reported in 3.B, and the indirect emissions from application of manure as fertiliser are reported in 3.D.b (see section 5.4.2).

To estimate the indirect emissions in sector 3.B we use the tier 2 method. That is, we use the ammonia emissions from the national ammonia emission inventory together with the default emission factors for NO_x from the EMEP/EEA Guidebook 2016, to estimate the amount of nitrogen volatilised (i.e. *N_{volatilization-MMS}*). For a summary of the ammonia emission model, see below under the paragraph “The national ammonia emission inventory”. The indirect N₂O emissions are then estimated with the default EF₄ from the 2006 IPCC guidelines.

$$N_2O = N_{volatilisation-MMS} \times EF_4 \times 44/28$$

All indirect emissions from manure management due to leaching and runoff are reported under agricultural soils (i.e. 3.D.b), and the notation key IE (Included Elsewhere) is used in 3.B. However, the nitrogen leaching from storage of manure is considered to be low, because Swedish law regulates that the storage must be designed to minimize the leaching and runoff from manure into the environment. However, the model used to estimate nitrogen loss from leaching and runoff (see sector 5.4.2.2.2) will also capture this part, and the complete emissions are reported in sector 3.D.b.

5.3.2.3.1 *Volatile nitrogen losses from manure management*

To estimate the total amount of nitrogen remaining after storage, i.e. the amount available for application to soils, the volatile nitrogen losses during storage as N₂O as well as NO_x and N₂ have to be taken into account. To estimate the fraction of nitrogen lost as NO_x, the default emission factors from the EMEP/EEA Guidebook are used, i.e., 0.01% and 1% of total ammoniacal nitrogen in slurry and solid manure, respectively. The amount lost as N₂O and N₂ is estimated using the difference between the fractions in Table 10.22 and Table 10.23 in the 2006 guidelines (Table 5.19).

Table 5.19. Default values from 2006 guidelines for nitrogen lost as N₂O, N₂ and leaching and run-off from manure management.

Animal group	Manure management system	Default fraction of N lost as N ₂ O, N ₂ and leaching and run-off
Dairy cattle	Liquid/Slurry	Not occurring
Dairy cattle	Solid storage	0.10
Dairy cattle	Deep bedding	0.10
Other cattle	Liquid/Slurry	Not occurring
Other cattle	Solid storage	0.05
Other cattle	Deep bedding	0.10
Swine	Liquid/Slurry	Not occurring
Swine	Solid storage	0.05
Swine	Deep bedding	0.10
Poultry	Poultry with litter	0.10
Other animals	Solid storage	0.03
Other animals	Deep bedding	0.10

5.3.2.3.2 *The national ammonia emission inventory*

The estimate of nitrogen lost as ammonia is mainly built on data collected through Statistics Sweden's survey on use of fertilisers and animal manure in agriculture²⁵⁷. The calculation methods have been developed by the Swedish EPA and Statistics Sweden in collaboration with the Swedish Board of Agriculture and the Swedish Institute of Agricultural and Environmental Engineering²⁵⁸. As from 2005, regional results are published at the website of Statistics Sweden²⁵⁹. In short, the calculations are made as follows:

$$\begin{aligned} A &= (V + L + S) \\ V &= D \times N \times P \times F(v) \\ L &= D \times N \times P \times (1 - F(v)) \times F(l) \\ S &= D \times N \times P \times T \times (1 - F(v)) \times (1 - F(l)) \times F(s) \end{aligned}$$

A = emission of nitrogen in ammonia

V = emission of nitrogen through stable ventilation (depending on type of handling, type of animal and type of manure)

L = emission of nitrogen during storing (depending on type of manure, storing method and type of animal)

S = emission of nitrogen during spreading (depending on type of manure, time of spreading, method of spreading and time period between spreading and mulching)

D = number of animals

N = production of nitrogen, kg, per type of animal, year and handling²⁶⁰

P = stable periods²⁶¹

T = Proportion of ammoniacal nitrogen

F(v) = emission of nitrogen through stable ventilation, % of total nitrogen content in stable manure²⁶².

F(l) = emission of nitrogen during storing, % of total nitrogen content in stable manure after ventilation losses²⁶³.

F(s) = emission of nitrogen during spreading, % of ammoniacal nitrogen content in stable manure after ventilation and storing losses²⁶⁴.

The calculated data is differentiated by type of animal, type and handling of manure, milk production, time and method of spreading and time period between spreading and mulching. Type of manure, way of storing and time of spreading etc. are estimated from the field investigation among farmers²⁶⁵. Data on ventilation-, storage- and spreading-losses originate from the Swedish Board of Agriculture and from Swedish Institute of Agricultural and Environmental Engineering. See the Swedish Informative Inventory

²⁵⁷ Statistics Sweden, MI 30-series.

²⁵⁸ Swedish Environmental Protection Agency 1997

²⁵⁹ Statistics Sweden, MI 37-series.

²⁶⁰ Swedish Board of Agriculture 1995; Swedish Board of Agriculture 2000; Swedish Board of Agriculture 2001

²⁶¹ Statistics Sweden, MI 30-series.

²⁶² Swedish Board of Agriculture 2005

²⁶³ Swedish Institute of Agricultural and Environmental Engineering 2002

²⁶⁴ Swedish Institute of Agricultural and Environmental Engineering 2002

²⁶⁵ Statistics Sweden, MI 30-series.

Report to the LRTAP Convention for a detailed description of the calculations and used emission factors²⁶⁶.

5.3.3 Uncertainties and time-series consistency

Due to more intense swine production, the nitrogen production for sows and pigs for meat production was updated in 2002. The time series for the implied emission factor have some steep steps. This is mainly an effect of that the surveys on the distribution of different manure management systems are only done biannually until 2013 and after that every third year, and that a small relative difference in that survey have a significant effect on the emissions because the emission factors differ considerably between different systems.

5.3.4 Source-specific QA/QC and verification

Annual increase or decrease is verified for the whole time series for all sub-sources to determine whether all annual changes are reasonable. We compare the times series for the emission with the time series for the activity data to confirm that they are in agreement. We regularly conduct crosschecks of country-specific factors against the IPCC default factors. We annually utilize experts from the Swedish board of agriculture to conduct expert peer review of the methods used and we have regular meetings with authorities that provide activity data to the inventory to ensure that the quality of the data are of satisfactory quality and that they in turn use appropriate QC methods.

5.3.5 Source-specific recalculations

The following recalculations are made in submission 2026:

- Updated number of goats and reindeer
- Calculation of methane is corrected for chickens

The total effect of the recalculations in 3.B for the two most recent recalculated years entailed an increase in the emissions corresponding to 0.19% and 0.28% for the year 2022 and 2023.

5.3.6 Source-specific planned improvements

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

²⁶⁶ http://www.ceip.at/ms/ceip_home1/ceip_home/status_reporting/

5.4 Agricultural Soils (CRT 3.D)

Since the subsectors included under agricultural soils represent relatively different processes they are divided into separate paragraphs and treated independently in the key categories analyses. Table 5.20 gives an overview of all emission factors used in this sector.

Table 5.20. Emission factors for N₂O emissions from soils.

Direct emissions from soils	Emission factor % N ₂ O-N of N-supply	Note
Mineral fertiliser (Aggregated)	1%	1
Manure (Aggregated)	1%	1
Sewage sludge (Aggregated)	1%	1
Other organic fertilizers (Aggregated)	1%	1
Crop residue (Aggregated)	1%	1
Mineralization	1%	1
Manure during Pasture/Range/Paddock	See table 5.18	1
Direct emission due to cultivation	Kg N₂O-N/ha/yr	
Cultivation of Histosols	10.3	2
Indirect emissions from soils	% N₂O-N of N-supply	
Atmospheric Deposition (Aggregated)	1% of emitted N	1
Nitrogen Leaching and run-off	0.75% of N lost from leaching	3

(1) 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories. (2) Lundblad 2024. (3) 2006 IPCC Guidelines.

5.4.1 Direct Soil Emissions (CRT 3.D.1)

5.4.1.1 SOURCE CATEGORY DESCRIPTION

This category includes the direct emission of nitrous oxide from managed soils. In terms of magnitude, the most important emissions are the ones from application of inorganic N fertilisers and cultivation of histosols. Also included in this category are emissions from crop residues, application of animal manure, grazing animals, use of sewage sludge and application of other organic fertilisers and mineralization/immobilization associated with loss/gain of soil organic matter. The summary of the latest key category assessment, methods and EF used, and information on completeness are presented in Table 5.21.

Table 5.21. Summary of source category description for the entire category CRT 3.D.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF		Method	EF	All sources estimated
		Level	Trend				Qualitative
3.D.1.a Inorganic N fertilizers	N ₂ O	X	X	T1	D	Yes
3.D.1.b.i Animal manure	N ₂ O	X	-	T1	D	Yes
3.D.1.b.ii Sewage sludge	N ₂ O	-	-	T1	D	Yes
3.D.1.b.iii Other organic fertilizers	N ₂ O	-	-	T1	D	Yes
3.D.1.c Urine and dung deposited by grazing animals	N ₂ O	-	-	T1	D	Yes
3.D.1.d Crop residues	N ₂ O	X	-	T1	D	Yes
3.D.1.e Mineralization/immobilization associated with loss/gain of soil organic matter	N ₂ O	-	-	T1	D	Yes
3.D.1.f Cultivation of organic soils (i.e. histosols)	N ₂ O	X	X	T2	CS	Yes

CS - Country Specific. T1 - tier 1. T2 - tier 2. D - Default.

5.4.1.2 METHODOLOGICAL ISSUES

5.4.1.2.1 Nitrous oxide emissions from inorganic N fertilisers (CRT 3.D.1.a)

Emissions from inorganic fertilisers are calculated as:

$$N_2O \text{ emission} = N_{FERT} \times EF_1 \times 44/28$$

The estimated emissions are based on amount of nitrogen in mineral fertilisers sold annually in Sweden (N_{FERT}). Statistics on sales of fertilisers, recalculated into nitrogen quantities, are published annually by Statistics Sweden (Table 5.22).

Table 5.22. Activity data used to estimate the direct soil emissions from inorganic and organic fertilisers.

Year	Inorganic fertilizers (t N)	Animal manure applied to soils (t N)	Fraction of N volatilised as NH ₃ during storage of animal manure	Fraction of N volatilised as N ₂ O, NO _x , N ₂ and lost through leaching and run-off during storage of animal manure	Fraction of N treated in co-digesters
1990	224 500	77 462	0.2021	0.0541	0.0000
1995	198 300	80 743	0.1893	0.0450	0.0000
2000	189 400	76 349	0.1899	0.0432	0.0012
2005	161 568	74 949	0.1870	0.0361	0.0029
2010	168 000	73 647	0.1843	0.0326	0.0060
2015	190 200	72 676	0.1845	0.0310	0.0261
2020	215 171	69 298	0.1855	0.0296	0.0356
2022	184 852	69 545	0.1849	0.0297	0.0307
2023	184 027	69 091	0.1841	0.0296	0.0329
2024	184 916	68 503	0.1826	0.0293	0.0313

Statistics on fertilisers and sludge are from Swedish Board of Agriculture and Statistics Sweden.

Table 5.22. (continued).

Year	Sewage sludge applied to soils (t N)	Other organic fertilizers applied to soils (excluding digestate from animal manure) (t N)	Animal manure digestate from co-digester applied to soils (t N)	Fraction of N volatilised as NH ₃ during digestae of animal manure in co-digester	Fraction of N volatilised as N ₂ O, NO _x , N ₂ and lost through leaching and run-off during storage of animal manure in co-digester
1990	1 180	1 700	0	0.0	0.0
1995	2 304	1 700	0	0.0	0.0
2000	1 758	1 800	105	0.1031	0.00006
2005	1 053	1 834	249	0.1050	0.00006
2010	2 224	2 921	506	0.1045	0.00006
2015	2 802	5 966	2 225	0.1053	0.00006
2020	4 799	6 974	2 911	0.1067	0.00006
2022	5 285	8 066	2 508	0.1066	0.00006
2023	4 831	8 195	2 673	0.1065	0.00006
2024	5 951	8 842	2 508	0.1065	0.00006

Statistics on fertilisers and sludge are from Swedish Board of Agriculture and Statistics Sweden.

5.4.1.2.2 Nitrous oxide from organic N fertilisers (CRT 3.D.1.b)

To estimate the N₂O emission from organic N fertilisers, the default methodology according to the IPCC Guidelines is used in combination with national estimates of N content in manure, sewage sludge and other organic fertilisers, respectively. The formula used to calculate N content in animal manure applied to soils (F_{AM}) is:

$$F_{AM} = \sum_T N_T \times Nex_T \times (1 - Frac_{LossMS}) \times (1 - Frac_{PRP}) \times (1 - Frac_{co-digesters})$$

Where N_T is the number of heads of livestock in category T in the country, Nex_T is the annual average excretion of N per head of category T in the country, $Frac_{LossMS}$ is the amount of N lost during storage as NH₃, NO_x and N₂ (table 5.22), $Frac_{PRP}$ is the fraction of the nitrogen in pasture, range and paddock manure and $Frac_{co-digesters}$ is the fraction of manure treated in co-digesters. To complete the annual amount of nitrogen applied to soils in 3.D.a.2, this value is complemented with N content in the smaller sources, sewage sludge, other organic fertilisers applied to soils and digestate from animal manure treated in co-digesters (which is part of other organic fertilisers but calculated separately). F_{ON} then denotes then the total amount of nitrogen applied. Statistics on the use of sludge have been collected intermittently by Statistics Sweden and the Swedish EPA from sewage treatment plants (table 5.22). The amount of sludge applied to agriculture soils has gradually increased over time in accordance with the aim in the EU Sewage Sludge Directive. The N content in other organic fertilisers applied to soils is estimated from Statistics Sweden's survey on "Use of fertilisers and animal manure in agriculture" (table 5.22) and "Production and use of biogas and digestate" produced by the Swedish Gas Association for the Swedish Energy Agency, where data on digestate from co-digesters used as fertiliser is presented. For the years preceding 2009 there are no data on co-digester digestate as fertiliser. For these years, data are extrapolated as an average of the available data points. The N₂O emissions are then estimated as:

$$N_2O \text{ emissions} = F_{ON} \times EF_1 \times 44/28$$

5.4.1.2.3 Urine and dung deposited by grazing animals (CRT 3.D.1.c)

To estimate the N₂O emissions from urine and dung deposited by grazing animals, the default emission factor of 0.4% is used for cattle and the default emission factor of 0.3% is used for sheep, goats, horses and reindeer. No other animal categories are applicable in this category. The emissions are calculated as:

$$emissions = \sum_{Ti} N_{Ti} \times Nex_{Ti} \times Frac_{PRP_{T,i}} \times EF_{3PRP,i} \times 44 / 28$$

N_T is the number of animals of type T in the country, Nex_T is the N-excretion of animals of type T , $Frac_{PRP}$ is the fraction of the manure allocated to pasture, range and paddock (Table 5.23), EF_3 is the default emission factor, where i decide which emission factor group the animal category belongs to (i.e. “cattle, poultry and pigs” or “sheep and other animals”). The nitrogen excretion for the different animal groups is presented in Table 5.15 and Table 5.17.

Table 5.23. Manure management systems, percent of manure deposited on pasture, range and paddock.

Year	Dairy cattle	Suckler cows	Heifers	Bulls and steers	Calves	Swine	Sheep, Goats	Reindeer	Horses	Poultry	Fraction of total amount of N excreted on pasture (Frac _{PRP})
1990	24.8	48.3	45.8	36.7	35.0	NO	50.0	100	50.0	NO	0.2922
1995	24.8	48.3	45.8	36.7	35.0	NO	50.0	100	50.0	NO	0.3014
2000	24.8	51.7	49.2	36.7	36.7	NO	50.0	100	50.0	NO	0.3144
2005	26.1	58.9	53.7	30.2	36.6	NO	50.0	100	50.0	NO	0.3240
2010	25.0	54.1	51.7	26.4	31.4	NO	50.0	100	50.0	NO	0.3180
2015	24.5	52.1	49.7	18.6	31.7	NO	50.0	100	50.0	NO	0.3066
2020	25.3	57.4	52.7	23.9	35.6	NO	50.0	100	50.0	NO	0.3237
2022	25.0	56.7	51.8	24.9	34.1	NO	50.0	100	50.0	NO	0.3224
2023	25.0	56.7	51.8	24.9	34.1	NO	50.0	100	50.0	NO	0.3234
2024	25.0	56.7	51.8	24.9	34.1	NO	50.0	100	50.0	NO	0.3219

Data from Statistics Sweden’s survey “Use of fertilisers and animal manure in agriculture”.

5.4.1.2.4 Crop residues (CRT 3.D.1.d)

To estimate the emissions of N₂O from nitrogen circulation from crop residues, both above- and below-ground residues are taken into account. From crops harvested green we assume no above-ground residues except stubble. To estimate above- and below-ground nitrogen, respectively, we use the following equations together with a combination of data in table 11.2 in the IPCC 2006 guidelines and country-specific data where available. The data on fraction of residues removed builds on a survey from 2012²⁶⁷ on how straw and tops from different crops are used.

$$Above\text{-}ground\ N_{(T)} = Crop_{(T)} \times Area_{(T)} \times R_{AG(T)} \times N_{AG(T)} \times Frac_{Renew(T)} \times (1 - Frac_{Remove(T)})$$

267 Statistics Sweden, 2013.

$$\text{Below-ground } N_{(T)} = \text{Crop}_{(T)} \times \text{Area}_{(T)} \times R_{BG(T)} \times N_{BG(T)} \times \text{Frac}_{\text{Renew}(T)}$$

$$\text{N}_2\text{O emissions} = \sum (\text{Above-ground } N_{(T)} + \text{Below-ground } N_{(T)}) \times \text{EF}_1 \times 44/28$$

Where $R_{AG(T)}$ is the ratio of above-ground residues dry matter to harvested yield (i.e. $AG_{DM(T)}/\text{Crop}_{(T)}$), and $R_{BG(T)}$ the corresponding value for below-ground residues. $\text{Crop}_{(T)}$ is the annual yield of crop T , $N_{AG(T)}$ and $N_{BG(T)}$ are the fractions of nitrogen in crop residues, above- and below-ground, respectively. $\text{Frac}_{\text{remove}(T)}$ is the fractions of crop residues that are removed from the field and $\text{Frac}_{\text{renew}(T)}$ is the fraction of total area under crop T that is renewed annually. The total annual amount of nitrogen in crop residues is then the sum of these both parameters summed over all crops (i.e. F_{CR}). See Table 5.24 for all parameters that are used in the calculation of total N-content in crop residues. For cereals, national factors are used for the fraction of aboveground residues and the corresponding N-content²⁶⁸. For other crops, a combination of national factors and IPCC default values are used²⁶⁹. The estimated activity data used as input to the emission calculations are presented in Table 5.25. The N_2O emissions from crop residues is calculated with the default emission factor.

²⁶⁸ Mattson, 2005.

²⁶⁹ Andrist Rangel et al. 2016 and IPCC Guidelines 2006.

Table 5.24. Data used for calculating nitrogen input from crop residues.

Crop	Fraction of dry matter content	Ratio of above-ground residues dry matter R_{AG}	Fraction of N in above-ground crop residues (N_{AG})	Fraction of crop residues removed ($Frac_{Remove}$)	Ratio of below-ground residues to above-ground biomass (R_{BG-BIO})	Fraction of N in below-ground crop residues (N_{BG})	Fraction renewed annually ($Frac_{Renew}$)
Winter wheat	0.86	0.875	0.0051	0.12	0.23	0.009	1
Spring wheat	0.86	0.9625	0.0044	0.1	0.28	0.009	1
Winter rye	0.86	1.075	0.0059	0.22	0.22	0.009	1
Winter barley	0.86	0.875	0.0077	0.22	0.22	0.014	1
Spring barley	0.86	0.825	0.0077	0.1	0.22	0.014	1
Oats	0.86	0.8875	0.0073	0.1	0.25	0.008	1
Mixed grain	0.86	0.8625	0.0075	0.27	0.22	0.009	1
Triticale	0.86	0.975	0.0076	0.12	0.22	0.009	1
Sugar beets	0.2	0.66	0.0225	0.007	0.2	0.014	1
Winter rape	0.91	1.71	0.0107	0.055	0.22	0.009	1
Spring rape	0.91	1.38	0.0107	0.055	0.22	0.009	1
Winter turnip rape	0.91	1.71	0.0107	0.055	0.22	0.009	1
Spring turnip rape	0.91	1.38	0.0107	0.055	0.22	0.009	1
Oil flax	0.91	1.3	0.0143	0.57	0.22	0.009	1
Potato	0.2	0.4	0.0325	0.013	0.2	0.014	1
Peas	0.85	0.91	0.0118	0.014	0.19	0.008	1
Peas for conservation	0.85	0.91	0.0118	0	0.19	0.008	1
Broad bean	0.85	0.88	0.0118	0.014	0.19	0.008	1
Brown bean	0.85	0.91	0.0118	0.022	0.19	0.008	1
Grass-clover mixtures	0.835	0.25	0.024	0	0.54	0.016	0.2
Lay for seed, no clover	0.835	0.84	0.0109	0.35	0.22	0.009	1
Maize	0.86	1	0.0094	0.19	0.22	0.007	1
Green fodder (cereals)	0.3	0.25	0.02	0	0.54	0.012	1
Green fodder (maize)	0.3	0.04	0.02	0	0.54	0.007	1
Green fodder (other)	0.3	0.15	0.02	0	0.54	0.016	1
Pasture ground	0.835	0.4	0.024	0	0.54	0.016	0.2

Table 5.25. Activity data for estimating N₂O emissions from crop residues.

Year	Total harvested product dry matter (tonnes)	Total above-ground residues dry matter (tonnes)	Total below-ground residues dry matter (tonnes)	Total N content in above-ground residues (tonnes)	Total N content in below-ground residues (tonnes)
1990	12 081 657	7 455 762	3 720 547	53 865	42 762
1995	9 391 580	5 584 360	2 780 341	41 084	32 989
2000	9 759 244	6 013 982	3 033 322	42 432	34 610
2005	9 228 332	5 645 238	2 880 763	40 523	33 225
2010	9 640 200	5 414 751	2 817 735	38 122	32 840
2015	11 678 122	7 031 373	3 652 365	46 280	41 321
2020	11 474 440	6 864 004	3 620 178	46 951	40 931
2022	11 080 162	6 795 223	3 538 104	46 845	39 657
2023	9 636 005	5 402 100	2 953 499	37 319	33 455
2024	11 280 104	6 289 433	3 389 746	43 216	38 801

Data on total crop yields are from the Swedish Board of Agriculture. Report series JO16.

5.4.1.2.5 Mineralization/immobilization associated with loss/gain of soil organic matter (CRT 3.D.1.e)

Management change of land can cause loss of soil organic C through oxidation and, simultaneously, mineralisation of N that can be converted to N₂O through nitrification and denitrification. The loss of N due to mineralisation is calculated for all land use categories and all land use change categories. The estimation of loss or gain of C (i.e. ΔC) is performed independently in eight different regions using the ICBM-model as described in section 6. The N₂O emissions from cropland remaining cropland are reported here and the other categories are reported in the LULUCF sector. The reported annual N₂O emission from nitrogen mineralisation is calculated according to the 2006 IPCC guidelines (see equation below), where *i* is the eight different agricultural production areas in Sweden. Mineralisation is generally a slow process, to compensate for that we apply a three years moving average on the emission estimate.

$$N_2O = \sum_{LU_i} [\Delta C_{Mineral,LU_i} \times 0.1] \times EF_1 \times (44/28)$$

5.4.1.2.6 Cultivation of organic soils (CRT 3.D.1.f)

The emission factor used to estimate emissions from cultivated histosols has been updated due to a recent literature review (Lundblad 2024). A value of 10.3 kg N₂O -N/ha is now used in the inventory. The area of organic soils on cropland 2008, 2015 and 2021 was re-assessed in a recent study²⁷⁰. The relationship between organic soil and total cropland area for intermediate years and the years from 1990 to 2007 is interpolated or extrapolated using the 2008-2015 trend in the relationship organic soils vs. total cropland area.

$$N_2O = Area_{Histosols} \times EF \times (44/28)$$

5.4.1.2.7 Uncertainties and time-series consistency

Two related parameters are the amount of nitrogen in sold fertiliser, estimated by the sales statistics, and the nitrogen in used fertilisers, estimated from interviews with

²⁷⁰ Lindahl and Lundblad. 2022

farmers. Sales statistics are collected annually by the Swedish board of agriculture and Statistics Sweden. Data has been collected in the same way from the producers and retailers since the early 1960s. Statistics on the use of fertiliser and manure have been collected every second or third year since the end of the eighties. Because the sales statistics also includes some smaller quantities of fertilisers sold for use outside the agricultural sector, the estimated nitrogen content in sold products has for most years been slightly higher. Differences could also arise due to storage of fertilisers between years, this should however even out in the long run. The decrease of amount of sold fertilisers in 2009 is due to an overconsumption in 2008 due to a dropped tax on fertilisers. The user statistics provide valuable information about the use of fertilisers in different crops and regions, but the sales statistics are considered to give a more accurate estimate of total use. Therefore, the latter are used in the inventory. Another advantage of the sales statistics is that it is updated annually.

Historically, statistics on the use of sewage sludge have been published irregularly and in different reports, and the time series for the earlier years has been created through interpolation and extrapolation. Gradually the quality of the data has increased and is now of adequate quality.

5.4.1.2.8 Source-specific QA/QC and verification

Annual increase or decrease is verified for the whole time series for all sub-sources to determine whether all annual changes are reasonable. We compare the times series for the emission with the time series for the activity data to confirm that they are in agreement. We regularly conduct crosschecks of country-specific factors against the IPCC default factors. We annually utilize experts from the Swedish board of agriculture to conduct expert peer review of the methods used and we have regular meetings with authorities that provide activity data to the inventory to ensure that the quality of the data are of satisfactory quality and that they in turn use appropriate QC methods.

5.4.1.2.9 Source-specific recalculations

The following recalculations are made in submission 2026:

- Changes in amount of nitrogen from animal manure because of updates in 3.B and a correction of EF in the calculation of ammonia from inorganic fertilisers.
- Updated number of goats and reindeer.
- Area of histosols has been updated for the whole time-series which affects N₂O emissions.
- The soil organic carbon stock on mineral soils has been updated for the whole time-series which affects N₂O emissions.

The total effect of the recalculations in 3.D.a for the two most recent recalculated years was a decrease of the estimated emissions with -0.02% and -1.30 for 2022 and 2023, respectively.

5.4.1.2.10 Source-specific planned improvements

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

5.4.2 Indirect Emissions (CRT 3.D.2)

5.4.2.1 SOURCE CATEGORY DESCRIPTION

In addition to the direct emissions from managed soils, indirect emissions also occur. The two pathways of indirect emissions from soils are through volatilization of nitrogen as NH₃ and NO_x, and through leaching and runoff of nitrogen. These emissions occur from, (i) application of synthetic fertilisers, (ii) application of manure and other organic fertilisers, (iii) crop residues, and (iv) nitrogen mineralisation. In addition to these sources, indirect emissions also occur from manure management, these emissions are described above.

To estimate the indirect N₂O emissions from atmospheric deposition (3.D.2.a) we use the tier 1 methodology from the guidelines in combination with the default emission factors from the EMEP/EEA air pollutant emission inventory guidebook 2023 concerning the fraction of N that volatilise as NO_x from inorganic and organic fertilisers, as well as NH₃ from inorganic fertilisers. For the fractions of NH₃ that volatilise from organic fertilisers we use country-specific values. To estimate the emissions from nitrogen leaching and run-off (3.D.2.b) we use a country-specific methodology. The summary of the latest key category assessment, methods and EF used, and information on completeness, are presented in Table 5.26.

Table 5.26. Summary of source category description for the entire category CRT 3.D.b, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
3.D.2.a	N ₂ O	X	-		CS	D	Yes
3.D.2.b	N ₂ O	X	-		CS	D	Yes

CS - Country Specific. D - Default.

5.4.2.2 METHODOLOGICAL ISSUES

5.4.2.2.1 Atmospheric deposition from agricultural soils

The formula used to estimate N₂O-N from atmospheric deposition is:

$$N_2O - N = [(F_{SN} \times Frac_{GASF}) + (F_{ON} \times Frac_{GASM}) + (F_{PRP} \times Frac_{GASG}) + (F_{CoD} \times Frac_{GASCoD})] \times EF_4$$

Where F_{SN} is the annual amount of nitrogen in inorganic fertiliser applied to soils (table 5.28). Frac_{GASF} is the fractions of N that volatilises from inorganic fertilisers, the amount that volatilises differs between different types of fertilisers²⁷¹ which means that Frac_{GASF} differ between different years (table 5.27 and table 5.28). F_{ON} is the annual amount of nitrogen in managed animal manure, sewage sludge and other organic fertiliser applied to soil. Frac_{GASM} describe the amount of nitrogen that volatilises from application of organic fertilisers (table 5.29). F_{PRP} is the annual amount of nitrogen in urine and dung deposited by grazing animals and Frac_{GASG} describe the fractions of N that volatilises from urine and dung deposited by grazing animals (table 5.30). F_{CoD} and Frac_{GASCoD} refer to the annual amount of digestate from animal manure from co-digesters applied to soil and

²⁷¹ EMEP/EEA air pollutant emission inventory guidebook 2023

fraction of volatilised N from the digestate (table 5.29). These fractions are estimated by the model used for the national ammonia emission inventory.

Table 5.27. Emissions of ammonia from different fertiliser types

Fertiliser	Volatilised as ammonia (g NH ₃ /kg N)
Anhydrous ammonia	20
Ammonium nitrate (AN)	24
Ammonium phosphate	84
Ammonium sulphate (AS)	84
Calcium ammonium nitrate (CAN)	24
Ammonium solutions (AN)	87
NK mixtures	24
NP mixtures	84
NPK mixtures	84
Other straight N compounds	24
Urea	195

Table 5.28. Amount of nitrogen in inorganic fertilisers (N t)

Year	Amount of nitrogen in inorganic fertilizers (t N)	Proportion of emitted fertiliser-N (Frac _{GASF})
1990	224 500	0.0384
1995	198 300	0.0377
2000	189 400	0.0371
2005	161 568	0.0408
2010	168 000	0.0368
2015	190 200	0.0366
2020	215 171	0.0360
2022	184 852	0.0343
2023	184 027	0.0371
2024	184 916	0.0347

Statistics on fertilisers are from Swedish Board of Agriculture.

Table 5.29. Amount of nitrogen in organic N fertilisers

Year	Amount of nitrogen in animal manure applied to soils (t N)	Amount of nitrogen in sewage sludge applied to soils (t N)	Amount of nitrogen in other organic fertilisers applied to soils (excluding nitrogen in digestate from animal manure) (t N)	Fraction of applied organic N fertilisers that volatilises (Frac _{GASM})	Amount of nitrogen in digestate from animal manure in co-digester (t N)	Fraction of applied organic N fertilisers that volatilises (Frac _{GASCoD})
1990	77 462	1 180	1 700	0.1695	0	0.0000
1995	80 743	2 304	1 700	0.1704	0	0.0000
2000	76 349	1 758	1 800	0.1698	105	0.1827
2005	74 949	1 053	1 834	0.1710	249	0.1883
2010	73 647	2 224	2 921	0.1652	506	0.1863
2015	72 676	2 802	5 966	0.1684	2 225	0.1985
2020	69 298	4 799	6 974	0.1593	2 911	0.1826
2022	69 545	5 285	8 066	0.1590	2 508	0.1771
2023	69 091	4 831	8 195	0.1593	2 673	0.1776
2024	68 503	5 951	8 842	0.1591	2508	0.1778

Table 5.30. Amount of nitrogen excreted on pasture by grazing animals and digestate from animal manure from co-digester

Year	Amount of nitrogen in urine and dung deposited by grazing animals (N t)	Fraction of nitrogen from grazing animals that volatilises (Frac _{GASG})
1990	43 001	0.0776
1995	45 499	0.0776
2000	45 709	0.0777
2005	46 380	0.0774
2010	44 107	0.0770
2015	42 059	0.0768
2020	43 825	0.0771
2022	43 457	0.0771
2023	43 434	0.0771
2024	42 589	0.0772

5.4.2.2.2 Nitrogen Leaching and run-off

The national estimate of nitrogen leaching is estimated by the Swedish University of Agricultural Sciences and calculated from the SOILNDB model²⁷², which is a part of the SOIL/SOILN model. This model is primarily used for the reporting to the Helsinki commission (HELCOM) to calculate Sweden's emissions of nitrogen and phosphorus to the Baltic Sea. The model was first developed during the 1980s in order to describe nitrogen processes in agricultural soils²⁷³. Since then, the model has been elaborated and tested on data from controlled leaching experiments. These tests show that the model

²⁷² Johnsson, 1990; Swedish EPA, 2002.

²⁷³ Johnsson et al., 1987.

estimates the leaching from soil with good precision²⁷⁴. By using national data on crops, yields, soil, use of fertiliser/manure and spreading time, the leaching is estimated for 22 regions. The regions are based on similarities in agricultural production areas. On average, data from this model has been published about every five years, intermittent years have been interpolated (Table 5.31). The SOILNDB model is not developed to individually estimate the nitrogen leakage that derives from manure management or from managed soils, consequently all emissions from leaching and runoff are reported here and the notation key IE (included elsewhere) is reported in sector 3.B. When calculating nitrogen leaching in the inventory, the average N leaching per hectare, calculated by the SOILNDB model, is multiplied by the total Swedish area of cropland used in the LULUCF sector. The SOILNDB model has continuously been updated during the years. This means that the nitrogen leaching from different years have been computed in different versions of the model and were not fully comparable. In Johnsson et al. (2024) the average nitrogen leaching per hectare is recalculated for 1995, 2005, 2013 and 2019 in the same version of the model and these nitrogen leaching values are used from submission 2025. The years before 1995 and after 2019 are assumed to have the same nitrogen leaching as 1995 and 2019 respectively and for the intermediate years linearly interpolated values are used.

Table 5.31. Parameters used to estimate indirect emissions from nitrogen leaching and run-off.

Year	Average N leaching per hectare (kg/ha)*	Total amount of nitrogen lost from leaching and run-off (t)	Fraction of nitrogen lost through leaching and run-off (FracLEACH)
1990	19.9	61 114	0.1375
1995	19.9	60 454	0.1501
2000	18.3	55 158	0.1394
2005	16.7	49 909	0.1382
2010	17.1	50 350	0.1375
2015	17.0	49 141	0.1218
2020	16.3	46 085	0.1068
2022	16.3	45 697	0.1110
2023	16.3	45 567	0.1189
2024	16.3	45 442	0.1149

* Estimated with the SOIL/SOILN model.

To estimate the implied $Frac_{LEACH}$, which is reported as additional information in the CRT tables for 3.D, the leached nitrogen according to the national model, is divided by the sum of applied nitrogen in inorganic fertilisers, organic fertilisers (including managed animal manure, also the part treated in co-digesters, sewage sludge and other organic fertilisers), amount of N deposited by grazing animals, above- and below-ground crop residues and amount of N mineralised in mineral soils. This quotient varies between 0.16 and 0.11 for different years, which is in the uncertainty range of the IPCC Guidelines' default value of $Frac_{LEACH}$ (default=0.3 with the uncertainty range 0.1-0.8).

²⁷⁴ Swedish EPA, 2002b.

5.4.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The average nitrogen leaching from agricultural soils per hectare, is estimated by the Swedish University of Agricultural Sciences. The reason for the continuous decrease between 1995 and 2005 is believed to mainly be dependent on changes in the crops used in Sweden, there after increased yield of fertilization/harvest, an increase in the area of catch crops, change in manured area and increased spring spreading of manure. The reason for the continuous decrease between 2005 and 2019 were increased fertilizer/harvest yield, crop mix change, change in manured area and increased spring spreading of manure.

This model is considered to be the best available in Sweden, taking many relevant factors into account. Since statistics on the use of fertilisers and manure are produced every second or third year,²⁷⁵ it is not possible to update the average leaching more frequently than that and due to economic reasons, the data has only been published intermittently.

5.4.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Annual increase or decrease is verified for the whole time series for all sub-sources to determine whether all annual changes are reasonable. We compare the time series for the emission with the time series for the activity data to confirm that they are in agreement. We regularly conduct crosschecks of country-specific factors against the IPCC default factors. We annually utilize experts from the Swedish board of agriculture to conduct expert peer review of the methods used and we have regular meetings with authorities that provide activity data to the inventory to ensure that the quality of the data are of satisfactory quality and that they in turn use appropriate QC methods.

5.4.2.5 SOURCE-SPECIFIC RECALCULATIONS

Changes in amount of nitrogen because of updates in 3.B and 3.D.1.

The total effect of the recalculations in 3.D.2 for the two most recent recalculated years was an increase of the estimated emissions with 0.21% and 0.13% for 2022 and 2023, respectively.

5.4.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

5.4.3 CO₂ emissions from liming (CRT 3.G)

5.4.3.1 SOURCE CATEGORY DESCRIPTION

Lime is used in agriculture and horticulture to mitigate acidification and used for structural liming to improve soil properties. The amount applied is from 2010 based on a survey among farmers on the usage of lime²⁷⁶. The statistics on use of lime is produced by Statistics Sweden every second year. Prior to that, the applied amount was instead estimated from the quantities lime sold for agricultural and horticultural purposes and

²⁷⁵ Statistics Sweden, MI 30-series.

²⁷⁶ Statistics Sweden, MI30 series. (www.scb.se/mi1001)

lime from sugar mills and steel production. This statistics was produced yearly by Statistics Sweden²⁷⁷.

A summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 5.32.

Table 5.32. Summary of source category description for the entire category CRT 3.G, according to approach 1.

CRT	Gas	Key Category Assessment (excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
3.G	CO ₂	X	-		T1	D	Yes

T1 tier 1. D Default.

5.4.3.2 METHODOLOGICAL ISSUES

The tier 1 method from the guidelines is used together with default emission factors. The emissions from liming is minor and do not motivate the time and resources to develop a tier 2 method with country-specific emission factors. A tier 2 method would give emissions that “are likely to be less than assumed using the Tier 1 approach” (2006 IPCC, section 11.3.1). Liming would then no longer be a key category. The applied quantities are separated into dolomite (CaMg(CO₃)₂) and limestone (CaCO₃), where dolomite and Mg-lime are reported as dolomite and all other categories are reported as limestone. All quantities are recalculated into amount of dry matter (table 5.33). The emissions are calculated as:

$$CO_2 = ((M_{Limestone} \times EF_{Limestone}) + (M_{Dolomite} \times EF_{Dolomite})) \times \frac{44}{12}$$

Where:

$M_{Limestone}$ is the annual applied amount of calcic limestone,

$M_{Dolomite}$ is the annual applied amount of calcic dolomite,

$EF_{Limestone}$ is the emission factor for limestone (0.12),

$EF_{Dolomite}$ is the emission factor for dolomite (0.13).

Table 5.33. Annual amount of limestone and dolomite applied to agricultural soils (t).

Year	Limestone	Dolomite
1990	255 860	127 600
1995	299 425	83 300
2000	251 850	101 500
2005	165 110	91 200
2010	211 830	62 640
2015	206 190	67 960
2020	213 231	60 038
2022	255 340	56 158
2023	255 340	56 158
2024	255 340	56 158

²⁷⁷ Statistics Sweden, MI30 series. (www.scb.se/mi1001)

5.4.3.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

In 2010, there was a change in the estimation method for the applied amount of lime in agriculture. Between 1990 and 2009, the amount is estimated from the quantity lime sold for agricultural and horticultural purposes plus lime from sugar mills and steel production. This was produced from a survey among all distributors of lime in Sweden. As from 2010, the applied amount is instead estimated from a survey among farmers where they are asked about their usage of lime in the previous year. The reason for the change was that the usage of liming products that was not sold through distributors were becoming more common. For example, by-products from paper mills that sometimes were given for free to the farmers and consequently not included in the sale statistics. Between 2010 and 2012, both surveys were run in parallel to examine the difference between the two estimates. The comparison also confirmed the suspicion that the usage statistics results in higher amounts. However, these by-products have only been largely available in the end of the time-series, so the overall trend has not been affected by this.

5.4.3.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Annual increase or decrease is verified for the whole time series for all sub-sources to determine whether all annual changes are reasonable. We compare the times series for the emission with the time series for the activity data to confirm that they are in agreement. We regularly conduct crosschecks of country-specific factors against the IPCC default factors. We annually utilize experts from the Swedish board of agriculture to conduct expert peer review of the methods used and we have regular meetings with authorities that provide activity data to the inventory to ensure that the quality of the data are of satisfactory quality and that they in turn use appropriate QC methods.

5.4.3.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been made in this category since last submission.

5.4.3.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

5.4.4 CO₂ emissions from urea application (CRT 3.H)

5.4.4.1 SOURCE CATEGORY DESCRIPTION

During urea manufacture, CO₂ is removed from the atmosphere. This CO₂ is subsequently emitted when adding the urea to soils during fertilisation. The emissions from this category are small in Sweden because the use of urea is limited.

A summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 5.34.

Table 5.34. Summary of source category description for the entire category CRT 3.H, according to approach 1.

CRT	Gas	Key Category Assessment (excluding LULUCF)			Method	EF	All sources estimated
		Level	Trend	Qualitative			
3.H	CO ₂	-	-		T1	D	Yes

T1 tier 1. D Default.

5.4.4.2 METHODOLOGICAL ISSUES

Data on the annual use of urea is from sales statistics are published annually by Statistics Sweden. The tier 1 method from the guidelines is used to estimate the emissions with the IPCC default emission factor (0.2 t of C/t of urea).

$$CO_2 = \text{Tonnes urea/yr} \times EF \times 44/12$$

5.4.4.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The same data source as for the calculation of direct emissions of N₂O from inorganic N fertilisers is used. Hence, the description of the time series consistency is found above under that paragraph.

5.4.4.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

Annual increase or decrease is verified for the whole time series for all sub-sources to determine whether all annual changes are reasonable. We compare the times series for the emission with the time series for the activity data to confirm that they are in agreement. We regularly conduct crosschecks of country-specific factors against the IPCC default factors. We annually utilize experts from the Swedish board of agriculture to conduct expert peer review of the methods used and we have regular meetings with authorities that provide activity data to the inventory to ensure that the quality of the data are of satisfactory quality and that they in turn use appropriate QC methods.

5.4.4.5 SOURCE-SPECIFIC RECALCULATIONS

No recalculations have been made in this category since last submission.

5.4.4.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

6 Land Use, Land-Use Change and Forestry (CRT sector 4)

6.1 Overview of LULUCF

Sweden reports carbon stock changes in Living biomass, Dead wood, Litter and Soil organic carbon for Forest land, Cropland, Grassland, Settlements and Wetlands. Except for peat production areas, Wetlands and Other land are considered unmanaged²⁷⁸.

The reporting also includes emissions and removals from:

- Harvested wood products (HWP)
- N₂O emissions associated with nitrogen fertilization of Forest land (4[I])
- N₂O and CH₄ emissions from drained organic soils and CH₄ emissions from drainage ditches on these soils (4[II])
- CO₂ from dissolved organic carbon (DOC) from drained organic soils,
- N₂O emissions due to mineralisation caused by land-use conversions or management change (4[III])
- Indirect N₂O emissions (4[IV])
- N₂O and CH₄ emissions from biomass burning (4[V])²⁷⁹

The extent of reporting of carbon pools, emissions, methodological tiers and result from the key category assessment for the LULUCF sector is summarized in Table 6.1.a and 6.1.b.

Table 6.1.a and 6.1.b Status of reporting of carbon pools, other emissions, methodological tiers and key categories according to approach 1, CRT 4.

6.1.a	Carbon pools				Other emissions				
	Living biomass	Litter	Dead wood	Soil carbon mineral/organic [†]	4(I)	4(II)**	4(III)	4(IV)	4(V)
4. LULUCF	-	-	-	-	-	-	-	T2	-
4.A.1 (Forest Land remaining Forest Land)	T3	T3	T3	T3/T2	T1	T2	T2	-	T2
4.A.2 (Land converted to Forest Land)	T3	T2	T3	T2	NO	T2	T2	-	NO

²⁷⁸ On a request from the ERT, emissions/ removals from changes in living biomass and mineral soils are now reported for Land converted to Other land and Wetlands— even though such land is considered unmanaged.

²⁷⁹ CO₂ emissions from biomass burning are included as stock changes in the Living biomass pool.

6.1.a	Carbon pools				Other emissions				
	Living biomass	Litter	Dead wood	Soil carbon mineral/organic [*]	4(I)	4(II)**	4(III)	4(IV)	4(V)
4.B.1 (Cropland remaining Cropland)	T3	T3	T3	T3/ T2	IE***	T2	IE***	-	IE****
4.B.2 (Land converted to Cropland)	T3	T2	T3	T2	IE***	T2	T2	-	IE****
4.C.1 (Grassland remaining Grassland)	T3	T3	T3	T3/ T2	NO	T2	T2	-	T2
4.C.2 (Land converted to Grassland)	T3	T2	T3	T2	NO	T2	T2	-	IE****
4.D.1 (Wetlands remaining Wetlands)	NA	NA	NA	NA/T2,T3	NA	T2	NA	-	NA
4.D.2 (Land converted to Wetlands)	NA	NA	NA	NA	NA	NA	NA	-	NA
4.E.1 (Settlements remaining Settlements)	T3	NE	NE	T2	NO	NE	NE	-	IE****
4.E.2 (Land converted to Settlements)	T3	T2	T3	T2	NO	NE	T2	-	IE****
4.F.1 (Other land remaining other land)	NA	NA	NA	NA	NA	NA	NA	-	NA
4.F.2 (Land converted to Other land)	T3	T2	T3	T2	NA	NA	NA	-	NA
4.G HWP	T3	-	-	-	-	-	-	-	-

* Includes DOC for organic soils, ** Includes N₂O and CH₄ from drained organic soils and CH₄ from ditches, *** Reported in the Agricultural sector, **** Reported under Grassland

6.1.b	Key category assessment		
	Gas	Level	Trend
4 Nitrogen Leaching and Run-off	N ₂ O	-	-
4.A Drained organic soils	CH ₄	X	-
4.A Drained organic soils	N ₂ O	X	-
4.A.1 Forest land remaining forest land	CH ₄	-	-
4.A.1 Forest land remaining forest land	CO ₂	X	X
4.A.1 Forest land remaining forest land	N ₂ O	-	-
4.A.2.1 Cropland converted to forest land	CO ₂	-	-
4.A.2.1 Cropland converted to forest land	N ₂ O	-	-
4.A.2.2 Grassland converted to forest land	CO ₂	X	X
4.A.2.3 Wetlands converted to forest land	CO ₂	-	-
4.A.2.4 Settlements converted to forest land	CO ₂	X	X
4.A.2.5 Other land converted to forest land	CO ₂	-	-
4.B Drained organic soils	CH ₄	X	X
4.B.1 Cropland remaining cropland	CO ₂	X	X
4.B.2.1 Forest land converted to cropland	CO ₂	-	-
4.B.2.2 Grassland converted to cropland	CO ₂	-	X
4.B.2.4 Settlements converted to cropland	CO ₂	-	-
4.C Drained organic soils	CH ₄	-	-
4.C.1 Grassland remaining grassland	CH ₄	-	-
4.C.1 Grassland remaining grassland	CO ₂	X	-
4.C.1 Grassland remaining grassland	N ₂ O	-	-
4.C.2.1 Forest land converted to grassland	CO ₂	X	X
4.C.2.2 Cropland converted to grassland	CO ₂	-	X
4.C.2.3 Wetlands converted to grassland	CO ₂	-	-
4.C.2.4 Settlements converted to grassland	CO ₂	-	-
4.C.2.5 Other land converted to grassland	CO ₂	-	-
4.D.1 Wetlands remaining wetlands	CH ₄	-	-
4.D.1 Wetlands remaining wetlands	N ₂ O	-	-
4.D.1.1 Peat extraction remaining peat extraction	CO ₂	X	X
4.D.1.3 Other wetlands remaining other wetlands	CO ₂	-	-
4.D.2 Land converted to wetlands	CH ₄	-	-
4.D.2 Land converted to wetlands	N ₂ O	-	-
4.D.2.3.1 Forest converted to wetlands	CO ₂	-	X
4.D.2.3.2 Carbon pools converted to wetlands	CO ₂	-	X
4.D.2.3.3 Grassland converted to wetlands	CO ₂	-	-
4.E.1 Settlements remaining settlements	CO ₂	X	X
4.E.2.1 Forest land converted to settlements	CO ₂	X	X
4.E.2.1 Forest land converted to settlements	N ₂ O	-	-
4.E.2.2 Cropland converted to settlements	CO ₂	-	X
4.E.2.2 Cropland converted to settlements	N ₂ O	-	-
4.E.2.3 Grassland converted to settlements	CO ₂	-	-
4.E.2.3 Grassland converted to settlements	N ₂ O	-	-
4.E.2.5 Other Land converted to settlements	CO ₂	-	-
4.E.2.5 Other Land converted to settlements	N ₂ O	-	-
4.F.2 Land Converted to Other Land	CO ₂	-	X
4.G Total HWP from domestic harvest	CO ₂	X	X

6.1.1 Emissions/removals in LULUCF 1990-2024

In 2024, the net removal from the Land Use, Land-Use Change and Forestry sector (LULUCF) was estimated to -54 238 kt CO₂ -eq. including net removals in harvested wood products and to -50 393 kt CO₂ -eq. when excluding net removals in harvested wood products. The net removal increased from 2023 to 2024 by 5 015 kt CO₂ -eq. As can be seen in figure 6.1 there was no clear long-term trend for many years in the LULUCF-sector as a whole. Due to a decline in forest growth, a long-term increase in harvest rate (except for the last years) and an increase in mortality, the net removal in living biomass has decreased. In recent years, the net uptake of living biomass has increased slightly. This is due to increased growth and reduced harvesting. This can be seen in figure 6.1 for forest land. There are also some inter-annual variations in different subcategories but also long-term trends due to land-use changes, for instance the total area used for crop production is continuously decreasing.

6.1.1.1 LAND-USE CATEGORIES AND EMISSION/REMOVALS IN CARBON POOLS

Forest is the largest land-use category in Sweden. The total forest area using the FAO forest definition is 28 Mha. The productive forest, i.e., where annual stem wood production per hectare and year is larger than 1 m³ and where forestry is considered is 23 Mha²⁸⁰. About 1.4 Mha of the productive forest is formally protected and 1.3 Mha is voluntarily protected resulting in 21 Mha used for wood supply²⁸¹.

Harvest of trees is more or less restricted to productive forests. There has been a gradually increase in felling during the reported period with a maximum harvest of 96 million cubic meters in 2021. Since then, logging has decreased and was noted at 87 million cubic meters in 2024²⁸². A severe storm in 2005 created a temporary peak. Harvest fluctuates between years due to changes in demand for forest products. Natural disturbance also influence on the net removal in living biomass. For many decades, the gross removals of CO₂ (growth) have increased and been higher than harvests (including mortality). However, around 2012 the growth started to decline although still being on a stable high level. In 2018 growth slowed considerable to around 118²⁸³ Mm³ stemwood (~162 Mt CO₂ whole tree biomass p year). The reduced growth may be explained by drought (especially in 2018), followed by bark-beetle attacks. In recent years, growth has recovered - likely due to better weather conditions during the summer.

The largest carbon pools are living biomass and soil organic carbon on Forest land. The largest annual stock change has traditionally been the change in the living biomass pool but between 2017 and 2023, the net change in mineral soils was larger (Figure 6.1 and 6.2). In the living biomass pool a net removal ranging between 5 (2020) and 40 (1991) Mt CO₂ year⁻¹ is reported for Forest land during the period whereas the net change in mineral soils has been stable between 20 and 23 Mt CO₂ year⁻¹.

The dead organic matter pool is a net sink, due to a continuous increase in dead wood, including stumps, and recently also a small increase in the fine litter (humus layer) of

²⁸⁰ Swedish University of Agricultural Sciences, 2023

²⁸¹ Grundberg et al., 2022

²⁸² Gross harvest data from the Forest agency: <https://www.skogsstyrelsen.se/statistik/statistik-efter-amne/bruttoavverkning/>

²⁸³ Average of 2019-2023. Based on data from the NFI

Forest land. This category has previously been reported as a source but due to gradually increasing litter amounts measured in the SFSI inventory the fine litter sub-pool is now a sink. The soil organic carbon pool resulted in net removals during the whole reported period. Note that some soils are sources (mainly drained organic soils) whereas others are sinks.

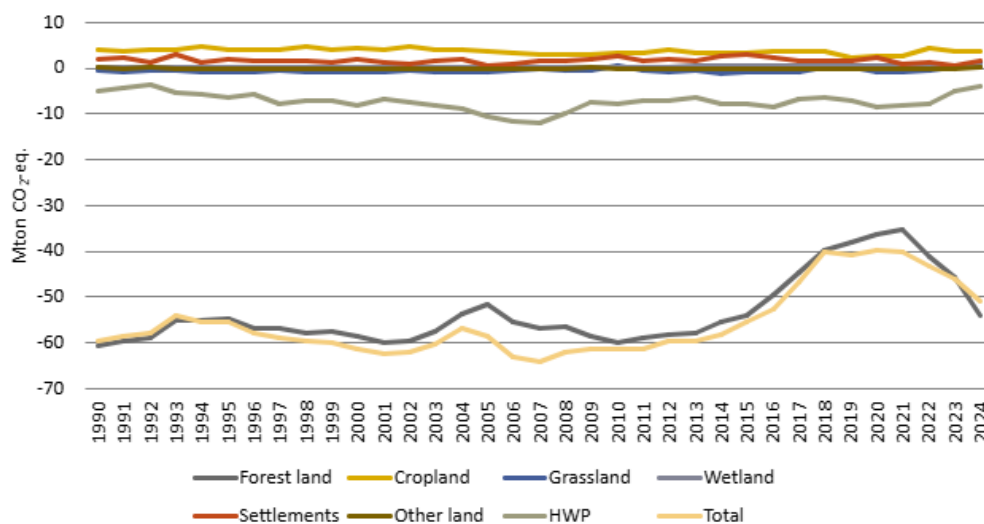


Figure 6.1. Net emissions/removals of GHG in the LULUCF sector from different land-use categories, harvested wood products (HWP) and the total for the sector.

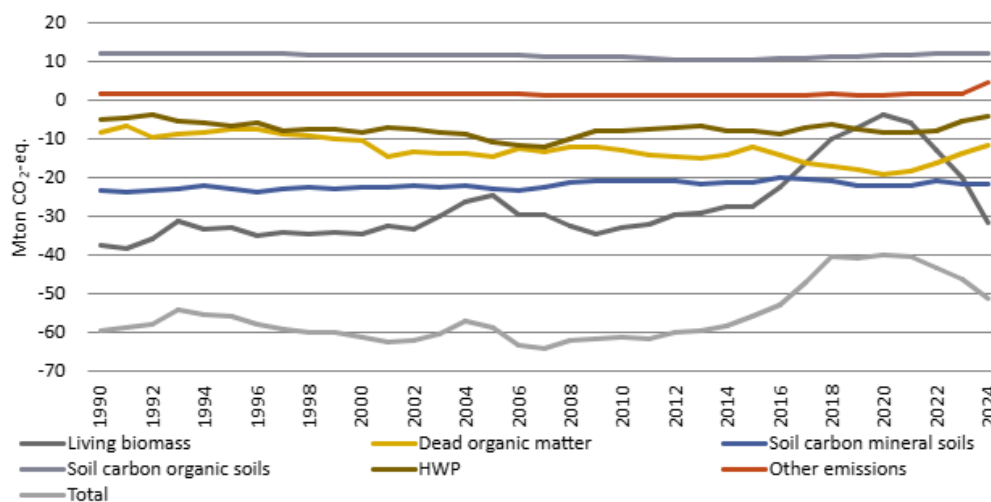


Figure 6.2. Net removals/emissions of GHG in the LULUCF sector from different carbon pools, other emissions (including CH₄ and N₂O from different sources), HWP and the total for the sector.

The HWP pool is a sink and has an inverse relationship with the fluctuations in living biomass as can be seen in Figure 6.2. Increased harvests results in increases in the HWP pool and at the same time reduces the net removals of CO₂ in the living biomass pool.

The major source within the LULUCF sector is the emissions from drained organic soils (Histosols) on Forest land and on Cropland. An area of about 4 Mha of the Forest land is classified as Histosols and around 1 Mha of the Histosols are drained. The Cropland area on Histosols is estimated to approx. 110 kha (2024) and all of that area is drained. Drained Histosols on Forest land is currently the most important net source of greenhouse gases in the Swedish LULUCF sector.

Emissions from Wetlands includes soil emissions from peat extraction areas and losses of carbon from the use of horticultural peat. It increases slightly over the entire reported period due to a slightly increasing long-term trend in the production area and a steady increase in the production of horticultural peat but levels off during some years, mainly due to a decrease in the area used for energy peat production. However, an increase in production area was observed in 2022 which persisted to 2024, which indicates that the area for the previous three years may have been underestimated.

There have been considerable variations in the reported sink for the soil organic carbon pool on mineral soils between submissions. These variations are partly caused by random variation in the sample. Since the total pool is huge and the changes in the pool are comparatively small, the numbers are sensitive to random variation when small changes are multiplied by large areas. It can be noted that a change of 0.1% in the soil carbon pool on Forest land is equivalent to more than 5 000 kt CO₂. The variation between years is reduced due to a method for interpolation and extrapolation of data that was introduced in submission 2023. The variation has decreased with time when more plots are re-inventoried. Since submission 2025, results from three completed soil inventories are included (1993-2002, 2003-2012 and 2013-2022). This year's soil inventory, with emission year 2024, was estimated with the same inventoried years as in submission 2025.

A summary of emissions/ removals is found in Tables 6.2a and 6.2b.

A summary of recalculations compared to previous submissions is found in section 6.4.5.

6.1.1.2 OTHER EMISSIONS 4(I), 4(II), 4(III), 4(IV) AND 4(V)

Data for categories commented below are presented in Table 6.2.b.

Emissions of N₂O from nitrogen fertilization of Forest land increased steadily from 2002 to 2010 but have decreased since then to a fairly stable level, due to a decrease in the use of fertilisers in forestry. A dramatic drop was observed in 2022 and 2023, most likely due to the increased costs for fertilizers and in 2024 the fertilization was back at same levels as in 2020 and 2021.

Emissions of N₂O and CH₄ from Histosols show no clear trend, but the emissions slightly decrease until 2012 whereafter they increase. This is due to variations in the estimate of the area of drained organic forest soils. The reasons for the decrease and following increase in area are under investigation. Emissions of non-CO₂ gases from drained organic soils include emissions from soils as well as direct emissions from ditches. The total emission of non-CO₂ gases from drained organic soils amount to 1 639 kt CO₂ eq. in 2024, which is a slight decrease from 1 677 kt CO₂ eq. in 1990, in line with the development in area of drained organic soils on Forest land. Note that N₂O emissions from Cropland are reported in the agricultural sector.

Emissions of CO₂ from DOC reported from drained Histosols follow the same trend as the non-CO₂ emissions for all land-use categories as they are based on the same area estimates.

N₂O emissions from mineralisation due to land-use conversion and management change which is included for all land use and land-use change categories (except Cropland remaining cropland) shows a slightly increasing trend until 2007 due to the accumulation of areas in land-use change categories, but levels off thereafter since land that has been 20 years in the transition categories is moved to the new land-use category.

The burnt area, which strongly drives the emissions from biomass burning, shows no trend. Except for 2014 and 2018 when large forest fires occurred, the emissions from these categories correspond to less than 0.2 Mt CO₂-eq. per year on average. The CO₂ emissions are reported as IE under 4(V), as the CO₂ emissions are included in net removals in the living biomass pool.

A summary of emissions/ removals is found in Tables 6.2a and 6.2b.

Table 6.2.a. Summary of net removals (-)/emissions (+) in living biomass (LB), dead wood, litter, dead organic matter (DOM), soil organic carbon (SOC) and harvested wood products (HWP) per land-use category. Note that carbon stock change in organic soils also includes DOC.

6.2a	Net emissions / removals (minus = removal) [Mt CO ₂ year ⁻¹]																						
	Forest land					Cropland				Grassland				Wetland		Settlement			Other land		HWP		
	LB	Dead wood	Litter	SOC		LB	DOM	SOC		LB	DOM	SOC		LB	Org	LB	DOM	SOC		LB		DOM	SOC
				Min	Org			Min	Org			Min	Org					Min	Org				
1990	-39.6	-4.2	-3.3	-21.6	6.9	0.0	0.0	-1.2	4.9	0.1	-0.5	-0.3	0.3	0.0	0.1	2.0	0.0	0.0	0.1	0.2		0.0	0.0	5.0
1995	-34.4	-4.6	-2.5	-21.6	6.9	-0.1	0.0	-0.7	4.7	-0.4	-0.5	-0.3	0.4	0.0	0.1	1.9	0.0	0.0	0.1	0.0	0.0	0.0	6.3
2000	-35.4	-7.4	-2.5	-21.7	7.0	-0.2	0.0	-0.1	4.4	-0.3	-0.4	-0.5	0.4	0.0	0.2	1.7	0.1	0.0	0.1	0.0	0.0	0.0	8.2
2005	-24.2	-11.7	-2.5	-21.5	6.9	-0.2	0.0	-0.6	4.2	-0.1	-0.4	-0.6	0.4	0.6	0.2	0.3	0.1	0.0	0.1	0.0	0.0	0.0	10.6
2010	-36.0	-9.4	-3.2	-19.3	6.4	-0.2	0.0	-0.8	3.9	1.2	-0.4	-0.7	0.4	0.1	0.3	2.3	0.1	0.0	0.2	0.0	0.0	0.0	7.7
2011	-33.0	-10.7	-3.2	-19.3	6.1	0.0	0.0	-0.8	3.9	0.0	-0.1	-0.7	0.3	0.0	0.3	1.2	0.1	0.0	0.2	0.0	0.0	0.0	7.3
2012	-30.9	-10.8	-3.6	-19.8	6.0	0.1	0.0	-0.2	3.8	-0.1	-0.1	-0.8	0.3	0.0	0.3	1.4	0.1	0.0	0.2	0.0	0.0	0.0	7.1
2013	-30.1	-10.7	-4.1	-20.3	6.0	-0.2	0.0	-0.4	3.7	0.1	-0.1	-0.8	0.2	0.0	0.3	1.3	0.1	0.0	0.2	0.0	0.0	0.0	6.4
2014	-28.8	-10.3	-3.8	-20.0	6.1	-0.2	0.0	-0.5	3.7	-0.3	-0.2	-0.8	0.2	0.0	0.4	2.0	0.1	0.0	0.3	0.0	0.0	0.0	7.7
2015	-29.8	-8.7	-3.2	-19.6	6.3	0.1	0.0	-0.6	3.6	0.1	-0.2	-0.8	0.2	0.0	0.4	2.4	0.1	0.0	0.3	0.0	0.0	0.0	7.6
2016	-23.9	-9.7	-4.5	-19.1	6.3	-0.2	0.0	-0.1	3.6	0.0	-0.2	-0.8	0.3	0.1	0.4	1.7	0.1	0.0	0.3	0.0	0.0	0.0	8.4
2017	-16.9	-11.0	-5.0	-19.4	6.5	-0.2	0.0	0.1	3.5	-0.2	-0.2	-0.8	0.3	0.0	0.4	1.1	0.1	0.0	0.3	0.0	0.0	0.0	6.9
2018	-11.5	-11.9	-4.7	-19.8	6.8	-0.2	0.0	0.0	3.5	0.9	-0.2	-0.8	0.4	0.0	0.4	1.1	0.1	0.1	0.3	0.0	0.0	0.0	6.3
2019	-9.1	-12.5	-5.3	-19.5	7.0	-0.1	0.0	-1.5	3.5	1.0	-0.2	-0.9	0.3	0.0	0.4	1.1	0.1	0.1	0.3	0.0	0.0	0.0	7.1
2020	-5.4	-13.5	-5.6	-20.2	7.1	-0.1	0.0	-0.9	3.5	-0.2	-0.2	-0.9	0.4	0.0	0.4	1.9	0.1	0.1	0.3	0.0	0.0	0.0	8.3
2021	-5.8	-12.4	-5.7	-20.1	7.3	-0.1	0.0	-1.0	3.5	-0.2	-0.2	-0.9	0.4	0.3	0.4	0.5	0.1	0.1	0.3	0.0	0.0	0.0	8.1
2022	-14.0	-9.9	-6.1	-20.0	7.6	0.4	0.0	0.2	3.4	-0.1	-0.2	-0.9	0.4	0.0	0.5	0.8	0.1	0.1	0.3	0.0	0.0	0.0	7.7
2023	-21.1	-7.4	-6.4	-20.0	7.6	0.6	0.0	-0.6	3.4	0.7	-0.2	-0.9	0.5	0.0	0.5	0.0	0.1	0.1	0.3	0.0	0.0	0.0	5.1
2024	-32.2	-4.9	-6.4	-19.9	7.6	0.0	0.1	-0.9	3.4	0.0	-0.2	-0.9	0.5	0.0	0.5	0.7	0.1	0.1	0.3	0.1	0.0	0.0	3.8

Table 6.2.b. Summary of other emissions. The total LULUCF removal is expressed as CO₂-eq. and includes both carbon stock changes and other emissions.

Year	Other emissions [kt substance year ⁻¹]								Total LULUCF Mt CO ₂ -eq year ⁻¹
	Fert.	Drainage		Min.	Ind.	Biomass burning			
	4 (I)	4(II)		4(III)	4(IV)	4 (V)			
	N ₂ O	CH ₄	N ₂ O	N ₂ O	N ₂ O	CO ₂	CH ₄	N ₂ O	
1990	0.16	21.90	4.01	0.02	0.026	IE	0.08	0.00	-59.6
1995	0.06	21.37	4.02	0.03	0.010	IE	0.08	0.00	-55.5
2000	0.06	20.81	4.04	0.04	0.009	IE	0.12	0.00	-61.2
2005	0.07	20.20	3.95	0.05	0.011	IE	0.24	0.00	-58.1
2010	0.19	19.04	3.67	0.05	0.029	IE	0.03	0.00	-61.1
2011	0.12	18.67	3.56	0.05	0.019	IE	0.10	0.00	-61.5
2012	0.11	18.22	3.43	0.05	0.017	IE	0.05	0.00	-59.7
2013	0.06	18.19	3.48	0.05	0.009	IE	0.12	0.00	-59.6
2014	0.05	18.10	3.55	0.05	0.008	IE	1.21	0.01	-58.2
2015	0.08	18.01	3.60	0.05	0.012	IE	0.07	0.00	-55.6
2016	0.07	18.05	3.63	0.05	0.011	IE	0.12	0.00	-52.6
2017	0.06	18.09	3.72	0.05	0.009	IE	0.09	0.00	-46.7
2018	0.07	18.48	3.83	0.05	0.011	IE	2.07	0.01	-40.2
2019	0.08	18.46	3.89	0.06	0.013	IE	0.12	0.00	-40.7
2020	0.10	18.49	3.92	0.06	0.016	IE	0.06	0.00	-39.8
2021	0.10	18.61	4.01	0.06	0.016	IE	0.09	0.00	-39.8
2022	0.02	19.04	4.17	0.06	0.004	IE	0.07	0.00	-43.1
2023	0.04	18.99	4.17	0.06	0.005	IE	0.07	0.00	-46.0
2024	0.10	18.99	4.18	0.06	0.015	IE	0.04	0.00	-54.2

6.2 Land-use definitions, the classification systems used and their correspondence to the land use, land-use change and forestry categories

6.2.1 Forest land

Sweden has defined Forest land according to the Global Forest Resources Assessment (FAO/FRA) 2005²⁸⁴. Forest land is land with a tree crown cover (or equivalent stocking level) of more than 10% at maturity, with a minimum area of 0.50 hectare and the trees should be able to reach a minimum height of 5 m at maturity *in situ*.

Forest land can temporary be unstocked due to human intervention such as final felling. Normally such land is replanted within a few years and Forest land is not considered deforested if not confirmed in field. Assessed land that meets the forest criteria above but where other land-use is predominating is not considered Forest land. For example, grazing land may fulfil the forest criteria except for the predominant land use and is thereby not considered Forest land but classified as Grassland. Tree-rows narrower than 10 m are not considered Forest land. Roads and power-line routes within forests are considered Forest land only if they are narrower than 5 m. Tree covered areas less than 0.5 ha does not fulfil the forest criteria and is reported as belonging to the neighbouring land use category which implies that carbon stock changes in living biomass may be reported under any land use category.

The definition of Forest land is consistent with former reporting to other international bodies like the FAO. However, to be able to trace both gross and net land use transfers, only permanent sample plots are used in the reporting under the UNFCCC/EU while both temporary (only visited once) and permanent (fixed position and re-inventoried) sample plots are normally used for most assessments and reporting of the state of the Swedish forests to other bodies. In both cases the expected values of estimates are the same but estimates are subject to the random variation of the sample.

All Forest land is assumed managed. The underlying data are consistent for the whole reporting period.

6.2.2 Cropland

Cropland is defined as regularly tilled agricultural land and all Cropland is assumed managed.

6.2.3 Grassland

Grassland is defined as agricultural land that is not regularly tilled and all Grassland is assumed managed. In the Swedish inventory this corresponds to natural grazing land. Grassland is agricultural land that due topography, stoniness, coarse and/or shallow soils or high groundwater table are unsuitable for cropland cultivation. It often has a diverse field layer vegetation of grasses and herbs and a sparse or medium dense shrub and tree vegetation.

²⁸⁴ Food and Agriculture Organization of the United Nations, 2004

6.2.4 Wetlands

Generally, Wetlands are assumed unmanaged and are defined as mires and areas saturated by freshwater. However, an area of approx. 10 000 ha that is used for peat extraction is included under Wetlands and therefore assumed managed. Since this submission carbon stock changes of land converted to Wetland is also reported.

6.2.5 Settlements

Settlements are defined as infrastructure components such as roads and railways, power lines within forests, municipality areas, gardens and gravel pits. All Settlements are assumed managed.

6.2.6 Other land

Other land is defined as all land not covered by the other categories above. It includes most of the mountain area in northwest Sweden. Other land is assumed unmanaged although carbon stock changes of land converted to Other land is reported. The reported land-use categories are based on 12 national land-use categories (Table 6.3) monitored by the Swedish National Forest Inventory (NFI).

Table 6.3. National Land-use Categories (used in the NFI) and their connection to the UNFCCC Land-use Categories. The area estimate in this example is based on both temporary and permanent sample plots representing the average 2020-2024 which implies that the total area is not exactly the same as in CRT table 4.1.

National Land-use Category (NFI)	Forest land	Other wooded land	Bare unprod. Land	Other land*	Total	Additional Explanation and corresponding UNFCCC-category (in bold).
Productive Forest land	23590				23590	Land which hosts a potential yield of stem-wood exceeding one cubic metre per hectare and year. Forest land.
Grazing Land				525	525	Not regularly cultivated, Grassland.
Arable Land				2805	2805	Regularly cultivated, Cropland.
Mire	2034	1183	1852		5069	Land which hosts a potential yield of stem-wood lower than one cubic metre per hectare and year, Forest land (if forest according to FAO) or Wetlands (larger part).
Rock Surface	642	125	162		929	Rocky or stony areas, Forest land (if forest according to FAO) or Other land*.
Sub alpine Coniferous Woodland	921	110	20		1050	Land-zone usually located between 1 and 7. Forest land (if forest according to FAO) or Other land*.

High Mountain	785	838	3330	4954	Usually unstocked or sparsely stocked, Forest land (if forest according to FAO) or Other land* .
Road and Railroad			523	523	For permanent use. Not only roadway and rail but also other connected areas as embankments, Settlements
Power line Within Forest			138	138	Minimum width 5 m, Settlements
Urban Land			1239	1239	Various kind of Settlements, Settlements
Other land*			51	51	Different kinds of land that is not covered by Other land-use categories. Examples: gravel pits, halting places and slalom slopes, Settlements
Freshwater			4392	4392	Lakes, rivers, streams, canals and ponds. Minimum width of 2 m, Wetlands.
<i>FL</i>	<i>27971</i>			27971	
<i>CL</i>			2805	2805	
<i>GL</i>			525	525	
<i>WL</i>		1183	1852	4392	7427
<i>S</i>			1951	1951	
<i>OL</i>		1073	3512	4585	
Total	27971	2256	5364	9673	45264

* Note that the national land use category Other land in the NFI of Sweden do not correspond to the UNFCCC land use category Other land.

The national land use categories “Protected area nature reserve”, “Other climate impediment” and “Military impediment” are included in other land use categories and the land use category “Sea” is not reported at all. Observe that the example in table 6.3 is based on both temporary and permanent sample plots in the NFI representing an average for 2020-2024. Thus, the total land area in Table 6.3 is not exactly the same as the total reported area in the CRT-tables.

6.2.7 Consistency in reporting land-use categories

The NFI has monitored land-use categories in a reasonably consistent way since 1983 (no appropriate data exists 1970-1982). Based on permanent sample plots, it is possible to trace both gross and net land-use transfers from 1983 to 2020. After 2020, only net changes in land use can be estimated since 2020 is currently the last year with a complete sample plot record (see section 6.2.8).

All land areas are included in the field inventory except urban land. Urban land is inventoried by remote sensing to be able to correctly determine areas. It is assumed that its relative importance for the Swedish carbon budget is negligible except when land is transferred to settlement due to land exploitation (emissions from such conversions to urban land are reported).

A few historical inconsistencies in the land-use category assessment have been identified and corrected. In the past (until 2003), protected areas (“Protected Area, Nature Reserve”; see section 6.2.7) were not regularly inventoried. From 2003 and onwards these areas are included in the land-use categories where it belongs. Usually there are data from at least one field inventory of “protected areas” earlier than 1990, but for some areas there are no data available. If no historical data are available, the change in carbon pools in former “protected areas” is assumed to be zero from 1990 to 2002. The FRA 2005 definition of Forest land was introduced in the field inventory in 1998 and therefore land-use assessments in earlier inventories has been re-evaluated. Treatment of former protected areas, re-evaluation of the assessment of land use and the methodology for correcting inconsistencies in the land-use category assessment are described in more detail in the methodology section.

Sweden has adopted Approach 3: Geographically explicit land-use conversion data in accordance with the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (and with the 2019 Refinement to the 2006 IPCC Guidelines for National Greenhouse Gas Inventories). In the Swedish context, a permanent sampling design (30 000 plots are revisited in the field) on all types of land is a prerequisite for Approach 3. In addition, the inventory began before the base year 1990 and follows the IPCC's recommended five-year inventory cycle. It is probably quite unique that not only land use and land use change but also important carbon pool changes (e.g. living biomass, dead wood, mineral soil) are measured using Approach 3.

6.2.8 Land use and land-use change matrix

The land use and land-use change matrix in Table 6.4 is based on all of the 30 000 permanent sample plots in the inventory (1990-2020). For example, the total area of Forest land remaining Forest land and conversions to Forest land (4.A.1 + 4.A.2.1 + 4.A.2.2 + 4.A.2.3 + 4.A.2.4 + 4.A.2.5) was 28122.63 kha in 2020. This implies that, given the sample, the land-use matrix is consistent with reported areas²⁸⁵. Due to a five-year inventory cycle, we can only provide a full record of data for the years 1990-2020. Therefore, land use for recent years (2021-2024) is extrapolated 1, 2, 3 or 4 years depending on the inventory cycle, respectively. In the CRT Table 4.1, land use and land-use change matrices for recent years (2021-2024) are based on measured net land use per year and assumptions about land use conversions. It may be logical that the accumulated area in CRT tables 4.A-F is linked to table 4.1. However, it is not possible to convert extrapolated and accumulated areas of land-use change reported in CRT tables 4.A-F to annual values. This is due to the fact that the information on land areas leaving and entering the reported categories would be lost in the extrapolation of the years 2021-2024. Interpolating and extrapolating inventory data to expand the sample is a better way (more accurate estimates with a lower sampling error) to estimate area changes compared to only use annual data (see annex 3:2 section 3.2.1.2). The IPCC acknowledge extrapolated data to improve the inventory but there are no guidelines on how to report CRT table 4.1 using extrapolated data.

²⁸⁵ Observe that Table 4.1 describes annual transitions between Land Use Categories while tables 4.A – 4.F describe the current area within each land use category. The total of e.g. Forest land in 4.1 is always the same as in 4.A. Given the sample, the consistency is valid for up to 15 significant figures but this is not the same as accuracy of the estimator. Uncertainty of estimates is stressed in chapter 6.4.3.

Table 6.4. Land Use Categories 2019, 2020 and gross and net land use transfers 2019-2020 (based on about 30 000 permanent sample plots inventoried 1983-).

Area [kha]	From Year 2018	To Year 2019					
		Forest Land	Crop- Land	Grass- Land	Wet- Land	Settle- ments	Other Land
F	28121.21	28096.83	0.12	3.30	7.30	13.02	0.63
C	2839.94	3.69	2824.18	6.01	0.31	5.74	0.00
G	499.13	3.81	2.76	492.57	0.00	0.00	0.00
W	7434.48	12.01	0.00	0.00	7422.47	0.00	0.00
S	1930.42	2.25	0.21	0.00	0.00	1927.96	0.00
O	4307.32	4.04	0.00	0.00	0.00	0.00	4303.28
Sum		28122.63	2827.27	501.88	7430.08	1946.72	4303.91

6.3 Information on approaches used for representing land areas and on land-use databases used for the inventory preparation

6.3.1 The Swedish National Forest Inventory (NFI) and the Swedish Forest Soil Inventory (SFSI).

The Swedish National Forest Inventory (NFI²⁸⁶) and the Swedish Forest Soil Inventory (SFSI²⁸⁷) are integrated in the same sample design, using the same permanent sample plots. The main objective of the NFI/SFSI is monitoring of forest production and environmental status.

The NFI plots are re-inventoried every fifth year and the SFSI plots are re-inventoried every tenth year since changes in the soil are expected to be slower than changes in living biomass. Topsoil cores are taken at every second sample plot and deeper soil horizons are sampled on every fourth sample plot. The reported data of changes in the living biomass and dead wood pools are based on the NFI measurements and changes in the litter and soil organic carbon pools are based on the SFSI measurements.

The NFI/SFSI is an annual, systematic, cluster-sample inventory of Sweden's forests (Figure 6.3a and 6.3b). Each year roughly a thousand survey sample clusters are inventoried in the field. One third of the clusters are temporary and two thirds are permanent. Only permanent sample plots are used for the UNFCCC reporting. The clusters are distributed all over the country in a pattern that is denser in the southern part than that in the northern part of the country. The clusters, referred to as tracts, are square-shaped with sample plots along each side. Each cluster consists of four to eight sample plots, depending on region. Each year, about 6000 permanent survey sample plots are inventoried in the field. On each circular sample plot, with a radius of 10 or 20 m depending on the assessed variable, information is collected about the trees, the stand and the site.

²⁸⁶ Ranneby et al., 1987

²⁸⁷ Swedish University of Agricultural Sciences, <http://www-markinventeringen.slu.se/>

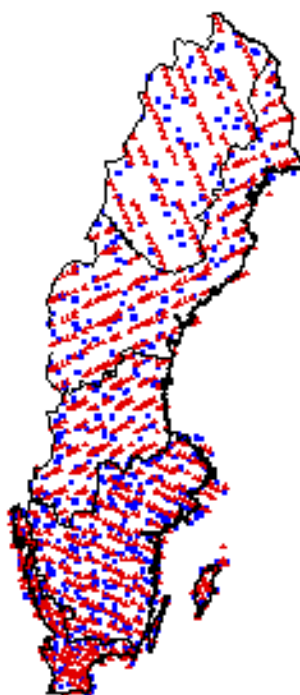


Figure 6.3a. Each year a permanent sample grid covering the whole country of Sweden, (red) is re-inventoried and a temporary sample grid (blue) is inventoried. Observe that the size and number of tracts differs by county. To be able to trace both gross and net land-use transfers, only permanent sample plots are used in the reporting. When estimating changes of e.g. C, the accuracy is higher using permanent than when using both temporary and permanent sampling plots. Each red dot in the map represents a cluster of sample plots (tract).

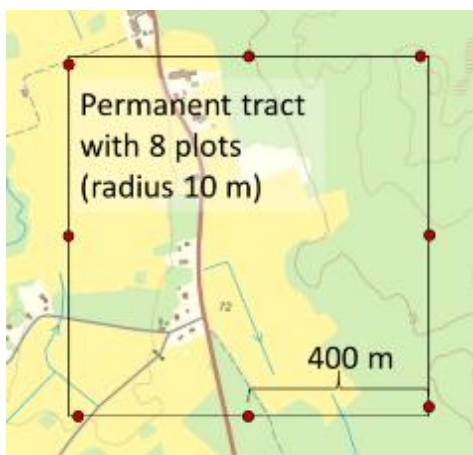


Figure 6.3b. The sample plots (red) are covering all relevant land uses. In the example above, plots are mainly located on Forest land and Cropland and some plots are divided into more than one land-use category. On the plots, measurements are made to estimate standing biomass of trees. Volume of dead wood per decay class is also measured on the plot. Soil samples from different soil horizons are sampled and analysed for C concentration and other properties. Litter is partly estimated using data from the plot and partly modelled.

The SFSI uses the 10-m radius sampling plot. A number of variables are recorded including general site variables, soil and humus type. The litter and different soil layers are sampled for laboratory analysis. The O, H or A horizon²⁸⁸ are sampled using an auger. The mineral soil used to be sampled in different but well-defined soil layers according to the distance from the soil surface and to some extent depending on the soil type. From 2003 and onwards the soil sampling has been harmonized with European soil monitoring efforts, e.g. Biosoil²⁸⁹ and soil samples are taken at fixed depths from the top of the mineral soil surface.

²⁸⁸ O and H are organic soil layers and A refers to a humus rich, top mineral soil layer.

²⁸⁹ <http://biosoil.jrc.it/>

6.3.1.1 SAMPLE BASED ESTIMATIONS

The sample frame consists of a sampling grid covering the entire land and freshwater area of Sweden (Figure 6.4). A sea archipelago zone where islands covered by vegetation might occur is also included in the frame, but no sea area is reported. The frame is divided into 31 strata (i.e. representing counties or parts of counties) and a specific number of sample units are sampled per stratum. Each tract is assumed to be the sample unit. The inventoried area of a tract is given a specific area weight and will consequently represent a larger area. The weighing is generated so that the sum of all represented areas will be equal to the total county area. The approx. 30,000 randomly distributed sample plots represent an unbiased sample of carbon pool changes and areas per land use category in Sweden. The position of these plots is confidential in order to avoid special management of the plots.

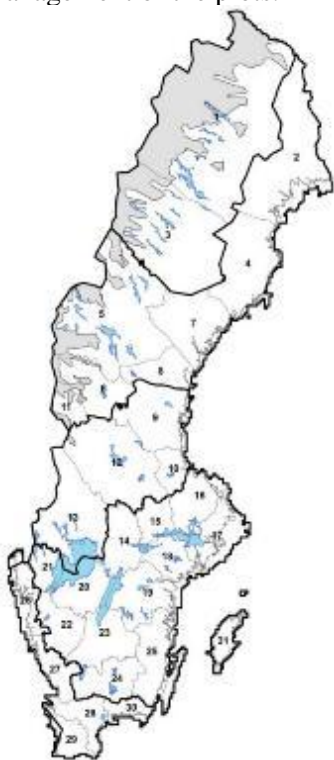


Figure 6.4. The country is divided into five regions, each with a different sample design and 31 strata used for stratification.

The land use of whole plots or parts of plots may change with time, but the tract will always represent the same total area. At the county level, the reported value of a change in a carbon pool (for example a change in the living biomass pool for the land-use category Forest land remaining Forest land) will be estimated by a ratio estimator²⁹⁰. Finally, the reported value on national level is estimated as the sum of the county values (for further information, see Annex to the NID section 3.2.1.1).

A five-year inventory cycle is used in the NFI, and five different samples were randomly distributed using systematic grids 1983, 1984, 1985, 1986 and 1987, respectively. Each of

²⁹⁰ Thompson, 1992

these samples consists of around 6000 sample plots. The expected value of an estimator is theoretically the same for any given sample but to reduce sample randomness all five samples are merged. Full sets of samples are currently only available for years until 2020 and consequently only 24000, 18000, 12000 and 6000 sample plots are available for the estimates of 2021, 2022, 2023 and 2024 respectively. Five years after any reporting year, all samples have been re-inventoried covering that particular year and the full set of data can be used to produce the estimate. Therefore, the four last years of the previous report are recalculated for the biomass carbon pool and revised in each submission. Note that the soil carbon pool is inventoried every ten years. This is because processes in the ground are considered slower. The changes in litter and soil pools are interpolated and extrapolated over the whole time series based on average measured change (see Annex Section 3.2.1.6).

Since the random variation in the estimates of areas is larger for the four most recent years (as also noted in the annual review reports), Sweden extrapolates each of the five sample series (cycles) using the trend for the five years prior to the year of the latest actual re-measurement, to enlarge the data set for the most recent years. In Figure 6.5, the extrapolation of each sample series and its consequences on the estimates of the total area are illustrated. The effect of the extrapolation levels out “strange” area and carbon stock variations evolving from the randomness of the sampling²⁹¹.

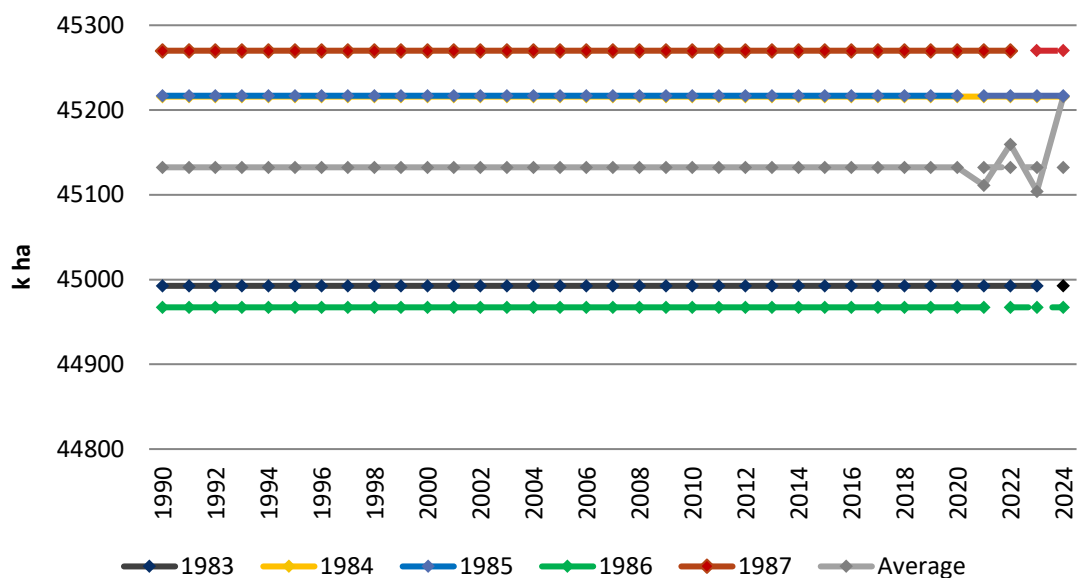


Figure 6.5. The total area of Sweden represented by five sub-samples (established in 1983, 1984, 1985, 1986 and 1987). Solid lines represent measured and dashed lines represent extrapolated values. The average solid line 1990-2024 represents average without extrapolated values and the average dashed line (2019-2024) represents the average with extrapolated values.

From submission 2025 the method to extrapolate net removals in living biomass for the four most recent years without a full record using the trend for the previous five year period has been exchanged to a new method. In this submission, growth is predicted using artificial intelligence technology (AI). The AI models for growth are trained based on historical growth using data from NFI plots, weather statistics and seasonal

²⁹¹ This improvement and the information provided is a response to reviewers (ARR 2011)

development on tree ring bore cores from temporary NFI-plots. Ingrowth (trees that become 100 mm in dbh) and mortality are considered. Harvest is modelled based on detection of changes in satellite images. The projections are made for the inventory cycles not inventoried to date. When the sample plot/cycle has been re-inventoried, the predicted value is discarded and replaced with the measured value (see Appendix 3.1.1.2). In the past, trend extrapolation has been used for living biomass, but it was recognised that there was a large risk of over or underestimation of net removals using past trends. The idea of replacing trend extrapolation with AI technology and remote sensing is to get a projected value that better matches the final measurement and thus to reduce the effect of recalculations.

Sweden reports human induced carbon stock changes only, where human induced has the interpretation of managed, i.e. the carbon stock change on unmanaged land is set to zero. However, the actual stock in living biomass on unmanaged land is considered when calculating stock changes after conversions between unmanaged and managed land and vice versa. This is possible since trees are inventoried on almost any land. All areas, managed or unmanaged, are reported. All carbon stock changes on land converted to managed land are reported. Forest land (Forest land dedicated to conservation purposes included) may sometimes be converted to unmanaged land, i.e. to Other land or Wetlands by natural degradation without harvest. Such conversions are considered non-human induced. Previously carbon stock changes related to these conversions were not reported but, due to a recommendation from the UNFCCC ERT, emissions/removals from managed land categories (Forest land, Cropland, Grassland, Settlements and Wetlands) to Wetland and Other land are now reported since methods are available in the 2006 IPCC Guidelines.

6.3.1.2 THE LULUCF REPORTING DATABASE

All of the permanent sample plots (design-based sampling) of the NFI (around 30 000) are used for estimates and an area-based estimator is used. Land use of each plot or sub-plot for plots divided in two or more land-use classes is described from the year of the first inventory and every fifth year thereafter. Each plot has one value each year between inventories. This value is measured or interpolated. If no land-use change has been identified for a plot, the land use of years between consecutive inventories is held constant. If land-use conversions are identified in field during the inventory, the year of change in land use is randomly set (see 6.3.1.3 and Table A.3.2.1 in Annex 3:2) to any year between the previous and the present inventory.

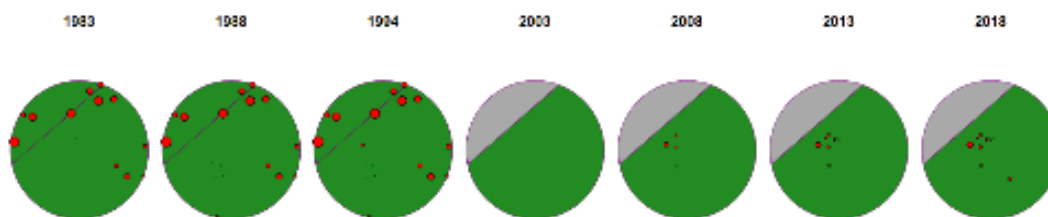


Figure 6.6. The figure shows measured data for a specific sample plot in the Swedish LULUCF database. The individual tree biomass on approximately 30 000 permanent sample plots is matched to land use and traced back to before the base year in a consistent way. Applying area-based sampling all 30 000 permanent sample plots represent the whole land and freshwater area in Sweden and carbon stock changes are estimated using the stock change method on these plots. Part of this specific plot was deforested (grey areas) between 1994 and 2003. The positioning of trees (red dots) is central when matching carbon stock changes in living biomass to land-use change (about 75% of deforested plots are divided into more than one land-use category). The position and biomass of the marked trees are identified at all inventories and demonstrate the possibility to match individual trees to land use over time.

6.3.1.3 LAND-USE TRANSFERS

The main requirement to detect land-use change is that the definition of the former land use is no longer met. For instance, if the definition of Forest land (6.2.1) does no longer hold, the land is considered converted to another land-use category. This rule is used regardless of whether the land is considered managed or unmanaged, which means that land can be transferred from managed land to unmanaged and vice versa. For instance, the growing conditions on tree covered unmanaged Wetlands or Other land may change so that the forest definition is met. Then such Wetlands and Other land will be reported as converted to Forest land. A transfer in the opposite direction may be when sparsely tree covered Forest land is degrading and the forest definition does no longer hold.

Land-use conversions are assumed to occur at a random year between consecutive re-measurements. If a land-use conversion is also related to a loss of living biomass (Forest land converted to another land category) between consecutive inventories, the biomass is assumed to drop to the new level or zero the anticipated year of land-use conversion (i.e. the year of land use change).

Every plot that is converted to another land-use category is reported for 20 years in the corresponding land-use change category. After 20 years the plot will be reported in the new land-use category (a remaining category) to which it was transferred. If a second land-use conversion occurs within the 20 years, the counting starts all over again and the second transfer is reported for 20 years in the new land-use transfer category. Since information on previous land use has been recorded within the NFI, it is possible to trace land-use transfers that have occurred since 1983/1987. Consequently, it is possible to decide how many years a sample plot has belonged to a certain land-use category and to which land-use category it was converted already from or even before the start of the reporting period (1990). This means that some land-use transfer categories include areas converted already before 1990.

The FAO definition of Forest land was introduced in the Swedish NFI in 1998. Until 1998, Forest land was assessed based on a national definition²⁹² of Forest land. Therefore, land-use categories need re-assessment for the period 1983-1997. There are two main cases of re-assessments which are handled as follows:

1. If the land-use category for a sample plot was registered as Forest land according to the FAO definition at the first inventory after 1997 and the national land-use category (see Table 6.4) had been the same at all earlier inventories since 1990, the plot is assumed to have always belonged to the land-use category Forest land.
2. If the land-use category was registered as Forest land according to the FAO definition at the first inventory after 1997 and the national land-use category (see Table 6.4) had changed since 1990, the first land-use category is assumed to remain until the year of conversion. If at consecutive inventories after that, the land-use category remains as Forest land, the plot is assumed to belong to the category Forest land all years after the year of conversion.

Two types of inconsistently classified land-use transfers have been identified and corrected:

1. Inconsistency over time in applying land-use category definitions.
2. Inconsistency in delineating borders between plots divided into more than one land-use category.

One example of the first type is when at different inventories, the land-use category of a sample plot has been classified as Forest land in the first inventory, as Wetland at the next inventory and then again as Forest land at the third inventory without any indications of human activities. A case like this is corrected in the post-data process so that the land-use category is assumed to be Forest land on all three occasions. This automatic correction has been used on data collected before 2003. After this year, a land-use category could only be changed during the inventory if indications of human activities are actually identified in the field, reducing the need for post-data processing. For the 2018 submission, all conversions from/to Forest land and from/to Wetlands or Other land, were carefully studied. The result was that many assumed but unsubstantiated land-use conversions were removed. Another example of the first type is when a recreation forest close to a city has been converted from Settlements (section 6.2.7, national land-use category 13, "Urban land", a category where tree biomass is not measured) to Forest land and the new land-use category consists of old trees. This has been corrected so the land use is assumed to be Forest land on both occasions.

One example of the second type is when the delineation of a divided plot, i.e. a plot representing more than one land-use category, has been changed during the re-inventory due to personal judgments by the inventory team rather than due to actual changes. These land-use changes should not be registered as land-use changes and have been corrected in the post-data process by keeping the newer delineation. This is the case if the assumed incorrect new delineation deviates approximately less than 0.75 m² from the old delineation. If the affected area is larger, the new delineation is assumed to be correct. Rules for automatic and manual corrections of inconsistencies and the actual corrections are saved and could be verified on request.

²⁹² The Swedish national definition of productive forest land used in national forest statistics defines productive forest land as land where the production is (or have the potential to reach) at least 1 cubic meter per hectare and year.

6.3.2 Other sources of information for activity data related to land use

In addition to the NFI, information on specific activities is used as land-use activity data for some of the reported categories. These are:

- the Swedish Civil Contingencies Agency for areas of wildfires,
- the Swedish Forest Agency for areas of controlled burning,
- the Swedish Geological Survey for areas of peat extraction.

6.3.3 Summary of sources for area estimation and stratification of areas for calculation of emissions and removals

In addition to the NFI and the SFSI, complementary data sources are required in order to estimate areas of certain combinations of land use categories and different soil types (Figure 6.7 and 6.8). For example, peat extraction areas are both small and rare in relative terms. The uncertainty in estimating peat extraction areas based on NFI plots would therefore be considerable. Additionally, to expand the rather limited data base on organic soils within the SFSI, it is supplemented with data on organic soils on NFI plots according to geographic information on soil types.



Figure 6.7. The figure shows a summary of sources for area estimation and stratification of areas for calculation of emissions and removals in the LULUCF-sector. Further explanations are provided in Figure 6.8.

Source(s) of area calculations	Source application
NFI	The National Forest Inventory determines the total area by sampling statistics based on an unbiased sample of plots of the entire land area using a 5-yr inventory cycle.
NFI	The National Forest Inventory determines the total area of organic soils by sampling statistics based on an unbiased sample of plots using a 5-yr inventory cycle.
NFI / SFSI	The Swedish Forest Soil Inventory provide the proportions of mineral and organic soils, the proportions of drained and undrained organic soils, and the distribution of soil fertility indicators and climate categories for drained organic soils based on an unbiased sample of plots using a 10-yr inventory cycle.
NFI / SGS survey	The National Forest Inventory determines the total area of Wetland by sampling statistics based on an unbiased sample of plots. The area of peat extraction gained from the SEP is assumed to be included in the total area of Wetland remaining Wetland.
NFI / SGS survey	The National Forest Inventory determines the total area of Settlements by sampling statistics based on an unbiased sample of plots.
SEP	Areas of peat extraction and production of peat for horticultural use is taken from The Swedish Environmental Reporting Portal.
NFI / SGS soil type map	The proportions of mineral and organic soils are calculated from NFI sample plots based on their soil type according to the soil type map of the Swedish Geological Survey.
NFI / SFSI	All settlements remaining settlements, except power-line routes in productive forests on organic soils, are assumed to be mineral soils. The proportions of mineral and organic soils, the proportions of drained and undrained organic soils, and the distributions of soil fertility and climate variations within drained organic soils on power-line routes in productive forests are assumed to be the same as that of the Forest land remaining Forest land category.
NFI / SBA / SGS soil type map	The proportions of mineral and organic soils are calculated for all cropland found in the block database of the Swedish Board of Agriculture based on their soil type according to the soil type map of the Swedish Geological Survey. All organic soils on Cropland are assumed to be drained.
Dependent on the source of the remaining category of the new land use	The proportions of mineral soils and organic soils are assumed to be the same as that of the remaining category of the new land use.
Dependent on the source of the remaining category of the new land use	The proportions of mineral and organic soils, the proportions of drained and undrained organic soils, and the distributions of soil fertility and climate variations within drained organic soils are assumed to be the same as for the corresponding remaining category of the new land use, with the exception of former cropland for which all organic soils are assumed to be drained.

Categories are either not observed (NO) or, for some unmanaged land use change categories, not estimated (NL).

Figure 6.8. Key to figure 6.7 explaining abbreviations and assumptions.

6.4 Description of categories (CRT 4A, 4B, 4C, 4D, 4E, 4F and 4G)

6.4.1 Definition of carbon pools and other sources

6.4.1.1 LIVING BIOMASS (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

The reported carbon pool changes refer to the biomass of all living trees with a height of at least 1.3 m. Thus, small trees, shrubs and other vegetation, such as herbs are not included in the figures. Both aboveground and belowground biomass are reported. Aboveground biomass is defined as living biomass above stump height (1% of tree height). Scots pine (*Pinus sylvestris*), Norway spruce (*Picea abies*) and birch (*Betula pendula* and *Betula pubescens*) constitute about 92% of the standing volume²⁹³. Other broad-leaved species constitute most of the remaining 8%. Below-ground biomass is defined as living biomass below stump height (1% of tree height) down to a root diameter of 2 mm while fine roots, <2 mm, are operationally defined as belonging to the dead organic matter pool or in the soil organic carbon pool. The living biomass pool is assessed for all land-use categories in the field inventory and reported for all land use categories except for Wetland remaining Wetland and Other land remaining Other land (both assumed unmanaged).

6.4.1.2 DEAD ORGANIC MATTER CRT-TABLES (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

Dead organic matter has been divided into dead wood and litter for Forest land. For the rest of the reported categories, dead wood and litter is reported aggregated as dead organic matter.

6.4.1.2.1 Dead wood (CRT 4A, 4B, 4C, 4D, 4E and 4F)

Dead wood is defined as fallen dead wood, snags or stumps including coarse and smaller roots (>2mm root diameter). Dead wood of fallen dead wood or snags should have a minimum stem diameter of 100 mm (at the smaller end) and a length of at least 1.3 m. Dead wood of stumps with corresponding roots are reported under Forest land remaining Forest land, while fallen dead wood and snags are reported for all relevant land-use categories.

6.4.1.2.2 Litter (CRT 4A, 4B, 4C, 4D, 4E and 4F)

Litter includes all non-living biomass not classified as dead wood, in various states of decomposition above the mineral or organic soil. This includes the litter, fomic, and humic layers of the O horizon. Living fine roots (<2 mm), are included in litter if found in the O horizon since they cannot be separated during sampling. Coarse litter is defined as dead organic material with a "stem diameter" between 10-100 mm and originating from dead trees. Fine litter from the previous season or earlier is regarded as part of the O horizon.

6.4.1.3 SOIL ORGANIC CARBON (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

Mineral soils

The soil organic carbon pool on forest land and grassland includes all carbon in the mineral soil below the O or H horizon (if they are <40 cm). The carbon pool considered is

²⁹³ Swedish University of Agricultural Sciences, 2023

soil organic carbon down to a depth of 0.5 m measured from the top of the mineral soil. In cropland mineral soils, only the topsoil down to a depth of 0.25 m is considered for carbon stock change calculations.

Organic soils

For forest land, cropland and grassland, organic soils classified as Histosols²⁹⁴ are included in the reporting and the entire depth of the soil profile is considered. Even if soil carbon is measured when the soil is classified as a Histosol, the carbon stock changes for these soils are based on emission factors (see below).

6.4.1.4 HWP (CRT 4G)

Harvested wood products are defined as all wood material leaving the harvest site. Reported emissions from the HWP carbon pool are based on pool changes of three product categories: sawn wood, wood-based panels, and paper products. Wood used for energy are considered to oxidize instantaneously when removed from site. The system covers only HWP from Swedish forests no matter where they are consumed (production approach). During recent years, stem volume corresponding to about 65 Mt CO₂ has been removed from the forest each year of which about half have been refined to one of the three product categories. The rest has been used to produce energy. About 86% of the produced amount of the three product categories are consumed abroad and 14% domestically.

6.4.1.5 DIRECT N₂O EMISSIONS FROM N FERTILIZATION (CRT 4(I))

To increase the forest production, some forest stands on mineral soils are occasionally fertilized – normally around ten years before final felling. Thus, we assume that fertilization occur only on Forest land remaining Forest land. In 1990, the fertilized forest area was estimated to 69 200 ha²⁹⁵. Thereafter, the annual fertilized area decreased for some years. Over time, this area has varied a lot and peaked in 2010 (80 200 ha). The fertilized area was about 22 500 ha in 2014 and increased steadily to 42 700 ha in 2021 but dropped to 14 900 ha in 2023. In 2024 the area increased to 40 500 ha. The activity data (fertilized areas) are based on an annual questionnaire sent to approximately 70 large-scale forest companies and a sample of 2000 small forest owners. This information is part of the official statistics of Sweden and is collected by the Swedish Forest Agency. Large-scale forest owners, defined as forest owners with more than 5000 ha of forest, contributes approximately 90% of fertilizer related emissions of N₂O and small-scale forest owners the remaining 10% of the emissions. To estimate the total annual emission, area figures are multiplied with a normal average amount of fertilizer N applied per hectare (ca 150 kg N per hectare). The normal average amount N applied per hectare is obtained from the companies that are distributing the fertilizer. There are only a few companies in this business.

6.4.1.6 N₂O AND CH₄ EMISSION FROM DRAINAGE AND REWETTING AND OTHER MANAGEMENT OF ORGANIC SOILS (CRT 4(II))

N₂O emissions from drained organic soils are included in the reporting. These emissions occur when the water table is lowered on organic soils, thereby causing a mineralisation of organic matter and a subsequent nitrification or denitrification of mineralized nitrogen which leads to N₂O emissions. Drainage through open ditches and/or lowering of lake

²⁹⁴ IUSS Working Group WRB. 2015.

²⁹⁵ Swedish Forest Agency, 2012

water levels was commonly used during the early part of the 20th century to increase productivity and to expand areas used for agriculture and forestry. The practice has more or less stopped due to a prohibition of new draining projects in the south and central parts of Sweden. Exceptions are made in two cases: (1) so called “protective drainage” that is done after clear cutting as a temporary measure to avoid a higher ground water table and (2) the drainage of peatland for peat extraction.

Emissions of CH₄ from these soils are mostly occurring from open ditches. On the drained soil itself, emissions of CH₄ are typically lower than it would be if the soil was not drained.

6.4.1.6.1 *Rewetting in Sweden*

In recent years, the Swedish government have provided support to restore wetlands and rewet drained organic soils through different funding programs to establish, rewet or restore wetlands²⁹⁶. However, rewetting of organic soils is still not reported under specific land use categories. This is due to lack of information on the land use after rewetting in the available data set of performed rewetting activities. In relation to the emissions and removals from soils, the effect of the current rewetting activities is marginal. In 2024 around 2159 ha were rewetted resulting in a decrease in emissions of around 10 kt CO₂-equivalents²⁹⁷.

6.4.1.7 N₂O EMISSIONS FROM NITROGEN MINERALIZATION/IMMOBILIZATION ASSOCIATED WITH LOSS/GAIN OF SOIL ORGANIC MATTER RESULTING FROM CHANGE OF LAND USE OR MANAGEMENT OF MINERAL SOILS (CRT 4(III))

A conversion in land use can be associated with a temporary increase in the mineralization of organic matter. A change in management of land causing loss of carbon can also contribute to mineralisation. Part of the released N may be converted to N₂O through denitrification. The loss of N due to mineralisation is calculated for all land-use categories and all land-use change categories. The release of N₂O is based on the estimated net carbon loss from the soil. Emissions of N₂O from cropland remaining cropland is reported in the agricultural sector.

6.4.1.8 INDIRECT NITROUS OXIDE (N₂O) EMISSIONS FROM MANAGED SOILS (CRT 4(IV))

In addition to the direct emissions of N₂O from managed soils that occur through a direct pathway (i.e., directly from the soils to which N is applied), emissions of N₂O also take place through two indirect pathways. The first one is the volatilisation of N following the application of synthetic and organic N fertilisers and the second one leaching and runoff of N from managed land. The indirect emissions are calculated using the results from direct emissions of N₂O (4(I) and 4(III)).

²⁹⁶ <https://www.naturvardsverket.se/amnesomraden/vatmark/bidrag-som-stod-for-att-anlagga-atervata-eller-restaurera-vatmarker/>

²⁹⁷ Lundblad, M. Återvätning 2024. PM. SLU.

6.4.1.9 N₂O, CH₄ AND CO₂ FROM BIOMASS BURNING (CRT 4(V))

Forest fires are rare in Sweden. Wildfires have been monitored by the Swedish Civil Contingencies Agency since 1996²⁹⁸ and the area of wildfires on forest land has varied between 200 and 22 000 ha year⁻¹. Controlled burning to improve regeneration of trees after clear-cutting is monitored and there is a complete record from 1990 and onwards held by the Swedish Forest Agency. Controlled burning as part of nature conservation measures is monitored from 2006. In recent years, an area of approximately 60-400 ha is burnt annually after clear-cutting and 100 to 400 ha is now annually burnt for nature conservation on forest land. The Swedish Civil Contingencies Agency (former Swedish Rescue Services Agency) reports the annual area of wildfires for three different land categories: “Forest”, “Sparsely covered by trees” and “No tree cover”. The definition of “Forest” almost corresponds to the national definition of productive forest. “Sparsely covered by trees” are areas sparsely covered by trees such as mires, forests in the mountain area and in parks. “No tree cover” is land with no trees such as agricultural land, open areas but also some mires. The assumed former stock on burned areas is based on estimates of aboveground living and dead biomass inventoried by the NFI by matching national definitions to the definition by the Swedish Civil Contingencies Agency. The area of wildfires is probably slightly underestimated since the reported numbers only include actual turnouts by the fire brigade. The accuracy of the estimated amount of carbon emitted as a result of fire per land category is probably low. This is due to a lack of knowledge about the burned stock in typically burned forests and a huge variation in fire intensity.

6.4.2 Methodological issues

6.4.2.1 BASE METHODOLOGY (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

Sweden reports emission/removals from carbon pools mainly according to the stock change method. The stock change method is combined with a sample-based inventory design which makes it possible to estimate errors of the stock change estimates. The Swedish National Forest Inventory (NFI²⁹⁹) has monitored the living biomass pool since 1983 and the dead wood pool since the mid-1990s. The Swedish Forest Soil Inventory (SFSI) has inventoried the soil organic and litter pools since 1993 using a ten-year inventory cycle. A particular advantage with the Swedish NFI is that it has been undertaken using permanent sample plots on all relevant land-use categories, which makes it possible to monitor net gains/removals in carbon pools for all land-use categories in a consistent and transparent manner (for further details, see Annex to the NID section 3.2.1.1). The SFSI uses the same permanent sample plots as the NFI, but soil sampling is only made on Forest land and Grassland and only on a sub-set of the sample plots.

6.4.2.2 METHODOLOGY LIVING BIOMASS (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

A national methodology (Tier 3) is used. The aboveground biomass per fraction is estimated by applying Marklund's³⁰⁰ biomass functions to trees on permanent sample

²⁹⁸ Swedish Rescue Services Agency, 2004

²⁹⁹ Swedish University of Agricultural Sciences, 2023

³⁰⁰ Marklund, 1987 and 1988

plots of the NFI³⁰¹. The belowground biomass is estimated by using Peterssons and Ståhl's³⁰² biomass functions on biomass data from the same trees as for the aboveground biomass. A conversion factor of 0.50 is used to convert biomass to carbon³⁰³. Estimates of the change in the carbon pools are based on repeated measurements. Data for years between the repeated measurements are interpolated and for three of five inventory cycles, data for the most recent reporting years are projected using AI technology. The stock change of for example year 2000, is calculated as the difference in stock between year 2000 and year 1999. Since the estimates are based on representative allometric single tree regression functions or on direct measurements, a low risk of bias is assumed. See the Annex to the NID, section 3.2.1.1. for further details.

6.4.2.3 DEAD ORGANIC MATTER CRT-TABLES (CRT 4A, 4B, 4C, 4D, 4E AND 4F)
Dead organic matter has been divided into dead wood and litter for Forest land. For the rest of the reported categories dead wood and litter is reported aggregated as dead organic matter.

6.4.2.3.1 Methodology dead wood CRT-tables (CRT 4A, 4B, 4C, 4D, 4E and 4F)

A national methodology (Tier 3) is used to estimate the dead wood pool. The inventory of dead wood began in 1994 for northern Sweden and from 1995 for the whole country. The carbon content in dead wood was calculated using conversion factors from volume per decay class to biomass for the species Norway spruce, Scots pine, birch and other broadleaves³⁰⁴. The volume is measured by the NFI. The methodology is further described in the Annex to the NID, chapter 3.2.1.4.1.

Carbon stock changes in belowground dead wood originating from stump and root systems of harvested trees is reported based on indirect measurements of harvest. The harvest is estimated based on estimates of growth (stem volume change based on measurements of increment bore cores of sample trees) converted to CO₂ minus the estimated net change in the living biomass carbon pool (see 6.4.2.2). The harvest of stems is converted to stump and root biomass by conversion factors. The conversion factors are based on estimates of stem volume³⁰⁵ and stump and root biomass³⁰⁶ applied to sample trees representing the standing stock of Swedish forests. The decay of stumps is modelled³⁰⁷ by simple decomposition rate functions. The described methodology is consistently used during the reported period. Emissions from stump and root systems originating from years earlier than 1990 are estimated using a similar methodology applied on stump and root systems from the time period between 1853 and 1989. The methodology is further described in the Annex to the NID, section 3.2.1.4.1.

³⁰¹ Ranneby et al., 1987

³⁰² Petersson and Ståhl, 2006

³⁰³ Mensah, A.A., and Petersson, H. (2024) Carbon concentration of living tree biomass of *Pinus sylvestris*, *Picea abies*, *Betula pendula* and *Betula pubescens* in Sweden. *Scandinavian Journal of Forest Research*, DOI10.1080/02827581.2024.2332439

³⁰⁴ Sandström et al., 2007

³⁰⁵ Näslund, 1947

³⁰⁶ Petersson and Ståhl, 2006

³⁰⁷ Melin et al., 2009

6.4.2.3.2 Methodology litter CRT-tables (CRT 4A, 4B, 4C, 4D, 4E and 4F)

A national methodology (Tier 3) is used to estimate the litter pool. The carbon in the litter pool is estimated based on three different sub-pools: (i) coarse litter, (ii) annual litter fall, and (iii) litter < 2 mm. Coarse litter is defined as dead organic material with a “stem diameter” between 10-100 mm and originating from dead trees. Coarse litter is not inventoried in field but calculated as 15% of the aboveground dead wood measured according to 6.4.2.3.1. Annual litter resulting from harvests is considered covered in the dead wood or coarse litter fraction described above. Litter fall from standing biomass is calculated using empirical functions based on stand properties and litter fall for deciduous species by biomass functions based on leaf biomass. This fraction of litter is regarded as an annual pool. The remaining part of this pool after one year is included in the O horizon or the top of the mineral soil and thus measured by the soil inventory. The fine litter (< 2 mm) is estimated through the O or H horizon sample, which is taken on an area basis, weighed and analysed for carbon content (for further details, see Annex to the NID, section 3.2.1.4.2).

6.4.2.4 METHODOLOGY SOIL ORGANIC CARBON (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

The change in the soil organic carbon pool is estimated using different approaches depending on the land use. For Forest land and Grassland on mineral soils, estimates are based on repeated soil sampling in combination with pedotransfer functions. For forest and grassland Histosols the emission estimates are based on emission factors in combination with area estimates of different sub-categories. For Cropland, the ICBM model^{308,309} is used to calculate changes in the soil organic carbon stock on mineral soils. Emissions from cropland Histosols are estimated using an emission factor and the area of cropland Histosols.

6.4.2.4.1 Forest land and Grassland on mineral soils (CRT 4.A.1 and 4.C.1)

The method is a Tier 3 method. The estimates are based on repeated measurements of several variables on the NFI plots. The basic function used to determine the amount of carbon in a soil layer is based on the soil carbon concentration in a certain soil layer and the amount of fine earth in that layer. The amount of fine earth is dependent on the bulk density and the volume fraction of gravel, stones and boulders in the soil (for further details, see the Annex to the NID, chapter 3.2.1.5).

6.4.2.4.2 Forest land and Grassland on organic soils (CRT 4.A.1 and 4.C.1)

The method is a Tier 2 method. Changes in the soil organic carbon pool on organic soils are calculated using emission factors. The emission factors rely on estimates of emissions divided into different classes of nutrient status and two different climate regimes. The nutrient status is determined by using the C:N-ratio in the soil while climate is divided geographically into a temperate and a boreal region. Emission factors were earlier taken from the IPCC 2013 supplement for Wetlands³¹⁰ but now updated emission factors based on a literature study are used³¹¹. Emission factors for dissolved organic carbon (DOC) are

³⁰⁸ the Introductory Carbon Balance Model

³⁰⁹ Andrén & Kätterer, 2001

³¹⁰ IPCC 2014

³¹¹ Lundblad 2024

based on a national survey (for further details, see the Annex to the NID, chapter 3.2.1.6). Data on emissions from grasslands are scarce and most often taken from studies looking at intensively used grasslands where nutrients are commonly applied. For this reason, the emission factors for Grasslands are the same as for Forest land. Swedish Grasslands included in the reporting are defined as natural pastures which have soils that are more similar in character to Forest land soils than Cropland soils (for further details, see the Annex to the NID, chapter 3.2.1.6).

6.4.2.4.3 Cropland on mineral soils (CRT 4B)

The method to estimate the carbon balance of agricultural soils is a Tier 3 method. The carbon changes in the mineral soil are calculated based on data from eight agricultural production regions using the model *ICBM-region*. The model is described in Andrén & Kätterer³¹². The calculations are based on daily weather data, annual crop harvest statistics, the use of manure in each region and the results from a nationwide survey of agricultural soils including data on carbon content and texture³¹³(for further details see the Annex to the NID, chapter 3.2.1.7).

6.4.2.4.4 Cropland on organic soils (CRT 4B)

The method to estimate the carbon balance of organic cropland soils is a Tier 2 method. A national emission factor for cropland on organic soils is used to calculate the mean annual carbon loss per area. The total area of organic soils under agricultural production has been estimated in a national survey³¹⁴. The area of organic soil in these studies has been linked to the changes in total cropland area so that a decreasing cropland area proportionally affects the area of cropland on organic soils (for further details see the Annex to the NID, chapter 3.2.1.8).

6.4.2.5 METHODOLOGY FOR DEAD WOOD, LITTER AND SOIL ORGANIC CARBON FOR CONVERSION BETWEEN LAND-USE CLASSES CRT-TABLES 4A.2.1-5, 4B.2.1-5, 4C.2.1-5, 4D.2.1-3, 4E.2.1-5 AND 4F.2.1-5

The method to estimate the emission/removals in the dead wood, litter and the SOC pools associated with land-use changes is a Tier 2 method. Except for dead wood and coarse litter) the carbon stock changes associated with conversion of lands is estimated using an emission/removal factor in combination with the land-use change area. For further details see the Annex to the NID, chapter 3.2.1.10.

6.4.2.6 HWP (CRT 4G)

The methodology used is a Tier 3 method developed from the Tier 2 described in the IPCC 2006 guidelines. The calculation of emissions from HWP is based on carbon stock changes.

Products originating from Swedish forests are included regardless of where the products are consumed, which means that the import is excluded while the export is included. This is denoted *the production approach* in the IPCC guidelines.

³¹² Andrén & Kätterer, 2001.

³¹³ Eriksson, 1997 and 1999

³¹⁴ Lindahl and Lundblad, 2022

Separate carbon stock changes for the three categories sawn wood, wood-based panels and paper products are calculated. Separate calculations are undertaken for products consumed abroad and products consumed domestically.

The carbon stock change depends on the difference between inflow of carbon in new products and outflow of discarded products, and is calculated using equation 12.1 from the IPCC 2006 GL. The outflow is calculated as a fraction of the previous year's pool and therefore a pool must be calculated in order to estimate an outflow. To achieve this, historical data mainly from the Swedish Forest Agency regarding production and trade starting from 1900 is used to build a pool for each product category. The period of data available is dependent on when the product first occurred, in some cases data is only available at the first occurrence of a product. In other cases data is first collected in a later phase and back-casting using a proportional decrease is applied. The outflow is calculated using the half-life as an independent variable, and the half-lives applied are 35 years for sawn wood, 25 years for wood-based panels, and 2 years for paper.

The inflow of carbon in new products was estimated using data regarding production and trade from the Swedish Forest Agency. A series of equations were developed to exclude imported carbon from each step of the refinement chain for each product category. The general form of the equations is

$$p_{dh} = p * [(c_{rm} - i_{rm}) / c_{rm}]$$

where p =production, dh =domestic harvest, c =consumption, rm =raw material and i =import. Statistics for paper include paper made from pulp and paper made from recovered paper (RP). The origin of RP is unclear. It is possible to exclude RP of non-domestic origin from the domestic production of paper (although imported RP might originally come from exported paper), but following exported paper is more complex. About 90% of the paper produced in Sweden is exported and, after being consumed abroad, is used to produce new paper abroad. To include paper from RP of domestic origin used abroad to produce new paper, the quota [production of RP/consumption of paper] in the EU + UK (to which about 75% of the paper produced in Sweden is exported) is multiplied with the outflow of discarded paper. The product is added to next year's inflow of paper from pulp from wood.

The conversion factors applied are 0.62 t per m³ for wood-based panels, 0.42 t per m³ for sawn wood, and 0.9 t woody biomass per t of paper. Carbon content for each category is set to 0.5. The conversion factor for wood-based panels was calculated as a mean value for the different panel categories produced, weighted with respect to produced volumes of the different categories respectively. The densities of the different panel categories came from Swedish Forest Industries association³¹⁵. A corresponding methodology was applied to sawn wood, i.e., a weighted mean value of wood densities for the harvested wood species, mainly Scots pine and Norway spruce, was calculated. Densities were calculated using stem biomass and volume from the Swedish NFI, supporting data were taken from Swedish Forest Industries association, and oral information from experts. Production of paper in tonnes was multiplied with 0.9 to adjust for added non-wood compounds during the manufacturing process. No such adjustment was made in cases when the inflow

³¹⁵ <https://www.traguiden.se/om-tra/materialet-tra/traets-egenskaper-och-kvalitet/densitet1/definitioner/> (In Swedish)

consisted of pulp instead of paper, for example, exported pulp. The factor 0.9 came from from the spread sheet model provided by the IPCC³¹⁶.

The amount of HWP put into landfills³¹⁷ is assumed to be 0.

Historical emissions differ somewhat compared to emissions reported in earlier years. In some cases, data on production and trade are preliminary and have undergone slight changes following years.

6.4.2.7 CO₂ EMISSION FROM PEAT EXTRACTION (CRT 4D)

The method used to estimate CO₂ emission from peat extraction areas is a Tier 2 approach. A limited area (around 10 000 ha) is used for peat extraction and reported under Wetlands remaining Wetlands. The reported CO₂ emissions refer to mineralization when extracting peat for fuel and agricultural purposes. The emitted CO₂ is calculated as the product of the extracted area and an emission factor (for further details see Annex 3:2). The off-site emissions from horticultural peat are reported assuming that the carbon is gradually oxidised over time. A country-specific method has been used for the calculations (see Annex 3:2).

Peat extraction is only ongoing on part of the production area. The peat extraction is usually proceeding many years on the same production area until the extraction is stopped, and site restoration begins (for further details see the Annex to the NID, section 3.2.1.9).

6.4.2.8 DIRECT N₂O EMISSIONS FROM N FERTILIZATION (CRT 4(I))

A Tier 1 methodology is used. All fertilization is assumed to occur on Forest land remaining Forest land³¹⁸. In year 1990, calcium nitrate (Ca(NO₃)₂) was the dominant fertilizer but thereafter the fertilizer used has been ammonium nitrate (NH₄NO₃) with 50% NO₃-N and 50% NH₄-N. The reported annual emission is calculated as the product of the applied amount and the emission factor (for further details see the Annex to the NID, section 3.2.2.1).

6.4.2.9 N₂O AND CH₄ EMISSIONS FROM DRAINAGE OF SOILS AND CH₄ FROM DITCHES (CRT 4(II))

A Tier 2 methodology is used, and the reported figures refer to N₂O and CH₄ for each land-use category with different emission factors depending on nutrient status and climate and multiplied with corresponding areas. Emissions of CH₄ include emissions from the soil itself and from ditches. N₂O and CH₄ from peat extraction land is also reported under 4(II) using the same area as reported for peat extraction under 4.D and corresponding emission factors. For further information and the emission factors used, see the Annex to the NID, section 3.2.2.2.

³¹⁶ IPCC_HWP_Tier_1_extend_FODWOOD v1 20 March06 Sept07 MODIF 22 10 08 KP

³¹⁷ Since 2004 it is prohibited to put combustable and organic waste on land-fills. Naturvårdsverkets föreskrifter och allmänna råd om hantering av brännbart avfall och organiskt avfall (NFS2004)

³¹⁸ ERT (centralized review submission 2009) recommended Sweden to report emissions from organic and mineral soils separately. The methodology is based on the total retained amount and there is no appropriate statistics available on where the fertilizer is applied.

6.4.2.10 N₂O EMISSIONS FROM NITROGEN MINERALIZATION/IMMOBILIZATION ASSOCIATED WITH LOSS/GAIN OF SOIL ORGANIC MATTER RESULTING FROM CHANGE OF LAND USE OR MANAGEMENT OF MINERAL SOILS (CRT 4(III))

A Tier 2 methodology is used. The reported annual N₂O emission from nitrogen mineralisation associated with loss of carbon resulting from land-use change or change in land-use of mineral soil is calculated according to equation 11.8 in IPCC 2006 GL (IPCC³¹⁹) using partially country-specific parameters (for further details the Annex to the NID, section 3.2.2.3).

6.4.2.11 INDIRECT NITROUS OXIDE (N₂O) EMISSIONS FROM MANAGED SOILS (CRT 4(IV))

A Tier 2 method is used to calculate the indirect emissions based on the use of fertilizers and mineralisation equation 11.9 and 11.10 in IPCC 2006 GL. The reported annual N₂O indirect emissions are based on the amount of added fertiliser and the mineralisation of N and assumptions on the volatilization and leaching of N₂O (for further details, see the Annex to the NID, section 3.2.2.4).

6.4.2.12 EMISSIONS FROM BIOMASS BURNING (CRT 4(V))

A Tier 1 methodology and IPCC default emission factors are used. All land categories are monitored but the reported emission is assumed to occur only on Forest land remaining Forest land and on Grassland remaining Grassland. The location of the burned areas is registered by the Civil Contingencies Agency (see section 6.4.1.8) and the fires in tree covered areas are matching areas defined as Forest land. The NFI registers if a fire has occurred on the sampling plot. This data has been used for verification and this far no fire has been identified on land converted to Forest land. Thus, we believe it is reasonable to report fires in former tree covered areas under Forest land remaining Forest land. Fires on non-tree covered areas are not separated into land use. However, the definition is closest to the definition of Grassland and, thus, all fires on non-tree covered areas are reported under Grassland remaining Grassland. Calculations are based on the amount of biomass per area, burnt area and emission factors. To avoid double-counting, CO₂ emissions from wildfires and controlled burning are included in carbon stock changes in living biomass (for further details see Annex 3:2). Sweden assumes that 25% of the pre-fire biomass stock is combusted during the fire. The IPCC 2006 GPG suggest emission factors that are slightly higher. However, Sweden finds a combusted proportion of 25% more realistic for Swedish conditions. This proportion is based on subjective observations in the field of remaining biomass after several wildfire events in Sweden such as the example in Figure 6.9.

³¹⁹ Intergovernmental Panel on Climate Change, 2006



Figure 6.9. Post-fire biomass after Swedish forest fire in the county Västmanland 2014.

6.4.3 Uncertainties and time series consistency

Since the Swedish reporting system of the LULUCF-sector mainly is based on sampling, a national method is used to estimate the overall uncertainty. Uncertainties in the reported estimates arise from random and systematic errors. Random errors dominate the uncertainty for the part of the living biomass, dead organic matter and soil organic pools that are calculated based on sampling data whereas systematic errors dominate the uncertainty for other emissions/removals. Uncertainties per greenhouse gas is found in the Annex to NID, table A.3.2.16.

Random errors could be estimated by straight forward statistical theory, but systematic errors are often hard to quantify. Generally, for Sweden, the systematic error induced by activity data is small compared to the error due to use of incorrect emission factors. Systematic errors are therefore either assumed through expert judgement or using the default error values according to IPCC³²⁰.

6.4.3.1 LIVING BIOMASS (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

The accuracy of the living biomass pool estimates depends mainly on the sample design of the NFI. Results from the control inventory of the NFI indicate that measurement errors, registration errors and errors caused by the instruments (callipers) could be assumed to be close to zero. Potential bias induced by incorrectly specified models and an unrepresentative derivation data are ignored. Research by Ståhl et al. (2014)³²¹ and Breidenbach et al. (2014)³²² indicate that the influence of model errors could be expected to be less than 1% of the total error budget. Estimates for reporting years 1990-2020 are based on approximately 30 000 sample plots and with a corresponding estimated standard error of 3 Mt CO₂/year. The estimate of uncertainty is quite stable between years, but the relative estimates vary due to changes in net removals. Estimates for reporting years 2021, 2022, 2023 and 2024 are based on measurements on approximately 24000, 18000, 12000 and 6000 sample plots, respectively, combined with projected data. To avoid a potential risk of systematic errors we gradually update projected data using data from re-measured sample plots (see Annex 3:2 for further details).

³²⁰ Intergovernmental Panel on Climate Change, 2006

³²¹ Ståhl et al., 2014.

³²² Breidenbach et al., 2014.

6.4.3.2 DEAD WOOD AND LITTER (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

Estimates of dead organic matter are based on sampled data from the litter pool and dead wood pool from the NFI and the SFSI. There is probably a small error in the estimates of dead wood due to incorrect measured volumes and to errors connected to the conversion from volume to carbon.

Coarse litter is calculated as 15% of the dead wood. The error of this proportion might be large since the knowledge of the relation between the amount of dead wood and coarse litter is poor.

The accuracy of the litter estimations is continuously improved since the reported figures can be based on more repeated measurements of permanent sample plots. For changes in carbon in the O horizon, the measurements are based on samples from 1993-2002 (first inventory), from 2003-2012 (second inventory) and from 2013 - 2022 (the third inventory). Changes are interpolated for each plot between inventories. Litter pool changes for 2023 and 2024 are extrapolated from the measured data. The sample error for the measured part of the litter carbon pool is calculated similarly to the living biomass calculation. The sample error for the change in the fine litter fraction on mineral soils is estimated to be 0.32 t C ha^{-1} ($n=7246$) for changes occurring between the first and second inventory and 0.34 t C ha^{-1} ($n=7180$) for changes between the second and the third inventory. Note that this is the sample error of the carbon stock change over 10 years. The dead wood measurements are from the period 1995 to 2023. Estimates of changes of dead wood in stumps on Forest land are indirectly based on harvest from growth minus net change in living biomass (both data sources from the NFI). The harvest rate is approximately verified by harvest statistics from production statistics (Swedish Forest Agency). The conversion from harvested stem volume to stump biomass may introduce a small systematic error.

6.4.3.3 SOIL ORGANIC CARBON (CRT 4A, 4B, 4C, 4D, 4E AND 4F)

The sample error for the soil organic carbon pool is calculated similarly to the living biomass calculation. The sample error for the carbon stock change in soil carbon on mineral soils is estimated to be 0.82 t C ha^{-1} ($n=3134$) for changes occurring between the first and second inventory and 0.94 t C ha^{-1} ($n=2952$) for changes between the second and the third inventory. Note that this is the sample error of the carbon stock change over 10 years. A problem associated with the used methodology is the risk of systematic errors in the sampling and analysis of data. Since there are rather small changes in large pools, even a small systematic error may cause a trend in the material. From 2003, the sampling methods of soil samples have been changed compared to the first inventory in order to avoid subjective judgments in sampling, e.g. regarding determination of soil horizon boundaries. This might give rise to problems of comparability between inventories but should improve the quality of the data by reducing future risks of systematic errors.

Significant efforts are made to check data and to remove possible sources of error in the field data collection. The uncertainty in activity data (area) for CO₂ emission from drained organic soils on Forest land is judged to be 25% and errors in the emission factor to 40%. The uncertainty in emission factors (carbon stock changes) for CO₂ emission from mineralization when extracting peat is judged to 25% and the uncertainty due to errors in the emission factor is judged to be 60%.

One of the major difficulties in reporting changes in DOM and SOC is that the pools are very large and the changes small in comparison to the pools. As seen in Figure 6.10, the reported changes are considerable in terms of carbon, and they do have an impact on the national carbon budget. However, the annual changes are still only in the order of a few % of the pool and are difficult to detect and the system is sensitive to systematic errors like small changes in data collection between inventories.

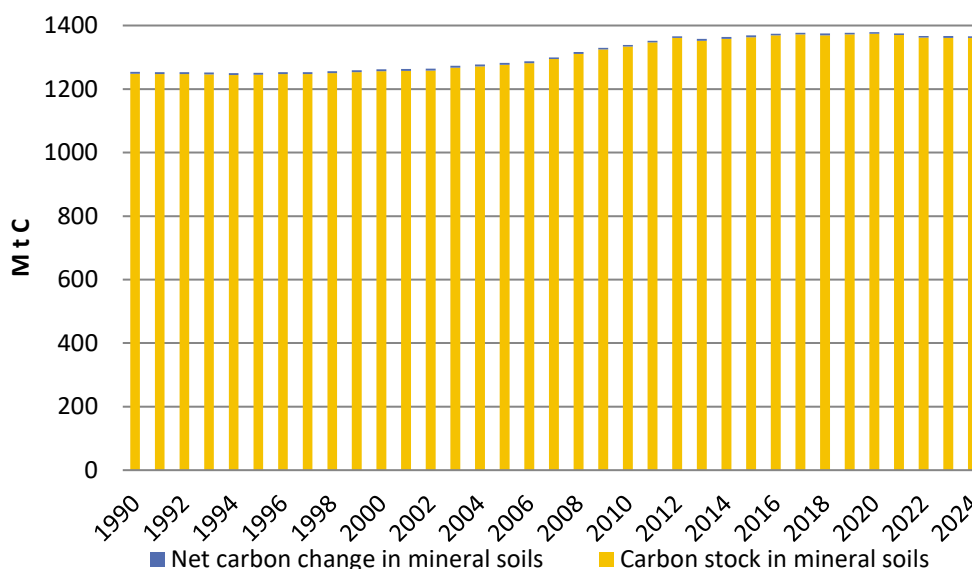


Figure 6.10. The reported change in soil carbon on mineral soils (blue bar) and the corresponding stock (yellow bar) for Forest land remaining Forest land.

6.4.3.4 HWP (CRT 4G)

Uncertainties in the data, conversion factors and oxidation of depleted products affect the HWP-estimates.

6.4.3.4.1 Data

Data from 1900 and onwards was used. The removals and HWP-production were crosschecked by the quota [(calculated total production of HWP of domestic harvest including black liquor and sawmill residues used for energy)/(removals of industrial round wood)]. The quota varied between 98% and 107% and averaged 102% during 1990-2013, indicating a slight overestimation of the HWP production. The production of black liquor was assumed to be equal to the production of chemical pulp of domestic origin. That is a rather rough assumption that causes some of the deviation.

6.4.3.4.2 Conversion factors

Wood density for round wood used by the sawmill- and wood-based panels industry was set to 0.42 t m^{-3} . More than 99% of the round wood used by the sawmills in Sweden was from Norway spruce (55%) and Scots pine (45%), and the density for the two conifers was calculated using data from the NFI and models for stem volume and stem biomass. In submission 2021 and 2022 the density 0.4 t m^{-3} was used. It was calculated using functions for all trees in the NFI. In the actual submission a corresponding analysis was made using sub sample trees for which height was registered, which ensures a more robust estimate for both volume and biomass, resulting in the density 0.42 t m^{-3} . Neither

sawn wood, nor wood-based panels was split into subcategories. Since sawn wood is produced from two conifers of similar density there is no reason to calculate separately for different species. Wood based panels (WBP) are produced in such low quantities that subcategories would have very low impact on the result. Further, the only WBP produced in Sweden at present is particle board and plywood. The conversion factor used for paper was 0.45. It was crosschecked as the quota between domestic production of paper (from wood pulp only, not from recovered paper) of domestic origin and domestic consumption of pulp of domestic origin. Thus, the reliability of the conversion factors should be acceptable.

6.4.3.4.3 Oxidation

The half-lives used for the different product categories is by far the most uncertain component in the calculations. Therefore, the uncertainty was estimated using varying half-lives. The half-lives were increased and decreased by 20%, and the uncertainty was estimated as the difference between the calculations using adjusted half-lives and the calculations using the default half-lives. A Monte Carlo analysis was used to estimate a mean standard deviation for the total emission which was converted to the uncertainty.

6.4.3.5 OTHER EMISSIONS (CRT 4(I) TO 4(V))

Generally, for all N₂O and CH₄ emissions, the error in activity data is small compared to the error associated with the emission factors.

4(I): For N₂O emissions from N-fertilization, the error due to activity data is judged to 3% (the Swedish Forest Agency) and the default total error to 25%. However, a recommendation from the IPCC is that the emission factor should be in the range 0.25% to 6% and the interpretation is that a poorly chosen emission factor could lead to an emission factor uncertainty that is much larger than 25%.

4(II): For emissions from drainage, the error in activity data (areas) is judged to 25%. The uncertainty in the emission factors is mainly based on the confidence intervals calculated from the data in the literature used to estimate the emission factors. The uncertainty in the emission factors for N₂O and for CH₄ are both above 100%.

4(III): The accuracy of estimates of N₂O emissions from mineralization associated with change in management or land use is assumed to be lower than for N₂O emissions from N fertilization. This is because it is assumed that the error of the activity data (ΔC from mineralization) is higher and due to a large potential error in the selected C:N ratio. Therefore, the uncertainty level is suggested to be 100%, also considering the uncertainties in IPCC default values.

4(IV): For the indirect emissions, the error in activity data corresponds to the error from the fertilization estimates and to the mineralisation. The uncertainty in the emission factors for indirect N₂O emissions is well above 100%.

4(V): Uncertainties from biomass burning arise from the errors in the estimated area that is burned and in the emission factors used. The emitted amounts per area unit depend on the biomass stock before the fire and the proportion of this biomass that is burned. The error of the estimated burned area is likely quite small but the knowledge of emitted amount per area is quite poor. The reported uncertainty is based on a default error coefficient from IPCC. According to the points raised in the discussion above on

uncertainties in CO₂ emissions from biomass burning, the uncertainty of N₂O and CH₄ emissions from biomass burning are assumed to be 100%.

Estimated and assumed uncertainties for LULUCF are summarized in Table 6.5.

Table 6.5. Estimated and assumed uncertainty for LULUCF (Uncertainty=2·relative “standard error”). *the absolute SE is around 3 Mton CO₂/year, and a relative uncertainty does not make sense.

Carbon pool / category	2-Relative Standard Error, %		
	CO ₂	N ₂ O	CH ₄
Living biomass (permanent land use)	20	-	-
Living biomass (land use change)	15-390*		
Dead wood	50	-	-
Litter	50	-	-
Mineral soils (4.A.1, 4.B.1, 4.C.1)	35	-	-
Mineral soils (land use change)	50	-	-
Drained organic soils (4.A.1, 4.C.1)	35	-	-
Drained organic soils (4.B.1)	35		
Fertilization (4[I])	-	50	-
Drainage (4[II])	-	100	100
Mineralisation (4[III])	-	100	100
Indirect N ₂ O (4[IV])		100	
Biomass burning (4[V])		100	100
HWP, 4G	25	-	-

6.4.3.6 COMPLETENESS

Each source/sink category has been reported only once. This is ensured by using only one source of information for the overall land area representation. One source of activity data is overlapping the area estimate from the NFI (peat extraction areas) but this is handled by reducing the area of permanent Wetland with the peat extraction area.

Sweden reports carbon stock changes in all carbon pools and all other emissions for all land-use categories that are considered managed (Forest land, Cropland, Grassland, Settlements and a small area of Wetland) and for all managed land converted to Other land, i.e. categories for which methods are provided in the 2006 IPCC Guidelines. The notation key “NO” is used when there is no observed occurrence for a certain category (e.g. uncommon land-use changes) and when the reported activity does not result in emissions/removals. The notation key “IE” is used when it is not possible to separate emissions/removals on relevant land-use categories and according to the use of the stock change method. In the latter case, either gains or losses are reported “IE”. The notation key “NA” is used for emissions/removals from unmanaged land. The notation key “NE” is used for categories not estimated and comprises categories that currently are optional to report.

6.4.4 Category-specific time series consistency, verification and QA/QC

6.4.4.1 TIME SERIES CONSISTENCY AND VERIFICATION

The time series of changes in carbon stocks for the living biomass pool is consistently measured from 1990 and onwards. The trend has been validated and confirmed by the default method (growth minus losses) but the level of the annual net removals could not be verified. We assume that most of the discrepancy could be explained by the basic biomass expansion factors applied using the default method. The time series for the dead wood pool (lying and standing) extrapolates data in the beginning of the period and this is because the inventory did not begin until the mid-1990s. Due to a relative high sampling error and a five-year inventory cycle, a trend is reported and thus it is quite difficult to match emissions/removals from dead wood to the correct year. This trend is estimated using a five-year, four-year, three-year, two-year and one-year running average for years 2020, 2021, 2022, 2023 and 2024, respectively. When based on a five-year running average, the data is fixed for future reporting and should represent the reported year. The dead wood pool including stumps constitutes a relatively large net removal. This could partly be explained by the fact that, since 1990, an increasing amount of dead wood and snags have been left after harvest. After 2018, large attacks of bark beetles have occurred on spruce. This has likely increased the net removal of standing and lying dead wood. Another reason may be that the inflow of new dead wood has increased from gradually more frequent windstorms, wildfires and other pathogen attacks, but no proper validation exists. The increased net removal of stumps is partially due to the harvest gradually increasing.

The time series of the dead wood pool is measured since 1994 with only minor changes in sampling methodology. The dead wood from stumps has consistently been measured indirectly from growth minus net removal from change in living biomass and verified by indirect measurements from harvest statistics. The reported removal average out annual fluctuations and is therefore in agreement with the reported changes in living biomass, while the annual variation in removals is larger using validation data (Figure 6.11).

The soil organic carbon has been sampled annually since 1993. In 2003, a revision of sampling methodology was made to harmonize sampling with international monitoring programs. Studies on the effects of these changes in sampling with respect to soil carbon pool estimates have not revealed any clear systematic differences. The time series for dead organic matter and soil organic carbon in forests have been compared to results from two process-oriented models. Models and measurements agreed well in estimation of the soil carbon pool and in the direction of change, but there were small differences with respect to the rate of change between the models and the measurements³²³.

³²³ Ortiz *et al.* 2009.

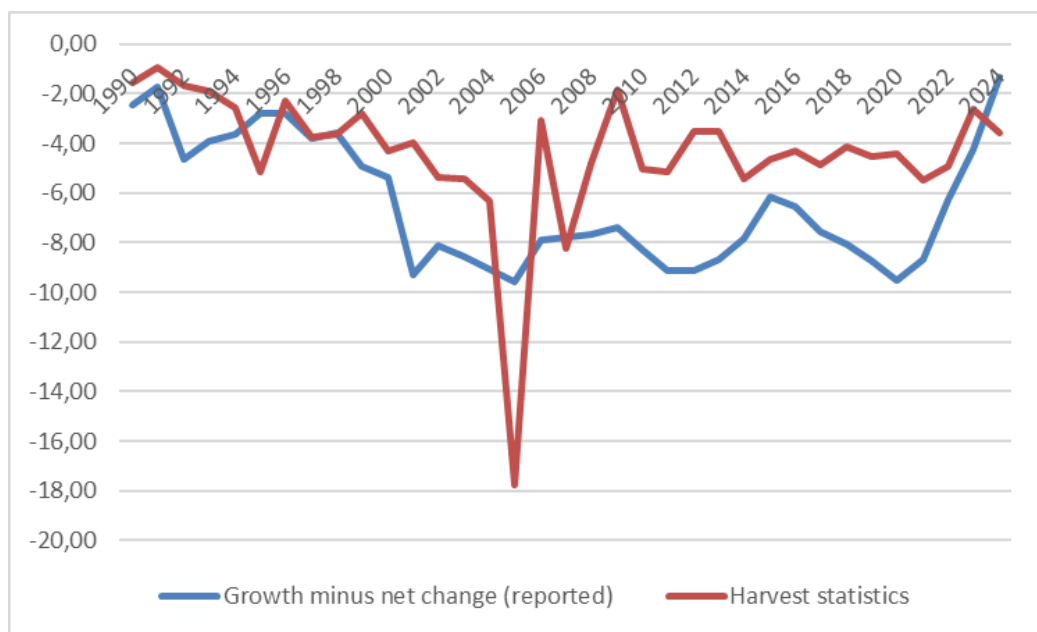


Figure 6.11. The reported net-removal from stumps (part of dead wood) is indirectly calculated from growth minus net-removal from living biomass (inflow) minus modelled decomposition (outflow). The validating net-removal from stumps is based on harvest statistics (inflow) minus modelled decomposition (outflow).

6.4.4.2 QUALITY ASSURANCE (QA)

The quality assurance system of the data collection within NFI used for the UNFCCC reporting has been described by the Swedish University of Agricultural Sciences³²⁴. These routines were improved during 2006. SLU also works closely with the Swedish EPA to enhance the QA/QC.

6.4.4.3 QUALITY CONTROL (QC)

An internal quality control has been performed. For reported activity data, descriptions of definitions, description of underlying models, description of sampling design and emission factors used were studied and no errors were found. This was also valid for descriptions of land areas, eventual transcription errors and references. Both calculations and units of estimates were cross checked and judged as reasonable. Original data from the NFI constitute official statistics of Sweden and were not checked. All data and documentation of methodologies used is archived by the SLU.

6.4.5 Source-specific recalculations

Recalculations can be separated into several categories of which the two first ones can be considered “ordinary” recalculations in the Swedish inventory due to the applied methodology using random sampling.

The first category is recalculations due to updated NFI data which affects the estimates for the previous four years as described in section 6.3.1.1. Small corrections of historical land-use changes may affect estimates for earlier years, especially for categories using area as activity data.

³²⁴ Karlton *et al.*, 2005.

The second category is recalculations related to extended datasets for litter and soil from the SFSI. Beginning from Submission 2023, a new system for interpolating this data was introduced. It is described in section 3.2.1.6 in the Annex. In essence, the new interpolation system averages the calculated change in litter and soil carbon pools over the entire time series. Quantitatively important recalculations are expected for each submission because of phasing in new data on carbon stock change each year. It should be noted that these recalculations are very small, relative changes in carbon stocks that become quantitatively important emissions or uptake of CO₂ due to the size of the carbon pool. An annual change of 1 ‰ in the soil carbon pool, i.e., 1% between inventories (10 years), in Forest remaining Forest represents an annual emission/uptake of around 5 Mton CO₂. After introduction of the new interpolation, any variation in the time series within the same submission is due to varying sample plot numbers for individual years. This variation is in turn due to sample plots leaving or joining the land-use category due to land-use change or that a 20-year period in a land-use change transfer class is coming to an end. For some land-use categories the proportion of plots that do change classification making them either to leave or join a certain land-use category during the reporting period is relatively high. In an assessment of the Grassland remaining Grassland category, it was found that 25% of plots classified as Grassland remaining Grassland at any time, had changed classification during the reporting period.

The third category is when new activity data (not related to NFI or SFSI) or emission factors have become available (i.e. better sales statistics, information on biomass burning or emission factors related to land-use change).

The fourth category is when the methods have been improved.

The fifth category is when an obvious computational error has been detected in the calculations and needs to be corrected.

The recalculations are summarized in Table 6.6.a. and Table 6.6.b. The total effect of the recalculation on Living biomass on Forest land remaining forest land is illustrated in Table 6.6.a and Figure 6.12.

6.4.5.1 LAND USE

Due to extrapolation, areas of land use and land-use change have been updated for recent years (6.2.9). This re-calculation is considered ordinary.

6.4.5.2 LIVING BIOMASS

To improve the accuracy of estimates, the living biomass pool and areas have been recalculated for the years 2020-2024 in the current submission. Each estimate for these years is now based on 6 000 more sample plots and incomplete inventory cycles have been projected to 2024, see section 6.3.1.1 and Appendix Table A3:2.2. This is from now on considered an ordinary re-calculation. This has resulted in increased recalculated net removals 2020-2023.

Small trees (dbh<100 mm) were previously estimated with regression to -3.99 Mton CO₂ year⁻¹ for all years 1990 and onwards. The same number was used in the accounting reference, which means that the effects of small trees were offset in the accounting. Now (from submission 2025) the net removal of change in living biomass is estimated using the permanent NFI-plots, which means that the re-calculated net removal for recent years

has decreased. This will require that also the accounting reference (FRL) needs to be corrected (see Appendix Table A3:2.4.).

6.4.5.3 DEAD WOOD, LITTER AND SOIL ORGANIC CARBON

Emissions from organic soils as well as carbon pool changes for land-use change categories have been recalculated due to updated activity data from the NFI (areas) and the SFSI (areas of Histosols and drained soils). The share of the organic soils for Settlements remaining Settlements and Forest Land to Settlements changed considerably.

Carbon stock changes on cropland have been revised due to development of the climatic input data used for the ICBM model. The climatic input data are used for the calculation of the ICBM annual soil climate parameter, which is affecting the soil organic C decomposition rates for each year. Gridded climatic data are provided by SMHI for temperature, precipitation, wind speed, relative humidity and cloudiness. The data sources used are the PTHVB database for temperature and precipitation. SMHI's models for the other parameters has been phased out and replaced with much improved estimates from ERA5. The consequence of this change in climatic input data is a slightly lower decomposition rate, leading to a slight increase in C stock change (the increase represents 0.6% per year).

6.4.5.4 NON-CARBON EMISSIONS

Recalculations were made for drained organic soils. The fraction of areas for land converted to CL, FL, WL and GL was updated to the same assumptions as drained organic soils.

6.4.5.5 HWP

Recalculations have been made due to an error in activity data in previous submission.

Table 6.6a. and Table 6.6.b. Recalculations of carbon stock changes and other emissions between submission 2025 and submission 2026 in the LULUCF-sector. Positive numbers indicate an increase in emissions or a decrease in removals and negative numbers indicate an increase in removals or a decrease in emissions. Note that a value of 0.00 in table 6.6.a means that the estimate is below 0.005 and that a value of 0.0 in table 6.6.b. that the estimate is below 0.05.

6.6 a	Difference in carbon stock changes between Submission 2025 and 2026 [Mt CO ₂]																					
	Forest land					Cropland				Grassland				Wet-land SOC	Settlement				Other land			HWP
	LB	DW	Litter	SOC		LB	DOM	SOC		LB	DOM	SOC			LB	DOM	SOC		LB	DOM	SOC	
				Min	Org			Min	Org			Min	Org	Min			Org					
1990	-10.3	-45.2	-0.5	-3.6	0.5	0.3	0.0	49.2	0.3	7.8	-0.6	0.3	0.0	0.0	0.0	0.0	-0.4	61.5	0.0	0.0	0.0	0.0
1995	-10.3	-11.3	-0.4	-3.5	0.5	0.3	0.0	30.5	0.3	7.8	-0.6	0.3	-0.4	0.0	0.0	0.1	-0.3	55.6	0.0	0.0	0.0	0.0
2000	-0.9	-44.9	-0.5	-3.5	4.7	1.1	0.0	35.3	0.3	3.1	-0.4	0.6	-0.4	0.0	0.0	0.1	-0.4	68.4	0.0	0.0	0.0	0.0
2005	1.0	11.7	-0.4	-3.0	11.2	-4.7	0.0	23.1	0.0	4.7	-0.2	0.5	-1.2	0.0	-0.1	0.1	-0.3	61.1	0.0	0.0	0.0	0.0
2010	68.0	9.3	-0.4	-2.5	36.0	-1.6	0.0	18.8	0.3	-122.1	0.5	1.3	-1.7	0.8	-200.9	-0.2	0.1	24.9	0.0	0.2	-0.1	0.0
2015	5.6	7.3	-0.6	-2.8	54.2	0.9	0.0	5.4	-0.6	3.8	0.1	1.3	-1.9	0.8	-5.6	-0.7	0.1	0.3	-1.2	0.2	-0.1	-33.1
2016	25.2	7.0	-0.8	-2.6	60.6	0.9	0.0	4.3	-0.6	3.8	0.1	1.3	-3.4	1.5	-37.7	-0.9	0.0	7.7	-1.2	0.2	-0.1	1.1
2017	23.4	6.7	-1.0	-2.6	66.0	0.9	0.0	8.1	-0.5	5.3	0.1	1.1	-3.4	1.5	-25.0	-0.9	0.0	7.7	-1.2	0.2	-0.1	3.7
2018	23.4	6.4	-0.9	-2.5	78.9	0.9	0.0	13.1	-0.5	5.3	0.1	1.2	-3.4	1.5	-25.0	-0.9	0.1	-1.9	-1.2	0.2	-0.1	-74.5
2019	23.3	133.9	-1.0	-2.3	88.1	0.9	0.0	10.4	-0.2	5.3	0.1	1.7	-4.9	1.5	-25.0	-0.9	0.0	3.5	-1.0	0.2	-0.1	-57.0
2020	-0.3	101.2	-4.4	-2.1	93.9	0.0	-1.4	18.6	0.6	-8.5	1.3	1.0	-5.2	2.6	0.0	-1.7	-0.8	1.9	-1.0	0.2	-0.1	198.6
2021	1152.1	-174.5	-2.8	-4.0	101.3	8.5	-2.0	18.9	2.9	-13.0	1.1	1.4	-7.8	0.4	-64.3	-1.8	-0.3	3.4	-0.2	0.2	-0.1	258.7
2022	3403.6	-730.2	-1.7	-3.7	106.6	-144.8	-2.8	28.9	2.9	-18.6	3.7	0.2	-9.3	-2.2	-43.4	-1.9	0.2	4.8	0.5	0.2	-0.5	-55.2
2023	4671.9	-919.2	18.5	-3.5	117.8	-13.6	-7.2	177.0	1.8	-12.5	4.1	0.0	-10.4	-1.4	-29.8	-1.8	0.5	7.3	7.3	0.1	-0.4	-137.8

Year	Other emissions [kt substance]								Total	
	Fert. 4 (I)	Drainage 4(II)		Mineralisation 4 (III)	Indirect 4 (IV)	Biomass burning 4 (V)			[Mt CO ₂ - eq]	[%]
	N ₂ O	CH ₄	N ₂ O	N ₂ O	CO ₂	CO ₂	N ₂ O	CH ₄		
1990	0.00	0.00	0.00	-0.01	0.00	NE	0.00	0.00	-219.36	0%
1995	0.00	0.00	0.00	-0.01	0.00	NE	0.00	0.00	-255.34	0%
2000	0.00	0.00	0.00	-0.02	0.00	NE	0.00	0.00	-233.80	0%
2005	0.00	0.00	0.00	-0.02	0.00	NE	0.00	0.00	-384.50	1%
2010	0.00	-0.01	0.00	-0.02	0.00	NE	0.00	0.00	614.13	-1%
2013	0.00	0.00	0.00	-0.02	0.00	NE	0.00	0.00	-547.06	1%
2014	0.00	0.00	0.00	-0.02	0.00	NE	0.00	0.00	-415.40	1%
2015	0.00	0.00	0.00	-0.02	0.00	NE	0.00	0.00	-282.53	1%
2016	0.00	-0.01	0.00	-0.02	0.00	NE	0.00	0.00	-244.18	0%
2017	0.00	-0.01	0.00	-0.02	0.00	NE	0.00	0.00	-318.73	1%
2018	0.00	-0.01	0.00	-0.02	0.00	NE	0.00	0.00	-426.74	1%
2019	0.00	-0.01	0.00	-0.02	0.00	NE	0.00	0.00	-919.57	2%
2020	0.00	-0.02	0.00	-0.02	0.00	NE	0.00	0.00	-525.04	1%
2021	0.00	-0.03	0.00	-0.02	0.00	NE	0.00	0.00	-3484.38	10%
2022	0.00	-0.02	0.00	-0.02	0.00	NE	0.00	0.00	-9565.33	28%
2023	0.00	-0.02	0.00	-0.02	0.00	NE	-0.04	0.00	-14833.56	48%

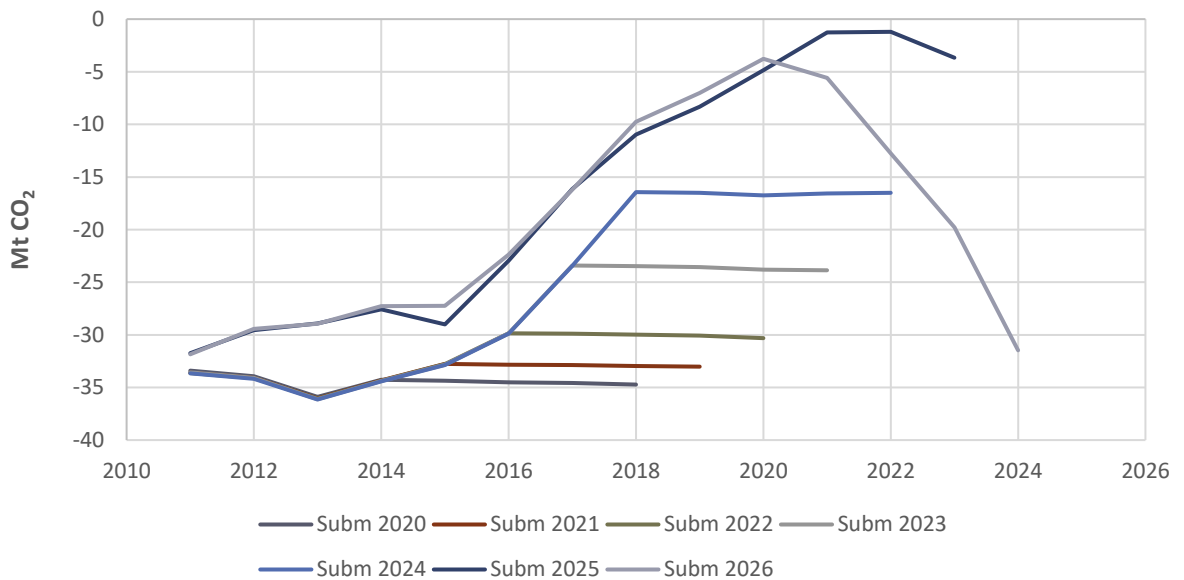


Figure 6.12. Reported changes in living biomass on Forest land remaining forest land (4A1) according to different submissions. The values (the five latest reported years) are continuously recalculated. This year the difference between submissions relates both to the new method for extrapolation of the last four years and the recalculation of small trees.

6.4.6 Planned improvements

Due to a recommendation from the ERT we have initiated a project for validation and potential improvement of the empirical models used to calculate annual litterfall. The project is on-going. If the project leads to improved models they will be included in submission 2026.

New research and successive development of methods as well as adapting the reporting to any new requirements under the UNFCCC in relation to the Paris agreement and the new LULUCF-regulation within the EU (EU 2018/841) and (EU 2023/839) may result in improvements in future Submissions.

7 Waste (CRT sector 5)

7.1 Overview of sector

In this sector, the most important emissions of greenhouse gases are those of methane (CH₄) from Solid waste disposal, CRT 5.A. Other sources of greenhouse gases are Biological treatment of solid waste, CRT 5.B and Wastewater treatment and discharge, CRT 5.D, from where emissions of methane and nitrous oxide (N₂O) are reported. In addition, emissions of carbon dioxide (CO₂), methane (CH₄), nitrous oxide, nitrogen oxides (NO_x), sulphur dioxide (SO₂), non-methane volatile organic compounds (NMVOC) and carbon monoxide (CO) are reported from (hazardous) Waste incineration, CRT 5.C. Waste incineration with energy recovery is included in the Energy sector, Public electricity and heat production (CRT 1.A.1.a).

Greenhouse gas emissions in CO₂-eq. from the waste sector have decreased constantly since the early 1990s (Figure 7.1), mainly because of decreasing quantities of organic waste deposited at landfills, which has reduced emissions of methane from landfills. Also, the quantities of recovered landfill gas were increasing from 1990 until 2003.

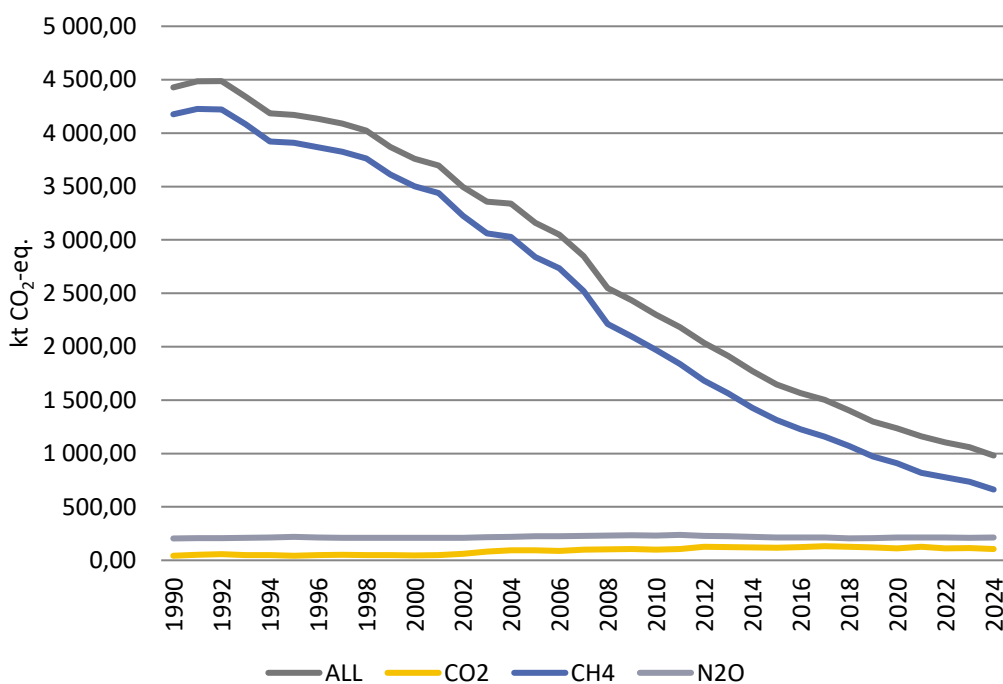


Figure 7.1. Total emissions of all greenhouse gases calculated as CO₂-eq. from CRT 5 Waste.

Biological treatment of solid waste (CRT 5.B) is the only subsector that shows an increasing trend for greenhouse gas emissions. The activities (both composting and anaerobic digestion of solid waste) have increased since the early 1990s in order to reduce quantities of organic solid waste to landfills.

For nitrous oxide, there has been a reduction of the quantity of nitrogen discharged from municipal wastewater treatment plants from the mid-1990s when nitrogen treatment in wastewater treatment plants in Sweden was developed.

Figure 7.2 shows that greenhouse gas emissions from the Waste sector (CRT 5) largely come from solid waste disposal (CRT 5.A). Methane in sub-sector 5.A represents between 90.3% (in year 1990) and 39.6% (in year 2024) of the total reported greenhouse gases in the Waste sector. Emissions of greenhouse gases from waste incineration were 11.3% of the total GHG emissions of CRT 5 in 2024.

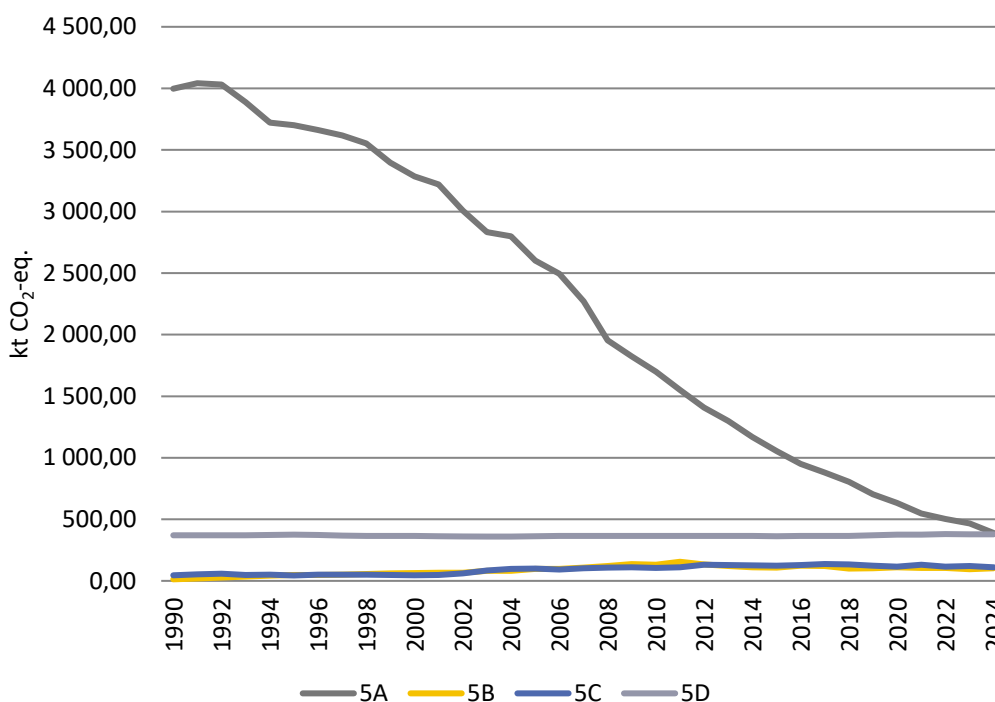


Figure 7.2. Total emissions of all greenhouse gases calculated as CO₂-eq. from the different waste sub-sectors (5A – Solid waste disposal, 5B – Biological treatment of solid waste, 5C – Incineration and open burning of waste, 5D Wastewater treatment and discharge).

7.1.1 Biogas production in Sweden

Most of the biogas is produced within the Waste sector (CRT 5). See further below in the CRT 5.A, CRT 5.B and CRT 5.D sections. According to a survey³²⁵ by the Swedish Energy Agency completed by Avfall Sverige & SMED on biogas production and utilization, the production of biogas (including landfill gas extraction) in Sweden in 2024 was 2 434 GWh which is equivalent to 174.6 kt of methane. The corresponding amount in 2005 was 1 285 GWh (equivalent to 92.2 kt of methane)³²⁶.

³²⁵ Swedish Energy Agency, 2025

³²⁶ Swedish Energy Agency, 2007

7.2 Solid waste disposal (CRT 5.A)

Waste management in Sweden has been developed considerably over the past twenty years. Legislation, such as the implementation of EU directives and national tax policies in the waste management field, has forced and encouraged investments in new technical solutions and waste treatment methods. There has been a comprehensive extension of the treatment capacity of Swedish incineration plants for household waste (with energy recovery) and development of waste management practices other than solid waste disposal on land (landfilling).

Since Sweden is a country with a developed mining and quarrying industry, mining waste is by far the most dominating single waste category in generation of waste and landfilling (in 2020, 91.9%³²⁷ of the landfilled waste). An overview of waste streams in Sweden in year 2022 (excluding major mineral waste) is presented in Figure 7.3.

In the 1990s, the amount of deposited waste (other than mining waste) decreased significantly. This is especially notable for household waste, which is a large part of municipal solid waste (MSW). Only 1.6% of the treated household waste was deposited in 2024³²⁸, which can be compared to 43.8% of the MSW in 1990 (data on the current definition of household waste is unavailable for year 1990). The remaining part of the treated household waste in 2024 was either incinerated (54.8%), recycled (23.0%), treated biologically (17.0%) or used as construction material (3.6%).

Today, landfilling is used for waste fractions that cannot be treated by other waste management practices like recycling, biological treatment or waste incineration. Landfilling of household waste was conducted at 47³²⁹ sites in 2024.

³²⁷ Swedish EPA, 2022

³²⁸ Swedish Waste Management 2025

³²⁹ Swedish Waste Management 2025

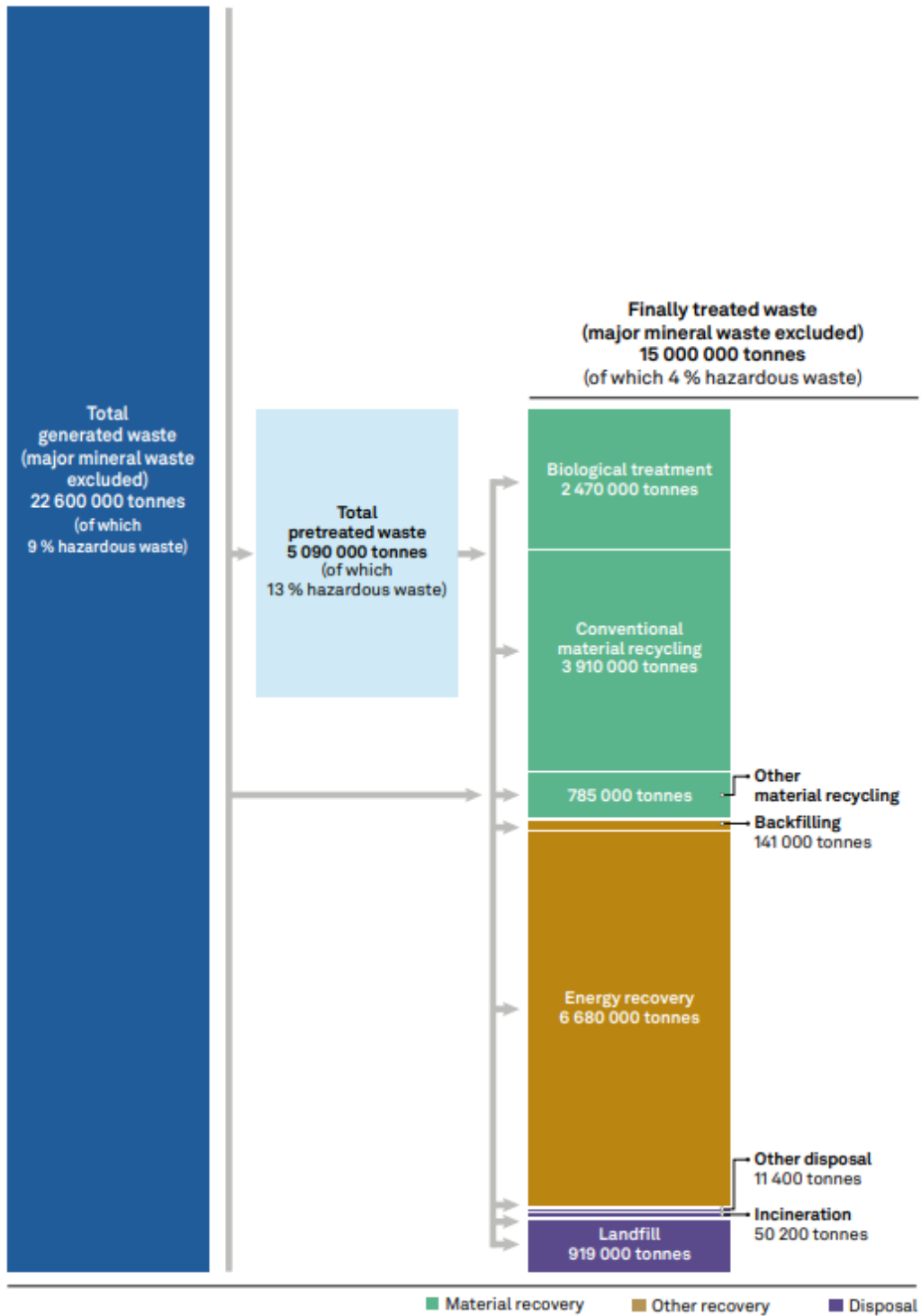


Figure 7.3. Waste streams in Sweden 2022 according to the Swedish EPA³³⁰. Major mineral waste is excluded.

³³⁰ Swedish EPA, 2024

7.2.1 Legislation and policies

7.2.1.1 LANDFILLING

Practises regarding landfills were regulated in 1969. Since then, the unmanaged (or illegal) landfills are very uncommon in Sweden.

Depositing has become an expensive waste management solution for disposal of waste. Since January 1st, 2000, there is taxation on the waste that enters landfills, currently 744 SEK³³¹ per tonne of waste liable to taxation. Another important change is the implementation of the national prohibitions on the landfilling of burnable and organic wastes in the 9-10 §§ of the Landfill Ordinance (2001:512). The landfilling of combustible wastes has been prohibited since 2002, and in 2005 the ban was extended to organic wastes. These prohibitions are regulated in more detail through regulation NFS 2004:4 from the Swedish EPA.

At the end of 2008, a new EU regulation for deposition came into force and almost 50% of the landfills for municipal waste were taken out of operation, according to the trade association Avfall Sverige – Swedish Waste Management.

7.2.1.2 LITTERING

In Sweden, there are some problems with unmanaged waste. *Littering* is occurring, in particular around recycling stations. Garden waste from households is sometimes disposed in the nearby nature instead of being treated properly. Animal carcasses and similar waste and by-products are sometimes disposed in situ and when so, shall be buried in accordance with the law.

When littering is discovered however, the clean-up is performed or the cost for the clean-up is paid by the responsible operator. If the responsible operator cannot be found, the relevant municipality is responsible to perform the clean-up of the site.

7.2.2 Managed waste disposal sites (CRT 5.A.1)

7.2.2.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting data on emissions of methane (CH₄) from CRT 5.A.1.a Managed waste disposal sites: Anaerobic.

For methane from CRT 5.A.1.b Managed waste disposal sites: Semi-aerobic and CRT 5.A.2 Unmanaged waste disposal sites, Sweden is reporting NO (not occurring), since there are no known semi-aerobic³³² or unmanaged waste disposal sites for organic waste or municipal solid waste in use³³³ in Sweden.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e., if any sources are not estimated (NE), is presented in Table 7.1.

³³¹ The Swedish Tax Agency 2025

³³² IVL Svenska Miljöinstitutet AB (Sundqvist), 2014

³³³ Nygren, 2010

Table 7.1. Summary of source category description, CRT 5.A.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
5.A.1	CO ₂	NA	NA		NA, NO	NA, NO	NA
	CH ₄	X	X		T2	D, CS	Yes
	N ₂ O	NA	NA		NA	NA	NA

CS Country Specific, D Default, T2 Tier 2.

7.2.2.2 METHODOLOGICAL ISSUES

7.2.2.2.1 National application to IPCC First Order Decay (FOD)

The method used for estimating methane emissions from municipal solid waste is the Tier 2 methodology, the IPCC First Order Decay model, with a slightly different time factor and with some estimates on the national gas potentials. The time factor year i , is calculated as:

$$\begin{cases} 1 - e^{-0.5k}, & i = 0 \\ e^{-k(i-0.5)} \cdot (1 - e^{-k}), & i = 1, 2, \dots \end{cases}, \text{ where } k \text{ is the generation rate constant.}$$

This model corresponds to the assumption that all waste is deposited on 1 July, which is approximately equivalent to a uniformly distributed deposition.

Comparisons between the suggested IPCC gas potentials and Swedish estimates show that the IPCC values tend to be higher, but considering the large methodological uncertainties, which is the same in both cases, the difference should be within a reasonable interval.

Historical data have been extrapolated five half-life periods back in time, which means that, for the calculations of 1990, all deposited gas potentials since 1952 are considered. All available historical information on national deposited quantities is used in the calculation. The quality of data on household waste is high since 1980, but data on organic industrial waste were scarce at that time. The consequence is that many assumptions on historical deposited waste quantities have been made, which have greater impact on the calculated emissions in 1990 than in 2024.

Table 7.2 presents emissions and waste data used for the years before 2006. The waste data are from various sources and uses national waste categories. These waste categories are different from the ones currently used in Sweden.

Table 7.2 Methane emission from Swedish landfills according to IPCC FOD method, deposited MSW*, sludges (containing DOC) and total (also reported as “Annual waste at the SWDS in CRT Table 5.A), 1990-2005.

Year	Gas emissions FOD method kt CH ₄	Deposited MSW* in kt	Deposited sludge from wastewater handling and pulp industry (containing DOC) in kt, (wet weight)	Total** in kt
1990	143	2 323	1 400	3 723
1991	144	2 223	1 262	3 485
1992	144	2 203	1 174	3 377
1993	139	2 199	1 086	3 285
1994	133	2 166	860	3 026
1995	132	1 974	850	2 824
1996	131	1 857	880	2 737
1997	129	1 843	975	2 818
1998	127	1 678	700	2 378
1999	121	1 756	620	2 376
2000	117	1 529	587	2 116
2001	115	1 488	514	2 002
2002	107	1 338	341	1 679
2003	101	1 034	223	1 257
2004	100	811	113	923
2005	93	541	58	598

* Includes household and similar waste, park and garden waste, industry- and non-industry specific waste (organic fractions), construction and demolition waste (organic fraction).

** Includes household and similar waste, park and garden waste, industry- and non-industry specific waste (organic fractions), construction and demolition waste (organic fraction), sludge from wastewater handling and pulp industry containing DOC (wet weight).

Table 7.3 is presenting emissions and waste data used from 2006. The waste data are from Sweden's reporting to the Commission according to the Waste Statistic Regulation and uses waste categories as defined in the regulation. In this table as opposed to the Tables 7.16 and Table 7.17, data on sludges in dry matter has been converted into wet weight in order to meet the requirements of the CRT.

Table 7.3. Methane emission from Swedish landfills according to IPCC FOD method, deposited solid waste (containing DOC), deposited sludges (containing DOC) and total (also reported as “Annual waste at the SWDS in CRT Table 5.A), 2006-2024.

Year	Gas emissions FOD method kt CH ₄	Deposited solid waste (containing DOC)* in kt	Deposited industrial effluent sludges and common sludge (containing DOC)* in kt, (wet weight)	Total in kt*
2006	89	1 249	180	1 429
2007	81	1 144	144	1 288
2008	70	1 039	108	1 147
2009	65	871	141	1 012
2010	61	648	164	813
2011	55	656	132	788
2012	50	664	99	763
2013	46	609	110	720
2014	42	555	121	677
2015	38	595	92	687
2016	34	635	63	698
2017	31	598	93	691
2018	29	562	123	685
2019	25	560	72	632
2020	23	558	22	580
2021	20	534	34	568
2022	18	510	45	555
2023	17	510	45	555
2024	14	510	45	555

* Activity data and statistics for 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022 are from Sweden's reporting to the Commission according to the Waste Statistic Regulation. Activity data and statistics for 2007, 2009, 2011, 2013, 2015, 2017, 2019, 2021, 2023 and 2024 are interpolated/extrapolated values.

Landfill gas extraction

Methane recovery at landfills is of great importance for the final emissions of methane in Sweden. 2006 Guidelines recommends that methane recovery should only be reported when references documenting the amount of methane recovery are available, which is the case in Sweden.

In Sweden, the first plant started to extract landfill gas in 1983. The activity increased until year 2003 when gas was recovered in 72 plants. Information on recovered gas (in energy units, MWh) is provided by Avfall Sverige and converted to quantity (t) methane by Statistics Sweden (see Table 7.4).

Table 7.4. Recovered and flared methane from landfill gas.

Year	Recovered and flared gas (t)	Year (cont.)	Recovered and flared gas (t)
1982	0 ¹	2007	24 553 ⁶
1983	NE ²	2008	28 444 ⁷
1990	12 000 ³	2009	25 248 ⁷
1991	13 500 ³	2010	22 409 ⁷
1992	16 000 ³	2011	21 046 ⁷
1993	23 000 ⁴	2012	19 924 ⁷
1994	30 000 ⁴	2013	17 839 ⁷
1995	30 000 ⁴	2014	17 023 ⁷
1996	30 000 ⁵	2015	16 115 ⁷
1997	30 000 ⁵	2016	15 154 ⁷
1998	30 000 ⁵	2017	13 389 ⁷
1999	33 000 ⁵	2018	12 170 ⁷
2000	34 000 ⁵	2019	12 194 ⁷
2001	32 400 ⁵	2020	11 324 ⁷
2002	35 947 ⁵	2021	11 540 ⁷
2003	36 449 ⁵	2022	10 432 ⁷
2004	30 135 ⁵	2023	9 364 ⁷
2005	29 418 ⁵	2024	10 168 ⁷
2006	24 567 ⁶		

1) No gas recovery. 2) 1st plants started. 3) Swedish EPA/RVF. 4) RVF, 1996c. 5) RVF, 1997-2006. 6) Avfall Sverige (Swedish Waste Management), 2007-2014, 7) Avfall Sverige (Swedish Waste Management) & SMED, 2015-2025.

The recovered and flared methane from landfill gas in Table 7.4 is calculated on the basis of the energy production in MWh using the lower heating value for methane.

In year 2024, 5.8% of the produced/collected biogas and landfill gas in Sweden was collected at 70 active or closed landfills³³⁴. The landfill gas extraction decreased from 457 GWh to 142 GWh between 2005 and 2024, since the amounts of deposited organic waste has decreased significantly the past years, due to the implementation of waste treatment policies. About 34.5% of the landfill gas³³⁵ was flared in 2024 (see Table 7.5).

Landfill gas is mainly used for heating but also for production of electricity. In year 2024, no³³⁶ landfill gas was used as vehicle fuel.

Table 7.5 shows quantities of produced energy from landfill gas and how much that has been flared in Sweden. Emissions from flaring and the utilization of the landfill is reported in CRT 1.

³³⁴ Swedish Waste Management & SMED 2025

³³⁵ Swedish Waste Management & SMED 2025

³³⁶ Swedish Waste Management & SMED 2025

Table 7.5. Energy recovery and flaring at landfills in Sweden, MWh³³⁷.

Year	2005	2010 ¹	2015 ¹	2020 ¹	2021 ¹	2022 ¹	2023 ¹	2024 ¹
Energy recovery	340 000	273 029	157 682	100 493	95 694	92 296	79 172	92 810
Whereof prod. of electricity	20 000	25 484	17 017	3 537	3 349	2 822	2 120	1 812
Flaring	70 000	39 293	63 858	57 335	65 139	53 105	51 332	48 913
Total	410 000	312 322	221 539	157 828	160 832	145 401	130 504	141 723

1) Avfall Sverige (Swedish Waste Management) & SMED, 2015–2025. The information from Avfall Sverige is supplemented by SMED on additional landfills in operation and all closed landfills, which are excluded by Avfall Sverige.

Other parameters

The Methane Correction Factor (MCF) for modern Swedish landfills is equal to one (1.0) (Table 7.6). Waste management was centralised during the 1970s. Before 1980, landfills were smaller and presumably less compact. Information that helps establish the MCF (cover material, mechanical compacting and levelling of waste) is missing. For calculations before 1980 the 2006 Guidelines default value for uncategorized SWDS was used. This value is the same as the former IPCC default value.

The IPCC default value 50% is used for the methane content in landfill gas (F) (Table 7.6). The value of DOC_F 0.5 has been chosen according to IPCC methodology.

Table 7.6 Other used parameters in the methane emission calculations.

Parameter	Value	Motivation
MCF – 1979	0.6	IPCC Uncategorized SWDS
MCF 1980 -	1	IPCC Managed - anaerobic(*)
F	50%	IPCC Default
DOCF	0.5	IPCC Default
OX	10%	National(**)
$t_{1/2}$	7.5 years	National(***)

(*) Swedish EPA, 1999b, (**) Swedish EPA, 1997b, (***) Swedish EPA, 1993b.

The oxidation factor is estimated to be 10%, and the half-life of the methanogenesis is 7.5 years.³³⁸ The choice of the half-life factor has also been motivated by the rather wet climate conditions in Sweden (MAP/PET>1), and that the 2006 IPCC Guidelines recommends the default value of 7 for such climate conditions.

Until about 1975, waste burning/incineration at landfills was a common waste treatment method. The landfills had no flue gas cleaning equipment and no regulation of the combustion process. The waste that was burned openly was unmanageable, bulky waste that is difficult to dispose of, such as demolition wood, brush and branches, furniture, packaging from commercial activities, and packaging from industrial activities.

³³⁷ Swedish Waste Management & SMED 2025

³³⁸ Börjesson, 2000

A study³³⁹ has been conducted on the subject matter as a response to a recommendation from TERT in submission 2024. According to the Swedish Environmental Protection Agency's inventory³⁴⁰, waste was burned at 389 of a total of 742 landfills (excluding landfills for sludge) around year 1974, which corresponds to 41.9% of the landfills. Open burning mainly took place at smaller landfills, and only a portion of the waste received was incinerated. Landfill burning ceased³⁴¹ about six years later.

Since the 389 landfills were mainly smaller in size, we estimate that these landfills received less waste than 41.9% of the total amount of waste in Sweden. Given that only a portion of the burnable waste at the 389 landfills was burned, our qualified guess is that 10% - 20% of the burnable waste received at Sweden's 742 landfills was burned around year 1974.

In our calculations in submission 2026, we have assumed (expert judgement) that before year 1976, 15% of the burnable waste at the landfills (household waste, garden waste, construction- and demolition waste and non-sector specific industrial waste) was burned, revising the previous assumption of 37%. From 1976 until 1980, decreasing values on burned waste are chosen (from year 1981: 0% burned waste).

7.2.2.2.2 WASTE STATISTICS IN SWEDEN, 1980 - 2005

The Swedish EPA made the first national survey on deposited waste in Sweden in 1980 (only for household waste and similar). Statistics Sweden collected similar data in 1985, 1990 and 1994. Since 1994, the Swedish Waste Management (former RVF) has carried out an annual survey on deposited waste. Thus, household waste is the most well-documented waste category, with high quality data available since 1980. Household waste is also the most important category for methane production in landfills. Statistics on deposited sludge from households and park and garden waste are available since 1990. Standard values on fractions of deposited household waste from 1970 and 1975 are also available at the Swedish Waste Management.

Statistics on organic waste from industries are much scarcer. There is information on industrial waste from the 1980s but organic fractions were not specified. The official statistics from 1993 and 1998 on waste from manufacturing do not emphasize generation and treatment of organic waste. Dedicated studies on quantities and treatment of biological waste from industry were carried out in 1993 and 1996 by the Swedish EPA. According to these studies, deposited sludge from the pulp industry has previously been the most important organic deposited industrial waste category. This waste category is also documented by surveys, carried out regularly until 2000 by the Swedish EPA and later by Swedish Forest Industries Federation. Today, sludge from the pulp industry is incinerated or composted.

³³⁹ SMED (Sundquist & Szudy), 2025. Utredning om historiska data avseende förbränning av avfall på deponier.

³⁴⁰ Swedish EPA, 1975. Avfallsanläggningar i Sverige.

³⁴¹ Swedish EPA, 1983. Avfallsanläggningar i Sverige.

7.2.2.2.3 WASTE STATISTICS IN SWEDEN, 2006 AND ONWARD

The Regulation of the European Parliament and the Council No 2150/2002 of 25 November 2002 on waste statistics (hereafter referred to as “the Waste Statistics Regulation” or “WStatR”) establishes rules and content for the reporting of waste statistics to the EU. Reporting in accordance with the regulation is to take place every second year. Reporting shall be submitted each time 18 months after the end of the reporting period. The first round of reporting by all member states was completed by 30 June 2006 and concerned waste generation and recovery and disposal of waste for the year 2004.

Official waste statistics in Sweden that is reported in accordance with WStatR to Eurostat, uses the Waste Statistical Nomenclature (EWC Stat) as nomenclature for the statistical waste categories. This is the case for all member states in the European Union. The EWC Stat codes are statistical aggregates of various sub codes called LoW codes (List of Waste codes). In the European Union, The List of Waste nomenclature contains more than 800 unique codes.

The treatment of waste is to be reported by treatment method categories. The method of treatment relates to various recovery and disposal operations (“R and D codes”) that are compiled into 6 different groups. Group 4, “Disposal operations: Land filling, deep injection, surface impoundment, permanent storage and others”, is relevant for “Solid waste disposal, CRT 5A”.

The Swedish EPA is responsible for the reporting in accordance with the regulation. So far, waste data have been reported for the reference years 2004, 2006, 2008, 2010, 2012, 2014, 2016, 2018, 2020 and 2022. No waste statistics on landfilling are compiled by the Swedish EPA for the intermediate years.

Background to the implementation of WStatR-data

The advantages of WStatR-data in relation to waste statistics for 1980-2005 (see above) are mainly that:

- WStatR-data uses more specific and better developed descriptions of waste classifications.
- It is produced regularly (every second year). Therefore, it is to a less extent based on extrapolations of old waste data and expert judgements. This means it is more sensitive for rapid changes in amounts of waste and DOC content.
- WStatR-data have per definition 100% coverage (completeness).

In 2010, a study³⁴² was carried out in order to analyse possibilities to use the reported waste data to WStatR for the calculations of methane from solid waste landfills.

The reference year 2008 was chosen for the microdata, since it was (at the time of the analysis) regarded as the most complete and suitable set of microdata regarding the degree of use of LoW in the national statistical waste database. The study recommended implementation of WStatR-data from reference year 2006 and onwards.

³⁴² SMED (Edborg, Stenmarck, Sundquist & Szudy), 2010

Estimation of DOC content

The national statistical waste database, which is used for storage of microdata for production of official waste statistics, is the source of information when estimating the DOC-values of the EWC Stat-codes.

In Sweden, the official waste statistics are produced by collecting microdata by using “LoW” codes. Since “LoW” is very detailed, it is also suitable for accurately estimating the DOC content (fraction of DOC) to the waste data aggregates of EWC Stat. Relevant waste categories are chosen (those which are containing Degradable Organic Carbon), and the DOC content of the chosen waste categories is investigated by analysing the microdata.

For each EWC Stat code, information on the identification of landfills, LoW codes and quantities of waste are gathered. The DOC content for each LoW code is judged by waste experts based on its definition and, in some cases, by studying the environmental reports from where the information of the microdata originated. When the DOC content for each LoW code is set for all LoW codes within each EWC Stat code, the DOC content for the EWC Stat code is estimated by weighting the DOC content of the LoW codes. This is done by using the information on the waste quantity for each LoW code. The quantification of uncertainty associated with the DOC values is also made by waste expert judgements (see further in section “Uncertainties and time –series consistency”).

The procedure of estimation of DOC content has so far been repeated five times since the reference year 2008. The first time was for the statistical reference year 2010 due to changes made by Eurostat of the definition of some of the EWC-stat codes. An investigation on the DOC-contents for these redefined EWC-Stat codes was necessary. The second time was for the statistical reference year 2016 to update the estimations of the DOC-content. The third time was for the reference years 2012 and 2014 (in submission 2021). The fourth time was for the reference year 2018 (in submission 2022). The fifth and most recent time was for the reference year 2020 (in submission 2024).

Interpolations and extrapolations are made for the intermediate years.

7.2.2.2.4 WASTE CATEGORIES, 1980-2005

Household waste, sludge and garden waste

Table 7.7 summarizes the available statistics on household waste, sludge from wastewater treatment and garden waste. Interpolation is used for the intermediate years. Before 1990, park/garden waste and sludge from households are assumed to be directly proportional to the population, with the same proportion as in 1990.

Table 7.7. Deposited household waste, garden waste and sludge (kt) and DOC content (fraction).

Year	Household waste (and similar)		Garden waste		Sludge from wastewater treatment, wet weight	
	Quantity	DOC content	Quantity	DOC content	Quantity	DOC content
1980	1 450 ¹	..	..	..	..	..
1985	1 040 ²	..	..	..	..	..
1986	1 020 ³	..	..	..	..	..
1988	1 080 ⁴	..	..	..	..	..
1990	1 400 ⁵	0.20 ¹⁷	70 ⁵	0.20 ¹⁹	900 ⁵	0.07 ²⁰
1994	1 380 ⁶	..	80 ⁶	0.20 ¹⁹	610 ⁶	0.07 ²⁰
1995	1 200 ⁷	0.19 ¹⁷	60 ⁷	0.20 ¹⁹	540 ⁷	0.07 ²⁰
1996	1 110 ⁸	..	70 ⁸	0.20 ¹⁹	470 ⁸	0.07 ²⁰
1997	1 150 ⁸	0.18 ¹⁸	50 ⁸	0.20 ¹⁹	455 ⁸	0.07 ²⁰
1998	1 020 ⁹	..	45 ⁹	0.20 ¹⁹	490 ⁹	0.07 ²⁰
1999	972.5 ¹⁰	..	45 ¹⁰	0.20 ¹⁹	490 ¹⁰	0.07 ²⁰
2000	869.5 ¹¹	0.18 ¹⁸	53 ¹¹	0.20 ¹⁹	345 ¹¹	..
2001	880 ¹²	..	44 ¹²	0.20 ¹⁹	330 ¹²	..
2002	820 ¹³	..	40 ¹³	0.20 ¹⁹	215 ¹³	..
2003	575 ¹⁴	..	33 ¹⁴	0.20 ¹⁹	155 ¹⁴	..
2004	380 ¹⁵	0.16 ¹⁸	0*		102 ¹⁵	..
2005	210 ¹⁶	..	0*		58 ¹⁶	..

1) Swedish EPA, 1983. 2) Statistics Sweden, 1988; RVF. 3) RVF, 1988. 4) RVF, 1990.
5) Statistics Sweden, 1992. 6-16) RVF, 1996-2006. 17) Ohlsson, T, 1998. 18) RVF, 2005:5.
19) 2006 IPCC Guidelines. 20) Sweco Viak, 2000-08-30.

* Included in household waste from reference year 2004.

.. Interpolated/extrapolated value

The composition of household waste has been investigated in many studies over the years. Ohlsson³⁴³ presents a historic overview of Swedish investigations, the first of which was carried out in 1977. The time series indicates a rather constant composition of components, except the paper content, which declines during the 1990s.

The chosen composition³⁴⁴ for 1990 and 1995 are presented in Table 7.8. The composition in the years between the surveys is interpolated. It should be pointed out that this type of analysis contains an unknown variation, and the source of error may be large. Ohlsson also shows that different studies may differ greatly in methods and results.

In 2005, another overview of household waste composition was published.³⁴⁵ Different fractions of household waste from southern Sweden have been analysed with the same methodology in 3 different years (1997, 2000 and 2004), see further in Table 7.8.

³⁴³ Ohlsson, 1998 and REFORSK, 1998

³⁴⁴ Ohlsson, 1998

³⁴⁵ RVF, 2005

Table 7.8. Content of Swedish household waste, %.

	1990	1995	1997	2000	2004
A, Paper and textiles	33	28	23	25	18
B, Garden/park waste, and diapers	14	14	14	11	13
C, Food waste	40	40	41	39	43
D, Wood	1	1	1	1	1

In Sweden the section of the Ordinance prohibiting the deposition of organic waste as landfill was implemented on January 1st, 2005. The waste treatment plants need permissions in order to deposit organic waste. The impact of the new legislation on the DOC content of deposited household waste has not been investigated and documented, but the waste composition and DOC content of deposited household waste has probably changed since the analysis from 2004. Separation of organic fractions made by the households should lead to a decrease of the DOC content. The organic fractions are treated by composting and anaerobic digestion. Organic fractions (and other fractions) from the mixed waste generated by households and companies are also separated at waste treatment plants before landfilling.

Methane potentials for sludges

The IPCC gives no gas potential for deposited sludge (already treated, for example, by anaerobic digestion) from wastewater treatment. The content of Degradable Organic Carbon (DOC) in sludge from wastewater treatment is approximately 7%.³⁴⁶ The gas potential of the sludge is reduced by 50% because it is treated.³⁴⁷ By using formulas for L_0 (methane generation potential) given in 2006 IPCC Guidelines the gas potential can be calculated to 24 kg/t of sludge.

For wastewater sludge from the pulp industry, a national value of 45 kg methane /t of waste is used.³⁴⁸

Industrial waste

As noted above, statistics on deposited industrial waste are not divided up into organic waste categories. Special studies of organic waste are considered to be the most important information sources of industrial waste categories. In 2004, a study on deposition of organic waste was carried out by Profu and financed by the Swedish EPA.³⁴⁹ The estimates have been made with the help of the information from many different sources such as national statistics, screening inspections of waste content, information on capacity of energy recovery from waste and extrapolation back in time using the industries part of Gross National Product (GNP). The study shows that great amounts of paper and wood have been deposited in construction and demolition waste, as well as in the category of “non-specific” industrial waste.

³⁴⁶ Recounted from RVF, 1996.

³⁴⁷ Sweco Viak, 2000.

³⁴⁸ Swedish EPA, 1993.

³⁴⁹ Profu, 2004.

The first study on “specific” organic industrial waste was published in 1993,³⁵⁰ the waste groups found to generate methane in landfills are presented in Table 7.9. The most important subgroup here is sludge from the pulp industry and the other subgroups are mainly from the food industry. The gas potentials stated in the report are based on literature studies and rotting experiments. The gas potentials are used in the methane calculations for 1990.

Table 7.9. Organic industrial waste, early 1990s (Swedish EPA, 1993).

Waste category	Produced quantity, kt/yr	Deposited fraction, %	Deposited quantity, kt/yr	Gas potential, Mm ³ CH ₄ /yr
Sludge from pulp industry	1000	50	500	31.5
Carcasses	8	35	2.8	0.63
Waste from slaughterhouses	40	5	2	0.45
Sludge from slaughterhouses	45	8	3.6	0.28
Entrails	30	5	1.5	0.09
Manure from slaughterhouses	10	5	0.5	0.03
Draff	5.5	0.5	0.0275	0.03
Waste from sugar beet industry	100	0.5	0.5	0.02
Waste from potato industry	46	0.5	0.23	0.01
Returned bread	13	3	0.39	0.11
Mycelia waste	2	1	0.02	0.01
Scrows waste	5.5	100	5.5	0.8
Waste from fishing industry	-	50	0	0.5
Whey	1 000	0	0	0
Tinned foods industry	53	50	26.5	1.55
Total:				
Sludge from pulp industry	-	-	500	31.5
Other	-	-	43.6	4.5

Data on deposited sludge from the pulp industry are available from a survey carried out annually from 1994 up to year 2000 by the Swedish EPA. In 2004, data on deposited sludge from the pulp industry are taken from the Swedish Forest Industries Federation. Data for the intermediate years have been interpolated. The reports contain detailed information on waste and waste treatment for each pulp and paper producer. Intermediate values (1991-1993) have been interpolated (Table 7.10).

³⁵⁰ Swedish EPA, 1993

Table 7.10. Values of deposited wastewater sludge from the pulp industry, wet weight.

Year	Quantity kt/year
1990	500 ¹
1994	250 ²
1995	310 ³
1997	520 ⁴
1998	210 ⁵
1999	130 ⁶
2000	242 ⁷
2001	184 ⁸
2002	126 ⁸
2003	68 ⁸
2004	10.5 ⁹
2005	0 ⁹

1) Swedish EPA, 1993. 2) Swedish EPA, 1995. 3) Swedish EPA, 1996b. 4) Swedish EPA, 1998b. 5) Swedish EPA, 1999. 6) Swedish EPA, 2000. 7) Swedish EPA, 2001. 8) Value interpolated no similar survey carried out. 9) Swedish Forest Industries Federation.

A study on organic industry-specific waste was published in 1996³⁵¹. In accordance with the report, the deposited waste categories are presented in Table 7.11. The gas potentials were calculated by Sweco Viak.

Table 7.11. Organic Industrial Waste 1996.

Waste category	Deposited quantity, kt/yr	Gas potential, Mm ³ CH ₄ /yr
Waste from slaughterhouses	22.5	0.88
Waste from potato and vegetable industries	11.5	0.64
Total:	34	1.52

Swedish EPA, 1996

The final gas potential is used as gas potentials in the methane calculations for 1996 and later. By using the two reports, values are interpolated between 1990 and 1996.

In addition to the gas potentials from these industries, the gas potentials for paper and cardboard waste from industries, which is not included in the referred reports, have to be added. Information on these gas potentials is extracted from a survey (“Waste from the manufacturing and minerals extraction industries in 1998”) made by the Swedish EPA and Statistics Sweden.³⁵² In 1998, about 6,000 t of paper and wrapping material were deposited. This quantity is added each year to the industrial waste already noted.

Composition of deposited waste

Table 7.12 illustrates the estimated composition of deposited waste (excl. mining waste) 1990-2005.

³⁵¹ Swedish EPA, 1996

³⁵² Statistics Sweden, 2000

Table 7.12. Composition of deposited waste (%).

Year	Paper	Food	Plastic	Glass	Textile	Napkins	Sludge from waste water	Sludge from pulp industry	Wood	Other inert	Other organic
1990	7.1	13.5	2.1	0.6	0.7	1.3	16.2	9.0	0.3	34.9	14.3
1991	7.4	14.6	2.2	0.7	0.8	1.5	15.5	9.0	0.3	34.5	13.6
1992	7.5	15.4	2.3	0.7	0.8	1.5	15.1	8.5	0.3	34.2	13.7
1993	7.5	16.1	2.4	0.7	0.8	1.6	14.5	8.0	0.4	34.1	14.0
1994	7.7	17.2	2.6	0.8	0.9	1.7	13.4	5.5	0.4	35.8	14.2
1995	6.8	15.8	2.4	0.7	0.8	1.6	12.5	7.2	0.3	36.9	15.1
1996	6.3	15.9	2.3	0.7	0.8	1.5	11.3	9.9	0.3	36.1	14.8
1997	5.6	16.0	2.5	0.7	0.8	1.6	10.8	12.4	0.3	35.5	13.8
1998	5.4	15.6	2.4	0.7	0.8	1.5	12.7	5.4	0.3	41.0	14.2
1999	5.2	15.0	2.3	0.7	0.8	1.5	12.7	3.4	0.3	40.7	17.5
2000	5.4	13.5	2.5	0.8	0.7	1.2	9.3	6.5	0.2	45.5	14.6
2001	5.8	14.2	2.7	0.8	0.8	1.2	9.5	5.3	0.2	45.2	14.4
2002	6.3	15.5	2.9	0.9	0.9	1.3	7.2	4.2	0.2	46.9	13.8
2003	5.0	13.0	2.3	0.7	0.7	1.1	5.8	2.5	0.1	55.4	13.5
2004	2.8	10.4	1.8	0.4	0.4	0.9	4.3	0.4	0.1	63.1	15.5
2005	1.9	7.8	1.2	0.2	0.2	0.6	2.8	0.0	0.1	72.2	13.0

7.2.2.2.5 Used statistics on deposited waste, 1952-2024

Landfilled quantities of DOC, 1952-2024

Table 7.13 below shows the calculated quantities of deposited DOC over the time period 1952-2024. These data are used as activity data when calculating the methane emissions by using the emissions with the FOD model. The data sources are the waste statistics described in the NID.

Table 7.13. Deposited quantities of Degradable Organic Carbon (DOC) 1952-2024, kt.

Year	DOC	Year	DOC	Year	DOC	Year	DOC
1952	566	1971	681	1990	655	2009	38
1953	570	1972	683	1991	611	2010	40
1954	575	1973	651	1992	591	2011	32
1955	579	1974	658	1993	575	2012	24
1956	584	1975	661	1994	536	2013	18
1957	589	1976	674	1995	498	2014	14
1958	592	1977	681	1996	476	2015	15
1959	596	1978	657	1997	479	2016	15
1960	603	1979	677	1998	407	2017	15
1961	610	1980	643	1999	422	2018	14
1962	617	1981	656	2000	375	2019	15
1963	623	1982	635	2001	350	2020	16
1964	634	1983	588	2002	296	2021	19
1965	642	1984	576	2003	224	2022	22
1966	649	1985	569	2004	173	2023	22
1967	654	1986	568	2005	115	2024	22
1968	663	1987	578	2006	88		
1969	668	1988	588	2007	70		
1970	677	1989	623	2008	52		

Used statistics 1952-2005

Tables 7.14 and Table 7.15 show the activity data 1952-2005 used in the calculations of methane emissions from solid waste disposal on land.

Table 7.14. Overview over used statistics on deposited waste and interpolated/-extrapolated values: Solid waste.

Year	Standard value: Household waste/citizen (kg)	Fraction deposited household waste	Fraction of burned household waste on landfills	Deposited household waste and similar, (kt)	Deposited park and garden waste, (kt)	Deposited organic industrial waste(**), (kt)	Deposited industrial waste (not industry specific), organic fraction(**), (kt)	Deposited construction and demolition waste, organic fraction(**), (kt)
1952	290	76%	15%	992	58	56	207	63
1954	290	76%	15%	1005	59	56	215	66
1956	290	76%	15%	1018	60	56	226	70
1958	290	76%	15%	1030	60	56	234	73
1960	290	76%	15%	1041	61	56	250	77
1962	290	76%	15%	1056	62	56	272	80
1964	290	76%	15%	1072	63	56	301	83
1966	290	76%	15%	1088	64	56	325	87
1968	290	76%	15%	1105	65	56	345	90
1970	290	76%(*)	15%	1122	66	56	364	94
1972	290	76%	15%	1129	66	56	372	97
1974	290	66%	15%	987	67	56	406	101
1976	290	66%	13%	1109	67	56	452	116
1978	290	58%	8%	1186	67	56	517	145
1980	-	-	4%	1450(*)	68	56	628	177
1982	-	-	0%	1300	68	56	627	182
1984	-	-	-	1100	68	56	579	161
1986	-	-	-	1020(*)	68	56	602	165
1988	-	-	-	1080(*)	69	56	624	170
1990	-	-	-	1400(*)	70(*)	56	622	175
1992	-	-	-	1390	75	58.2	554	126
1994	-	-	-	1380(*)	80(*)	60.3	564	82
1996	-	-	-	1110(*)	70(*)	62.5	536	78
1998	-	-	-	1020(*)	45(*)	62.5	477	73
2000	-	-	-	869.5(*)	53(*)	62.5	473	71
2001	-	-	-	880(*)	44(*)	62.5	439	62
2002	-	-	-	820(*)	40(*)	62.5	370	45
2003	-	-	-	575(*)	33(*)	62.5	323	40
2004	-	-	-	380(*)	0(***)	62.5	321	47
2005	-	-	-	210(*)	0(***)	62.5	231	37

(*) Taken from statistical sources. Other values are interpolated or extrapolated.

(**) Estimate.

(***) Included in household waste from reference year 2004.

Table 7.15. Overview over used statistics on deposited waste and interpolated/extrapolated values: Sludge, kt wet weight.

Year	Deposited sludge from waste water treatment, (kt)	Deposited sludge from pulp industry, (kt)
1952	748	500
1956	768	500
1960	786	500
1964	809	500
1968	834	500
1972	852	500
1976	862	500
1980	871	500
1984	875	500
1988	890	500
1992	750	424
1996	470(*)	410(*)
2000	345(*)	242(*)
2001	330(*)	184
2002	215(*)	126.3
2003	155(*)	68
2004	102(*)	10.5(*)
2005	58(*)	0(*)

(*) Taken from statistical sources. Other values are interpolated or extrapolated.

Used statistics and DOC values 2006-2009

Table 7.16 shows waste statistics for 2006 and 2008 used in the calculations of methane emissions from solid waste disposal on land. The EWC-Stat code nomenclature EWC-Stat Rev. 3 was used in the reporting for the years 2006 and 2008. Waste statistics for 2007 and 2009 are interpolated/extrapolated. It also shows estimated DOC values³⁵³ for each waste category.

³⁵³ SMED (Edborg, Stenmarck, Sundquist & Szudy), 2010

Table 7.16. Overview of used statistics* 2006 and 2008 on deposited waste, kt, and estimated DOC content, %.

EWC-Stat code (Rev. 3.)	Description of waste categories	2006 ^(*)	2008 ^(*)	DOC content
03.1	Chemical deposits and residues	C	176.95	2
03.2	Industrial effluent sludges: <u>Dry matter</u>	11.91	10.58	9
05.	Health care and biological wastes: <u>Hazardous</u>	C	0.00	8
05.	Health care and biological wastes	C	0.01	8
07.2	Paper and cardboard wastes	38.98	2.30	36
07.5	Wood wastes	C	1.84	40
07.6	Textile wastes	0.23	0.97	24
09A	Animal and vegetal wastes (<i>excl. 09.11 & 09.3</i>)	11.55	6.06	15
09.11	Animal waste of food preparation and products	0.30	0.34	15
09.3	Animal faeces, urine and manure	0.37	0.08	9
10.1	Household and similar wastes	203.82	119.99	18
10.2	Mixed and undifferentiated materials	482.74	222.44	3.1
10.3	Sorting residues	311.48	507.60	2.5
11A	Common sludges (<i>excl. dredging spoils</i>): <u>Dry matter</u>	26.38	13.14	28
Total		1 428.88	1 146.60	

* Waste statistics for 2006 and 2008 are from Sweden's reporting to the Commission in accordance to the Waste Statistic Regulation. (C: Confidential)

Used statistics and DOC values 2010-2024

The EWC-Stat codes in Table 7.17 and Table 7.18 differs somewhat compared to those in Table 7.16. This is due to changes in the EWC-Stat code nomenclature. EWC-Stat Rev. 4 was implemented from the year 2010 and onward. List of Waste codes (used for administrative purposes) are aggregated to EWC-Stat codes (used for the reporting of EU statistics) or Eurobase codes (used for publication in the dissemination database Eurobase). A link to a conversion table³⁵⁴ for the codes mentioned above is provided in the reference section.

The used statistics and DOC values for 2010-2024 are presented in separate tables below.

Waste statistics

Table 7.17 shows waste statistics for 2010, 2012, 2014, 2016, 2018, 2020 and 2022 used in the calculations of methane emissions from solid waste disposal. Waste statistics for 2011, 2013, 2015, 2017, 2019, 2021, 2023 and 2024 are interpolated/extrapolated.

³⁵⁴CIRCABC, 2021

Table 7.17. Overview of used statistics* 2010-2022 on deposited waste, kt.

EWC- Stat code (Rev. 4.) or Euro base code	Description of waste categories							
		2010 ^(*)	2012 ^(*)	2014 ^(*)	2016 ^(*)	2018 ^(*)	2020 ^(*)	2022 ^(*)
02A	Chemical wastes	85.30	93.60	126.00	158.00	159.00	151.00	128.60
03.2	Industrial effluent sludges: <u>Dry matter</u>	1.28	7.78	19.10	5.60	1.54	1.68	4.68
03.2	Industrial effluent sludges: <u>Dry matter Hazardous</u>	7.00	10.40	9.59	7.78	26.60	3.72	6.23
03.3	Sludges and liquid wastes from waste treatment: <u>Dry matter</u>	0.09	0.20	0.02	0.58	0.01	0.02	C
05.	Health care and biological wastes: <u>Hazardous</u>	0	0	0	-	-	-	-
05.	Health care and biological wastes	0	-	-	-	-	-	-
07.2	Paper and cardboard wastes	0.56	-	-	-	-	-	C
07.5	Wood wastes	0.06	6.46	4.39	-	0.72	0.20	C
07.6	Textile wastes	0	-	0.58	0.04	-	-	-
09.1	Animal and mixed food waste	1.18	0.40	0.25	0.06	0.08	0.01	C
09.2	Vegetal wastes	2.30	0.24	0.07	0	0	0	C
09.3	Animal faeces, urine and manure	0	-	-	-	-	-	0.28
10.1	Household and similar wastes	17.00	26.80	21.90	26.70	7.23	46.7	158.60
10.2	Mixed and undifferentiated materials	262.00	289.00	116.00	206.00	231.00	199.00	C
10.3	Sorting residues	280.00	247.00	286.00	244.00	164.00	161.00	C
11A	Common sludges (<i>excl.</i> <i>dredging spoils</i>): <u>Dry matter</u>	26.20	5.31	1.56	1.87	2.05	0.15	0.26
Total		682.97	687.19	585.25	650.63	592.23	563.43	C

* Waste statistics for 2010, 2012, 2014, 2016, 2018, 2020 and 2022 are from Sweden's reporting to the Commission in accordance with the Waste Statistic Regulation. (C: Confidential)

DOC values

Table 7.18 shows DOC values for 2010³⁵⁵, 2012³⁵⁶, 2014³⁵⁷, 2016³⁵⁸, 2018³⁵⁹ and 2020³⁶⁰ used in the calculations of methane emissions from solid waste disposal. DOC values for 2011, 2013, 2015, 2017, 2019 and 2021-2024 are interpolated/extrapolated.

³⁵⁵ SMED (Sundqvist & Szudy), 2012

³⁵⁶ SMED (Sundqvist & Szudy), 2020

³⁵⁷ SMED (Sundqvist & Szudy), 2020

³⁵⁸ SMED (Sundqvist & Szudy), 2018

³⁵⁹ SMED (Sundqvist & Szudy), 2021

³⁶⁰ SMED (Sundqvist & Szudy), 2024

Table 7.18. Overview of used DOC values estimations, %.

EWC-Stat code (Rev. 4.) or Euro base code	Description of waste categories	DOC content estimations, %					
		2010 ^(*)	2012 ^(**)	2014 ^(**)	2016 ^(**)	2018 ^(**)	2020 ^(**)
02A	Chemical wastes	0.5	1.00	0.993	0.99	1,00	1,00
03.2	Industrial effluent sludges: <u>Dry matter</u>	12.5	0.03	0	0.17	0.59	11
03.2	Industrial effluent sludges: <u>Dry matter Hazardous</u>	2	0	0	0	0	0
03.3	Sludges and liquid wastes from waste treatment: <u>Dry matter</u>	0	0	0	0	9.24	0
05.	Health care and biological wastes: <u>Hazardous</u>	8	9	9	-	-	-
05.	Health care and biological wastes	8	-	-	-	-	-
07.2	Paper and cardboard wastes	36	-	-	-	-	-
07.5	Wood wastes	40	40	40	-	40	40
07.6	Textile wastes	24	-	15	15	-	-
09.1	Animal and mixed food waste	13	9	3.77	14.1	9	9
09.2	Vegetal wastes	20	20	20	20	20	-
09.3	Animal faeces, urine and manure	9	-	-	-	-	-
10.1	Household and similar wastes	18	3.4	3.8	3.4	9.11	8.71
10.2	Mixed and undifferentiated materials	8.5	4.25	3.04	3.1	3.05	3.23
10.3	Sorting residues	2.5	2.17	2.23	2.3	2.41	1.99
11A	Common sludges (<i>excl. dredging spoils</i>): <u>Dry matter</u>	28	28	28	28	28	28

* DOC content estimations are based on waste data from year 2008 and 2010.

** DOC content estimations are based on year specific waste data.

The variation of the DOC values for EWC-Stat categories with small quantities and few entries is sometimes high, since a single entry or a few entries of waste data can have a large impact on the composition of a particular EWC-Stat code for a single year. This is the case for the EWC-Stat categories: 03.2 "Industrial effluent sludges", 07.6 "Textile wastes" and 10.1 "Household and similar wastes". The DOC value for the EWC-Stat category 10.1 "Household and similar wastes" in year 2010 originates from year 2008, when some landfills were granted exemption from the national ban on landfilling organic waste.

7.2.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Because of the simplifications in the used top-down model and the difficulties in estimating many of the parameters, the estimated emissions in the waste sector are uncertain. The time dependency in methane production makes the model estimate further dependent on assumptions of waste management from earlier years. The uncertainty is highest in 1990 and then decreases, mainly due to better and more frequent activity data on household waste during the 1990s.

Since 2006, a new data source is used for all waste quantities and DOC values (see further in section Waste statistics in Sweden, 2006 and onward). The use of a new data source has led to lower uncertainties since the data on DOC can be estimated with better precision. The uncertainty for emission year 1990 for AD is 40%, compared to 25% for 2024, while the uncertainty of EF remains at 50%. This means that the uncertainty has decreased from the base year (1990) to the most recent year (2024), which illustrates the improvements that has been made by using the new data source.

The time series in the waste sector are calculated consistently and in line with the 2006 IPCC Guidelines. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

7.2.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

7.2.2.4.1 *Quality Assurance and Quality Control*

All quality procedures according to the Swedish QA/QC plan (Manual for SMED's Quality System in the Air Emission Inventories) have been implemented during the work with this submission.

7.2.2.4.2 *Verification of data and reducing compiling errors*

Statistics Sweden and IVL Swedish Environmental Research Institute has on behalf of the Swedish EPA scrutinized the activity data (quantities of deposited; household waste, park and garden waste, sludge from wastewater treatment) used for calculations. The accuracy in these activity data is judged to be good.

7.2.2.5 SOURCE-SPECIFIC RECALCULATIONS

Recalculations have been done for methane from CRT 5.A.1 Managed waste disposal sites for the years 1990-2023. The reasons for the recalculations were:

-implementation of newly available³⁶¹ estimates on fraction of waste burned at SWDS 1952-1980.

-revision of data on collection of landfill gas for some landfills for the years 2018-2023.

The emission estimates changed by between -1.40% and 3.93%.

7.2.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. Therefore, no activities are specified in this section.

³⁶¹ SMED (Sundquist & Szudy), 2025. Utredning om historiska data avseende förbränning av avfall på deponier.

7.3 Biological treatment of solid waste (CRT 5.B)

In Sweden, biological waste treatment such as composting and anaerobic digestion of solid waste are common waste management practices.

Biological treatment of waste has a long tradition in Sweden, but the interest and importance has varied during the years. Already during the 1950's, there were three more technically advanced composting plants in operation, treating unsorted household waste. However, the waste composition changed during the 50's and the composting plants were closed down due to operational problems.

The next composting period started around 1975, and during the next ten years about 14 more advanced plants were built. These were based on a technology similar to what today is called Mechanical-Biological-Treatment (MBT). These were built with governmental subsidies (50% of the investment). It was difficult to find markets for the products from these plants (compost, RDF and metals) and the plants had difficult operational problems. One after one the plants closed down and around 1990 there were only a few plants still in operation. Of importance in this context is that from the 1980's, all waste treatment plants were equipped with weighing-machines and computerized registering systems.

In the beginning of the 1990's, there were an increasing interest for composting source-separated household waste, such as food waste and garden waste. Several plants were put in operation, and some of the earlier MBT plants were reconstructed to manage source-separated biowaste. The role of composting of source-separated biowaste became more and more important during the 1990's and several new plants were put in operation. The growth of composting was also encouraged by a landfill tax that was put in action from 2000. Composting also continued to grow in the beginning of the 2000's, encouraged by increased landfill tax and bans on landfilling of combustible waste from 2002, and of organic waste from 2005.

The issue of the standards of the composting plants was raised when the problems of emissions of methane (CH₄) and nitrous oxide (N₂O) rose. From around 2005, all compost plants treating food waste were obliged to have a closed process, collecting and treating the off-gases from the compost. From 2005, the quantities of waste treated by composting have varied between 350 000 – 700 000 t/year. The trend is decreasing from year 2011, as quantities of waste treated by anaerobic digestion are increasing³⁶².

The trend for home composting of food waste is slightly descending in Sweden over the past ten years. For the same period, separate collection of food waste in households has expanded.

Anaerobic digestion has an old tradition in Sweden. It became common during the 1970's and 1980's to stabilize sewage sludge from sewage treatment plants, which was connected to an expansion of the sewage treatment systems in the country. The biogas was usually used as a fuel in the district heating system. During the 1990's, there was a growing interest for biogas as vehicle fuel to substitute diesel oil and petrol, for examples

³⁶² Swedish Waste Management 2010-2025

in buses and cars, connected to the global warming discussions, and a general campaign from the government and parliament to decrease the dependence of fossil oil. The interest in biogas was also transferred to waste management. The first anaerobic digestion plant for *source-separated biowaste from household* were put into operation in the fall of 1994, though co-digestion of *manure, waste from food production* and sometimes *sludge from municipal wastewater treatment plants* were practiced before that. The already mentioned landfill ban for organic waste and the increasing landfill tax urged on the development. There were also governmental subsidies available for projects aiming at reducing the use of fossil fuel. However, there were some operational problems connected with the first period of anaerobic digestion, but from about 2008, the problems have been solved and the amount to anaerobic digestion is increasing. In 2024³⁶³ the amount of waste to anaerobic digestion was 1928 kt and is forecasted to continue to increase for some years in the future.

Of interest in this context is that both the compost and the digestate are used. The compost is mostly used as raw material for garden soil and similar. The digestate is to more than 97%³⁶⁴ used as fertilizer by farmers.

Data on composted amounts of waste are available since at least 1990, while data on amounts of waste to anaerobic digestion are available since 1995, when anaerobic digestion of source-separated biowaste from household started.

Biogas production at anaerobic digestion plants

Statistics on biogas production at anaerobic digestion plants are published annually by the Swedish Energy Agency. The data is in the unit of GWh and is converted into kilotons methane when reported in the CRT as background information. In 2024³⁶⁵, 50.7% of the produced biogas in Sweden was produced at anaerobic treatment plants for solid waste. The biogas production at these plants is equivalent to 88.5 kt of methane (or 1233 GWh). 3.4% of the biogas produced at anaerobic treatment plants for solid waste was flared in 2024, and 91.3% was upgraded into fuel for vehicles. Emissions from flaring and the utilization of the biogas is reported in CRT 1.

7.3.1 Composting (CRT 5.B.1) and anaerobic digestion at biogas facilities (CRT 5.B.2)

7.3.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting data on emissions of methane (CH₄) and nitrous oxide (N₂O) from CRT 5.B.1 Composting, and methane from CRT 5.B.2 Anaerobic digestion at biogas facilities. Emissions of methane (CH₄) and nitrous oxide (N₂O) from home composting of food waste are estimated from submission 2026.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 7.19.

³⁶³ Swedish Waste Management & SMED 2025

³⁶⁴ Swedish Waste Management 2010

³⁶⁵ Swedish Energy Agency, 2025

Table 7.19. Summary of source category description, CRT 5.B, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources estimated
		Level	Trend	Qualitative			
5.B.1	CO ₂	NA	NA		NA	NA	NA
	CH ₄	-	-		T1	D	Yes
	N ₂ O	-	-		T1	D	Yes
	CO ₂	NA	NA		NA	NA	NA
5.B.2	CH ₄	-	-		T2	CS	Yes
	N ₂ O	NA	NA		NA	NA	NA

CS Country Specific, D Default, T1 Tier 1, T2 Tier 2.

7.3.1.2 METHODOLOGICAL ISSUES

7.3.1.2.1 Methodologies used

Equations 4.1 and 4.2 in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories are used when calculating methane and nitrous oxide emissions (see below).

Methane

EQUATION 4.1
CH₄ EMISSIONS FROM BIOLOGICAL TREATMENT

$$CH_4 \text{ Emissions} = \sum_i (M_i \cdot EF_i) \cdot 10^{-3} - R$$

Where:

- CH₄ Emissions = total CH₄ emissions in inventory year, Gg CH₄
- M_i = mass of organic waste treated by biological treatment type *i*, Gg
- EF = emission factor for treatment *i*, g CH₄/kg waste treated
- i* = composting or anaerobic digestion
- R = total amount of CH₄ recovered in inventory year, Gg CH₄

Nitrous oxide

EQUATION 4.2
N₂O EMISSIONS FROM BIOLOGICAL TREATMENT

$$N_2O \text{ Emissions} = \sum_i (M_i \cdot EF_i) \cdot 10^{-3}$$

Where:

- N₂O Emissions = total N₂O emissions in inventory year, Gg N₂O
- M_i = mass of organic waste treated by biological treatment type *i*, Gg
- EF = emission factor for treatment *i*, g N₂O/kg waste treated
- i* = composting or anaerobic digestion

7.3.1.2.2 Emission factors used

Default emission factors from Table 4.1 in 2006 IPCC Guidelines (according to the changes in 9th Corrigenda for the 2006 IPCC Guidelines, July 2015) are used in the

calculations (see Table 7.20) with the exception of the country-specific emission factors³⁶⁶ used from year 2005 when calculating methane emissions from anaerobic digestion (see Table 7.21).

Table 7.20. Default emission factors used.

Type of biological treatment	IPCC Default CH ₄ Emission Factors (g CH ₄ /kg waste treated) on a wet weight basis.	IPCC Default N ₂ O Emission Factors (g N ₂ O/kg waste treated) on a wet weight basis.
Composting	4	0.24
Anaerobic digestion at biogas facilities	0.8 (Year 1990-2004)	Assumed negligible

The emissions of nitrous oxide from CRT 5.B.2 Anaerobic digestion at biogas facilities are reported as NA (not applicable) since the 2006 IPCC Guidelines assumes that the emissions are negligible.

Table 7.21. Country-specific emission factors used; CRT 5.B.2 Anaerobic digestion at biogas facilities.

Year	CH ₄ Emission Factors (g CH ₄ /kg waste treated) on a wet weight basis.
2005	1.0 ¹
2006	1.1 ¹
2007	0.9 ¹
2008	1.1 ¹
2009	1.2 ¹
2010	1.3 ¹
2011	1.6 ¹
2012	1.3 ¹
2013	0.7 ¹
2014	0.6 ¹
2015	0.6 ¹
2016	0.7 ¹
2017	0.8 ¹
2018	0.7 ¹
2019	0.7 ¹
2020	0.8 ¹
2021	0.8 ¹
2022	0.8 ²
2023	0.8 ²
2024	0.8 ²

1) are calculated with measurement data), 2) are extrapolated from year 2021.

³⁶⁶ SMED (Sundqvist & Szudy), 2023

For the earlier years, the country-specific emission factors are higher than the default factor. The emission factors cover the additional emissions that come with upgrading the generated methane into fuel for vehicles. With time, the technical improvements (chemical scrubber and regenerative thermal oxidizers) have decreased the emissions related to upgrading. In this sector, the upgrading of methane into fuel for vehicles has increased from 4.9 kt to 80.8 kt (or 1532%) from year 2005 to year 2024³⁶⁷.

7.3.1.2.3 *Statistics used as activity data*

The statistics used as activity data (Table 7.22) are produced by Swedish Waste Management (Avfall Sverige former RVF). The data are judged to be of high quality. The data on waste quantities are in wet weight and have an estimated water content of 65%. Data on “Annual waste amount treated” reported in the CRT Table 5.B are based on these quantities but are converted to into quantities in dry matter by using the factor 0.35.

The past decade, some municipalities have changed treatment method for biological waste from composting to anaerobic digestion. Waste to anaerobic digestion increased by 247% from 2011 to 2024. The number of anaerobic digestion plants increased from 16 to 32 during this period.

Emissions from home composting of food waste are included in the inventory since submission 2026. A study³⁶⁸ on home composting has been conducted on the subject matter as a response to a recommendation from TERT in submission 2024. The statistics used as activity data is presented in Table 7.22.

³⁶⁷ Swedish Energy Agency, 2025

³⁶⁸ SMED (Sundquist & Szudy), 2025. (Utredning om data avseende hemkompostering för skattning av utsläpp av CH₄ och N₂O år 1990–2024.

Table 7.22. Composted waste and waste to anaerobic digestion.

Year	Waste to composting facilities, (t, wet weight)	Food waste to home composting, (t, wet weight)	Waste to anaerobic digestion facilities, (t, wet weight)
1990	70 950 ¹	0 ¹³	..
1991	..	5 000 ¹³	..
1992	..	10 000 ¹³	..
1993	..	15 000 ¹³	..
1994	..	20 000 ¹³	..
1995	246 000 ²	25 000 ¹³	44 650 ²
21996	..	30 000 ¹³	..
1997	235 000 ³	35 000 ¹³	..
1998	..	40 000 ¹³	..
1999	280 000 ⁴	45 000 ¹³	..
2000	290 000 ⁵	50 000 ¹³	..
2001	..	50 000 ¹³	..
2002	301 525 ⁶	50 000 ¹³	220 316 ⁶
2003	293 188 ⁶	50 000 ¹³	223 463 ⁶
2004	273 952 ⁶	50 000 ¹³	244 374 ⁶
2005	459 830 ⁷	50 000 ¹³	258 070 ⁷
2006	452 390 ⁷	50 000 ¹³	283 730 ⁷
2007	515 290 ⁷	50 000 ¹³	356 090 ⁷
2008	568 700 ⁷	50 000 ¹³	405 580 ⁷
2009	630 500 ⁷	50 000 ¹³	535 930 ⁷
2010	566 210 ⁸	50 000 ¹³	661 620 ⁸
2011	690 100 ⁹	51 500 ¹³	555 050 ⁹
2012	558 831 ¹⁰	51 800 ¹³	695 940 ¹⁰
2013	528 470 ¹¹	48 700 ¹³	945 550 ¹¹
2014	467 920 ¹²	48 300 ¹³	1 227 990 ¹⁴
2015	418 340 ¹²	44 500 ¹³	1 616 110 ¹⁵
2016	476 138 ¹²	42 900 ¹³	1 614 920 ¹⁶
2017	450 362 ¹²	37 100 ¹³	1 562 210 ¹⁷
2018	351 755 ¹²	37 040 ¹³	1 631 400 ¹⁸
2019	354 830 ¹²	33 140 ¹³	1 710 000 ¹⁹
2020	373 800 ¹²	32 460 ¹³	1 763 010 ²⁰
2021	343 692 ¹²	31 120 ¹³	1 733 520 ²¹
2022	330 841 ¹²	32 410 ¹³	1 789 800 ²²
2023	276 580 ¹²	33 000 ¹³	1 808 590 ²³
2024	310 786 ¹²	31 955 ¹²	1 928 390 ²⁴

1) Svensk Avfallshantering 1990, 2) Naturvårdsverket: Aktionsplan Avfall, 3) Svensk Avfallshantering 1998, 4) Svensk Avfallshantering 2000, 5) Svensk Avfallshantering 2001, 6) Svensk Avfallshantering 2005, 7) Svensk Avfallshantering 2010, 8-11) Svensk Avfallshantering 2011-2014, 12) Avfall Sverige / Swedish Waste Management (including oral communication), 13) SMED (Sundquist & Szudy), 2025, 14-24) Svensk Avfallshantering 2015-2025.

7.3.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The used uncertainties are presented below.

7.3.1.3.1 *Methane*

Composting

Emission factor “Methane Emission Factors (g CH₄/kg waste treated) on a wet weight basis: ± 30% (Expert judgement).

Activity data “Fraction of MSW sent to composting facility”: ± 5% (Expert judgement).

Anaerobic digestion at biogas facilities

Emission factor “Methane Emission Factors (g CH₄/kg waste treated) on a wet weight basis: ± 25% (Expert judgement).

Activity data “Fraction of MSW sent to anaerobic digestion at biogas facilities”: ± 5% (Expert judgement)

7.3.1.3.2 *Nitrous oxide*

Composting

Emission factor “Nitrous Oxide Emission Factors (g N₂O/kg waste treated) on a wet weight basis: ± 50% (Expert judgement).

Activity data “Fraction of MSW sent to composting facility”: ± 5% (Expert judgement)

The time series in the waste sector are calculated consistently and in line with the 2006 IPCC Guidelines. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

7.3.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

7.3.1.4.1 *Quality Assurance and Quality Control*

All quality procedures according to the Swedish QA/QC plan (Manual for SMED’s Quality System in the Air Emission Inventories) have been implemented during the work with this submission.

7.3.1.5 SOURCE-SPECIFIC RECALCULATIONS

Recalculations have been done for methane and nitrous oxide from CRT 5.B.1

Composting for the years 1990-2023. The reasons for the recalculations were:

-implementation of AD³⁶⁹ on quantities of home composted food waste for the years 1990-2023.

-revisions of AD on quantities of composted waste for the years 1990-1996, 2001-2004 and 2023.

For the years 1990-2023, the emission estimates changed by between -1.34% and 60.39%.

7.3.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan. Therefore, no activities are specified in this section.

³⁶⁹ Sundquist & Szudy, 2025. Utredning om data avseende hemkompostering för skattning av utsläpp av CH₄ och N₂O år 1990–2024

7.4 Incineration and open burning of waste (CRT 5.C)

7.4.1 Waste incineration (CRT 5.C.1)

7.4.1.1 SOURCE CATEGORY DESCRIPTION

Sweden has one plant for incineration of hazardous wastes. Emissions from incineration of hazardous waste, and in later years also MSW (Municipal solid waste) and industrial waste, from this plant are reported in CRT 5.C.1. The fossil and biogenic fractions of CO₂ emissions are, according to the IPCC 2006 Guidelines, reported separately. Emissions from other MSW incineration plants combusting waste for energy purposes are included in CRT 1. The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), are presented in Table 7.23.

Table 7.23. Summary of source category description, CRT 5.C.1, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources Estimated
		Level	Trend	Qualitative			
5.C	CO ₂	X	-		T3	PS	Yes
	CH ₄	-	-		T2	PS	Yes
	N ₂ O	-	-		T2	PS	Yes

PS Plant Specific. T2 Tier 2. T3 Tier 3.

7.4.1.2 METHODOLOGICAL ISSUES

For this source category, the methodology and time series consistency are in line with the 2006 IPCC Guidelines.

Emissions from incineration of hazardous waste, and in later years also MSW and industrial waste, from one large plant are reported in CRT 5.C. Reported emissions are for the whole time series obtained from the facility's Environmental report or directly from the facility on request. CO₂, SO₂, NO_x and CH₄ are measured continuously in the fumes at the plant. NMVOC are until 2007 as reported by the facility. For 2007 – 2015, the NMVOC emissions are calculated based on IEF for 2007 and yearly incinerated amounts of waste. From 2016 NMVOC emissions, also based on continuous measurements, have been obtained directly from the facility.

In 2003 capacity was increased substantially at the plant by taking one new incinerator into operation. The new incinerator incinerates a mixture of MSW, industrial waste and hazardous waste. As presented in Table 7.24, emissions of CO₂ from incineration of biogenic waste are reported in CRT 5.C.1.1.b and CO₂ from incineration of non-biogenic waste are reported in CRT 5.C.1.2.b. Emissions of CH₄ and N₂O from incineration of biogenic and non-biogenic waste are reported in CRT 5.C.1.2.b.

Table 7.24. Notation keys for emissions reported in CRT 5.C.

CRT	Greenhouse gas source and sink categories	CO ₂		CH ₄ and N ₂ O	
		Notation key	Emissions included in CRT	Notation key	Emissions included in CRT
5.C.1.1.a	Biogenic municipal solid waste	IE	5.C.1.1.b	IE	5.C.1.2.b
5.C.1.1.b	Biogenic other waste (hazardous)	Emissions reported		IE	5.C.1.2.b
5.C.1.2.a	Non-biogenic municipal solid waste	IE	5.C.1.2.b	IE	5.C.1.2.b
5.C.1.2.b	Non-biogenic other waste (hazardous)	Emissions reported		Emissions reported	

As a consequence of increased capacity, the emissions after 2003 increased compared to earlier years. Only a minor part (1 – 2%) of the total amount of waste incinerated for energy purposes in Sweden are incinerated in the facility included in 5.C. All other emissions from incineration of MSW are reported in CRT 1.

Emissions reported are CO₂, CH₄, N₂O, NO_x, SO₂, NMVOC and CO.

For the period before 2003 the company considers reported CO₂ emissions to be almost 100% fossil³⁷⁰. For the years from 2003 onwards, it is assumed that the share of biogenic material in the combusted MSW is 50 – 63% – this is according to the study performed by the facility in 2008, the study by Swedish Waste Management³⁷¹ from 2012, and the revision of CO₂ emissions before submission 2020. MSW constitutes about one third of the total combusted waste, which means that the share of biogenic CO₂ emissions in the total facility CO₂ emissions is currently about 17%.

Before 2008 occasional measurements of CH₄ in the flue gas were performed. The company reported CH₄ emissions around 1.1 t for 2008. This information, together with information on incinerated amounts of waste 1990 until 2007, has been used for estimating a time series 1990 – 2008 for emissions of CH₄ in CRT 5C. From 2008 reported CH₄ emissions are based on continuous measurements in the flue gas. Also, N₂O from waste incineration is reported for the entire time series. The estimates are based on occasional measurements of the N₂O concentrations in the flue gas together with information on yearly flue gas volumes 2003 – 2022. For 1990 until 2002 the volumes are not known and for these years the flue gas volumes have been estimated using the average of the ratios between volumes and incinerated amounts of waste for 2003 to 2008. Activity data and implied emission factors/emission factors used for the CH₄ and N₂O estimates are presented in Table 7.25.

³⁷⁰ Personal communication, Hanna Eriksen, Hanna.Eriksen@sakab.se, 2012-08-23

³⁷¹ Swedish Waste Management. RAPPORT U2012:05. Determination of the fossil carbon content in combustible municipal solid waste in Sweden.

Table 7.25. Activity data and implied emission factors/emission factors used for estimations of CH₄ and N₂O emissions in CRT 5.C.

Year	Total amounts of incinerated waste kt	Flue gas volume 1000 m ³	CH ₄ IEF, kg/kt	N ₂ O EF, g/1000 m ³
1990	30	220 674*	7.73**	15.00
1995	33	240 637*	7.73**	15.00
2000	28	205 778*	7.73**	15.00
2005	126	1 099 338	7.73**	15.00
2010	156	1 007 061	5.79	15.00
2011	163	1 229 605	6.09	15.00
2012	158	1 194 418	7.81	15.00
2013	153	1 128 670	7.73	15.00
2014	153	1 201 632	5.27	15.00
2015	155	1 162 650	3.58	15.00
2016	148	1 133 767	4.78	15.00
2017	150	1 158 546	6.67	15.00
2018	153	1 183 838	9.38	15.00
2019	155	1 167 810	8.26	15.00
2020	151	819 965	9.48	15.00
2021	146	1 159 047	5.16	15.00
2022	135	1 204 523	1.82	15.00
2023	135	926 619	4.70	15.00
2015	155	1 162 650	3.58	15.00
2020	151	819 965	9.48	15.00
2021	146	1 159 047	5.16	15.00
2022	135	1 204 523	1.82	15.00
2023	135	926 619	4.70	15.00
2024	145	1 045 625	4.78	15.00

* = estimated volume

** = IEF for 2008 used for estimations 1990 - 2007

7.4.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

According to 2006 IPCC Guidelines, for a default emission factor, the uncertainty has been estimated at $\pm 100\%$, and the uncertainty for plant specific activity data (amount of incinerated waste) is $\pm 5\%$. The Swedish reporting of N₂O is based on an emission factor and measured yearly amounts of flue gas. The uncertainty for N₂O emission factor is set to ± 100 , and the uncertainty for activity data is set to 5%.

In 2006 IPCC Guidelines, it is not easy to find information concerning uncertainties of measured amounts emitted CO₂, but corresponding information for measured CH₄ is likely to be in order of $\pm 10\%$. Due to lack of other information, the emission uncertainty for CO₂ and CH₄ are set to $\pm 10\%$.

As can be seen in Table 7.25 the implied emission factor (IEF) for CH₄ varies. Reported emissions for 2008 – 2024 are based on continuous measurements and the reason for the variation may be explained by variations in the composition of the incinerated waste.

7.4.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

7.4.1.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations are made in submission 2026.

7.4.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

7.4.2 Open burning of waste (CRT 5.C.2)

7.4.2.1 SOURCE CATEGORY DESCRIPTION

In Sweden, accidental fires in landfills and storages of waste fractions occur, resulting in emissions of CO₂, CH₄ and N₂O. However, as there is no recorded statistics of the annual amount of waste consumed by these fires, emissions cannot be estimated with satisfactory certainty.

The 2006 IPCC Guidelines provide default methods for estimating activity data only for countries in which the urban population is below 80% of total population. Otherwise, one can assume that no open burning of waste occurs in the country. As the Swedish urban population is larger than 80% no default method for estimating activity data exists.

A rough estimation suggests that collected emissions of CO₂, CH₄ and N₂O amounted to about 4 kt CO₂-eq. in 2002, based on assumptions of the fossil carbon content of the waste, default emission factors and statistics on landfill fires in 2002 collected in a report from 2003³⁷². Corresponding statistics are however not available for other years and since legislative changes have resulted in large changes in the waste fraction compositions; this information cannot be assumed to be valid for later years. As the estimated emissions for 2002 are below 0.05% of national emissions (below 31 kt CO₂-eq) they can be considered insignificant, and as the effort to collect data is disproportionate to the emission levels, the emissions are reported as “Not Estimated” in line with the UNFCCC reporting guidelines.

Small scale waste burning of garden waste also occurs in Sweden, however as only biogenic materials are burned in these fires, no fossil CO₂ emissions occur. Emissions of CO, SO₂, NO_x and NMVOC from small scale waste burning of garden are calculated with emission factors from EMEP/EEA Guidebook 2019.

7.4.2.2 METHODOLOGICAL ISSUES

Emission factors for open burning of waste from EMEP Guidebook 2019 were used to estimate emissions of CO, SO₂, NO_x and NMVOC.

As there are no national statistics regarding the extent of garden burning and bonfires, instead statistics on number of small houses have been used. The data should be considered as indicative levels of emissions from these sources.

³⁷² Bränder i avfall vid deponier och förbränningsanläggningar (2003) RVF rapport 2003:11, ISSN 1103-4092

7.4.2.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

The time series is consistent. The uncertainties are calculated according to EMEP Guidebook 2019. The uncertainties are: CO \pm 200%, NMVOC \pm 201%, NO_x \pm 200% and SO₂ \pm 191%

7.4.2.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

No source-specific QA/QC or verification is performed.

7.4.2.5 SOURCE-SPECIFIC RECALCULATIONS

No source-specific recalculations have been performed in submission 2026.

7.4.2.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

7.5 Wastewater treatment and discharge (CRT 5.D)

In Sweden, wastewater treatment is practised both in municipal wastewater treatment plants, in private wastewater systems and in some industries. Both methane and nitrous oxide are emitted from these activities. Most of the wastewater treatment facilities (municipal and industrial) in Sweden are using *aerobic* processes, where smaller amounts of methane are generated because of the use of aeration in the wastewater treatment process.

Municipal wastewater treatment facilities

There are almost 500 municipal wastewater treatment plants in Sweden with treatment capacity for more than 2,000 personal equivalents. 95% of the wastewater is treated mechanically, biologically and chemically. In some larger plants, or plants with sensitive recipients, special nitrogen treatment is performed. Some of these wastewater treatment plants also receive wastewater from industries without internal wastewater treatment. There are also several smaller plants or private plants (WWTPs < 2,000 personal equivalents) of varying standard.³⁷³ In year 2024, anaerobic digestion of sludge and biogas production was performed at 131³⁷⁴ municipal wastewater treatment plants in Sweden (for more information, see below on biogas production).

Uncollected wastewater treatment

In addition, there are also approximately 1.3 million people in Sweden that are not connected to any wastewater treatment plant. Instead, this population is connected to on-site wastewater treatment. A wide range of technologies are used for on-site treatment of wastewater in Sweden, but it is most common that the technologies involve a septic tank followed by a leach field or similar. The sludge in the septic tank is pumped and transported to a municipal wastewater treatment plant and co-digested with the sludge generated at the wastewater treatment plant. The methane emissions due to co-digestion of sludge from septic tanks are included in the inventory as well as on-site emissions from septic tanks.

Industrial wastewater treatment facilities

The industrial wastewater is treated both internally and in municipal wastewater treatment plants. *Aerobic* processes are the most common kind, but there are a few exceptions. In 2024 there were eight (8) facilities using *anaerobic* wastewater treatment processes in Sweden, all of them are in the food industry and in the pulp and paper industry. Biogas is produced at these eight facilities (for more information, see below on biogas production).

There are no activities³⁷⁵ in Sweden such as *anaerobic digestion of sludge* at industrial plants with internal wastewater treatment. The pulp and paper industry incinerates most of the sludge generated from treatment of the wastewater, in their boilers or chemical recovery systems. Some of the sludge is used to cover landfills or is treated by composting and sold as soil improvement.

³⁷³ Swedish EPA & SMED, 2003

³⁷⁴ Swedish Energy Agency, 2025

³⁷⁵ Memo "Occurrence of treatment of sludge by anaerobic digestion in Swedish industries", Statistics Sweden, 2011 "

In a more recent study³⁷⁶, the food industry was scrutinized in order to find facilities within the food industry with internal wastewater treatment that practices anaerobic digestion of sludge. No such activities were found. The conclusion in the study is that sludge from these kinds of plants is either transported to external biogas facilities or used untreated as fertilizer on nearby farms.

Biogas production at municipal and industrial wastewater treatment facilities

Considerable quantities of heat and bioenergy are recovered from sewage and wastewater.³⁷⁷ Anaerobic wastewater treatment and anaerobic digestion of sludge generates methane for production of electricity, heating, vehicle fuel and for local gas distribution networks. Some of the methane is flared. Emissions from flaring and the utilization of the biogas is reported in CRT 1.

Municipal wastewater treatment facilities

In 2024, 29.3%³⁷⁸ of the produced biogas in Sweden was produced at municipal wastewater treatment plants. The biogas production (by anaerobic digestion of sludge) at wastewater treatment plants increased by 27.4% from 2005 to 2024. 10.7% of this biogas was flared and 60.5% was upgraded into fuel for vehicles in 2024.

Industrial wastewater treatment facilities

In year 2024, four (4) facilities in the food industry and four (4) facilities in the pulp and paper industry practiced anaerobic wastewater treatment with energy recovery. 6.0% of the produced biogas in Sweden was produced in these industries. The biogas production at these industries increased by 133.3% from 1990 to 2024. 23.8% of the biogas produced was flared. 16.3% of the produced methane was upgraded.

7.5.1 Domestic wastewater (CRT 5.D.1) and Industrial wastewater (CRT 5.D.2)

7.5.1.1 SOURCE CATEGORY DESCRIPTION

Sweden is reporting data on emissions of methane (CH₄) and nitrous oxide (N₂O) from CRT 5.D.1 Domestic wastewater and CRT 5.D.2 Industrial wastewater.

The summary of the latest key category assessment, methods and EF used, and information on completeness, i.e. if any sources are not estimated (NE), is presented in Table 7.26.

³⁷⁶ SMED (Karlsson & Szudy), 2021

³⁷⁷ Ministry of the Environment, 2001

³⁷⁸ Swedish Energy Agency, 2025

Table 7.26. Summary of source category description, CRT 5.D, according to approach 1.

CRT	Gas	Key Category Assessment, excluding LULUCF			Method	EF	All sources Estimated
		Level	Trend	Qualitative			
5.D.1	CO ₂	NA	NA		NA	NA	NA
	CH ₄	X	-		T2	CS	Yes
	N ₂ O	X	-		T1	D, CS	Yes
5.D.2	CO ₂	NA	NA		NA	NA	NA
	CH ₄	-	-		T2	CS	Yes
	N ₂ O	-	-		T1	D	Yes

CS Country Specific, D Default, T1 Tier 1, T2 Tier 2, T3 Tier 3.

7.5.1.2 METHODOLOGICAL ISSUES

7.5.1.2.1 Methodologies used (CH₄)

Equations 6.1 and 6.4 in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories (vol. 5, chap. 6) are used when calculating methane emissions (see below).

Domestic wastewater (CRT 5.D.1)

Emissions from the wastewater treatment ponds and sludge treatment are estimated separately.

EQUATION 6.1
TOTAL CH₄ EMISSIONS FROM DOMESTIC WASTEWATER

$$CH_4 \text{ Emissions} = \left[\sum_{i,j} (U_i \cdot T_{i,j} \cdot EF_j) \right] (TOW - S) - R$$

Where:

- CH₄ Emissions = CH₄ emissions in inventory year, kg CH₄/yr
- TOW = total organics in wastewater in inventory year, kg BOD/yr
- S = organic component removed as sludge in inventory year, kg BOD/yr
- U_i = fraction of population in income group *i* in inventory year, See Table 6.5.
- T_{i,j} = degree of utilisation of treatment/discharge pathway or system, *j*, for each income group fraction *i* in inventory year, See Table 6.5.
- i* = income group: rural, urban high income and urban low income
- j* = each treatment/discharge pathway or system
- EF_j = emission factor, kg CH₄ / kg BOD
- R = amount of CH₄ recovered in inventory year, kg CH₄/yr

Methane emissions from the wastewater treatment train

Swedish WWTPs can be assumed to be well managed and according to 2006 IPCC Guidelines, emissions the wastewater treatment train, i.e. sedimentations tanks and biological treatment, then can be considered negligible. However, national measurements³⁷⁹ shows that methane emissions do occur, and an emission factor of 2.7 g methane/incoming kg COD is suggested. Recalculated to a methane correction factor (MCF), this factor corresponds to 0.036. Note that the default value of B₀ is used.

³⁷⁹ Swedish Water & Wastewater Association, 2014

The application of equation 6.1 from the 2006 IPCC Guidelines on the wastewater treatment train nationally results in emissions around 1,300 tonnes methane.

Methane emissions from sludge treatment (anaerobic digestion of sewage sludge)

Methane emissions from on-site sludge treatment located at municipal WWTPs is estimated on the basis of total organics in wastewater removed, the amount of sludge generated and the methane potential of the sludge. The total amount of BOD within the sludge going to sludge treatment is calculated based on Oonk³⁸⁰. In total, 70% of the BOD in incoming wastewater is estimated to end up as undigested sludge. Of this, 90% is assumed to be digested (expert judgement).

Apart from this load, WWTPs anaerobic digesters in Sweden receives external additions of organic material that is not included in incoming wastewater. This part is assumed to add another 15% of organic material to the anaerobic digesters.

These calculations give an estimate of the organic load on digester, i.e. TOW to be used in Equation 6.1. S, i.e. sludge removed from the process, is calculated based on the assumption that 55% of the organic material is degraded in a well-functioning digestion process. The value of MCF for the process has been adjusted to 0.95. With these estimations, Equation 6.1 returns national gas production in the same order as the amount given in national statistics³⁸¹.

When estimating the emissions, the national production of methane from the sector is used together with emission factors from national measurements³⁸² at WWTPs of methane emissions from the sludge digestion process. The emissions are in between 2% – 3% of the total biogas production.

Methane emissions from other sludge treatment methods are considered negligible.

Methane emissions from uncollected wastewater treatment

Methane emissions from uncollected wastewater treatment, i.e. domestic wastewater that is not treated in a municipal WWTP, is calculated with Equation 6.1, but with an adjusted value for MCF. The load on these facilities is calculated³⁸³ with the estimate that 1 300 000 people use such facilities to 100%. It is assumed that these facilities all look similar and are equipped with a septic tank followed by some kind of aerobic treatment step such as a drainage field. The default value of 0.5 for MCF is considered *to high* for Swedish conditions, as less than 50% of incoming organic load is degraded in the anaerobic septic tanks³⁸⁴. In Sweden, between 20% and 30% of incoming organic load is removed and degraded in septic tanks³⁸⁵ under conditions that can be assumed to be

³⁸⁰ Oonk, 2020

³⁸¹ Swedish Energy Agency, 2007–2025

³⁸² Swedish Waste Management, 2023

³⁸³ SMED, 2015 (Olshammar, Ek, Rosenquist, Ejhed, Sidvall & Svanström)

³⁸⁴ SMED, 2015 (Olshammar, Ek, Rosenquist, Ejhed, Sidvall & Svanström)

³⁸⁵ SMED, 2015 (Olshammar, Ek, Rosenquist, Ejhed, Sidvall & Svanström)

anaerobic. Therefore, the MCF-value of 0.22 from Diaz-Valbuena³⁸⁶ and Leverenz³⁸⁷ describes the Swedish conditions better than the 2006 IPCC Guidelines default value of 0.5.

None of the produced methane is considered recovered.

Industrial wastewater (CRT 5.D.2)

Emissions from aerobic wastewater treatment ponds, on-site treatment of sludge generated in those aerobic ponds, and anaerobic digestion of wastewater are estimated separately.

<p>EQUATION 6.4 TOTAL CH₄ EMISSIONS FROM INDUSTRIAL WASTEWATER</p> $CH_4 \text{ Emissions} = \sum_i [(TOW_i - S_i) EF_i - R_i]$
--

Where:

- CH₄ Emissions = CH₄ emissions in inventory year, kg CH₄/yr
- TOW_{*i*} = total organically degradable material in wastewater from industry *i* in inventory year, kg COD/yr
- i* = industrial sector
- S_{*i*} = organic component removed as sludge in inventory year, kg COD/yr
- EF_{*i*} = emission factor for industry *i*, kg CH₄/kg COD for treatment/discharge pathway or system(s) used in inventory year
If more than one treatment practice is used in an industry this factor would need to be a weighted average.
- R_{*i*} = amount of CH₄ recovered in inventory year, kg CH₄/yr

All aerobic wastewater treatment plants are well managed, and the methane correction factor is assumed to be 0. For these installations, the application of equation 6.4 of the 2006 IPCC Guidelines results in negligible methane emissions.

Sweden has chosen a *country-specific method* to estimate the emissions from anaerobic wastewater treatment. Energy statistics from the annual statistical report “Production of biogas and digestate year YYYY”³⁸⁸ are used to quantify methane generation from anaerobic wastewater treatment. By using statistical information on produced quantity of biogas for flaring and energy recovery (in GWh), the produced quantity of methane in kilotonnes is calculated by using the lower heating value for methane. The following assumptions and parameters are used:

- a. Energy content: 9,95 MWh/1000 Nm³ methane
 - b. 1 Nm³ methane = 0,714 kg methane
- which results in 1 GWh = 0.07175 kilotonne methane.

³⁸⁶ Diaz-Valbuena et al., 2011

³⁸⁷ Leverenz et al., 2010

³⁸⁸ Swedish Energy Agency, 2007-2025

According to wastewater treatment expertise³⁸⁹, the loss of methane in the biogas production process should be between 2% and 5%, assuming 5% of methane being emitted in 1990–2000; a gradual decrease from 5% to 2% in 2001–2009; and 2% from 2010 onwards. The EF (from 5% to 2%) it is based on expert judgment on the effect of an increased awareness of methane leakages at biogas facilities and efforts to minimize methane leakages from those facilities.

7.5.1.2.2 Emission factors used (CH_4)

Domestic wastewater (CRT 5.D.1)

B_0 : The maximum methane producing capacity (B_0) is set to 0.6 kg CH_4 /kg BOD (equals to 0.25 kg CH_4 /kg COD).

Methane is emitted from three processes:

- the wastewater treatment train,
- the digestion process of municipal sludge, and
- septic tanks.

MCF (Methane correction factors):

The MCF for the wastewater treatment train, i.e. primary sedimentation, biological treatment and chemical treatment, is determined to 0.036 based on national measurements.

The MCF for digestion, i.e. “anaerobic stabilisation” is estimated to 0.95. This value is higher than the default value in 2006 IPCC Guidelines. This higher value is used to fit calculated production of biogas at Swedish WWTP with national statistics of the production.

The MCF for septic tanks and thus for uncollected WWT is set to 0.22 as the default MCF value of 0.5 is too high for Swedish conditions, as less than 50% of the organic load on these facilities is degraded/removed in the septic tank.

Industrial wastewater (CRT 5.D.2)

For the country-specific method, the estimate of the loss of methane in the biogas production process is³⁹⁰:

- 5% for year 1990-2000,
- descending for year 2001-2009,
- 2% from year 2010 and onwards.

Example: In year 2024, 147 GWh³⁹¹ biogas (or 10.55 kt methane) was produced (including flared quantities). By using the value 2% as the leakage factor, the emission of methane is calculated to 0.22 kt for year 2024.

³⁸⁹ SMED (Szudy, Ek, Linné, Olshammar), 2017

³⁹⁰ SMED (Szudy, Ek, Linné, Olshammar), 2017

³⁹¹ Swedish Energy Agency, 2025

7.5.1.2.3 Statistics used as activity data (CH₄)

Domestic wastewater (CRT 5.D.1)

TOW (total organics in wastewater) is calculated by using the value of BOD (60 g BOD/person). In Sweden, BOD₇ rather than BOD₅ is used, but according to Swedish statistics, a specific load of 60 g BOD₇/person/day is reasonable³⁹².

The activity data P (population) is calculated for the following two categories (A and B):
(A) population connected to municipal wastewater treatment facilities and
(B) population with uncollected WWT, i.e. local wastewater treatment facilities, often at household level.

(A) is calculated by using the total population in Sweden minus (B). The population not connected to municipal wastewater discharge system (B), 1 300 000 people, is an estimate³⁹³.

An additional industrial load is added to (A). In year 1990 we assume the industrial load is 25% but reducing to 15% from year 2020 and onward. This is an expert judgement based on that the organic load on WWTP per connected person has decreased the past decades. A reasonable explanation for this that the industrial load has decreased, rather than that people discharge less organic material to the sewer net. This approach differs somewhat from the calculations of the nitrogen load (see further in section 7.5.1.2.6 Statistics used as activity data (N₂O)).

Swedish WWTP also receives external organic material (food waste, grease etc) that is fed directly into the digesters. When calculating the load on the digesters another 15% is added on top of the load from undigested sludge. This load is assumed to increase linearly from 0% in year 2000 to 15% in year 2010.

No industrial load is assumed for on-site treatment facilities, i.e. uncollected WWT.

Industrial wastewater (CRT 5.D.2)

Activity data for the country-specific method are statistical data on energy recovery from anaerobic wastewater treatment processes (see Table 7.27 below). Data published by the Swedish Energy Agency are available for year 2005-2024. For the years 1990, 1995 and 2000, data on biogas production at wastewater treatment facilities have been compiled within a project³⁹⁴ for investigating historical data on biogas production. See further in section "Biogas production at wastewater treatment facilities".

³⁹² Swedish Water & Wastewater Association, 2016

³⁹³ SMED, 2018 (Olshammar)

³⁹⁴ SMED (Szudy, Ek, Linné, Olshammar), 2017

Table 7.27. Biogas production on facilities in the pulp and paper industry and the food industry with anaerobic wastewater treatment, GWh.

Year	Flaring	Energy recovery	Total
1990	3 ¹	60 ¹	63 ¹
1995	3 ¹	90 ¹	93 ¹
2000	3 ¹	96 ¹	99 ¹
2005	0 ²	94 ²	95 ²
2006	1 ²	91 ²	91 ²
2007	0 ²	123 ²	123 ²
2008	3 ²	127 ²	130 ²
2009	10 ²	93 ²	103 ²
2010	7 ²	106 ²	113 ²
2011	10 ²	114 ²	124 ²
2012	10 ²	108 ²	118 ²
2013	16 ²	102 ²	118 ²
2014	21 ²	105 ²	126 ²
2015	29 ²	88 ²	117 ²
2016	34 ²	94 ²	128 ²
2017	29 ²	96 ²	125 ²
2018	34 ²	109 ²	143 ²
2019	43 ²	100 ²	143 ²
2020	39 ²	95 ²	134 ²
2021	37 ²	112 ²	149 ²
2022	67 ²	132 ²	199 ²
2023	40 ²	112 ²	152 ²
2024	35 ²	112 ²	147 ²

1) SMED (Szudy, Ek, Linné, Olshammar), 2017, 2) Swedish Energy Agency, 2007-2025

7.5.1.2.4 Methodologies used (N₂O)

The direct and indirect nitrous oxide emissions are quantified on the basis of available statistics of N in both the influent and the effluent of wastewater treatment plants.

<p>EQUATION 6.7 N₂O EMISSIONS FROM WASTEWATER EFFLUENT $N_2O \text{ Emissions} = N_{\text{EFFLUENT}} \cdot EF_{\text{EFFLUENT}} \cdot 44 / 28$</p>
--

Where:

N₂O emissions = N₂O emissions in inventory year, kg N₂O/yr

N_{EFFLUENT} = nitrogen in the effluent discharged to aquatic environments, kg N/yr

EF_{EFFLUENT} = emission factor for N₂O emissions from discharged to wastewater, kg N₂O-N/kg N

The factor 44/28 is the conversion of kg N₂O-N into kg N₂O.

Equations 6.7 in the 2006 IPCC Guidelines for National Greenhouse Gas Inventories are used when calculating nitrous oxide emissions for both centralized wastewater treatment processes and from nitrogen in effluent (see below).

7.5.1.2.5 Emission factors used (N_2O)

For direct (or internal) emissions from biological nitrogen removal, a country-specific emission factor (0.0074 N_2O -N/kg N) is used for in WWTPs >2000 pe. The national value³⁹⁵ is based on six annual environmental reports from two WWTPs > 2000 pe, where the amount of nitrogen in inlet converted to nitrous oxide was reported.

The default emission factor from vol. 5, chap. 6.3.1.2 of the 2006 IPCC Guidelines (0.005 N_2O -N/kg N) is used for indirect emissions from:

- effluent from WWTPs > 2000 pe
- effluent from WWTPs < 2000 pe
- effluent from industrial wastewater

7.5.1.2.6 Statistics used as activity data (N_2O)

National statistics on N in both the influent and the effluent (or discharge) of municipal wastewater treatment plants and industries are used as activity data.

Available statistics on N in the influent of large wastewater treatment plants are used for estimations of direct emissions at large wastewater treatment plants.

Available statistics on N in the effluent of large wastewater treatment plants are used as AD for indirect emissions.

For the part of the population not connected to large wastewater treatment plants, an estimate is made of N discharge on open waters on the basis of the amount of N per capita in the influent of wastewater treatment plants.

Domestic wastewater (CRT 5.D.1)

According to Swedish environmental protection law, all municipal wastewater treatment plants designed for more than 2,000 person equivalents, including industry, must report their discharges in environmental reports delivered to their supervision agency. Data from these reports (Table 7.28) are compiled and national statistics are published every second year by the Swedish EPA.³⁹⁶ The production time for these publications varies, and sometimes the statistics is not available until two years after the reference year.

³⁹⁵ IVL Svenska Miljöinstitutet AB (Westling, Tjus & Ek), 2014

³⁹⁶ Statistics Sweden, MI 22 SM, Swedish EPA and SMED.

Table 7.28. Influent and discharge of nitrogen, removal efficiency: Large municipal wastewater treatment plants (from treatment of domestic, commercial and industrial wastewater).

Year	Influent of nitrogen (t)	Discharge of nitrogen (t)	Removal efficiency (%)
1990	..	26 200	..
1992	..	25 310	..
1995	..	25 940	..
1998	40 086	21 376	47
2000	41 269	18 977	54
2002	40 999	18 036	56
2004	41 417	17 779	57
2006	42 956	18 347	57
2008	42 360	18 433	56
2010	42 292	17 419	59
2012	41 967	17 120	59
2014	41 340	15 743	62
2016	41 049	15 414	62
2018	41 294	14 982	64
2020	41 737	14 779	65
2022	42 151	14 844	65

Source: MI 22 SM, Swedish EPA and SMED

The statistics on influent and discharge of nitrogen excludes municipal wastewater treatment plants designed for less than 2,000 person equivalents, and people in rural areas, who are not connected to municipal wastewater treatment. The nitrogen load per person for the population excluded in the statistics is assumed to be the same as for persons connected to WWTPs >2000 and is estimated after subtraction of the 20% industrial load. The fraction of industrial and commercial co-discharged nitrogen has a default = 1.25, meaning that the per capita load after the industrial load has been subtracted is $1/1.25 = 80\%$. The number of people connected to WWTPs < 2000 is estimated by subtracting total population in Sweden with the number of people connected to WWTPs > 2000 pe.

Industrial wastewater (CRT 5.D.2)

Data from environmental reports from industrial wastewater handling (Table 7.29) are compiled to statistics and published every second year (except statistics on the pulp- and paper industry, which is available yearly). The industrial sector covers: pulp and paper industry, oil refineries, chemical industry, iron and steel industry, food manufacturing industry, manufacturing of wood products and mining and quarrying industry. The production time for these publications varies, and sometimes the statistics is not available until two years after the reference year.

Table 7.29. Discharges of nitrogen from mining and quarrying and manufacturing industries: Pulp and paper industry (total), Oil refineries (total), Chemical industry (inland and coastal), Iron and steel industry (inland and coastal), Food manufacturing industry (inland and coastal), Manufacturing of wood products (inland and coastal) and Mining and quarrying (total), (t).

Year	Pulp and paper (tot.)	Oil ref. (tot.)	Chem. (inl.)	Chem. (coast.)	Iron and steel (inl.)	Iron and steel (coast.)	Food (inl.)	Food (coast.)	Wood prod. (inl.)	Wood prod. (coast.)	Mining (tot.)
1990	5 500	..	..	..	..	..	..	..	..	..	..
1992	3 630	..	..	..	..	..	..	..	..	..	..
1994	3 200	..	..	..	..	..	..	..	..	..	..
1995	3 844	80	..	385	..	70	..	0	..	..	..
1997	3 433	..	..	..	..	..	..	..	..	..	..
1998	3 307	78	..	423	..	230	..	1	..	..	..
1999	3 042	..	..	..	..	..	..	..	..	..	..
2000	3 241	38	..	361	..	114	..	..	..	..	..
2001	3 014	..	..	..	..	..	..	..	..	..	..
2002	3 169	68	..	268	..	72	..	3	..	..	..
2003	3 162	..	..	..	..	..	..	..	..	..	..
2004	3 039	30	..	224	..	54	..	11	2	6	451
2005	3 222	..	..	..	..	..	..	..	..	..	..
2006	3 200	39	..	144	..	74	..	17	2	3	496
2007	2 825	..	..	..	..	..	..	..	..	..	..
2008	2 830	26	256	139	807	68	89	27	2	2	480
2009	2 600	..	..	..	..	..	..	..	..	..	..
2010	2 590	45	205	140	769	84	96	25	0	4	321
2011	2 500	..	..	..	..	..	..	..	..	..	..
2012	2 560	30	178	133	700	84	86	17	0	2	310
2013	2 325	..	..	..	..	..	..	..	..	..	..
2014	2 470	30	179	138	490	77	101	25	0	0	610
2015	2 550	..	..	..	..	..	..	..	..	..	..
2016	2 185	31	177	107	430	117	88	30	0	0	677
2017	2 289	..	..	..	..	..	..	..	..	..	..
2018	2 123	32	54	91	443	93	91	17	0	0	561
2019	1 699	..	..	..	..	..	..	..	..	..	..
2020	2 012	29	153	74	432	65	100	8	0	0	620
2021	2 071	..	..	..	..	..	..	..	..	..	..
2022	1 859	21	132	94	543	73	98	20	0	0	637
2023	1 881	..	..	..	..	..	..	..	..	..	..
2024	..	..	..	..	..	..	..	..	..	..	..

Source: NV 4657, NV 4434, NV 4657, NV 4924, NV 4987, NV 5114, Swedish Forest Industries Federation, MI 22 SM, Swedish EPA and SMED

7.5.1.3 UNCERTAINTIES AND TIME-SERIES CONSISTENCY

Because of the simplifications in the used top-down model and the difficulties in estimating many of the parameters, the estimated emissions in the waste sector are uncertain. The used uncertainties are presented below.

7.5.1.3.1 Methane

Domestic wastewater

Activity data:

“Human population”: ± 5% (Default)

“BOD per person”: ± 15% (Expert judgement)

Population served by unsewered sanitation: ± 15% (Expert judgement)

“Correction factor for additional industrial BOD discharged into sewers”: ± 20% (Default)

Correction factor for external organic matter into digesters: ± 20%.

Emission factors and methane correction factors:

“Maximum methane producing capacity (B_0)”: $\pm 30\%$ (Default)

MCF-wastewater treatment: -50% to $+100\%$ (Expert judgement)

MCF-sludge treatment: not relevant as this is not determining emissions. The part leaking to the atmosphere is determining the quantity of the methane emissions from the sludge treatment.

MCF-uncollected WWT: $\pm 50\%$ (Expert judgement)

EF-methane leakage: -50% to $+100\%$. This is a nationally derived factor from measurements of methane leakages at sludge treatment at WWTP. This factor tells how much of the total produced biogas that is emitted to the atmosphere.

Industrial wastewater

Emission factor “The loss of methane in the energy recovery process”: $\pm 25\%$ (Expert judgement)

Activity data “Energy recovery from anaerobic wastewater treatment processes (MWh)”: $\pm 5\%$ (Expert judgement)

7.5.1.3.2 Nitrous oxide

Domestic wastewater

Emission factor “kg N_2O -N/kg N”: $\pm 50\%$ (Expert judgement)

Activity data “Total nitrogen in influent and effluent” $\pm 10\%$ (Expert judgement)

The statistics of discharges from municipal wastewater treatment plants are biased from sources of inaccuracy such as under coverage, non-response or no observations and sample errors “within” the treatment plants. No objective methods of calculating accuracy measures have been developed, but data on nitrogen are considered to have a margin of inaccuracy of well under 10% at national level.

2006 IPCC Guidelines states that “Large uncertainties are associated with the IPCC default emission factors for nitrous oxide from effluent. Currently insufficient field data exist to improve this factor. Also, the nitrous oxide emission factor for plants is uncertain, because it is based on one field test.” At the moment 50% is used for the emission factors for nitrous oxide”. It is referred as an expert judgement.

Industrial wastewater

Emission factor “kg N_2O -N/kg N”: $\pm 50\%$ (Expert judgement)

Activity data “Total nitrogen in influent and effluent” $\pm 10\%$ (Expert judgement)

The statistics of discharges from industrial wastewater treatment facilities are biased from sources of inaccuracy such as under coverage, non-response or no observations and sample errors “within” the treatment plants. No objective methods of calculating accuracy measures have been developed, but data on nitrogen are considered to have a margin of inaccuracy of well under 10% at national level.

2006 IPCC Guidelines states that “Large uncertainties are associated with the IPCC default emission factors for nitrous oxide from effluent. Currently insufficient field data exist to improve this factor. Also, the nitrous oxide emission factor for plants is uncertain, because it is based on one field test.” At the moment 50% is used for the emission factors for nitrous oxide”. It is referred as an expert judgement.

The time series in the waste sector are calculated consistently and in line with the 2006 IPCC Guidelines. When statistics are not produced annually, interpolation and extrapolation have been necessary tools for imputation.

7.5.1.4 SOURCE-SPECIFIC QA/QC AND VERIFICATION

All quality procedures according to the Swedish QA/QC plan (Manual for SMED's Quality System in the Air Emission Inventories) have been implemented during the work with this submission.

7.5.1.5 SOURCE-SPECIFIC RECALCULATIONS

Recalculations have been done for methane and nitrous oxide from CRT 5.D.1 Domestic wastewater for the years 2021-2023. The reasons for the recalculations were:

- revisions of AD on upgraded biogas.
- availability of new data on nitrogen discharges from large municipal wastewater treatment plants.

For the years 2021-2023, the emission estimates increased by between 0.20% and 0.46%.

Recalculations have been done for nitrous oxide from CRT 5.D.2 Industrial wastewater for the years 2021-2023. The reasons for the recalculations were:

- availability of new data on nitrogen discharges from mining and quarrying and manufacturing industries.

For the years 2021-2023, the emission estimates increased by between 1.06% and 4.63%.

7.5.1.6 SOURCE-SPECIFIC PLANNED IMPROVEMENTS

Category-specific improvements will be decided after the finalization of the submission as part of the national QA/QC plan.

8 Other

Not applicable for Sweden.

9 Indirect CO₂ and nitrous oxide emissions

Sweden does not calculate and report indirect emissions of CO₂.

9.1 Indirect N₂O emissions from atmospheric deposition of nitrogen in NO_x and NH₃

9.1.1 Source category description

Sweden calculates and reports indirect emissions of N₂O from other sectors than agricultural and LULUCF.

9.1.2 Methodological issues

Indirect emissions of N₂O, from sectors other than agriculture and LULUCF, are calculated using Equation 7.1 from 2006 IPCC Guidelines, Volume 1 and default emission factor EF₄ (0.010) given in Table 11.3 of Volume 4. The method assumes that N₂O emissions from atmospheric deposition are reported by the country that produced the original NO_x and NH₃ emissions.

Equation 7.1. Calculation of indirect N₂O emissions, from 2006 IPCC Guidelines, Volume 1.

<p>EQUATION 7.1 N₂O EMISSIONS FROM ATMOSPHERIC DEPOSITION OF NO_x AND NH₃</p> $N_2O_{(t)} = \left[\left(NO_x - N_{(t)} \right) + \left(NH_3 - N_{(t)} \right) \right] \cdot EF_4 \cdot 44 / 28$
--

Data regarding NO_x and NH₃ emissions have been obtained from the present submission for UNFCCC and CLRTAP, respectively. Emissions from international transportation have been excluded from the calculations since these are not included in the national total emissions. It has been considered that emissions from aviation are reported differently in the CRT- and NFR-tables, and the CRT format has been followed in this regard. Activity data for the CRT / NFR codes 3B, 3D and 4 have been excluded as indirect emissions are already reported in the inventory for these codes.

9.1.3 Uncertainties and time-series consistency

No formal uncertainty analysis has been performed as the uncertainty for activity data (in this case NO_x and NH₃ emissions in the relevant CRT / NFR codes) do not exist at the aggregated level. The emission factor uncertainty is ± 80% according to the range given in Table 11.3 of Chapter 7.3 of Volume 1 of IPCC, 2006.

9.1.4 Source-specific QA/QC and verification

Emissions of NO_x reported under UNFCCC have been cross-checked with emissions reported under CLRTAP.

9.1.5 Source-specific recalculations

No recalculations were performed during submission 2026.

9.1.6 Source-specific planned improvements

No major improvements are currently planned for next submission.

10 Recalculations and improvements

The recalculations performed are due to comments and implemented recommendations from the national and international review teams, and national prioritizations. Some recalculations have been done to correct for small errors in earlier inventories detected during the work with the present inventory. The explanations and justifications for the recalculations made in this submission since the previous submission, together with descriptions on their implications for the emission levels, are given in more detail in the sector-specific sections.

Below, a summary description of the most significant revisions of methods and data are described by sector.

10.1 Explanations and justifications for recalculations

10.1.1 Energy, CRT 1

10.1.1.1 STATIONARY COMBUSTION

In submission 2026 the following main revisions were made:

- Methanol was recoded as a biogenic fuel instead of as a fossil fuel after discussions with the forestry industry
- The entire time series for oil refineries have been allocated to stationary combustion (1a1b) for a more consistent time series
- Revision of AD in 1A2g and 1a4 for 2023 are due to the final energy balances not being available for year 2023 during data collection in submission 2025 (but becoming available in submissions 2026).

10.1.1.2 MOBILE COMBUSTION

10.1.1.2.1 Aviation

- No recalculations in submission 2026.

10.1.1.2.2 Road traffic

In submission 2026, the following changes have been made to the HBEFA road model:

- Calibration of load patterns was made for HDV (*Heavy Duty Vehicles*) for the period 2021-2023. This leads to increases and decreases of fuel consumption for the relevant time series and category 1AA3B (Heavy duty trucks and buses).
- Distribution of traffic work among traffic situations has been updated for 2023.

In addition to the changes made in the road model HBEFA, the following changes have been made:

- In 2023 and 2024, some of the diesel fuel combustion was MK3, and not MK1 as previously assumed. This has been accounted for in this submission, resulting in a higher amount of CO₂ for 2023 (an increase of 0,35%).
- In previous submissions, CH₄ and N₂O from biogas was shown as coming from natural gas. In submission 2026, it is shown as coming from biogas. The update does not entail any change in total emissions.
- A reallocation of fuel between working machinery and road traffic has resulted in small increase of CO₂-eq emissions in road traffic for the entire time series. This is due to a development project regarding working machinery (see 3.2.20.5).

10.1.1.2.3 Navigation

In submission 2026 the following main revisions were made:

- Minor changes in the amounts of marine gasoil and diesel for the year 2023.

10.1.1.2.4 Non-road mobile machinery

In submission 2026 the following main revisions were made:

- Updates on 1A3e “other machinery” and the old machine population, the aggregated machine group +24-year-old machines. This group of machines mainly includes machinery specifically used in the road infrastructure sector and have for long made up 25-50% of the total machine population. Since EU-regulations forced a change from stage 0 to stage 5 (today) engines, it was concluded that the amount of +24-year-old machines can not make up a large share of the total amount of active machines as these aren’t allowed to be used. Aside from changing the number of +24-year-old machines the operating hours for new machines (machine year 0) was decreased by 50% to better match the fact that the average machine mange half a year of operating hours during the year it was brought to the market. The recalculation effect in 1A3e is around 1-6% decrease in CO₂-emissions over the time series. The decrease is greater for the latter part of the time series. This is because emissions from the old machine population gradually constituted a larger share of the total emissions as the old population grew.
- Update on stock of mobile cranes, wheel loaders, and backhoe loaders against the Swedish road traffic register, with respect to age distribution and scrappage rates. The updates resulted in emission revisions in the CRT codes where the above-mentioned machines are present.

10.1.1.2.5 Fishing

No recalculations in submission 2026.

10.1.1.3 FUGITIVE EMISSIONS

Emissions from oil refineries (1990-2020) are in submission 2026 re-allocated from sub-categories within the category CRT 1.B (fugitive emissions) to the category CRT 1.A.1.b (stationary combustion), to keep time-series consistency.

10.1.2 Industrial processes and product use, CRT 2

2.D.3: Solvent use: Activity data from the Swedish Chemicals Agency is only available with a one-year-delay. In submission 2026 activity data for 2023 is updated.

For a complete list and more detailed information on recalculations: see the sections “Source-specific recalculations” in section “Industrial processes and product use (CRT sector 2)”.

10.1.3 Agriculture, CRT 3

Since last submission there are minor recalculations due to updates in activity data. See under the paragraphs, source-specific recalculations, in the agriculture chapter for a complete list of all recalculations. There is also a correction of the EF in the ammonia calculation in inorganic fertilizers according to Guidebook 2023 which affects the indirect nitrous oxide emissions.

10.1.4 LULUCF, CRT 4

An important part of the difference between the two latest submissions for the LULUCF-sector is due to the ordinary update according to the methodology used, i.e. the continuous update of the statistics from the NFI and the soil inventory.

This year a major revision of the method to extrapolate the net removals in living biomass for inventory plots not yet re-inventoried was performed, see section 6.3.1.1 and Appendix Table A3:2.2. In addition, the method to estimate net removals in small trees was revised. Small trees (dbh<100 mm) were previously estimated with regression to -3.99 Mton CO₂ year⁻¹ for all years 1990 and onwards. Now the net removal of change in living biomass is estimated using the permanent NFI-plots, which means that the recalculated net removal for recent years has decreased (see Appendix Table A3:2.4.).

The total effect of the recalculation on Living biomass on Forest land remaining forest land is illustrated in Table 6.6a and Figure 6.12.

As for the previous submission, the approach to estimating carbon stock changes in dead wood, litter and mineral soil for several land – use change categories has been revised. For further details, see NID Annex 3:2.

10.1.5 Waste, CRT 5

Recalculations have been done for:

- methane from CRT 5.A.1 Managed waste disposal sites for the years 1990-2023,
- methane and nitrous oxide from CRT 5.B.1 Composting for the years 1990-2023,
- methane and nitrous oxide from CRT 5.D.1 Domestic wastewater for the years 2021-2023, and
- nitrous oxide from CRT 5.D.2 Industrial wastewater for the years 2021-2023.

For more detailed information on recalculations: see the sections “Source-specific recalculations” in section “Waste (CRT sector 5)”.

10.2 Implications for emission levels

As can be seen in Table 10.1 below, the recalculations carried out in the 2026 submission (compared to the 2025 submission) are below one percent on the national total emissions (excluding LULUCF, expressed as CO₂-eq.) for all years. The table also displays recalculations by CRT sector and year. Most significant revisions can be seen for the LULUCF sector.

10.3 Implications for emission trends

The national total emissions of GHG have changed for all inventory years due to the recalculations. As can be seen in Table 10.1 below, national total emissions (excluding LULUCF) in 1990 were changed by +52 kton CO₂-eq between the 2025 submission and the 2026 submission. National total emissions (excluding LULUCF) in 2023 were changed by -152 kton CO₂-eq between the 2025 submission and the 2026 submission.

Table 10.1. Recalculations of GHG emissions between submission 2025 and submission 2026 by CRT sector and total.

Year	Total (excl. LULUCF)		Total (incl. LULUCF)		CRT 1		CRT 2		CRT 3		CRT 4		CRT 5	
	kt CO ₂ -eq.	%	kt CO ₂ -eq.	%	kt CO ₂ -eq.	%	kt CO ₂ -eq.	%	kt CO ₂ -eq.	%	kt CO ₂ -eq.	%	kt CO ₂ -eq.	%
1990	52	0.07%	25 203	-186.59%	-98	-0.19%	0	0.00%	-1	-0.01%	25 151	-29.69%	151	3.54%
1991	45	0.06%	-1 679	-11.62%	-97	-0.18%	0	0.00%	5	0.07%	-1 724	3.03%	138	3.16%
1992	40	0.06%	-1 735	-11.54%	-96	-0.18%	0	0.00%	11	0.16%	-1 775	3.17%	125	2.87%
1993	39	0.06%	-1 761	-9.21%	-91	-0.17%	0	0.00%	16	0.22%	-1 800	3.45%	114	2.70%
1994	20	0.03%	-1 667	-8.31%	-104	-0.19%	0	0.00%	20	0.27%	-1 688	3.14%	104	2.55%
1995	3	0.00%	-1 741	-9.00%	-102	-0.19%	1	0.01%	9	0.13%	-1 744	3.24%	95	2.33%
1996	9	0.01%	-1 788	-8.47%	-89	-0.15%	2	0.02%	10	0.14%	-1 797	3.21%	86	2.14%
1997	-10	-0.01%	-1 798	-12.09%	-87	-0.16%	2	0.02%	-4	-0.05%	-1 788	3.12%	79	1.96%
1998	-9	-0.01%	-1 670	-11.42%	-76	-0.14%	2	0.03%	-7	-0.10%	-1 662	2.87%	72	1.82%
1999	-13	-0.02%	-1 794	-16.06%	-69	-0.14%	3	0.04%	-12	-0.17%	-1 782	3.06%	66	1.73%
2000	-30	-0.04%	-1 746	-20.20%	-72	-0.15%	3	0.04%	-22	-0.31%	-1 716	2.88%	60	1.63%
2001	-16	-0.02%	-1 801	-21.26%	-53	-0.11%	3	0.03%	-20	-0.29%	-1 785	2.95%	54	1.49%
2002	-13	-0.02%	-1 911	-20.27%	-57	-0.11%	2	0.03%	-8	-0.12%	-1 898	3.16%	49	1.42%
2003	7	0.01%	-1 882	-16.45%	-48	-0.09%	2	0.03%	-7	-0.10%	-1 889	3.24%	60	1.81%
2004	26	0.04%	-1 635	-11.63%	-44	-0.09%	4	0.04%	7	0.11%	-1 662	3.02%	60	1.82%
2005	0	0.00%	-1 340	-14.07%	-53	-0.11%	4	0.05%	14	0.22%	-1 340	2.36%	35	1.13%
2006	-2	0.00%	-1 800	-39.37%	-53	-0.11%	3	0.04%	17	0.26%	-1 798	2.93%	32	1.04%
2007	-2	0.00%	-2 818	-79.03%	-45	-0.10%	5	0.06%	10	0.16%	-2 816	4.60%	28	1.00%
2008	5	0.01%	-1 075	-71.94%	-49	-0.11%	5	0.06%	25	0.38%	-1 081	1.78%	25	0.98%
2009	3	0.00%	-1 031	44.51%	-41	-0.09%	4	0.07%	18	0.28%	-1 034	1.71%	22	0.91%
2010	-9	-0.01%	2 977	53269.86%	-49	-0.10%	4	0.05%	16	0.26%	2 986	-4.66%	19	0.84%
2011	-6	-0.01%	1 571	-47.22%	-48	-0.11%	3	0.04%	21	0.33%	1 577	-2.50%	17	0.79%
2012	-7	-0.01%	4 272	-59.82%	-44	-0.11%	3	0.04%	19	0.30%	4 279	-6.69%	15	0.74%
2013	-8	-0.01%	6 915	-61.29%	-43	-0.11%	3	0.05%	19	0.30%	6 923	-10.41%	12	0.65%
2014	-24	-0.04%	6 818	-58.95%	-59	-0.16%	5	0.06%	21	0.32%	6 842	-10.52%	11	0.60%
2015	-33	-0.06%	3 951	-62.70%	-64	-0.17%	5	0.06%	17	0.27%	3 984	-6.69%	9	0.52%
2016	-37	-0.07%	7 201	-108.75%	-62	-0.16%	5	0.07%	12	0.18%	7 238	-12.10%	7	0.48%
2017	-45	-0.09%	7 408	-404.03%	-67	-0.18%	5	0.06%	11	0.17%	7 454	-13.77%	6	0.40%
2018	-4	-0.01%	5 549	97.43%	-25	-0.07%	5	0.07%	11	0.17%	5 553	-12.14%	5	0.35%
2019	-5	-0.01%	5 544	138.88%	-27	-0.08%	4	0.06%	13	0.20%	5 550	-12.01%	4	0.34%
2020	-13	-0.03%	8 699	-337.88%	-32	-0.10%	4	0.07%	11	0.17%	8 712	-17.94%	3	0.25%
2021	-11	-0.02%	9 006	-788.39%	-29	-0.09%	7	0.10%	8	0.13%	9 017	-18.45%	4	0.31%
2022	-47	-0.10%	2 705	-396.39%	-54	-0.17%	6	0.08%	1	0.01%	2 752	-6.00%	0	0.02%
2023	-152	-0.34%	-22 810	-108.65%	-124	-0.41%	-5	-0.08%	-28	-0.44%	-22 658	96.86%	4	0.39%

10.4 Recalculations and other changes made in response to the UNFCCC review process

In Table 10.2, the findings of the latest UNFCCC review (FCCC/ETF/TERR.1/2024/SWE/Add.1, of 30 July 2025) are presented together with the status of implementation in Sweden and references to sections in this NID.

Table 10.3 presents the status of implementation of each recommendation listed in the most recently (of 28 August 2025) published individual Final Review Report, pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(3) of Regulation (EU) No 2018/842.

Information on responses and implementation of UNFCCC review report recommendations included in the previous Swedish submissions are available in previous Swedish NIDs.

Table 10.2 Status of implementation of each recommendation listed in the most recently published individual UNFCCC review report, including reasons for not implementing such a recommendation, and reference to relevant section of this NID.

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
GENERAL FINDINGS				
2.G.1	Specified in paragraphs 30–33 of the MPGs CRTs	<p>The total emissions reported for the energy and IPPU sectors were not consistent with the totals reported in the NID. For example, in the energy sector, the total emissions reported in CRT 1 (26,397.82 kt CO₂ eq) were lower than those reported in the NID (p.112) (30,868.21 kt CO₂ eq). Similarly, for the IPPU sector, total emissions were reported in CRT 2(l) as 3,947.92 kt CO₂ eq, which is lower than the total reported in the NID (p.205) (6,924 kt CO₂ eq).</p> <p>During the review, Sweden explained that the version of the ETF GHG inventory reporting tool at the time of reporting was affected by software bugs that impacted the sum of emissions when “C” was reported for some subcategories under the energy and IPPU sectors, thereby resulting in incorrect totals. The Party also explained that, since the submission, some of the bugs have been fixed in an updated version of the ETF GHG inventory reporting tool, and the CRTs were resubmitted during the review. Owing to confidentiality requirements, Sweden concealed the values entered in certain cells and replaced them with “C”. As a result, the values in the summary cells above these entries have still not been correctly calculated by the tool. Sweden reported “C” at a higher category level for 2022 only (categories 2.B and 2.D), meaning that the total emissions reported for that year are still an underestimate, even after the resubmission of the CRTs. The TERT noted that, although the totals have been corrected for the energy sector, some differences remain between the resubmitted CRT 2(l) and the NID for the IPPU sector. Specifically, the total reported in CRT 2(l) was 5,806.20 kt CO₂ eq, whereas the NID reports 6,924 kt CO₂ eq (p.205), which is considered complete and correct. The TERT commends Sweden for resubmitting the CRTs during the review.</p> <p>The TERT recommends that Sweden make all efforts to ensure that total emissions for the IPPU sector in CRT 6 are complete and cover all emissions, including those identified as confidential. For that purpose, the</p>	Resolved. Sweden has in preparation of submission 2026 been in contact with the secretariat in regard to this issue, however, has not come to a technical solution that would give correct sector and national totals with the current reporting of “C” for categories 2.B and 2.D. Therefore, to ensure that sector totals and national totals are correctly summarized, Sweden has chosen to allocate emissions in CRT 2.B to CRT 2.H.1 for year 2022, thus avoiding the use of “C” at the higher category level.	4.2. Chemical industry (CRT 2.B)

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
		TERT suggests Sweden work closely with the secretariat to overcome the identified bugs in the ETF GHG inventory reporting tool.		
2.G.2	Specified in paragraph 31 of the MPGs Notation keys	Sweden reported blank cells in a number of CRTs, including CRTs 1.A, 2(I), 2(II), 3.A, 3.B and 5.A. During the review, the Party clarified that notation keys were not entered in these cells because a problem occurred when the data were transferred to the CRTs from the Swedish database. The TERT recommends that the Party use notation keys where numerical data are not available when completing the CRTs.	Addressing. Sweden has made efforts to fill blank cells with the correct notation keys in submission 2026.	CRT several tables
2.G.3	Specified in paragraph 31 of the MPGs CRTs	The Party did not include explanations in CRT 9 for categories reported as "NE". During the review, the Party explained that it is still developing its internal database and reporting system to ensure full alignment with the new ETF GHG inventory reporting tool and complete functionality regarding the import and export of explanations related to the reporting of "NE". The TERT recommends that Sweden include an explanation wherever "NE" is reported in CRT 9.	Addressing. Sweden has made efforts to include explanations in CRT 9 for categories reported as "NE" in submission 2026. The information is however not fully included in submission 2026 and the efforts will continue in preparation of submission 2027.	CRT 9
ENERGY				
3.E.1	Specified in paragraph 26 of the MPGs 1. General (energy sector)	The Party reported "C" and "IE" for many energy subcategories throughout the time series. For example, with regard to petroleum refineries (category 1.B.2.a (oil)), for subcategory 1.B.2.a.iv (refining/storage) emission estimates were reported for 1990–2014, "C" was reported for 2015–2020 and "IE" was reported for 2021–2022. In addition, for subcategory 1.A.1.b (petroleum refining) emission estimates were reported for 1990–2018 and 2021, while "C" was reported for 2019–2020 and 2022. The changes in approach and notation key use throughout the time series reduce the time-series consistency and comparability of the Party's results. During the review, the Party stated that it aims to minimize the use of "C" to ensure maximum transparency while ensuring that confidential data are protected. The Party also stated that, to ensure time-series consistency, it will consider reporting all emissions from refineries in CRT 1.A.1.b for the whole time series in future submissions.	Resolved. The Party reported in its NID section 3.3.2.2 (p.192). To keep a consistent time series, emissions from refineries for all years are reported in CRT 1A1b starting from submission 2026	3.3.2.2 METHODOLOGICAL ISSUES

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
		<p>The TERT encourages the Party to review its reporting of “IE” and “C”, particularly with regard to category 1.A.1.b, with a view to improving time-series consistency and comparability.</p>		
3.E.2	<p>Specified in paragraph 36 of the MPGs Fuel combustion – reference approach</p>	<p>The Party reported on differences between its national estimates of CO2 emissions from fuel combustion and those obtained using the reference approach. There are significant differences between the two approaches; for example, the estimate for natural gas for 2022 was 34.1 per cent higher under the reference approach compared with the sectoral approach.</p> <p>During the review, the Party provided additional data and analysis that showed that the difference was mostly due to statistical differences reported in the energy balances, which, the Party confirmed, were related to the difference between fuel delivered and fuel consumed. The Party stated that the additional data and analysis will be included in future submissions.</p> <p>The TERT encourages the Party to include additional analysis on the effects of statistical differences in the energy balances to help to explain the differences between the results of the reference and sectoral approaches.</p>	Addressing	3.2.1 Comparison of the sectoral approach with the reference approach and section 4 in NID Annex
3.E.3	<p>Specified in paragraph 31 of the MPGs 1.A Fuel combustion – biomass – CH4 and N2O</p>	<p>The Party did not report estimates or notation keys for CH4 and N2O emissions from biomass for motorcycles for 1998–2022, in light-duty trucks for 1998–2015 or in off-road vehicles and other machinery under agriculture/forestry/fishing in CRTs 1.A.(a)s3 or 1.A.(a)s4. This is not in accordance with the MPGs, which state that notation keys should be used where numerical data are not available.</p> <p>During the review, the Party explained that “IE” should have been reported, but the notation keys were not entered properly owing to problems with the ETF GHG inventory reporting tool.</p> <p>The TERT recommends that the Party use “IE” to indicate that the emission estimates have been included elsewhere or separately estimate and report the CH4 and N2O emissions from biomass fuels.</p>	Resolved. Emissions are being reported.	-
3.E.4	<p>Specified in paragraph 47 of the MPGs 1.A.3.b</p>	<p>The Party’s IEFs for CH4 and N2O emissions from biomass fuels consumed in road transport were lower than those of other developed country Parties.</p>	Resolved. Emissions of CH4 and N2O from biomass are now being reported as such.	3.2.17.5 Source-specific recalculations

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
	Road transportation – biomass – CH4 and N2O	<p>During the review, the Party stated that most emissions from road transport were calculated using the Handbook Emission Factors for Road Transport road emissions model and included elsewhere under a fossil fuel equivalent subcategory, such as gasoline or diesel. However, emissions calculated without the model were reported as CH4 and N2O emissions from biofuels in the CRTs. The TERT noted that this approach does not support comparability between Parties and is not transparently described in the NIR or CRTs. The Party also stated that, in the next submission, CH4 and N2O emissions from biofuels will be reported against biomass, with the exception of biogas, which will be reported against biomass in the 2026 submission.</p> <p>The TERT recommends that the Party report all CH4 and N2O emissions from the combustion of biofuels as biomass rather than reporting the emissions under their fossil fuel equivalent.</p>		
INDUSTRIAL PROCESSES AND PRODUCT USE				
4.I.1	<p>Specified in paragraph 39 of the MPGs 2.C.1</p> <p>Iron and steel production – CO2</p>	<p>The Party reported in its NID (figure 4.4.1, p.245) a carbon flow chart, indicating that only liquefied petroleum gas and oils were used as input materials in rolling mills and back-up steam under subcategory 1.A.2.a.</p> <p>During the review, Sweden provided additional information, explaining that natural gas, coke oven gas and blast furnace gas were also consumed by both rolling mills and back-up steam equipment.</p> <p>The TERT recommends that the Party revise the carbon flow chart in the NID (figure 4.4.1) to ensure that all fuels – in particular gaseous fuels – used as input materials are accurately represented.</p>	Resolved. Carbon flow chart in NID Section 4.3.1.2.2 is updated to correctly account for all fuel and carbon flows.	4.3.1.2.2 Primary iron and steel production (CRT 2.C.1.b)
4.I.2	<p>Specified in paragraphs 31 and 40 of the MPGs 2.A.1</p> <p>Cement production – CO2</p>	<p>In table 4.2.2 of the NID (p.210), the Party reported information on the amount of clinker produced and the associated CO2 emission estimates for 1990–2021. However, for 2022, “C” was reported instead of clinker production data, CO2 emissions from clinker production and emissions from cement kiln dust. In addition, the cells for CO2 emissions from organic carbon content in materials and from limestone used in flue gas cleaning were left blank for 2022. Furthermore, in the same table, emissions from cement kiln dust were reported as “IE” for 2005–2021, with no explanation provided as to where in the inventory these emissions were included.</p>	Resolved. Clarification that cement kiln dust emissions are reported with clinker production is added in NID.	4.1.1. Cement production

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
		<p>During the review, the Party explained that information on CO₂ emissions from cement production had previously been fully disclosed, with no request from the sole cement producer in the country to treat the data as confidential; however, for the most recent submission, the company requested that AD and information on emissions related to both its plants not be disclosed in the NID and CRTs. The Party provided access to the confidential data during the review and the TERT concluded that emissions from cement production were not underestimated. Sweden justified its use of "IE" by stating that, under the EU ETS, cement kiln dust emissions are reported together with clinker production emissions for 2005 onward.</p> <p>The TERT recommends that the Party explain that cement kiln dust emissions are reported together with emissions from clinker production.</p>		
4.1.3	<p>Specified in paragraph 40 of the MPGs 2.C.1</p> <p>Iron and steel production – CO₂</p>	<p>The Party described in the NID (p.250) the fuels used by pelletizing plants (2.C.1.e) and indicated that stationary combustion emissions were reported under subcategory 1.A.2.g, in the energy sector. While assessing confidential data provided by the Party during the review, including a breakdown in the calculation of emissions by fuel type, the TERT noted that, although not all fuels were described in the NID (liquefied petroleum gas was missing), all fuels consumed in pelletizing plants were accurately reported under subcategory 1.A.2.g.viii in the relevant CRT.</p> <p>During the review, the Party agreed that not all fuels were described in the NID and confirmed that hard coal is the main fuel used at these plants, further clarifying the information provided during the review.</p> <p>The TERT recommends that the Party clearly describe in the NID all fuels used in pelletizing plants.</p>	<p>Resolved. The Party reported in its NID section 3.2.1.5 (p.145) the fuels used in pelletizing plants.</p>	<p>3.2.15 3.2.15 Other Industries (CRT 1.A.2.g)</p>
4.1.4	<p>Specified in paragraph 40 of the MPGs 2.C.1</p> <p>Iron and steel production – CO₂</p>	<p>The Party reported in the NID (p.242), under category 2.C.1.a, that CO₂ flaring emissions occur in electric arc furnaces, although such emissions are not typically expected during regular operations.</p> <p>During the review, Sweden shared information on an investigative project by SMED on flaring emissions and clarified that, at one secondary steel facility, gasoil flaring occurs when pipelines and tanks are emptied as part of an annual maintenance procedure.</p>	<p>Resolved. The Party explained in NID section 4.3.1.1.1 that flaring in secondary steel production occurs as a part of maintenance procedures.</p>	<p>4.3.1.1.1 Secondary steel production (CRT 2.C.1.a)</p>

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
		<p>The TERT recommends that the Party explain in the NID (section 4.4.1.1.1) that gasoil is only flared in electric arc furnaces during maintenance procedures</p>		
4.I.5	<p>Specified in paragraph 40 of the MPGs 2.C.1</p> <p>Iron and steel production – CO₂</p>	<p>The Party described in the NID (p.249) carbon balance inputs for sponge iron production, without specifying the carbon outputs of either products or byproducts.</p> <p>During the review, Sweden shared the classified AD on direct reduced iron and the carbon contents used to calculate CO₂ emission estimates for subcategory 2.C.1.c. The TERT concluded that the carbon content of sponge iron products and byproducts needs to be confirmed with the sponge iron producer.</p> <p>The TERT recommends that the Party specify the carbon outputs from iron products and byproducts in section 4.4.1.2.3 with a view to clarifying the carbon balance parameters considered in the calculation of emissions for subcategory 2.C.1.c, in accordance with the information provided during the review.</p>	<p>Resolved. The Party reported in its NID section 4.3.1.2.3 (p.255) a specification of carbon output for sponge iron production.</p>	<p>4.3.1.2.3 Direct reduced iron (CRT 2.C.1.c)</p>
AGRICULTURE				
5.A.1	<p>Specified in paragraph 39 of the MPGs 3.A.1</p> <p>Cattle – CH₄</p>	<p>In its NIR (p.321), Sweden reported that the distribution of calves (older or younger than six months) is model assisted, noting that 60 per cent are assumed to be younger than six months, and the rest are assumed to be older than six months. No further details of the model were provided.</p> <p>During the review, Sweden indicated that no data exist on the distribution of calves younger or older than six months; only statistics on the total number of calves (younger than one year) are available. Furthermore, since the method used for the inventory takes into account calves younger and older than six months, the assumption on the share of calves younger than six months (60 per cent) was used to enable inventory calculations to be carried out.</p> <p>The TERT recommends that Sweden include in its NID additional information on the model or method used to estimate the distribution of calves (older or younger than six months) and provide a clear explanation of the assumptions and data limitations underlying this distribution.</p>	<p>Resolved. The Party reported in its NID section 5.1 that the distribution of calves in different age groups is an assumption.</p>	<p>5.1 Overview of sector</p>

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
5.A.2	Specified in paragraphs 39–40 of the MPGs 3.A.1 Cattle – CH4	<p>The Party did not provide information on GE in silage and concentrate in its NIR. The TERT noted that information on GE in silage and concentrate is available in Bertilsson (2016), but this information was not included in the NIR.</p> <p>During the review, Sweden clarified that values for GE in silage and concentrate (20.0 and 18.4 MJ GE/kg TS respectively) were used in its calculations for the inventory. The Party indicated that a project aimed at updating the method for calculating enteric fermentation has been completed. Although the results were not ready in time to be included in the 2025 GHG inventory submission, the Party plans to implement them for its 2026 submission.</p> <p>The TERT recommends that Sweden provide transparent information on GE in silage and concentrate in its next submission.</p>	Resolved. The Party reported in its NID section 5.2.2.1.1 the values of the Gross Energy intake from silage and concentrate.	5.2.2.1.1 Dairy cattle
5.A.3	Specified in paragraphs 21 and 23 of the MPGs 3.A.2 Sheep – CH4	<p>According to the decision tree for CH4 emissions from enteric fermentation in the 2006 IPCC Guidelines (vol. 4, chap. 10, figure 10.2, p.10.25), a tier 2 approach should be used to estimate emissions for species where enhanced livestock characterization is available. However, Sweden used a tier 1 methodology and default EFs to estimate emissions from enteric fermentation for sheep when an enhanced characterization for sheep is available from Eurostat data. Moreover, information on Swedish breeds is available in the FAO Domestic Animal Diversity Information System.</p> <p>During the review, Sweden stated that information on the number of sheep and lambs is available, but not on feed and weight statistics. The reason for not using a tier 2 method is the lack of available data for GE.</p> <p>The TERT recommends that Sweden apply a higher-tier method and include in the NID the relevant parameters for estimating the CH4 EF and CH4 emissions from enteric fermentation. If the Party is unable to adopt a higher-tier method for the category owing to a lack of resources, the TERT recommends that the Party explain why its chosen method is not in line with the corresponding decision trees of the IPCC guidelines.</p>	Resolved. The Party has given an explanation why a Tier 1 method is used for sheep.	5.2.2.1 EMISSION FACTORS, METHANE
5.A.4	Specified in paragraphs 21	In its NIR (table 5.21, p.342), Sweden reported that direct N2O emissions from agricultural soils was identified as a key category. Sweden reported in its NID (table 5.21, p.342) that a tier 1 methodology was used, together with default EFs from the Wetlands Supplement, for estimating direct N2O	Resolved. The Party has updated the inventory with a CS EF. It is reported in its NID section 5.4.1.2.6.	5.4.1.2.6 Cultivation of organic soils (CRT 3.D.1.f)

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
	<p>and 23e of the MPGs</p> <p>3.D.1 Direct N₂O emissions from managed soils – N₂O</p>	<p>emissions from managed soils for category 3.D.a.6 (cultivation of organic soils (i.e. histosols)), which is a key category. This is not in accordance with the 2006 IPCC Guidelines, which require the use of a higher-tier method for key categories.</p> <p>During the review, the Party clarified that the EF for histosols will be updated for the next submission, for which a country-specific value of 10.3 kg N₂O-N/ha will be used. Sweden added that, according to the Wetlands Supplement (chap. 2, p.2.32), the use of a country- or region-specific EF in the tier 1 equation constitutes a tier 2 method.</p> <p>The TERT recommends that Sweden estimate direct N₂O emissions from managed soils for category 3.D.a.6 (cultivation of organic soils (i.e. histosols)), which is a key category, using a tier 2 approach. If the Party is unable to adopt a higher-tier method for the category owing to a lack of resources, the TERT recommends that the Party explain why its chosen method is not in line with the corresponding decision trees of the IPCC guidelines</p>		
5.A.5	<p>Specified in paragraph 39 of the MPGs</p> <p>3.D.1.b.ii Sewage sludge applied to soils – N₂O</p>	<p>In CRT 3.D, the increase in the amount of sewage sludge applied to soils for 2019–2021 is larger compared with the other years in the time series.</p> <p>During the review, the Party clarified that, for the 2024 submission, the AD for sewage sludge applied to soils were updated for 2019–2021. This is because there was a delay in delivering these statistics owing to the timing of Sweden's reporting of these data to the EU. However, the Party indicated that the sewage sludge statistics will be produced on a yearly basis going forward. The Party also explained that the amount of sludge applied to soils increased in 2019–2021, continuing the trend of a long-term increase, which began in 2002. A (near) ban on treating sewage sludge as landfill or in combustion, in conjunction with efforts to encourage the use of good-quality sewage sludge in agriculture, has led to an increase in the amount of sewage sludge in Sweden. As an EU member State, Sweden follows the EU directive on sewage sludge (directive 86/278/EEC), which regulates the use and quality of sewage sludge in agriculture.</p> <p>The TERT recommends that the Party explain in the NID the reason for the increase in the amount of sewage sludge applied to soils, particularly between 2019 and 2021.</p>	<p>Resolved. The Party reported in its NID section 5.4.1.2.2 the reason why the amount of sewage sludge applied to soils is increasing.</p>	<p>5.4.1.2.2 Nitrous oxide from organic N fertilisers (CRT 3.D.1.b.ii)</p>

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
LAND USE, LAND USE CHANGE AND FORESTRY				
6.L.1	Specified in paragraphs 21 and 23 of the MPGs 4. General (LULUCF) – CO ₂	Sweden used tier 1 methods for estimating CSC in organic soils under forest land and cropland (tables 6.1.a and 6.1.b of the NID) even though these are key categories. During the review, Sweden explained that its use of higher-tier methods was previously limited owing to insufficient data. However, a literature review conducted in 2024 enabled the use of updated country-specific EFs, and tier 2 methods are expected to be implemented for the next NIR submission. The TERT recommends that Sweden implement a higher-tier approach for estimating CSC in organic soils under forest land and cropland.	Resolved. The emission factors are revised in submission 2025 to Tier 2.	6.4.2.4.2 Forest land and Grassland on organic soils (CRT 4.A.1 and 4.C.1) in NID and 3.2.1.6 METHODOLOGY SOIL ORGANIC CARBON FOREST LAND AND GRASSLAND ON MINERAL SOILS CRT 4A AND 4C in Annex
6.L.2	Specified in paragraph 39 of the MPGs 4. General (LULUCF) – CO ₂	Sweden used 25 cm as the soil depth for cropland, which is shallower than the 30 cm soil depth recommended by the 2006 IPCC Guidelines (vol. 4, section 2.3.3.1). In addition, the Party assumed zero carbon at 50 cm depth in grassland. During the review, Sweden clarified that, for cropland, a soil depth of 25 cm aligns with the ploughing depth and is validated by ICBM data. The Party also explained that, regarding grassland interpolation, pre-2012 data were limited to 10 cm depth with no data on soil carbon at deeper depths, making the zero-carbon assumption necessary for grassland. As for forest land, data exist for depths of 55–65 cm and interpolated soil carbon stocks are reported down to 50 cm depth. Sweden also provided information on multi-depth sampling activities that have been ongoing since 2013 on grassland; these data will be used for the first time in the next submission. The TERT recommends that Sweden include in the NID the rationale for using a cropland soil depth of 25 cm, rather than the 30 cm soil depth recommended in the 2006 IPCC Guidelines.	Resolved. Included now in NID.	3.2.1.8 METHODOLOGY SOIL ORGANIC CARBON FOR CROPLAND ON MINERAL SOILS CRT 4B
6.L.3	Specified in paragraphs 22 and 39 of the MPGs	Sweden's methodology for estimating litterfall in the NIR relies on empirical regression models (e.g. Berg, 1999a; Berg, 1999b; and Johansson, 1999); however, the results were not validated against independent measurements.	Not resolved. The validation results were not ready for submission 2026 but will be ready for submission 2027.	-

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
	4.A Forest land – CO2	<p>During the review, Sweden clarified that a database of litterfall data (which includes Sweden and its neighbouring regions) has been compiled, and the model validation will be completed before the 2026 submission.</p> <p>The TERT recommends that Sweden provide the validation results for the empirical regression models used for estimating litterfall.</p>		
6.L.4	<p>Specified in paragraphs 22 and 39 of the MPGs</p> <p>4.A.2 Land converted to forest land – CO2</p>	<p>The TERT noted insufficient documentation in the NID justifying the EFs used for litter and mineral soils in conversions of cropland to forest land or grassland.</p> <p>Sweden explained that CSC factors were based on Karlton et al. (2015) and soil inventory data, and assumptions were used (e.g. a 100-year equilibrium period for conversions from cropland to forest land). Sweden also indicated that many CSC factors were re-evaluated while preparing the 2025 NIR. Additionally, two research projects will be implemented in 2025 with a view to gaining more insight into how these carbon pools are affected by land-use changes.</p> <p>The TERT recommends that Sweden provide in the NID information justifying the EFs used for litter and mineral soils in conversions of cropland to forest land or grassland.</p>	Resolved. The study of 2025 was not completed for submission 2026. A summary table was included to complement the text in Annex.	3.2.1.11.2 Litter and soil organic carbon
6.L.5	<p>Specified in paragraph 39 of the MPGs</p> <p>4.D Wetlands – CO2</p>	<p>Table A3:2.11 of the annex to the NID provides EFs for peat extraction areas (including DOC and ditch-related emissions) but does not reference the relevant sections or tables of the Wetlands Supplement.</p> <p>During the review, Sweden explained that the EFs used for estimating emissions from peat production land were derived from Lindgren and Lundblad (2014), which are in line with the EFs in the Wetlands Supplement, specifically CO2 EFs from table 2.1, DOC from table 2.2, CH4 from table 2.3, CH4 from ditches from table 2.4 and N2O-N from table 2.5.</p> <p>The TERT recommends that Sweden improve the transparency of the information provided by indicating the sources of the EFs used, clearly referencing the relevant tables from the IPCC guidelines.</p>	Resolved. EF were revised in submission 2025.	3.2.1.10 METHODOLOGY CO2 EMISSIONS AND NON-CO2 EMISSIONS FROM MINERALIZATION WHEN EXTRACTING PEAT CRT 4D AND 4 (II)
6.L.6	Specified in paragraphs 21 and 23 of the MPGs	Sweden's NID (section 6.4.2.9) did not clearly distinguish between IPCC default EFs and country-specific EFs for non-CO2 emissions from drained organic soils.	Resolved. EF were revised in submission 2025 to Tier 2.	3.2.1.10 METHODOLOGY CO2 EMISSIONS AND NON-CO2 EMISSIONS FROM

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
	4(II) Emissions/removals from drainage and rewetting and other management of organic/mineral soils – CH ₄ , N ₂ O	<p>During the review, Sweden confirmed that all EFs for non-CO₂ emissions from drained organic soils were directly sourced from the Wetlands Supplement and country-specific EFs were not used, referencing, inter alia, table 2.3 (CH₄), table 2.4 (CH₄ from ditches) and table 2.5 (N₂O-N) of the Wetlands Supplement. The TERT noted that, as emissions or removals from drainage and rewetting and other management of organic or mineral soils is a key category, the use of countryspecific EFs is expected.</p> <p>The TERT recommends that Sweden use a higher-tier method to estimate emissions or removals of CH₄ and N₂O from emissions or removals from drainage and rewetting and other management of organic or mineral soils.</p>		MINERALIZATION WHEN EXTRACTING PEAT CRT 4D AND 4 (II)
WASTE				
7.W.1	<p>Specified in paragraphs 26 and 39 of the MPGs</p> <p>5.A Solid waste disposal – CH₄</p>	<p>The DOC content reported in tables 7.16 and 7.18 of the NID varies significantly over the time series for certain waste categories. For example, the DOC content reported ranges from 0 to 12.5 per cent for industrial effluent sludges (dry matter); from 3.4 to 18 per cent for household and similar waste; and from 3.1 to 8.5 per cent for mixed and undifferentiated material.</p> <p>During the review, the Party explained that DOC values are estimated every other year using specific waste composition data reported using the European List of Waste codes, which explains the observed fluctuations in DOC content over the time series, which are due to variations in actual waste composition.</p> <p>The TERT recommends that the Party include in the NID a clear explanation of how DOC content is calculated, provide an analysis of the fluctuations observed over the time series and explain how accuracy of its CH₄ emission estimates for solid waste disposal is ensured.</p>	Not resolved. Resolving W.4, W.5, W.6 has been prioritized over resolving W.1 and W.2	-
7.W.2	<p>Specified in paragraph 39 of the MPGs</p> <p>5.A Solid waste disposal – CH₄</p>	<p>Table 7.5 of the NID reports energy recovery and flaring at landfills in MWh, while table 7.4 of the NID reports the quantities of recovered and flared CH₄ from landfill gas in units of mass (t CH₄). For emission calculations, CH₄ quantities must be expressed in units of mass (t CH₄).</p> <p>During the review, the Party explained that the information on recovered and flared gas for operational landfills was provided by Swedish Waste Management (in energy units, MWh), and the values were converted into</p>	Not resolved. Resolving W.4, W.5, W.6 has been prioritized over resolving W.1 and W.2	-

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
		<p>units of mass (t CH₄) by SMED (Statistics Sweden), whereas data on recovered and flared CH₄ for closed landfills are collected and processed by SMED (Statistics Sweden).</p> <p>The TERT recommends that the Party report CH₄ recovery at landfills by including in the NID a description of the different data-collection procedures used, clearly distinguishing between the data sources for recovered and flared gas at both open and closed landfills.</p>		
7.W.3	<p>Specified in paragraph 40 of the MPGs</p> <p>5.A Solid waste disposal – CH₄</p>	<p>The total deposited solid waste reported in table 7.3 of the NID and CRT 5.A (580.01 kt) is not consistent with the total in table 7.17 of the NID (563.43 kt).</p> <p>During the review, the Party clarified that the data reported in table 7.17 (as well as in tables 7.16 and 7.18) of the NID are presented as dry matter for four waste categories: 03.2 industrial effluent sludge, 03.2 hazardous industrial effluent sludge, 03.3 sludges and liquid waste from waste treatment and 11.A common sludge (excluding dredging spoils). This is consistent with Sweden's official waste statistics, which report these waste categories as dry matter. The Party also confirmed that these solid waste data are used in conjunction with DOC as dry matter, ensuring that the methodology aligns with standard practices for estimating CH₄ emissions.</p> <p>The TERT recommends that the Party clearly explain in the NID the reasons for the discrepancy in the reporting of total deposited waste between tables 7.3 and 7.17 in the NID and provide additional information on conversion of deposited waste into wet matter.</p>	<p>Resolved. Explanations and additional information are provided in the NID.</p>	<p>7.2.2.2.1 National application to IPCC First Order Decay (FOD)</p>
7.W.4	<p>Specified in paragraph 40 of the MPGs</p> <p>5.A Solid waste disposal – CH₄</p>	<p>The EWC-Stat codes used in the NID, specifically in table 7.17 for waste statistics and in tables 7.16 and 7.18 for DOC content, do not consistently use the standard EWC-Stat code nomenclature. Moreover, both EWC-Stat, version 4, codes and Eurobase codes (e.g. 02A, 05 and 11A) are used simultaneously in tables 7.16–7.18 of the NID, which may cause confusion.</p> <p>During the review, the Party explained that the official waste statistics are reported in accordance with the European List of Waste codes. The waste types, classified on the basis of the European List of Waste, are then aggregated into representative categories using the EU conversion table for converting EWC-Stat, version 4, codes to List of Waste codes as part of the inventory compilation process.</p>	<p>Resolved. Additional clarification, explanation and reference have been provided in the NID.</p>	<p>7.2.2.2.5 Used statistics on deposited waste, 1952-2024; References Section 7</p>

ID#	Reporting requirement	Description of area of improvement with recommendation or encouragement	Response /Status of implementation	Section in NID
		<p>The TERT recommends that the Party clearly indicate that both nomenclatures (the EWC-Stat, version 4, codes and the Eurobase codes) are used in tables 7.16–7.18, describe the waste aggregation procedure in the NID and include a reference to the conversion table.</p>		
7.W.5	<p>Specified in paragraph 39 of the MPGs</p> <p>5.B Biological treatment of solid waste – CH4</p>	<p>The amount of CH4 recovered from anaerobic digestion at biogas facilities (category 5.B.2) was reported correctly in CRT 5.B (as amount of CH4 flared and amount of CH4 for energy recovery), but a transparent description was not provided, as the NID does not reference the source of the data.</p> <p>During the review, the Party explained that data on the amount of CH4 recovered are provided by the Swedish Energy Agency.</p> <p>The TERT recommends that the Party explain how information on the quantities of CH4 recovered is obtained and include a reference to the Swedish Energy Agency data in section 7.3 of the NID on biogas production at anaerobic digestion plants.</p>	<p>Resolved. Additional explanations and a reference have been provided in the NID.</p>	<p>7.3 Biological treatment of solid waste (CRT 5.B)</p>

Table 10.3 Status of implementation of each recommendation listed in the most recently published individual Final Review Report, pursuant to Article 38(1a) of Regulation (EU) No 2018/1999 and Article 4(3) of Regulation (EU) No 2018/842

EMRT - ID	Category, gas, year	Review recommendation from the TERT	Response / status of implementation	Chapter/ section in the NIR
SE-2B10-2025-0002	2B10 Other (chemical industry), CO ₂ , 2021-2023	The TERT noted that the sectoral totals for 2022 for CO ₂ and CH ₄ for sector '2. Industrial processes and product use' did not include the emissions from categories reported as confidential ('C'). During the review, Sweden explained that due to a bug in the CRT reporter programme (i.e. the ETF – GHG inventory reporting tool) it was not possible for Sweden to import values at the parent categories (sectoral level) when notation key 'C' was used in the child categories (category or sub-category level). Therefore, the emissions in categories reported as 'C' were considered as zero in the sectoral totals in CRT tables, leading to underestimation of emissions. Sweden provided a revised estimate for year 2022. The TERT agreed with the revised estimate provided by Sweden. The TERT recommends that Sweden include the revised estimate in its next submission.	Resolved. Sweden has in preparation of submission 2026 been in contact with the secretariat in regard to this issue, however, has not come to a technical solution that would give correct sector and national totals with the current reporting of "C" for categories 2.B and 2.D. Therefore, to ensure that sector totals and national totals are correctly summarized, Sweden has chosen to allocate emissions in CRT 2.B to CRT 2.H.1 for year 2022, thus avoiding the use of "C" at the higher category level.	4.2. Chemical industry (CRT 2.B)
SE-1A1-2024-0001	1A1 Energy Industries, CO ₂ , 2022	For category 1A1 Energy Industries and 1A2 Manufacturing Industries and Construction for the year 2022, the TERT noted that the reporting problem in the ETF tool identified in the 2024 review, where summary cells above confidential data were incorrectly calculated, was not fully fixed. During the review, Sweden provided the TERT with the CRT tables showing confidential data. The TERT noted several aggregation errors at category and sub-category level but concluded that the total emissions were correctly calculated for 1A1 and 1A2 in the national total. The TERT therefore notes that this issue does not relate to an over- or under-estimate of emissions. The TERT recommends that Sweden continue its work to correct the errors identified in the reporting.	Addressing.	-

EMRT - ID	Category, gas, year	Review recommendation from the TERT	Response / status of implementation	Chapter/ section in the NIR
SE-1A2g-2025-0004	1A2g Other (manufacturing industries and construction), CO2, 2022	For category 1A2g Other, Liquid Fuels, and CO2 for the year 2022, the TERT noted that CRT Table 1.A(a)s2 displayed a high value of the CO2 IEF of 113.99 t/TJ, compared with 72.07 t/TJ in 2021 and 72.20 t/TJ in 2023. In response to a question raised during the review, Sweden explained that the high value resulted from a technical bug in the CRT reporter software (i.e. the ETF tool), which miscalculates summary cells when notation key 'C' is used. A hotfix released by the UNFCCC in February 2025 resolved these errors for all years except 2022, where the error persists. Sweden informed the TERT that the correct IEF of 72.07 t/TJ was applied in the emissions calculations, and thus the reported CO2 emissions themselves are accurate, while the AD has been aggregated incorrectly. The TERT notes that this issue does not relate to an over- or under-estimate of emissions. The TERT recommends that Sweden continue the efforts to ensure that correct IEF values are presented in the CRT tables.	Addressing	-
SE-1AB-2025-0001	1AB Reference approach, CO2, 2023	For total CO2 emissions in the reference and sectoral approaches for the years 2022 and 2023, the TERT noted a significant change in the reported difference, from +12.7% in the October 2024 submission for 2022 to -11% in the 2025 submission for 2023, as presented in CRT Table 1.A(c). The TERT notes that this issue does not relate to an over- or under-estimate of emissions but concerns a lack of transparency in the comparison of the reference and sectoral approaches. In response to a question raised during the review, Sweden explained that the discrepancy is due to a limitation in the reporting software: some of the sums including confidential data are not correct in the CRT tables. The TERT recommends that Sweden continue its efforts to resolve the reporting issue regarding reference approach and clearly explain this issue in the NID until it is fully resolved. The reporting issues related to sectoral approach are included under observation SE-1A1-2024-0001 above.	Addressing	-

EMRT - ID	Category, gas, year	Review recommendation from the TERT	Response / status of implementation	Chapter/ section in the NIR
SE-2F1-2025-0003	2F1 Refrigeration and Air Conditioning, HFCs, 1990-2023	For 2F1 Refrigeration and Air Conditioning and other F-gas subcategories, the TERT noted that significant amounts of F-gases are reported in the section on recovery. Recovered gases are increasingly being reused in the same or other equipment because of increasing prices for fresh refrigerants. Not including reused HFCs in the top-down estimate of the refrigerant supply will likely result in a systematic under-estimation of emissions. The TERT also notes that the current estimate is in accordance with the 2006 IPCC Guidelines and that available data does not allow to include the impact of HFC reuse in the inventory. The TERT decided not to carry out a technical correction, because due to lack of data, a technical correction would not have improved accuracy of the estimates. Therefore, the TERT recommends that Sweden collect data and information on F-gas reuse in different subcategories, include these in the emission estimates, and provide a description of the situation in their NID.	Resolved. No method changes will be made regarding data collection as there is no central data collection in Sweden and there is neither any indication of significant over/under-estimations when comparing	4.6.1.2 Methodological issues

PART 2: SUPPLEMENTARY INFORMATION REQUIRED UNDER ARTICLE 7, PARAGRAPH 1

11 Information on changes in national system

Since we are entering a new reporting and accounting period in 2021 Sweden has made a review of the national system to be in line with the reporting requirements under EU legislation (Governance regulation 2018/1999) and reporting requirements under the climate convention and the Paris Agreement.

Sweden has updated the climate reporting ordinance and the agreements following by the ordinance. We have added two more agencies for delivering of data – Swedish eHealth Agency and Swedish Medical Products Agency. Data from Geological Survey of Sweden aren't needed anymore since the responsibility for peat production now is regulated in the Environmental code and Swedish Environmental Protection Agency is responsible for this reporting.

12 References

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13 Units and Abbreviations

t	1 (metric) tonne = 1 megagram (Mg) = 10 ⁶ g
toe	tonne oil equivalent 1 toe = 41.87 GJ
Mg	1 megagram = 10 ⁶ g = 1 tonne
Gg	1 gigagram = 10 ⁹ g = 1 kilotonne (kt)
Tg	1 teragram = 10 ¹² g = 1 megatonne (Mt)
TJ	1 terajoule
AR	Afforestation and Reforestation
ARTEMIS	Assessment and Reliability of Transport Emission Models and Inventory Systems
AWMS	Animal Waste Management System
C	Carbon or Confidential
CH ₄	Methane
EMIR	Emissions database of the county administrative boards
ERT	Expert Review Team
CFCs	Freons
CKD	Cement kiln dust
CMP	Meeting of the Parties to the Kyoto Protocol
CO	Carbon monoxide
CO ₂	Carbon dioxide
COP	Conference Of the Parties
CORINAIR	EMEP/CORINAIR Emission Inventory Guidebook
CRT	Common Reporting Table
D	Deforestation
DOM	Dead organic matter
SOC	Soil organic carbon
EC	Environmental Class
EAA	European Aluminium Association
EEA	European Environment Agency
EF	Emission Factors
EU	European Union
EMV	Emission Model for Road Traffic
ETS	Emission Trading Scheme
FAME	Fatty Acid Methyl Ester (earlier called RME)
F-gases	Fluorinated gases (HFCs, PFCs, SF ₆)
FM	Forest management
FMV	Swedish Defence Material Administration
FAO	Food and Agriculture Organisation of the UN
FOD model	IPCC First Order Decay model
FOI	Swedish Defence Research Agency
FORTV	Swedish Fortification Department
FRA	Forest Resource Assessment
FRA	National Defence Radio Institute
FTP	Federal Test Procedure
GHG	Greenhouse gases
Good Practice Guidance	IPCC Good Practice Guidance and Uncertainty Management in National Greenhouse Gas Inventories IPCC NGGIP
GWP	Global Warming Potential
Halocarbons	Organic compounds containing one or more halogens

HBEFA	Handbook Emission Factors for Road Transport
HWP	Harvested Wood products
HFCs	Hydrofluorocarbons
IE	Included Elsewhere
IEA	International Energy Agency
IEF	Implied Emission Factors
Industrial statistics	Industrial energy statistics
IPCC	Intergovernmental Panel on Climate Change
IPCC Guidelines	Revised 1996 Guidelines for National Greenhouse Gas Inventories
IPCC EFDB	IPCC Emission factor data base
ISIC	International Standard Industrial Classification of All Economic Activities
IVL	IVL Swedish Environmental Research Institute AB
Jernkontoret	Swedish Steel Producers' Association
KemI	The Swedish Chemicals Agency
KP	the Kyoto protocol
LPG	Liquefied Petroleum Gas
LTO	Landing and Take-Off
LUCF	Land-use change and forestry
LULUCF	Land-use, land-use change and forestry
MI	Markinventeringen (Swedish soil inventory)
MSW	Municipal solid waste
N ₂ O	Nitrous oxide
NAP	Swedish national allocation plan
NA	Not Applicable
NBF	National Board of Forestry
NCV	Net Calorific Value
NE	Not Estimated
NFI	National Forest Inventory
NID	National Inventory Report
NMVOG	Non Methane Volatile Organic Compounds
NO	Not Occuring
NO _x	Nitrogen oxides
NSFSV	National Survey of Forest Soils and Vegetation
MTC	Motor Test Center
O ₃	Ozone
PA	Production approach
PAH	Polycyclic aromatic hydrocarbons
PDCA	Plan, Do, Check, Act
PFCs	Perfluorocarbons
QA/QC	Quality assurance and Quality control
Quarterly statistics	Quarterly fuel statistics
RIS	Riksinventeringen av skog (national forest inventory)
RME	Rapeseed Methyl Ester fuel
RVF	Swedish Association of Waste Management
SF ₆	Sulphur hexafluoride
SDC	Forest industry information association
SGU	Geological Survey of Sweden
SJV	Swedish Board of Agriculture

SLU	Swedish University of Agricultural Sciences
SMED	Swedish Environmental Emissions Data
SMHI	Swedish Meteorological and Hydrological Institute
STA	Swedish Transport Administration
STAg	Swedish Transport Agency
SO ₂	Sulphur dioxide
SPBI	Swedish Petroleum and Biofuel Institute
Swedish EPA	Swedish Environmental Protection Agency
TCCCA	transparency, consistency, completeness, comparability and accuracy
TSP	Total amount of suspended particles
TPS	Technical Production System
UNFCCC	United Nations Convention on Climate Change
VBA	Visual Basic for Applications
VETO	Mechanistic model for simulations on road traffic
VTI	Swedish Road- and Transport Research Institute
WBCSD	World Business Council for Sustainable Development
WRI	World Resource Institute